MotionChip™ II

TML Programming

TECHNOSOFT

User Manual

Preliminary

TECHNOSOFT

MotionChip™ II
TML Programming

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Read This First

About This Manual

This book presents the Technosoft Motion Language (in short **TML**) and how to use it for the programming of drives built around **MotionChip II**. The book includes the following information:

- TML basic concepts
- Motion programming
- Functional description of the TML instructions
- Communication channels and protocols
- Detailed description of each TML instruction including: syntax, binary code and examples.

Scope of This Manual

The TML programming of drives based on **MotionChip II** involves 2 steps:
Step 1 - Parameters setup
Step 2 - Motion programming

The goal of first step is to set the TML parameters in accordance with the user application data. This step is described in the user manual ***MotionChip II Configuration Setup***.

This manual describes the second step – Motion programming.

Both steps can be performed using **IPM Motion Studio** – a development platform offering easy-to-use graphical programming for devices based on MotionChip II. The output from IPM Motion Studio is a TML program, which can be downloaded into the non-volatile memory of the drive and can be started automatically after power on.

Depending on your application configuration, you have the following options for splitting the tasks between your host and your drive based on MotionChip II:

1. ***Host control is absent***. The complete motion application is programmed in the drive using TML
2. ***Host control is done via I/O handshake***. The host commands are set via digital or analogue signals. The drive answers also using digital signals
3. ***Minimal host control via a communication channel***. The host control is reduced at calling motion functions implemented in the drive non-volatile memory and requesting

status information. The motion functions from the drive memory can be developed separately using IPM Motion Studio

4. ***Extended host control via a communication channel***. The host sends all the TML commands needed to program the motion, but does not perform the drive setup. This is done via a TML program executed automatically after power-on. The TML program can be developed using IPM Motion Studio.
5. ***Full host control via a communication channel.*** In this case the host performs both the drive setup and the motion programming. There is no TML program stored in the drive.

You need this manual only if you plan to use options 4 or 5. The options 1 to 3 can be handled using IPM Motion Studio platform and its user-friendly, graphical programming.

Remarks:

- *The 3rd option requires the host to handle a limited number of TML instructions, typically just for calling functions and asking/getting status data. You can quickly find the code of these instructions and how to pack them into communication messages by using the IPM Motion Studio tool **Binary Code Viewer**.*
- *Option 5 requires a good understanding of how to determine the TML parameters values. This information is presented in the user manual **MotionChip II Configuration Setup**.*

Notational Conventions

This document uses the following conventions:

- TML – Technosoft Motion Language
- Program examples are shown with a special font. Here is an example:

```
ENIO#36;   //Configure dual function pin as I/O line 36
user_1 = IN#36;   //Read I/O line 36 data into variable user_1
```

Related Documentation from Technosoft

MotionChip II Configuration Setup (part no. P091.055.MCII.STP.UM.xxxx) describes the MotionChip II operation and how to setup its registers and parameters starting from the user application data. This is a technical reference manual for all the MotionChip II registers, parameters and variables.

MotionChip II Data sheet (part no. P091.055. MCII-QFP100.DST.xxxx) presents the MotionChip II features and specifications, and how to interface it with typical external devices

IPM Motion Studio User Manual (part no. P091.088.E075.UM.xxxx) describes how to use the IPM Motion Studio – the complete development platform for MotionChip II including: motion system setup & tuning wizard, motion sequence programming wizard, testing and debugging tools like: data logging, watch, control panels, on-line viewers of TML registers, parameters and variables, etc.

If you Need Assistance …

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1. TML Basic Concepts

1.1 TML Overview

The Technosoft Motion Language (TML) is a high-level language allowing you to:

- Setup a drive built with MotionChip II for a given application
- Program and execute motion sequences

The setup part consists in assigning the right values for the TML registers and parameters. Through this process you can:

- Describe your application configuration (as motor and sensors type)
- Select specific operation settings (as motor start mode, PWM mode, sampling rates, etc.)
- Setup the controllers' parameters (current, speed, position), etc.

The next part is for motion programming. Here the TML allows you to:

- Set various motion modes (profiles, contouring, electronic gearing or camming, etc.)
- Change the motion modes and/or the motion parameters on-the-fly
- Execute homing sequences
- Control the program flow through:
    - Conditional jumps and calls of TML functions
    - TML interrupts generated on pre-defined or programmable conditions (protections triggered, detection of transitions on limit switch or capture inputs, etc.)
    - Waits for programmed events to occur
- Handle digital I/O and analogue input signals
- Execute arithmetic and logic operations
- Perform data transfers between axes
- Control motion of an axis from another one via motion commands sent between axes
- Send commands to a group of axes (multicast). This includes the possibility to start simultaneously motion sequences on all the axes from the group

Due to a powerful instruction set, the motion programming in TML is quick and easy even for complex motion applications. The result is a high-level motor-independent program which once conceived may be used in other applications too.

1.2 TML Environment

The TML environment includes three basic components:

1. "TML processor"
2. Trajectory generator
3. Motor control kernel

The software-implemented "TML processor" represents the core of the TML environment. It decodes and executes the TML commands. Like any processor, it includes specific elements as program counter, stack, ALU, interrupt management and registers.

The trajectory generator computes the position, speed, torque or voltage reference at each sampling step, depending on the selected motion mode.

The motor-control kernel implements the control loops including: the acquisition of the feedback sensors, the controllers, the PWM commands, the protections, etc.

When the "motion processor" executes a motion command, it translates them into actions upon the trajectory generator and/or the motor control kernel.

1.3 Program Execution

The TML programs are executed sequentially, one instruction after the other. A 16-bit instruction pointer (IP) controls the program flow. As the binary code of a TML instruction may have up to 5 words, during its execution the IP is increased accordingly. When the execution of a TML instruction ends, the IP always points to the next TML instruction, or more exactly to the first word of its binary code.

The sequential execution may be interrupted by one of the following causes:

- A TML command received through a communication channel (on-line commands);
- A branch to the interrupt service routine (ISR) when a TML interrupt occurs;
- The need to send the master position to the slave axes when the current axis is set as master for electronic gearing or camming
- A `GOTO` or `CALL` instruction;
- A return from a TML function – `RET` or from a TML interrupt – `RETI;`
- During the execution of the instructions: `WAIT!` (wait event), `SEG` (new contour segment) and data transfers between axes of type `local_variable = [x]remote_variable`, which all keep the IP unchanged (i.e. loop on the same instruction) until a specific condition is achieved
- After execution of the `END` instruction.

The on-line commands have the highest priority and act like interrupts: when an on-line command is received through any communication channel, it starts to be executed immediately after the current TML instruction is completed.

If an on-line command is received during a wait loop, e.g. when WAIT! or SEG commands are processed, the wait loop is temporary suspended, to permit the execution of the on-line command.

The TML works with 3 types of commands, presented in **Table 1.1.**

Table 1.1 *Type of TML commands*

TML Command Type	Execution	
	From a TML program	**Send via communication**
Immediate	√	√
Sequential	√	-
On-line	-	√

The immediate commands may be send via a communication channel, or can reside a TML program. These commands don't require any wait loops to complete. Their execution is straightforward and can't be interrupted by other TML commands.

The sequential commands require a wait loop to complete i.e. will not permit IP to advance until the wait condition becomes true. In this category enter commands like:

`WAIT!;` // Wait a programmed event to occur

`SEG` *`Time`*`,` *`Increment`*`;` // Set a contour segment with parameters *Time* and *Increment* to be executed when the previous one ends

`local_variable = [x]remote_variable;` // Get value of *remote_variable* from axis x and put it in *local_variable*

The sequential commands can reside only in a TML program saved in the local memory.

Remark: *If a sequential command is sent via a communication channel, it is immediately executed as if the wait loop condition is always true.*

The on-line commands may be sent only via a communication channel. These commands can't be included in a TML program. The on-line commands do not have an associated mnemonic and syntax rules as they are do not need to be recognized by the TML compiler.

Remark: *Some of the on-line commands are implemented in debugging tools like the* ***Command Interpreter*** *from* ***IPM Motion Studio****, which was specifically designed to allow sending commands via a communication channel. In this manual, these commands are presented with a "mnemonic" like that used in the Command Interpreter.*

1.4 TML Program Structure

The main section of a TML program starts with the instruction BEGIN and ends with the instruction `END`. It is divided into two parts:

- Setup part
- Motion programming part

The setup part starts after `BEGIN` and lasts until the `ENDINIT` instruction, meaning "END of INITitialization". This part of the TML program consists mainly of assignment instructions, which shall set the TML registers and the TML parameters in accordance with your application data. When the `ENDINIT` command is executed, key features of the TML environment are initialized according with the setup data. After the `ENDINIT` execution, the basic configuration involving the motor and sensors types or the sampling rates, cannot be changed unless a reset is performed.

Remark: *The* ***MotionChip II Configuration Setup*** *user manual specifies which TML parameters may not change after execution of the `ENDINIT` instruction*

The motion programming part starts after the `ENDINIT` instruction until the `END` instruction. All the TML programs (the main section) should end with the TML instruction `END`. When `END` instruction is encountered, the sequential execution of a TML program is stopped.

Apart from the main section, a TML program also includes the TML interrupt vectors table, the interrupt service routines (ISRs) for the TML interrupts and the TML functions. A typical structure for a TML program is presented in **Figure 1.1**

```
      BEGIN;                // TML program start
       ...
                            // Setup part of the main section
       ...
      ENDINIT;              // end of initialization
       ...
                            // Motion programming part of the main section
       ...
      END;                  // end of the main section

InterruptTable:             // start of the interrupt vectors table
   @Int0_Axis_disable_ISR;
   @Int1_PDPINT_ISR;
   @Int2_Software_Protection_ISR;
   @Int3_Control_Error_ISR;
   @Int4_Communication_Error_ISR;
   @Int5_Wrap_Around_ISR;
   @Int6_Limit_Switch_Positive_ISR;
   @Int7_Limit_Switch_Negative_ISR;
   @Int8_Capture_ISR;
   @Int9_Motion_Complete_ISR;
   @Int10_Update_Contour_Segment_ISR;
   @Int11_Event_Reach_ISR;
Int0_Axis_disable_ISR:            // Int0_Axis_disable_ISR body
      ...
      RETI;                       // RETurn from TML ISR
      ...
Int11_Event_Reach_ISR:            // Int11_Event_Reach_ISR body
      ...
      RETI;                       // RETurn from TML ISR
Function1:                        // Start of the first TML function named Function1
      ...
      RET;                        // RETurn from TML function named Function 1
      ...
FunctionX:                        // Start of the last TML function named FunctionX
      ...
      RET;                        // RETurn from the last TML function named Function X
```

Figure 1.1 *Typical structure of a TML Program*

1.5 TML Instruction Coding

The TML instruction code consists of 1 to 5, 16-bit words. The first word is the operation code. The rest of words (if present) represent the instruction data words. The operation code is divided into two fields: Bits 15-9 represent the code for the operation category.

For example all TML instructions that perform addition of two integer variables share the same operation category code. The remaining bits 8-0 represent the operand ID that is specific for each instruction.

Operation Code
Data (1)
…
Data (4)

Operation Code Structure

Operation Category	**Operand ID**
15 ……………………9	**8 ……………………….. 0**

1.6 TML Data

The TML works with the following categories of data:

- TML registers
- TML parameters
- TML variables
- User variables

All TML data are identified by their name. The names of the TML registers, parameters or variables are predefined and do not require to be declared. The names of the user variables are at your choice. You need to declare the user variables before using them.

The TML uses the following data types:

- `int` 16-bit signed integer
- `uint` 16-bit unsigned integer
- `fixed` 32-bit fixed-point data with the 16MSB for the integer part and the 16LSB for the factionary part.
- `long` 32-bit signed integer
- `ulong` 32-bit unsigned integer

The data type `uint` or `ulong` are reserved for the TML predefined data. The user-defined variables are always signed. Hence you may declare them of type: `int`, `fixed` or `long`.

Remark: *An unsigned TML data means that in the MotionChip II firmware its value is interpreted as unsigned. Typical examples: register values, time-related variables, protection limits for signals that may have only positive values like temperature or supply voltage, etc. However, the same* *data will interpreted as signed if it is used in a TML instruction whose operands are treated as signed values.*

Each TML data has an associated address. This represents the address of the data memory location where the TML data exists. In TML the data components may be addressed in 2 ways:

- **direct**, using their name in the TML instruction mnemonic

Example:

`CPOS = 2000;` // write 2000 in CPOS parameter (command position)

- **indirect**, using a pointer variable. The pointer value is the address of the data component to work with

Example:

```
user_var = 0x29E;  // write hexadecimal value 0x29E representing CPOS address in
                   // the user-defined pointer variable user_var
(user_var),dm = 2000;  // write 2000 in the data memory address pointed by
                       // user_var i.e. in the CPOS parameter
```

Remark: *direct addressing may be used with all TML data having addresses between 0x200 and 0x3FF. This covers most of the TML data including the user-defined variables. There are however some TML data with extended addresses placed outside this range typically between 0x800 and 0x9FF. These variables shall be addressed either using the indirect addressing presented above or by using another direct addressing mode specifically foreseen for writing values in the variables with extended addresses:*

- **direct with extended address**, using the TML data name

Example:

`CPOS,dm = 2000;` // write 2000 in CPOS using direct mode with extended address

In the TML instructions the operands (variables) are grouped into 2 categories:

- **V16**. In this category enter all the 16-bit data from all the categories: TML registers, TML parameters, TML variables, and user parameters. From the execution point of view, the TML makes no difference between them
- **V32**. In this category enter all the 32-bit data either long or fixed from all the categories: TML registers, TML parameters, TML variables, and user parameters. From the execution point of view, the TML makes no difference between them

Remarks:

- *It is possible to address only the high or low part of a 32-bit data, using the suffix (H) or (L) after the variable name.*

Examples:

```
CPOS(L) = 0x4321; // write hexadecimal value 0x4321 in low part of CPOS
CPOS(H) = 0x8765; // write hexadecimal value 0x8765 in high part of CPOS
                  // following the last 2 commands, CPOS = 0x87654321
```

- *The TML compiler always checks the data type. It returns an error if an operand has an incompatible data type or if the operands are not of the same type*
- *A write operation using indirect addressing is performed on one or two words function of the data type. If the data is a 16-bit integer, the write is done at the specified address. If the data is fixed or long the write is performed at the specified address and the next one. A fixed data is recognized by the presence of the do, for example:* ***`2.`*** *or* ***`1.5.`*** *A long variable is automatically recognized when it's size is outside the 16-bit integer range or in case of smaller values by the presence of the suffix L, for example:* ***`200L`*** *or* ***`–1L`****.*

Examples:

```
user_var = 0x29E;  // write CPOS address in pointer variable user_var
(user_var),dm = 1000000;  // write 1000000 (0xF4240) in the CPOS parameter i.e
                          // 0x4240 at address 0x29E and 0xF at next address 0x29F
(user_var),dm = -1;// write -1 (0xFFFF) in CPOS(L). CPOS(H) remains unchanged
(user_var),dm = -1L;// write –1 seen as a long variable (0xFFFFFFFF) in CPOS i.e.
                              // CPOS(L) = 0xFFFF and  CPOS(H) = 0xFFFF
user_var = 0x2A0;  // write CSPD address in pointer variable user_var

(user_var),dm = 1.5;  // write 1.5 (0x18000) in the CSPD parameter i.e
                          // 0x8000 at address 0x2A0 and 0x1 at next address 0x2A1
```

- *In an indirect addressing, if the pointer variable if followed by + sign, it is automatically incremented by 1 or 2 depending on the data type: 1 for integer, 2 for fixed or long data.*

Examples:

```
user_var = 0x29E;  // write CPOS address in pointer variable user_var
(user_var+),dm = 1000L;  // write 1000 seen as long in CPOS, then increment
                          // user_var by 2
(user_var+),dm = 1000;  // write 1000 seen as int at address 0x29A (0x29E+2) ,
                          // then increment user_var by 1
```

1.6.1 TML Registers

There are 3 categories of TML registers:

- Configuration registers
- Command registers
- Status registers

The configuration registers contain essential configuration information like motor and sensors type, or basic operation settings like PWM mode, motor start method, etc. The configuration registers must be set up during the setup part before the `ENDINIT` instruction

The command registers hold configuration settings that can be changed during motion. These settings refer to the activation/deactivation of software protections, to the use of TML interrupts and to communication options.

The status registers provide information about: communication, active motion mode and control loops, system protections, TML interrupts. The status registers can be used to detect events and to make decisions in a TML program.

Configuration registers (R/W):

SCR – System Configuration Register. It's used to define the basic application configuration: motor and sensors types, presence of brake circuit.

OSR – Operating Settings Register. Used to define specific system operating settings, as: current offset detection mode, Brushless AC motor start procedure, PWM special features.

Command registers (R/W):

CCR – Communication Control Register. Contains settings for SPI.

ICR – Interrupt Control Register. Used to disable/enable TML interrupts.

PCR.5-0 – Protections Control Register. Used to activate different protections in the system, as: maximum current, I^2t, over- and under-voltage and over-temperature.

Status registers (RO):

AAR - Axis Address Register. Keeps the Axis ID and the group ID.

CBR – CAN Baud rate Register. Keeps the current settings for CAN-bus baud-rate.

CER – Communication Error Register. Contains error flags for the communication channels.

CSR – Communication Status Register. Contains status flags for the communication channels.

ISR - Interrupt Status Register. Contains interrupt flags set by the TML interrupt conditions.

MCR – Motion Command Register. Contains information about the motion modes: reference mode, active control loops, positioning type - absolute or relative, etc.

MSR – Motion Status Register. It's used internally by the TML kernel; the register bits give indications about motion progress and specific motion events as software protections, control error, wrap-around, limit switches, captures, contour segments, events, axis status, etc.

PCR.13-8 - Protections Control Register. Used to examine the status of different protections in the system, as: over-current, $I^2 t$, over- and under-voltage and TEMP1, TEMP2 inputs over limits.

The TML registers have reserved mnemonics, but no especially dedicated instructions. Hence, in a TML program, registers are treated like any other TML parameter or variable.

The configuration and command registers can be read or written. The status registers can only be read.

1.6.2 TML Parameters

The TML parameters allow you to setup the parameters of the TML environment according with your application data. Though most of the TML parameters have their own address, there are some that share the same memory address. They are used in application configurations that exclude each other, and thus are not needed at the same time.

Some TML parameters must be setup during the initialization phase. They are used to define the real-time kernel, including the PWM frequency and the control loops sampling periods, and should not be changed after the execution of the `ENDINIT` command. The other parameters can be initialized, used and changed any time, before or after the `ENDINIT` command.

1.6.3 TML Variables

The TML variables provide you status information about the TML environment like the motor position, speed and current, the position, speed and current commands, etc. These values may be used to take decisions in the motion program or for analysis and debug.

The TML variables are read-only (RO). Modifying their value during motion execution may cause an improper operation of the motion system. There are however, specific situations when some TML variables may also be written (R/W variables).

Most of the TML variables are internally initialized after power-on, or during the setup phase at the execution of the `ENDINIT` command.

Activating the on-chip logger module, real-time data tracking can also be implemented for any of these variables.

1.6.4 User variables

Besides the TML pre-defined variables, you can also define your own user variables. You can use your variables in any TML instruction accepting variables of the same type.

The user variables type can be: integer, fixed (point) or long (integer) (see **Table 1.2**).

Table 1.2. *TML data type*

Type	Format	Representation	Range
Int	Signed integer	16 bits	-32768 ¸ 32767 (0x8000 ¸ 0x7FFF)
Long	Signed long integer	32 bits	-2147483648 ¸ 2147483647 (0x80000000 ¸ 0x7FFFFFFF)
Fixed	(Integer part).(fractional part)	32 bits	-32768.999969 ¸ 32767.999969 (0xFFFF.FFFF ¸ 0x7FFF.FFFF)

The address of the user variables is automatically set in order of declaration starting with 0x03B0. First integer variable takes address 0x3B0, next one 0x3B1, etc. An `int` variable takes one memory location. A `long` or `fixed` variable takes 2 consecutive memory locations. In this case the variable address is the lowerst one.

Example:

```
int user_var1;          // user_var1 address is 0x3B0
long user_var2;         // user_var2 address is 0x3B1
fixed user_var3;        // user_var3 address is 0c3B3
int user_var4;          // user_var4 address is 0x3B5
```

Remark: *you have to declare a user variable before using it first time.*

1.7 TML Development tools

As mentioned earlier, a TML program has 2 parts: the **setup** and the **motion programming**.

You should always start with the setup part. This consists in assigning the right values for the TML registers and parameters according with your application data: motor and sensors type, operating conditions, controller settings, etc.

Once the setup process is completed, you can start programming your application motion.

You can do these steps either by writing directly the TML program by using a higher-level tool like **IPM Motion Studio** which generates automatically the TML program starting from your input data.

IPM Motion Studio is an integrated development platform specifically designed to help you develop and test motion applications in TML. It comes with a user-friendly interface allowing you to introduce your motor data, select different operation options for the drive and perform a series of validation tests including identification of the motor parameters, operation conditions and the controllers tuning. Based on this information the IPM Motion Studio automatically generates the TML instructions needed to set the right values into the TML registers and parameters.

For the motion programming, IPM Motion Studio offers the **Motion wizard** – a collection of user-friendly dialogues through which you can quickly define your motion application. The Motion wizard automatically generates TML source code (TML instructions) based on your inputs.

IPM Motion Studio is a complete development platform. Embedded code development tools allow you to further edit or directly compile, link and generate executable code to be downloaded to the drive. Finally, advanced graphics tools – like data logger, control panel and view/watch of TML parameters, registers and memory – can be used to analyze the behavior of the motion system.

1.8 Memory Map

The MotionChip II works with 2 separate address spaces: one for TML programs and the other for data memory. Each space accommodates a total of 64K 16-bit word.

The first 16K of the TML program space (0 to 3FFFh) are reserved and can't be used. The next 16K, from 4000h to 7FFFh are mapped to a serial SPI-connected EEROM with the maximum size 32K bytes (seen as 16K 16-bit words). This space can be used to store TML programs, cam tables or other user data in a non-volatile memory. The recommended way to organize the EEPROM memory space is:

- TML program at the beginning of the EEPROM memory, starting with first address 4000h.
- Cam tables, after the TML program
- Other data until the end of the EEPROM

Remarks:

- *If the MotionChip II is set in AUTORUN mode, it checks the contents of the first EEPROM location at address 4000h. If the data read matches with the binary code of the TML instruction `BEGIN` (the first instruction in a TML program), then the instruction pointer IP is set to 4000h and the TML program from the EEPROM is executed*

- *The overall dimension of a TML program includes apart from the main section, the TML interrupt vectors table, the interrupt service routines (ISRs) for the TML interrupts and the TML functions*
- *IPM Motion Studio, uses the last 68 words of the EEPROM space/read some data about the drive like: product ID, firmware ID, etc.*

The next 2K of the TML program space from 8000h to 87FFh represents the Motion Chip II internal SRAM memory. From it, the first 200h, from 8000h to 81FFh are reserved for the internal use. The rest from 8200h to 87FFh may be used to temporary store TML programs.

The MotionChip II firmware can be programmed on two versions of DSP made by Texas Instruments: TMS320LF2407A or TMS320LF2406A.

The TMS320LF2406A has no external interface, hence only the internal SRAM may be used as TML program memory in the address range 8200h to 87FFh. The remaining TML program memory space from 8800h to FFFFh is invalid.

The TMS320LF2407A offers the possibility to connect an external SRAM, which can be mapped in the last 32K more exactly in the address range 8800h to FFFFh (all TML program memory accesses in the address range 0x8000 to 0x87FF are using the internal SRAM). By connecting a 32Kx16 external SRAM, the total TML program space in SRAM memory becomes from 8200h to FFFFh.

The data memory space is used to store the TML data (registers, parameters, variables), the cam tables during runtime (after being copied from the EEPROM memory) and for data acquisitions. The TML data are stored in reserved area, while the others are using the same Motion Chip II internal SRAM memory.

In the data memory space, the internal SRAM is mapped at a different address range 800h to FFFh From this the first 200h, from 800h to 9FFh (corresponding to 8000h to 81FFh in TML program memory space) are reserved for the internal use. The rest from A00h to FFFh corresponding to 8200h to 87FFh in the TML program memory space) may be used for data acquisitions and/or to store cam tables during runtime. As this space is available in both the TML program space and the data space it is the user responsibility to decide how to split it between the two and to avoid overlapping them.

In the case of TMS320LF2407A, if an external SRAM is connected it can be mapped both on the TML program space and in the data space. Typically, the external SRAM is mapped at the same addresses in both the TML program and the data space. Therefore the data memory extends with the external SRAM space from 0x8000 to 0xFFFF.

The recommended way to organize the SRAM memory (both for TML programs and data) is:

A) For MotionChip II based on TMS320LF2406A:

- Data acquisitions at the beginning of the internal SRAM memory, starting from address A00h
- Cam tables, only if used, after the data acquisitions until the end of the internal SRAM.

Typically, you should start by checking if or how much space you need to reserve for cam tables, and use the rest of the SRAM for data acquisitions

Remark: *You may also store TML programs in the internal SRAM memory. However, this will further reduce the limited space available for data acquisitions and cam tables. Therefore it is highly preferable to store the TML programs in the EEPROM space. Typically, you may want to use the SRAM memory instead of the EEPROM memory for TML programs only during the application development in order to speed-up testing due to a faster access*

B) For MotionChip II based on TMS320LF2407A:

- Data acquisitions at the beginning of the external SRAM memory not overlapped with the internal SRAM, starting from address 8000h
- TML programs (for faster testing instead of using the EEPROM)
- Cam tables, only if used, after the data acquisitions until the end of the internal SRAM.

Remarks:

- *In IPM Motion Studio, if you chose to download and execute a TML program from the SRAM memory the default start address proposed is C000h i.e. half of the overall external SRAM space*
- *Data acquisitions may start directly from address 8000h, if this is the beginning of the external SRAM. When used as data memory, the external SRAM is also visible in the range 8000h to 87FFh. When used as program memory, the same address range is mapped into the internal SRAM. However, if you plan to examine the memory contents using an IPM Motion Studio tool like View | Memory, be aware that the values displayed in the range 8000h to 87FFh do not represent the data acquisition results but the internal SRAM values.*

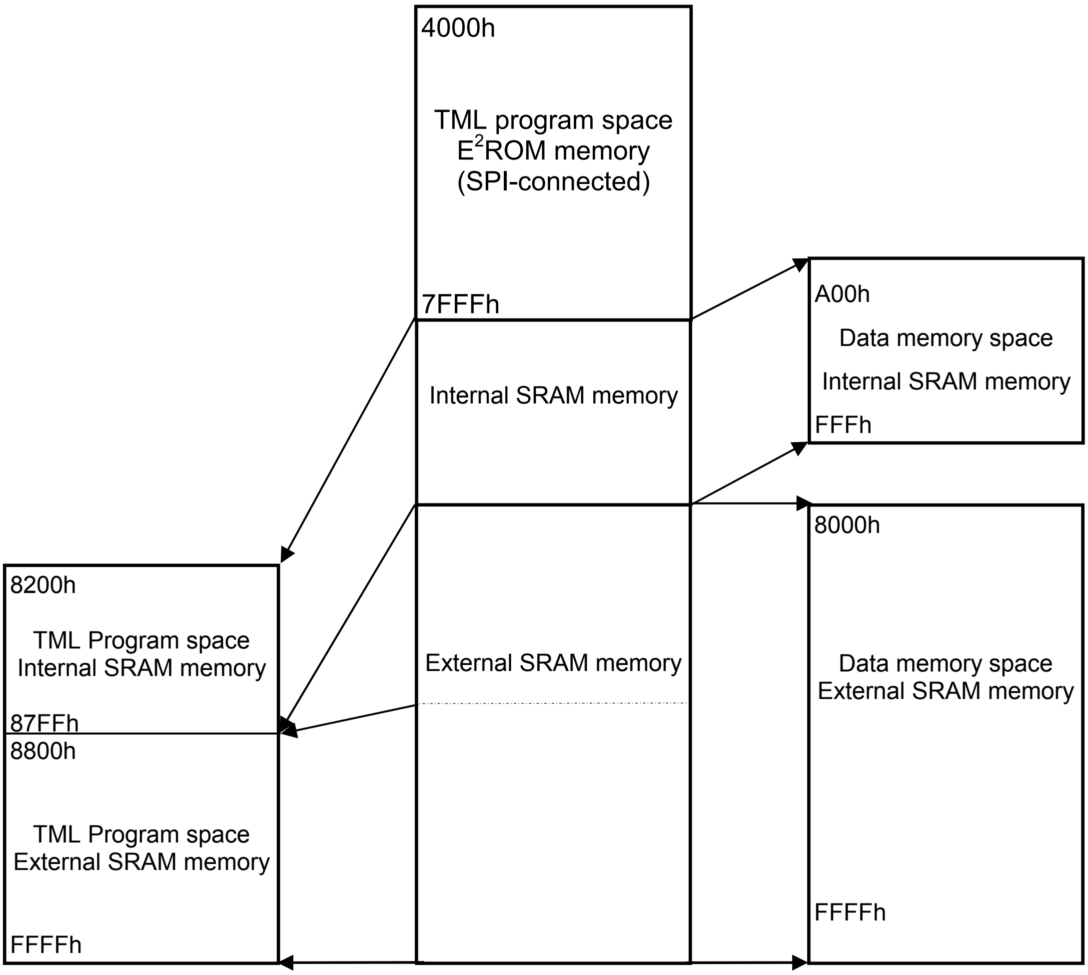

Figure 1.2. *Memory map MotionChip II based on TMS320LF2407A*

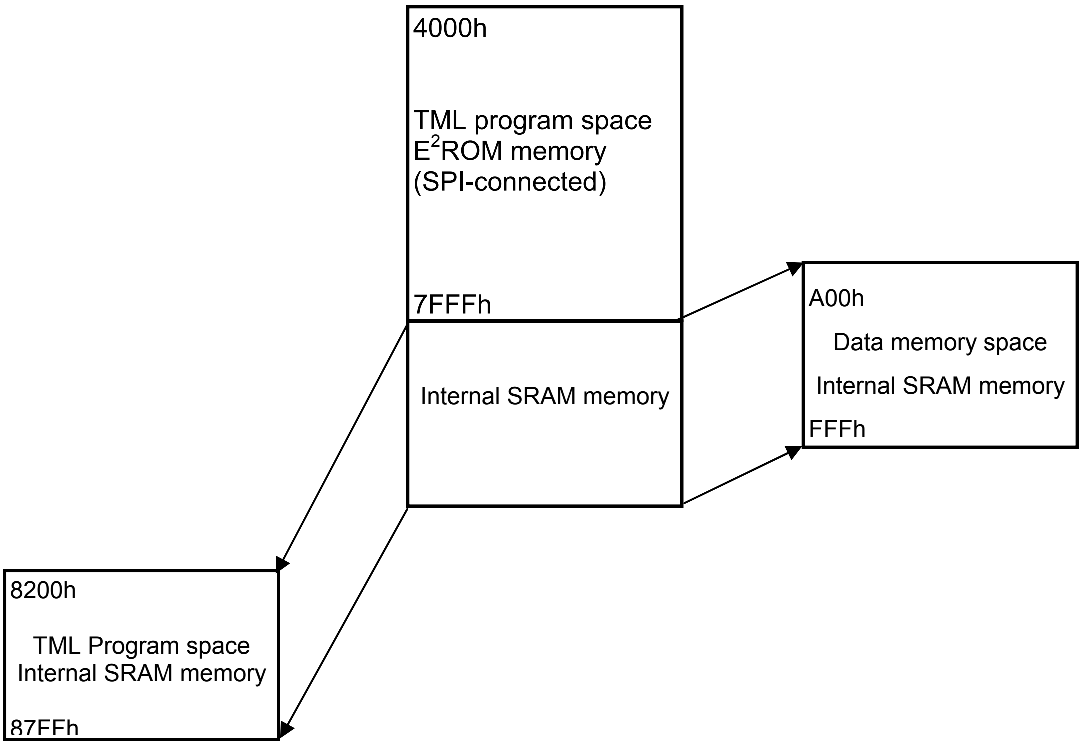

Figure 1.3. *Memory map MotionChip II based on TMS320LF2406*

1.9 AUTORUN mode

After power on the MotionChip II checks the status of its analogue input ADCIN9. If this input is low, the MotionChip II is set in the **AUTORUN** mode.

In the **AUTORUN** mode, the MotionChip II, reads the first EEPROM memory location at address 0x4000 and checks if the binary code corresponds to the TML instruction `BEGIN`. If this condition is true, the TML program saved in the EEPROM memory is executed starting with the next instruction after `BEGIN`.

If analogue input ADCIN9 is high, the MotionChip II enters in the **slave** mode where it waits to receive commands via a communication channel. Even if there is a valid TML program in the EEPROM, this is not executed.

During a TML program execution, the MotionChip II can enter in the **slave** mode and thus stopping the TML program execution after the execution of the `END` command or after receiving `STOPx` (x=0,1,2 or 3) command from an external device, via a communication channel.

1.10 Logger feature

Step to follow, in order to use the logger features:

- Setup the logger header
- Setup the logger pointer
- If the drive is in Axison state, the data acquisition is done at each current or speed/position loop period, depending by logger configuration

The following table presents the map of logger buffer.

Buffer	Logger buffer address	Name	Description
Logger Header	*LOG_START_ADDR*+0	*N_POINTS*	Number of points left to be acquired. During the acquisition this value is decremented to 0.
	LOG_START_ADDR+1	*INT_CNT*	Internal sampling counter. It must be initialized with the same value as sampling multiplier
	LOG_START_ADDR+2	*S_MULTPL*	Sampling multiplier
	LOG_START_ADDR+3	*FREE_LOC*	The address of next free buffer location. It must be initialized with *LOG_START_ADDR* + 4 + *NO_16B_VARS*
	LOG_START_ADDR+4	*ADDR1*	1st 16-bit location address which it will be acquired
	LOG_START_ADDR+5	*ADDR2*	2nd 16-bit location address which it will be acquired
	LOG_START_ADDR+6	*ADDR3*	3rd 16-bit location address which it will be acquired
	…	…	…
	LOG_START_ADDR+3+ *NO_16B_VARS*	*ADDRn*	Last 16-bit location address which it will be acquired
	LOG_START_ADDR+4+ *NO_16B_VARS*	*END_LIST*	End of address list = 0 value
Data Buffer	*LOG_START_ADDR*+5+ *NO_16B_VARS*		1st 16-bit data acquired - first point
	LOG_START_ADDR+6+ *NO_16B_VARS*		2nd 16-bit data acquired - first point
	…		…
	LOG_START_ADDR+6+ 2 * *NO_16B_VARS*		1st 16-bit data acquired - second point
	LOG_START_ADDR+7+ 2 * *NO_16B_VARS*		2nd 16-bit data acquired - second point
	…		…

	LOG_START_ADDR +4+ *NO_16B_VARS* + (*N_POINTS* * *NO_16B_VARS)*		Last 16-bit data acquired - last point

Note: 1. The *LOG_START_ADDR* must have the bits 0 and 1 set to 0, i.e. a value multiple of 4.

2. *NO_16B_VARS* = number of 16-bit locations which must be acquired.

3. A 32-bit variable can be acquired as 2 x 16-bit variables

Address	**Name**	**Description**
0x0365	*LOG_PTR*	Internal pointer to logger buffer. Bits 15-2 = bits 15-2 of *LOG_START_ADDR* Bits 1-0 = logger active in: 01 – Speed/ Position control loop 10 – Current control loop

Example for the acquisition of *APOS* and *ATIME* variables in speed/position loop period. The acquisition buffer starts at the address 0x0A00.

Buffer	**Address: data (hex)**	**Name**	**Description**
Logger Header	0A00: 012C	*N_POINTS*	Acquisition of 300 points
	0A01: 0004	*INT_CNT*	Internal counter. It must be initialized with the same value as sampling multiplier.
	0A02: 0004	*S_MULTPL*	Sampling multiplier = 4, i.e. 1 acquisition point at 4 samplings
	0A03: 0A09	*FREE_LOC*	The address of next free buffer location
	0A04: 0228	*ADDR1*	The address of APOS variable (32-bits) - low part
	0A05: 0229	*ADDR2*	The address of APOS variable (32-bits) - high part
	0A06: 02C0	*ADDR3*	The address of ATIME variable (32-bits) - low part
	0A07: 02C1	*ADDR4*	The address of ATIME variable (32-bits) - high part
	0A08: 0000	*END_LIST*	End of address list = 0 value
Data Buffer	0A09: xxxx		Acquired value – APOS(L) – first point
	0A0A: xxxx		Acquired value – APOS(H) – first point
	0A0B: xxxx		Acquired value – ATIME(L) – first point

	0A0C: xxxx		Acquired value – ATIME(H) – first point
	0A0D: xxxx		Acquired value – APOS(L) – second point
	0A0E: xxxx		Acquired value – APOS(L) – second point
	0A0F: xxxx		Acquired value – ATIME(L) – second point
	0A10: xxxx		Acquired value – ATIME(H) – second point
	…		…
	0EB8: xxxx		Acquired value – ATIME(H) – last point

Address: data (hex)	**Name**	**Description**
0365: 0A01	*LOG_PTR*	Internal pointer to logger buffer. Bits 15-2 = 00001010000000(bin) = bits 15-2 of *LOG_START_ADDR* Bits 1-0 = 01(bin) = logger active in Speed/ Position control loop

When the acquisition is done in speed/ position control loop the acquisition period is:

Acquisition period [s] = SLPER [bits] * <Sampling multiplier> [bits] * <PWM period>[s]

When the acquisition is done in current control loop the acquisition period is:

Acquisition period [s] = CLPER [bits] * <Sampling multiplier> [bits] * <PWM period>[s]

Example:

- SLPER = 20
- <Sampling multiplier> = 4
- <PWM period> = 50 x 10^{-6} [s]

Acquisition period [s] = 20 x 4 x 50 x 10^{-6} [s] = 4 x 10^{-3} [s]

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2. TML description

This chapter describes the TML - Technosoft Motion Language. The TML provides instructions for the following categories of operations:

- Motion programming and control
- Program flow control
- I/O handling
- Assignment and data transfer
- Arithmetic and logic manipulation
- Data transfer between axes
- Miscellaneous

2.1 Motion programming and control

These instructions allow you to program the MotionChip II built-in motion controller in order to set different motion modes and trajectories. **Table 2.1** summarizes all the motion modes supported. These are divided into 2 categories function of how the motion reference is generated:

- Motion modes with reference provided by an external device via an analog input, pulse & direction signals, a master encoder or via a communication channel
- Motion modes with reference computed by the internal reference generator. In this category enter all the other motion modes

Table 2.1. *Motion modes*

<table>
<tr><th rowspan="2">Motion Modes</th><th colspan="4">Control Type</th></tr>
<tr><th>Position</th><th>Speed</th><th>Torque</th><th>Voltage</th></tr>
<tr><td>Position profiles</td><td>√</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Speed profiles</td><td>–</td><td>√</td><td>–</td><td>–</td></tr>
<tr><td>Contouring (point to point with linear interpolation)</td><td>√</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td rowspan="2">External reference read from the analogue input REFERENCE or set by an external device via a communication channel</td><td rowspan="2">√</td><td rowspan="2">√</td><td>√ SL</td><td>√ SL</td></tr>
<tr><td>√FL</td><td>√ SL</td></tr>
<tr><td>Pulse and direction</td><td>√</td><td>√</td><td>–</td><td>–</td></tr>
<tr><td>Electronic Gearing/Camming – master</td><td>√</td><td>√</td><td>–</td><td>–</td></tr>
<tr><td>Electronic Gearing – slave</td><td>√</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Electronic Camming – slave</td><td>√</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Stop</td><td>–</td><td>√</td><td>√</td><td>√</td></tr>
<tr><td>Test (limited ramp)</td><td>–</td><td>–</td><td>√FL</td><td>√FL</td></tr>
</table>

2.1.1 Position Profile Modes

In the position profile modes, the motor is controlled in position. You specify the position to reach (relative or absolute), the acceleration/deceleration rate and the slew (travel) speed. The reference generator computes the position trajectory, which results with a trapezoidal or triangular speed profile. During motion, you can change on the fly all the profile parameters (see par. 2.1.10)

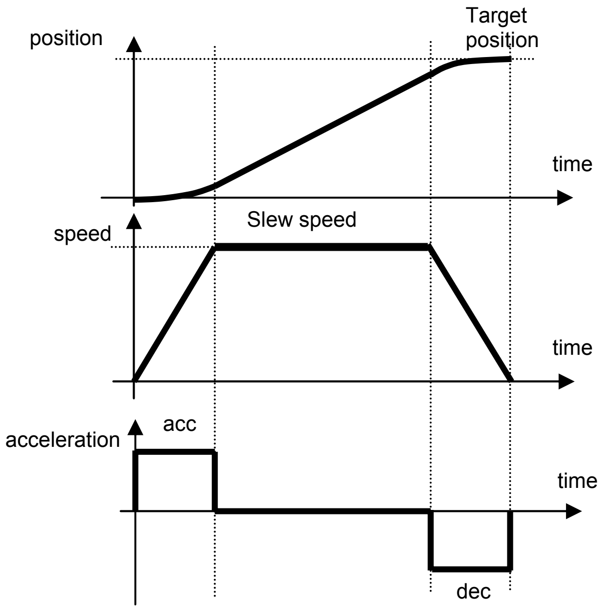

Figure 2.1. *Position profile parameters*

Once programmed, the motion profile parameters are memorized. If you intend to use the same values as previously defined for the acceleration rate, the slew speed, the position increment or position to reach you don't need to set these again, each time you program a new position profile.

Depending on the control structure used, four position profile modes are possible:

Table 2.2. *Position Profile - Motion Modes*

Position Profile Motion Modes	**Controlled Loops**		
	Position	**Speed**	**Torque**
PP3	√	√	√
PP2	√	√	–
PP1	√	–	√
PP0	√	–	–

The selection of one of the above position profile modes, must match with the setup data. For example, you can choose to perform a position control with or without closing the speed loop and with torque/current loop closed. In the first case, the position controller provides a speed command for the speed controller who on its turn provides a current command for the current controller. In this case, you should use the TML instruction `MODE PP3`. In the second case, the position controller provides directly the current command for the current controller and you should use the TML instruction `MODE PP1`. As the tuning for the position controller is different in the 2 cases, it is not possible to switch on the fly between `MODE PP3` and `MODE PP1`. During the setup phase you have to chose one option and set the parameters accordingly. Then during the motion programming, you need to use the appropriate motion mode.

Remarks:

- *As in most applications the current/torque control is needed, the IPM Motion Studio does not cover the setup options where current loop is not closed. Therefore, using IPM Motion Studio, you can chose only between 2 options: position loop with speed loop and current loop (`MODE PP3`) and position loop without speed loop and with current loop (`MODE PP1`).*
- *Closing all the loops offers a good control of the motor speed while closing only position and current loop may provide better performances for high-dynamic applications requiring quick positioning moves. When position loop is closed without the speed loop (`MODE PP1`) you can increase the position loop bandwidth 2-3 times more compared with the case when all the 3 loops are closed (`MODE PP3`).*

Related TML Parameters

CPOS	Command position (long) – desired position (absolute or relative) in **position units**[1]
CSPD	Command speed (fixed) – desired slew speed in **speed units**
CACC	Command acceleration (fixed) – desired acceleration / deceleration in **acceleration units**

Related TML Variables

TPOS	Target position (long) – position reference computed by the reference generator at each slow loop (position/speed loop) sampling period when a position profile mode is performed. Measured in **position units**
TSPD	Target speed (fixed) – speed reference computed by the reference generator at each slow loop sampling period when a position profile mode is performed. Measured in **speed units**
TACC	Target acceleration (fixed) – acceleration/deceleration reference computed by the reference generator at each slow loop sampling period when a position profile mode is performed. Measured in **acceleration units**
APOS	Actual position (long) – motor position measured in **position units**

[1] See par. 2.8 for details about the MCII internal units and their correspondence with the International Standard (IS) units

ASPD	Actual speed (fixed) – motor speed measured in **speed units**

Related TML Instructions

CPR	Command position is relative
CPA	Command position is absolute
MODE PPx	Set position profile mode x (x = 0, 1, 2, 3)
TUM1	Generate new trajectory starting from the actual values of position and speed reference (i.e. don't update the reference values with motor position and speed)
TUM0	Generate new trajectory starting from the actual values of motor position and speed (i.e. update the reference values with motor position and speed)
UPD	Update motion mode and parameters. Start motion

STOP0, **STOP1**, **STOP2** or **STOP3** – Stop motion using methods 0 to 3

In all position profile modes, the motion parameters CPOS, CSPD, CACC can be changed any time during motion. The reference generator automatically re-computes the position trajectory in order to reach the new commanded position, using the new values for slew speed and acceleration.

Figure 2.2 shows an example where slew speed and acceleration rate are changed, while the commanded position is kept the same.

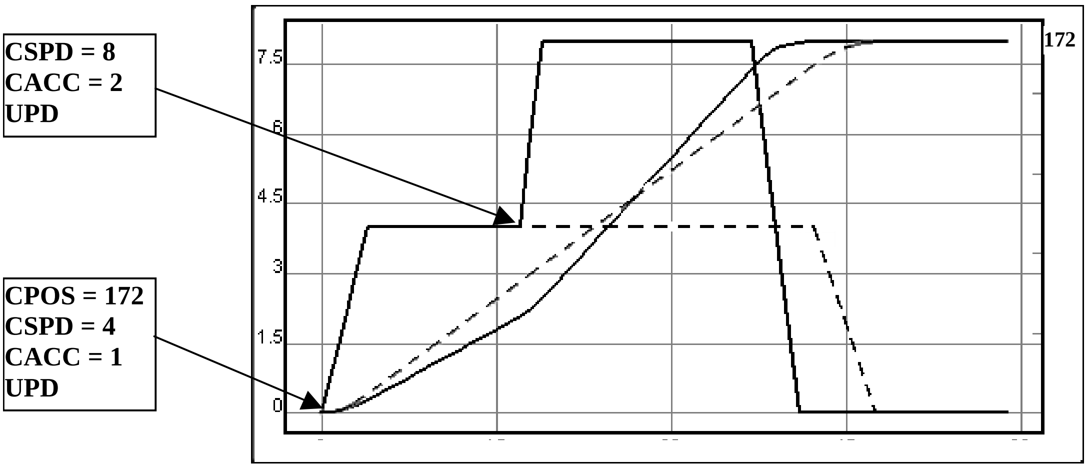

Figure 2.2. *Position profile. On-the-fly change of motion parameters*

There is no restriction for the commanded position. If during motion, a new position command is issued that requires reversing the motor, the reference generator does automatically the following operations:

- stops the motor with the programmed deceleration rate

- accelerates the motor in the opposite direction till the slew speed is reached, or till the motor has to decelerate
- stops the motor on the commanded position

In position profile modes, the reference generator automatically eliminates the round-off errors, which may appear when the commanded position cannot be reached with the programmed slew speed and acceleration/deceleration rate. This situation is illustrated by the example below.

Example:

The commanded position is 258 counts, with the slew speed 18 counts/sampling and the acceleration rate 4 counts/sampling^2. To reach the slew speed, two options are available:

- Accelerate to 16 in 4 steps, then from 16 to 18 in a 5th step. Acceleration space is 49 counts
- Accelerate from 0 to 2 in 1st step, then from 2 to 18 in 4 steps. Acceleration space is 41 counts

For the deceleration phase, the options and spaces are the same. But, no matter which option is used for the acceleration and deceleration phases, the space that remains to be done at constant speed is not a multiple of 18, i.e. the position increment at each step.

So, when to start the deceleration phase? **Table 2.3** presents the possible options, and the expected errors.

Table 2.3. *Round-off error example. Options and expected errors.*

Acceleration Space [counts]	Deceleration Space [counts]	Space to do at constant speed [counts]	Time to go at constant speed [sampling steps]	Deceleration starts after [samplings]	Target position Error [counts]
49 counts	49 counts	258 – 2 * 49 = 160 counts	160/18 = 8.8	5 + 8 = 13	- 16
				5 + 9 = 14	+ 2
49 counts	41 counts	258 – 49 – 41 = 168 counts	168/18 = 9.3	5 + 9 = 14	- 6
				5 + 10 = 15	+ 12
41 counts	49 counts	258 – 41 – 49 = 168 counts	168/18 = 9.3	5 + 9 = 14	- 6
				5 + 10 = 15	+12
41 counts	41 counts	258 – 2 * 41 = 176 counts	176/18 = 9.7	5 + 9 = 14	-14
				5 + 10 = 15	+4

TML comes with a different approach. It monitors the round-off errors and automatically eliminates them by introducing, during deceleration phase, short periods where the target speed is kept constant. Hence, the target position is always reached precisely, without any errors.

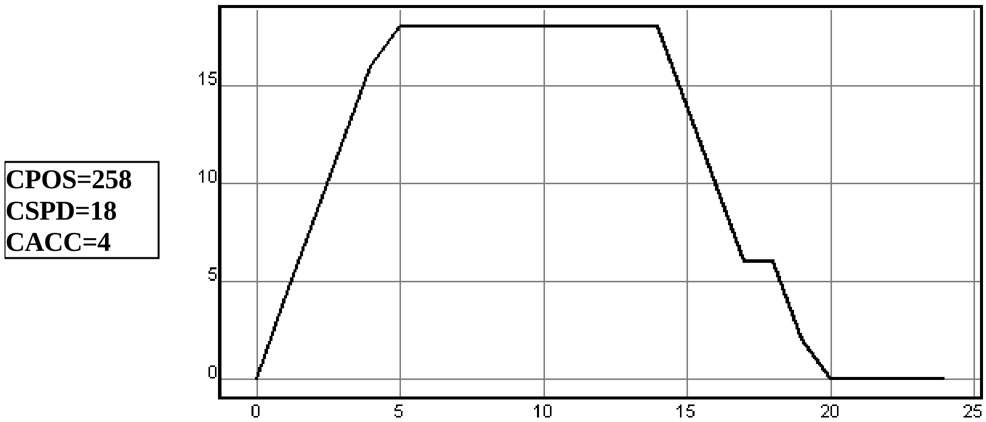

Figure 2.3. *Position profile. Automatic elimination of round-off errors*

Figure 2.3 shows the target speed generated by TML for the above example. During the deceleration phase, the target speed:

- decelerates from 18 to 6 in 3 steps (target position advances by 36 counts)
- is kept constant for 1 step (target position advances by 6 counts)
- decelerates from 6 to 2 in one step (target position advances by 4 counts)
- decelerates from 2 to 0 in the last step (target position advances by 1 count)

Hence the deceleration space is 47 counts, which, added to 49 counts for acceleration phase and to the 162 counts for constant speed, gives exactly the 258-count commanded position.

Programming Example

```
CACC = 1.5;       // command acceleration = 1.5
                  // encoder counts/sampling^2
CSPD = 20.;       // command speed = 20 counts/sampling
CPOS = 20000;     // command position = 20000 counts
CPA;              // command position is absolute
MODE PP3;         // set position profile mode 3
TUM1;             // keep the position and speed reference
UPD;              // update - start the motion
!MC;              // set event on motion complete
WAIT!;            // wait for the event to occur
```

Remarks:

- Once a position profile is started, you can find when the motion is completed, by setting an event on motion complete and waiting until this event occurs (see for details par. 2.2)
- *The TML instruction **`TUM1`** must always be executed AFTER setting the motion mode and BEFORE executing the **`UPD`** command. When a motion mode command is executed it includes the `TUM0` command. However, as the new motion mode becomes active only after the `UPD` command, if `TUM1` command is set, it overwrites `TUM0` set together with the motion mode*

2.1.2 Speed Profile Modes

In the speed profile, the motor is controlled in speed. You specify the acceleration/deceleration rate and the jog speed. The speed sign specifies the direction. The motor accelerates until the jog speed is reached. During motion, you can change on the fly the jog speed and the acceleration/deceleration rate. Use a stop command to stop the motion.

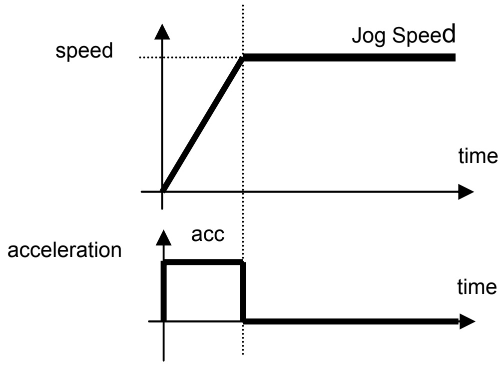

Figure 2.4. *Speed profile parameters*

Depending on the control structure used, two speed profile modes are possible:

Table 2.4. *Speed Profile - Motion Modes*

Speed Profile Motion Modes	Controlled Loops		
	Position	Speed	Torque
SP1	–	√	√
SP0	–	√	–

Like in the position profile modes, the selection of one of the above speed profile modes, must match with the setup data.

Remarks:

- *As in most applications the current/torque control is needed, the IPM Motion Studio does not cover the setup options where current loop is not closed. Therefore, using IPM Motion Studio, you have only one option: speed loop with current loop closed (`MODE SP1`).*
- *You can switch on the fly between a position control mode closing all the loops like `MODE PP3` and a speed control mode closing speed and current loops like `MODE SP1`. However if you use a position control mode closing only position and current loop like `MODE PP1`, because in this case the speed loop is disabled switching between the position and speed control may create problems and therefore it is not recommended*

Related TML Parameters

CSPD Command speed (fixed) – desired jog speed in **speed units**. Sign gives direction.

CACC Command acceleration (fixed) – desired acceleration / deceleration in **acceleration units**

Related TML Variables

TPOS	Target position (long) – position reference computed by the reference generator at each slow loop (position/speed loop) sampling period, while performing a speed profile. TPOS is computed by integrating the speed profile. Measured in **position units**
TSPD	Target speed (fixed) – speed reference computed by the reference generator at each slow loop sampling period, while performing a speed profile. Measured in **speed units**
TACC	Target acceleration (fixed) – acceleration/deceleration reference computed by the reference generator at each slow loop sampling period, while performing a speed profile. Measured in **acceleration units**
APOS	Actual position (long) – motor position measured in **position units**
ASPD	Actual speed (fixed) – motor speed measured in **speed units**

Related TML Instructions

MODE SPx	Set speed profile mode x (x = 0, 1).
TUM1	Generate new trajectory starting from the actual values of position and speed reference (i.e. don't update the reference values with motor position and speed)
TUM0	Generate new trajectory starting from the actual values of motor position and speed (i.e. update the reference values with motor position and speed)
UPD	Update motion mode and parameters. Start motion

STOP0, **STOP1**, **STOP2** or **STOP3** – Stop motion using methods 0 to 3.

Programming Example

```
CACC = 1;        // command acceleration = 1.0 counts/sampling^2
CSPD = -25.5;    // command speed = -25.5 counts/sampling
                 // negative command speed = negative direction
MODE SP1;        // set speed profile mode 1
UPD;             // update - start the motion
```

2.1.3 Position/Speed/Torque/Voltage Contouring Modes

In contouring mode, you can program an arbitrary profile whose contour is described by a succession of linear segments. Depending on the reference type, four options are available:

- **Position contouring -** the motor is controlled in position. The arbitrary profile represents a position reference
- **Speed contouring** – the motor is controlled in speed. The arbitrary profile represents a speed reference
- **Torque contouring** – the motor is controlled in torque. The arbitrary profile represents a current reference
- **Voltage contouring** – the motor is controlled in voltage. The arbitrary profile represents a voltage reference

The position contouring and the speed contouring have been foreseen for normal operation. You may use them together with the position profile and the speed profile to generate the desired position or speed trajectory. You can switch between these four motion modes at any moment.

The torque contouring and the voltage contouring have been foreseen only for setup tests. The torque contouring may be used, for example, to check the response of the current controllers to other input signals than the step signal used in the Current Controller Tuning Test. The voltage contouring may be used, for example, to check the motors behavior under a constant voltage or any other voltage shape.

A contouring segment has 2 parameters: the time and the reference increment. The time parameter represents the segment duration expressed in **time units** i.e. in number of slow (position/speed) loop sampling periods. The reference increment represents the amount of reference variation per time unit i.e. per sampling period.

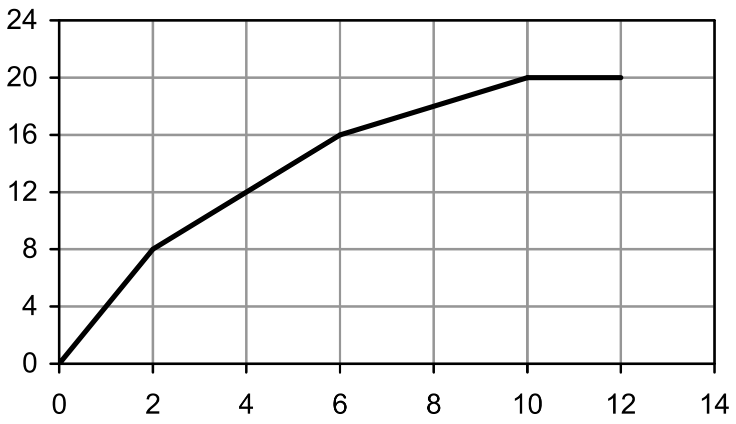

Figure 2.5. *Reference generation in contouring modes*

Example:

A position contouring segment starts at position 0 and reaches position 2000 encoder counts in 1 second. Considering a slow-loop sampling period 1ms, the contouring segment data are:

Time = 1000 (1000 x 1ms = 1s)
Reference increment per sampling = 2 (1000 x 2 = 2000)

In position or speed contouring, the starting point is either the current value of the target position/speed (if `TUM1` command is set between the motion mode setting and the `UPD` command), or the actual value of the motor position/speed (if `TUM1` is omitted)

In torque/voltage contouring, the starting value is set by the user in the high part of the TML parameter `EREF` i.e. in `EREF(H)`. After reset, the default value of `EREF(H)` is zero.

The contouring modes require a local memory where to place the sequence of contour segments to be executed. First, the contouring mode must be set and the first segment should be provided. Then the contouring mode can be activated with the `UPD` command.

Once a contouring mode is activated, the rest of the segments are automatically executed. The sequence of contour segments must end with a segment where the time interval is 0.

When a sequence of contour segments is executed, the TML instruction pointer IP advances as the segments are executed. When the reference generator starts working with a new segment, at TML program level the IP advances to the execution of the next contour segment instruction. The execution of a TML instruction for a contour segment means to copy the segment data into a local buffer and then wait (i.e. loop on the same instruction) until the previous segment, currently under execution at reference generator level will end. This procedure permits to immediately start the execution of the next contour segment when the current one ends because the next segment data are already available in a local buffer. Each time the reference generator starts to execute a new segment, the IP advances to the next contour segment and its data are transferred into the local buffer.

Table 2.5 presents the possible contouring modes.

Table 2.5. *Contouring Modes*

Category	**Motion Modes**	**Controlled Loops**		
		Position	**Speed**	**Torque**
Position Contouring	PC3	√	√	√
	PC2	√	√	–
	PC1	√	–	√
	PC0	√	–	–
Speed Contouring	SC1	–	√	√
	SC0	–	√	–
Torque Contouring	TC	–	–	√
Voltage Contouring	VC	–	–	–

Remarks:

- *The selection of one of the above position contouring modes or speed contouring modes must match with the setup data like in the case of position and speed profiles (see par. 2.1.1 and 2.1.2 for details)*
- *As in most applications the current/torque control is needed, the IPM Motion Studio does not cover the setup options where current loop is not closed. Therefore, using IPM Motion Studio, you can choose for position contouring only 2 options: position loop with speed loop and current loop (`MODE PC3`) and position loop without speed loop and with current loop (`MODE PC1`), and for speed contouring only the option with both speed and current loop closed (`MODE SP1`)*

Related TML Parameters

REF0(H) Starting value (int) – torque/voltage contouring in torque/voltage units
Time Value or variable (uint) – segment time interval in **time units**

Increment Value or variable (fixed) – segment reference increment per time unit measured in:

- **speed units** for a position contouring segment
- **acceleration units** for a speed contouring segment
- **current units / time units** for torque contouring
- **voltage units / time units** for voltage contouring

Related TML Variables

TPOS Target position (long) – position reference computed by the reference generator at each slow loop (position/speed loop) sampling period when position or speed contouring is performed. During speed contouring, TPOS is computed by integrating TSPD. Measured in **position units**

TSPD Target speed (fixed) – speed reference computed by the reference generator at each slow loop sampling period when position or speed contouring is performed. Measured in **speed units**

TACC Target acceleration (fixed) – acceleration/deceleration reference computed by the reference generator at each slow loop sampling period when position or speed contouring is performed. Measured in **acceleration units**

IQREF Current reference – computed by the reference generator at each slow loop sampling period when torque contouring is performed. Measured in **current units**

UQREF Voltage reference – computed by the reference generator at each slow loop sampling period when voltage contouring is performed. Measured in **voltage command units**

APOS Actual position (long) – motor position measured in **position units**

ASPD Actual speed (fixed) – motor speed measured in **speed units**

IQ Motor current – measured in **current units**

Related TML Instructions

MODE PCx Set position contouring mode x (x = 0, 1, 2, 3)

MODE SCx Set speed contouring mode x (x = 0, 1)

MODE TC Set torque contouring

MODE VC Set voltage contouring. Voltage reference represents motor voltage for DC motor, and quadrature component (Q-axis) of the voltage vector for AC motors

SEG Time, Increment Set a contour segment with parameters Time and Increment

TUM1 Generate new trajectory starting from the actual values of position and speed reference (i.e. don't update the reference values with motor position and speed)

TUM0 Generate new trajectory starting from the actual values of motor position and speed (i.e. update the reference values with motor position and speed)

UPD Update motion mode and parameters. Start motion

STOP0, **STOP1**, **STOP2** or **STOP3** – Stop motion using methods 0 to 3

Programming Example (see Figure 2.5)

```
MODE PC3;         // set position contouring mode 3
SEG 2, 4.;        // set 1st segment. Increment position reference
                  // with 4 counts/sampling in the next 2 samplings
UPD;              // update – start motion
SEG 4, 2.;        // set 2nd segment
SEG 4, 1.;        // set 3rd segment
SEG 2, 0.;        // set 4th segment
SEG 0, 0.;        // end contour sequence
```

Remarks:

- *At the end of a contouring sequence, the last reference value is kept constant*
- *The TML parameter `REF0`, used to set the initial value for the torque or voltage contouring mode is also used (under the name `EREF`) in the external mode as reference set on-line via a communication channel by an external device (see par 2.1.4)*
- *The `SEG 0,0` command signals the end of a contouring sequence, time value being zero.*
- *The TML command `SEG` is a **sequential** command. This means that `SEG` command must be executed only as part of a TML program and not as a command sent on-line via a communication channel. If a host sends contouring segments on-line, each time a segment command is received, it starts to be executed immediately, canceling previous segment processing. Therefore the generated trajectory is incorrect.*

2.1.4 External Position/Speed/Torque/Voltage Modes

In the external modes, you can drive your motor using a reference provided by an external device, in one of the following ways:

- As an analogue signal connected to a dedicated analogue input of the MotionChip II named REFERENCE (10-bit resolution)
- As a continuously updated data sent by the external device via a communication channel into the dedicated TML variable EREF

In both cases, depending on the reference type, you can have:

- Position external modes, where the motor is controlled in position and the external reference is interpreted as a position reference
- Speed external modes, where the motor is controlled in speed and the external reference is interpreted as a speed reference
- Torque external modes, where the motor is controlled in torque and the external reference is interpreted as a current reference.
- Voltage external modes, where the motor is controlled in voltage and the external reference is interpreted as a voltage reference.

The position and speed external modes have been foreseen for normal operation. With the torque external mode you can set your drive as a torque amplifier. The voltage external mode is foreseen for test purposes.

The torque and voltage external modes with analogue reference have two options:

- torque/voltage slow – reference is read at each slow-loop (position/speed) sampling period
- torque/voltage fast – reference is read at each fast-loop (torque/current) sampling period

In the torque and voltage external modes with reference set via communication in the TML variable `EREF`, only slow option is available i.e. reference is read at each slow-loop (position/speed) sampling period.

By default, after power on, the external mode with reference set via communication in `EREF` is enabled. In order to activate the external mode with reference read from a dedicated analogue input, you need to execute the TML command `EXTREF 1`.

Before enabling an external mode with analogue reference, during the setup phase, you need to establish how to interpret a value read from the analogue input. Put in other words, you need to set the associated TML parameters in order to get the desired range for a position, speed, current or voltage command.

Table 2.6 presents the possible external modes.

Table 2.6 *External Modes*

Category	Motion Modes	Controlled Loops		
		Position	Speed	Torque
Position External	PE3	√	√	√
	PE2	√	√	–
	PE1	√	–	√
	PE0	√	–	–
Speed External	SE1	–	√	√
	SE0	–	√	–
Torque External Slow	TES	–	–	√
Torque External Fast	TEF	–	–	√
Voltage External Slow	VES	–	–	–
Voltage External Fast	VEF	–	–	–

Remarks:

- *The selection of one of the above position external modes or speed external modes must match with the setup data like in the case of position and speed profiles (see par. 2.1.1 and 2.1.2 for details)*
- *As in most applications the current/torque control is needed, the IPM Motion Studio does not cover the setup options where current loop is not closed. Therefore, using IPM Motion Studio, you can choose for position external only 2 options: position loop with speed loop and current loop (`MODE PE3`) and position loop without speed loop and with current loop (`MODE PE1`), and for speed external only the option with both speed and current loop closed (`MODE SE1`)*

Related TML Parameters

EREF 32-bit TML parameter needed only for the external modes with reference set on-line via a communication channel. EREF is where the external device must write the reference. Depending on the reference type, EREF is seen as a:

- 32-bit long value representing the position reference in **position units** for the external position modes
- 32-bit fixed value representing the speed reference in **speed units** for the external speed modes
- 16-bit integer value read from EREF(H) representing the current or voltage reference in **current units** or **voltage units** for the external torque or voltage modes

Examples:

```
EREF = 2000;      // External position mode. Reference is set to 2000 position units
EREF = 1.5;       // External speed mode. Reference is set to 1.5 speed units
EREF(H) = 5000; // External torque mode. Reference is set to 5000 current units
```

CADIN, SFTDIN, AD5OFF 16-bit TML parameters needed only for the external modes with analogue reference. Are used to define the desired range for the position, speed, current or voltage command that corresponds to the analogue input range. For details regarding how to set these parameters see ***MotionChip II Configuration Setup*** user manual

Related TML Variables

AD5 16-bit unsigned integer value representing the value read from the analogue input REFERENCE. The output of the 10-bit A/D converter is set in the 10 MSB (most significant bits) of the AD5

TPOS Target position (long) – position reference updated at each slow loop (position/speed loop) sampling period, when position external mode is performed. TPOS is set function of the analogue input value or with the EREF value. Measured in **position units**

TSPD Target speed (fixed) – speed reference updated at each slow loop sampling period when position or speed external mode is performed. TSPD is set function of the analogue input value or with the EREF value during external speed mode and is computed from TPOS in external position mode. Measured in **speed units**

TACC Target acceleration (fixed) – acceleration or deceleration reference computed by the reference generator at each slow loop sampling period from the position or speed external references. Measured in **acceleration units**

IQREF Current reference – updated at each fast or slow loop function of the analogue input value or set with EREF value, when torque external mode is performed. Measured in **current units**

UQREF	Voltage reference – updated at each fast or slow loop function of the analogue input value or set with EREF value, when voltage external mode is performed. Measured in **voltage command units**
APOS	Actual position (long) – motor position measured in **position units**
ASPD	Actual speed (fixed) – motor speed measured in **speed units**
IQ	Motor current – measured in **current units**

Related TML Instructions

MODE PEx	Set external position mode x (x = 3, 2, 1, 0)
MODE SEx	Set external speed mode x (x = 1, 0)
MODE TES	Set external torque mode slow
MODE TEF	Set external torque mode fast
MODE VES	Set external voltage mode slow
MODE VES	Set external voltage mode fast
EXTREF 0	Set external reference type: provided on-line in EREF via communication
EXTREF 1	Set external reference type: read from analog input
EXTREF 2	Set external reference type: read from second encoder input
UPD	Update motion mode and parameters. Start motion

STOP0, **STOP1**, **STOP2** or **STOP3** – Stop motion using methods 0 to 3

Programming Example

```
EXTREF 1;        // external reference read from analog input
MODE SE1;        // set speed external mode 1
UPD;             // update – activate new mode
```

Remarks:

- *TML instruction EXTREF 2 sets a third way of providing an external reference: using incremental encoder signals connected to the MotionChip II 2nd encoder inputs. This external mode is used only for electronic gearing and camming modes and will be presented later on*
- *TML instructions EXTREF 0, 1 or 2 are exclusive. After power on, EXTREF 0 is set by default. After an EXTREF 1 command, EXTREF 0 is disabled and all the external reference modes are read from the analogue input*

2.1.5 Position/Speed Pulse & Direction Modes

In the pulse & direction modes, you can drive your motor using a "Pulse & Direction" command provided by an external device. The "Pulse & Direction" command consists of 2 digital signals that must be connected to especially dedicated inputs:

- *Pulse* – a sequence of pulses. Each pulse represents a **position unit**. The sum of the pulses indicates the position displacement to be performed. The variation of number of pulses per **time unit** represents a speed reference.
- *Direction* - a digital signal, which indicates the reference sign. Depending on Direction value the pulses are counted up or down

Hence the pulse and direction signals can be interpreted either as a position reference or as a speed reference. Depending on the reference type you can have:

- Position pulse & direction modes, where the motor is controlled in position.
- Speed pulse & direction modes, where the motor is controlled in speed.

Table 2.7 presents the possible pulse & direction modes.

Table 2.7 *Pulse & Direction Modes*

Category	Motion Modes	Controlled Loops		
		Position	Speed	Torque
Position Pulse & Direction	PPD3	√	√	√
	PPD2	√	√	–
	PPD1	√	–	√
	PPD0	√	–	–
Speed Pulse & Direction	SPD1	–	√	√
	SPD0	–	√	–

Remarks:

- *The selection of one of the above position pulse & direction modes or speed pulse & direction modes must match with the setup data like in the case of position and speed profiles (see par. 2.1.1 and 2.1.2 for details)*
- *As in most applications the current/torque control is needed, the IPM Motion Studio does not cover the setup options where current loop is not closed. Therefore, using IPM Motion Studio, you can choose for position pulse & direction only 2 options: position loop with speed loop and current loop (`MODE PPD3`) and position loop without speed loop and with current loop (`MODE PPD1`), and for speed pulse & direction only the option with both speed and current loop closed (`MODE SPD1`)*

Related TML Variables

TPOS Target position (long) – position reference computed by the reference generator at each slow loop (position/speed loop) sampling period when position or speed pulse & direction modes are performed. Measured in **position units**

TSPD Target speed (fixed) – speed reference computed by the reference generator at each slow loop sampling period when position or speed pulse & direction modes are performed. Measured in **speed units**

TACC Target acceleration (fixed) – acceleration/deceleration reference computed by the reference generator at each slow loop sampling period when position or speed pulse & direction modes are performed. Measured in **acceleration units**

APOS Actual position (long) – motor position measured in **position units**
ASPD Actual speed (fixed) – motor speed measured in **speed units**

Related TML Instructions

MODE PPDx Set position pulse & direction mode x (x = 3, 2, 1, 0)
MODE SPDx Set speed pulse & direction mode x (x = 1, 0)
UPD Update motion mode and parameters. Start motion
STOP0, **STOP1**, **STOP2** or **STOP3** – Stop motion using methods 0 to 3

Programming Example

```
MODE PPD3;        // set pulse & dir mode 3
UPD;              // update – activate new mode. Motion starts
                  // when external device provides pulses
```

2.1.6 Electronic Gearing Modes

In the electronic gearing modes, one drive is set as master and other drives are set as slaves. The slaves follow the master position with a programmable ratio. The slaves can get the master position in two ways:

- The master sends its position via a communication channel. This option requires having the drives connected on a CAN-bus or RS-485 network. The master sends either the motor position (if OSR.15 = 0 i.e. bit 15 from OSR register is 0) or the position reference (if OSR.15 =1), once at each slow loop (speed/position loop) sampling time interval
- The signals of the encoder connected to the master drive are also connected to the 2nd encoder input of the slave drives.

In both cases the slaves perform a position control. They compute the master position increment and multiply it with their programmed gear ratio. The result represents the increment of the reference position for the slaves, which is added to previous reference position to obtain the new reference position for the slaves.

Remarks:

- *You need to program a drive as master in electronic gearing only if the master position is sent via a communication channel. If actual position is sent, the master can work in any motion mode. If target position is sent, the master should work in a mode that generates a target position*
- *By default the slow loop sampling period is set at 1ms. If you intend to use the RS-485 to send a master position, be aware that the transmission time for this operation at maximum baudrate of 115200 is close to 1ms and therefore occupies almost the entire communication bandwidth. One way to reduce the overall communication charge is to increase with 50-100% the slow-loop sampling period*

Master mode

The master mode can be enabled with the TML command SGM followed by an UPD (update) and can be disabled by the TML command RGM followed by an UPD. In both cases, this has no effect on the motion executed by the master.

When a drive is set as master, it starts sending its actual position APOS or its target position TPOS to the axis or the group of axes specified in the TML parameter SLAVEID. This contains either the axis ID of one slave or the value of a group ID+256 i.e. the group of slaves to which the master should send its position.

Before enabling the master operation for electronic gearing, you need to initialize the slaves with the master position by setting the master to send its (actual or target/reference) position to the slaves in the dedicated TML parameter MPOS0. This initialization is necessary to make sure that the slaves got the latest master position before entering in the slave mode.

Examples:

```
[255]MPOS0 = APOS; // set MPOS0 on slave axis 255 with actual position of the master
[255]MPOS0 = TPOS; // set MPOS0 on slave axis 255 with target position of the master
[G2]MPOS0 = TPOS; // set MPOS0 on all slave axes from group 2 with target position of
                  //  the master
```

Remark: *Make sure when the master position initialization is performed that all slave drives are powered and in communication. Otherwise the initialization with master position will fail.*

Slave mode

When a drive should work as slave for electronic gearing, the following settings must be checked or performed before enabling the electronic gearing slave mode:

1) Set gear ratio. This is specified via 3 TML variables: GEAR, GEARSLAVE and GEARMASTER

GEARSLAVE and GEARMASTER represent the numerator and denominator of the Slave / Master ratio. GEARSLAVE is a signed integer, while GEARMASTER is an unsigned integer. GEARSLAVE sign indicates the direction of movement: positive – same as the master, negative – reversed to the master. GEAR is a fixed value containing the result of the gear ratio i.e. the result of the division GEARSLAVE / GEARMASTER. In order to eliminate any cumulative errors the electronic gearing slave mode includes an automatic compensation of the round off errors when the gear ratio has an irrational value like: Slave = 1, Master = 3, giving a ratio of 1/3 = 0.33333 which can't be represented exactly.

Example: in order to implement a gear ratio of 2/3, you need to set:

```
GEARSLAVE = 2;      // gear ratio numerator
GEARMASTER = 3;     // gear ratio denominator
GEAR= 0.66667;      // gear ratio value
```

2) Enable master position calculation from 2nd encoder inputs, if the master position is provided via its encoder signals.

This operation is done with TML instruction EXTREF 2. The initial value of the master position is set by default to 0. It may be changed to a different value by writing the desired value in data memory at location 0x81C. This operation can be performed by the following TML code:

```
user_var = 0x81C;        // set user variable user_var with 0x81C - the address of the master
                         // position computed from 2nd encoder inputs
user_var),dm = initial_value;     // write initial_value  in data memory (dm) at
                         // address pointed by user_var i.e. in the master position
```

Remarks:

- *The initial master value is a 32-bit long integer value. However, if the initial value to write is small enough to be represented as a 16-bit integer (i.e. between –32768 and +32767) add after the initial value an L (for example: 200L) to indicate that this value is a long not an integer. This will initialize the 16MSB part too (i.e. the next memory location 0x81D)*
- *Initialization of the drives for reading the master position from the 2nd encoder inputs requires one speed/position sampling period (typically 1ms). After EXTREF 2 command do not enable immediately the slave operation. Introduce a wait time of 1 speed/position sampling period (see for details par. 2.2)*

3) Set master resolution e.g. the number of encoder counts per one revolution of the master motor. The slaves need the master resolution to compute correctly the master position and speed (i.e. position increment). This operation can be performed by the following TML code:

```
user_var = 0x81A;        // set user variable user_var with 0x81A - the address of the master
                         // resolution parameter
user_var),dm = resolution_value;   // write resolution_value in data memory (dm) at
                         // address pointed by user_var i.e. in the master resolution
```

Remark: *The master resolution is a 32-bit long integer value. If master position is not cyclic (i.e. the resolution is equal with the whole 32-bit range of position), set master resolution to 0x80000001. When this value is used, no modulo operation is performed on the position counted from the 2nd encoder inputs.*

4) Enable synchronization with the master if the master position is provided via communication. When the synchronization is enabled, the slave performs a slight adjustment of the moments when the speed/position loop control is performed to synchronize them with the moments when the master sends its position. This allows the slaves to always have a new master position before starting to use it. In order to:

- Enable the synchronization with the master, set TML variable `EFLEVEL = 0;`
- Disable the synchronization with the master, set TML variable `EFLEVEL = 0xFFFF;`

Remark: *The synchronization must be enabled only after the master starts sending its position and must be disabled before or immediately after the master stops sending its position. Do not leave a slave with the synchronization enabled while the master is disabled. During this period the motor control performance is slightly degraded*

5) Enable operation in one of the electronic gearing slave modes. Depending on the control structure, the following four motion modes are possible for the slaves.

Table 2.8. *Electronic Gearing Slave - Motion Modes*

Electronic Gearing Slave Motion Modes	Controlled Loops		
	Position	Speed	Torque
GS3	√	√	√
GS2	√	√	–
GS1	√	–	√
GS0	√	–	–

Remarks:

- *The selection of one of the above electronic gearing modes must match with the setup data like in the case of position and speed profiles*
- *As in most applications the current/torque control is needed, the IPM Motion Studio does not cover the setup options where current loop is not closed. Therefore, using IPM Motion Studio, you can chose only between 2 options: position loop with speed loop and current loop (`MODE GS3`) and position loop without speed loop and with current loop (`MODE GS1`).*

Related TML Parameters

SLAVEID the axis or group ID to which the master sends its position. When group ID is used, the `SLAVEID` is set with group ID value + 256 (int)

MREF Slave location where the master sends its position (long). Measured in **master position units**

MPOS0 Slave location where the previous master position is stored (long). The master increment is computed on each slave axis as `MREF – MPOS0`. Measured in **master position units**

GEAR Slave(s) gear ratio value (fixed). Negative values means opposite direction

GEARMASTER Denominator of gear ratio (uint)

GEARSLAVE Numerator of gear ratio (int). Negative values means opposite direction

MASTERRES Master resolution used by slave(s) (long) Set at extended address 0x81A. Can be read/written using indirect addressing commands. Measured in **master position units**

APOS2 Master position computed from 2nd encoder inputs on slave axes (long). Set at extended address 0x81C. Can be read/written using indirect addressing commands. Measured in **master position units**

MSPD Master speed computed from 2nd encoder inputs on slave axes (long). Set at extended address 0x820. Can be read/written using indirect addressing commands. Measured in **master speed units**

EFLEVEL Set to 0 enables and set to 0xFFFF disables the synchronization of the slave(s) with the master when master position is sent via communication (int)

Related TML Variables

TPOS Target position (long) – position reference computed by the reference generator at each slow loop (position/speed loop) sampling period when

	electronic gearing slave modes are performed. Measured in **position units**
TSPD	Target speed (fixed) – speed reference computed by the reference generator at each slow loop sampling period when electronic gearing slave modes are performed. Measured in **speed units**
TACC	Target acceleration (fixed) – acceleration/deceleration reference computed by the reference generator at each slow loop sampling period when electronic gearing slave modes are performed. Measured in **acceleration units**
APOS	Actual position (long) – motor position measured in **position units**
ASPD	Actual speed (fixed) – motor speed measured in **speed units**

Related TML Instructions

SGM	Set electronic gearing master mode
RGM	Reset electronic gearing master mode
EXTREF 0	Receive master position via a communication channel
EXTREF 2	Read master position from second encoder input
MODE GSx	Set electronic gear slave mode x (x = 3, 2, 1, 0)
TUM1	Generate new trajectory starting from the actual values of position and speed reference (i.e. don't update the reference values with motor position and speed)
TUM0	Generate new trajectory starting from the actual values of motor position and speed (i.e. update the reference values with motor position and speed)
UPD	Update motion mode and parameters. Start motion

STOP0, **STOP1**, **STOP2** or **STOP3** – Stop motion using methods 0 to 3

Programming Example

```
// On slave axis (Axis ID = 1):
      GEAR = 0.66667;  // set gear ratio value
      GEARMASTER = 3;  // set gear ration denominator
      GEARSLAVE = 2;   // set gear ratio numarator
      EXTREF 0;        //receive master position via a
                       //communication channel
      EIR = 0x081A;    // set EIR variable with address of MASTERRES
      (EIR),dm = 2000L; // set MASTERRES = 2000
      MODE GS3;        //set gear slave mode 3
      TUM1;      // keep the position and speed reference (optional)
      UPD;       // update – activate gear slave mode. Slave starts
                 // following the master position
// On master axis:
      SLAVEID 1;       // slave axis has Axis ID = 1
      SGM;             // set electronic gearing master mode
      SRB OSR,0xFFFF,0x8000; // send target position
      [1]MPOS0 = TPOS; // set master target position on slave axis
      UPD;             // update – activate new mode. Master starts
                       // sending its position
```

Remark: *When a drive is set in an electronic gearing slave mode, it starts to add the position increment (computed from the master position increment and the gear ratio) to its current position. Hence electronic gearing mode is a relative move, which on each slave starts from its current position. If needed, the slave position may be modified before enabling the slave operation using the `SAP 0` TML command (see par. 2.1.10 for details)*

2.1.7 Electronic Camming Modes

In the electronic camming mode, one drive is set as master and other drives are set as slaves. The slaves execute a cam profile function of the master position. A cam table describes the cam profile. The cam table consists of 2 columns of points: X for the master and Y for the slave.

The slaves can get the master position in two ways:

- The master sends its position via a communication channel. This option requires having the drives connected on a CAN-bus or RS-485 network. The master sends either the motor position (if OSR.15 = 0 i.e. bit 15 from OSR register is 0) or the position reference (if OSR.15 =1), once at each slow loop (speed/position loop) sampling time interval
- The signals of the encoder connected to the master drive are also connected to the 2nd encoder input of the slave drives.

In both cases the slaves perform a position control. The master position represents the input in the cam table. The output of the cam table is the slave position reference. Between the cam table points, linear interpolation is performed.

Remarks:

- *You need to program a drive as master in electronic camming only if the master position is sent via a communication channel. If actual position is sent, the master can work in any motion mode. If target position is sent, the master should work in a mode that generates a target position*
- *By default the slow loop sampling period is set at 1ms. If you intend to use the RS-485 to send a master position, be aware that the transmission time for this operation at maximum baudrate of 115200 is close to 1ms and therefore occupies almost the entire communication bandwidth. One way to reduce the overall communication charge is to increase with 50-100% the slow-loop sampling period*

Master mode

The master mode is the same as for electronic gearing. It can be enabled with the TML command `SGM` followed by an `UPD` (update) and can be disabled by the TML command `RGM` followed by an `UPD`. In both cases, this has no effect on the motion executed by the master. No other initialization is needed for electronic camming.

When a drive is set as master, it starts sending its actual position `APOS` or its target position `TPOS` to the axis or the group of axes specified in the TML parameter `SLAVEID`. This contains either the axis ID of one slave or the value of a group ID+256 i.e. the group of slaves to which the master should send its position

Slave mode

When a drive should work as slave for electronic camming, the following settings must be checked or performed before enabling the electronic camming slave mode:

1) Load a previously defined cam table into SRAM program memory.

The cam table contains equally spaced values for X at: 1, 2, 4, 8, 16, 32, 64 or 128. Between the points of the table, linear interpolation is performed. It is not mandatory to define the cam table for 360 degrees of the master. You may also define shorter cam tables, which for example may be active between angles 120 and 200 degrees of the master. In this case, the slave position remains unchanged outside the active area of the cam. You can continuously run the master in any direction with the slaves performing a glitch free transition when the cam table is restarted.

A cam table has the following format:

- 1st word (1 word = 16-bit data):
  - **Bits 15-13** – the power of 2 of the interpolation step. For example, if these bits have the binary value 010 (2), the interpolation step is $2^2 = 4$, hence the master X values are spaced from 4 to 4: 0, 4, 8, 12, etc.
  - **Bits 12-0** – the length -1 of the table. The length represents the number of points
- 2nd and 3rd words: the master start position (long), expressed in **master position units**. 2nd word contains the low part, 3rd word the high part
- 4th and 5th words: Reserved. Must be set to 0
- Next pairs of 2 words: the slave Y positions (long), expressed in **position units**. The 1st word from the pair contains the low part and the 2nd word from the pair the high part
- Last word: the cam table checksum, representing the sum modulo 65536 of all the cam table data except the checksum word itself

Once define, a cam table must be downloaded into the EEPROM memory of the drive. Before enabling an electronic camming slave mode, the cam table must be copied from the EEPROM into the SRAM program memory. This operation can be done using the TML command:

```
INITCAM LoadAddress, RunAddress
```

where `LoadAddress` is the EEPROM memory address where the cam table was loaded and `RunAddress` is the SRAM program memory address where to copy the cam table. After the execution of this command the TML variable `CAMSTART` takes the value of the `RunAddress`.

Remarks:

- When electronic camming slave mode is performed, only the cam table from the SRAM program memory is used to compute the slave position
- It is possible to download in the EEPROM memory several cam tables. You can use `INITCAM` command to copy one or all of them into the SRAM program memory. In the last case, in order to switch between several cam tables all you need to do is to change the value of the TML parameter `CAMSTART` which points to the beginning of the cam table to be used when electronic camming slave mode is activated
- `LoadAddress` and `RunAddress` values be expressed as decimal values

In **IPM Motion Studio**, you can quickly create or import a cam table using its menu command **Tools | Edit CAM files**. For example, you can specify your cam table in a simple text file as 2 columns of values (expressed in master and slave **position units**): first column for the X points, next one for the Y points. Using the **Import** feature, IPM Motion Studio translates your data into the cam table format mentioned above (files with extension **.cam**). You can create as many cam tables as you like. Then using the menu command **Project | Settings - General** tab, you can choose from the list of all cam tables defined, the cam(s) to be used in your application, named active cams. Using menu command **Application | Download CAM**, you can download the active cams into the EEPROM and finally in the **Motion Wizard**, the electronic camming dialogue, you can select from the **Use Table** list of active cams, which one to be used. Following this selection the TML instruction `INITCAM` is generated with `LoadAddress` and `RunAddress` values automatically computed by IPM Motion Studio

Remarks:

- *Some applications may require starting the electronic cam from the Y position corresponding to the current position of the master. You can find the Y position (cam table output) before activation of the electronic camming slave mode (in order to move the motors to this position) in the following way:*
  - *Activate a position profile mode, for example to keep the current position*
  - *Set TML parameter `GEAR` = 0, then wait one slow loop sampling period (see par 2.2)*
  - *Read the Y position from TML variable `EREF`*

  In order to stop computing Y when electronic cam slave mode is not active, set `GEAR` to a non-zero value, for example: `GEAR=0.5`. TML parameter `GEAR` is also used in electronic gearing slave mode to keep the gear ratio value.
- *You can define a cam offset for each slave in order to shift the cam profile versus the master position. Let's take for example a cam table defined between master angles: 100 to 250 degrees. If you define a 50 degrees cam offset, the cam profile will execute between master angles: 150 and 300 degrees. The following relation exists between: the master position (`MREF`), the cam offset (`CAMOFF`), the cam table X input (`MPOS0`) and the master resolution (`MASTERRES`):*

```
MPOS0 = (MREF – CAMOFF) % MASTERRES
```

2) Enable master position calculation from 2nd encoder inputs, if the master position is provided via its encoder signals.

This operation is done with TML instruction `EXTREF 2`. The initial value of the master position is set by default to 0. It may be changed to a different value by writing the desired value in data memory at location 0x81C.

This operation can be performed by the following TML code:

```
user_var = 0x81C;        // set user variable user_var with 0x81C - the address of the master
                         // position computed from 2nd encoder inputs
user_var),dm = initial_value;      // write initial_value  in data memory (dm) at
                         // address pointed by user_var i.e. in the master position
```

Remarks:

- *The initial master value is a 32-bit long integer value. However, if the initial value to write is small enough to be represented as a 16-bit integer (i.e. between –32768 and +32767) add after the initial value an L (for example: 200L) to indicate that this value is a long not an integer. This will initialize the 16MSB part too (i.e. the next memory location 0x81D)*
- *Initialization of the drives for reading the master position from the 2nd encoder inputs requires one speed/position sampling period (typically 1ms). After EXTREF 2 command do not enable immediately the slave operation. Introduce a wait time of 1 speed/position sampling period (see for details par. 2.2)*

3) Set master resolution e.g. the number of encoder counts per one revolution of the master motor. The slaves need the master resolution to compute correctly the master position and speed (i.e. position increment). This operation can be performed by the following TML code:

```
user_var = 0x81A;         // set user variable user_var with 0x81A - the address of the master
                          // resolution parameter
user_var),dm = resolution_value;   // write resolution_value in data memory (dm) at
                          // address pointed by user_var i.e. in the master resolution
```

Remark: *The master resolution is a 32-bit long integer value. If master position is not cyclic (i.e. the resolution is equal with the whole 32-bit range of position), set master resolution to 0x80000001. When this value is used, no modulo operation is performed on the position counted from the 2nd encoder inputs.*

4) Enable synchronization with the master if the master position is provided via communication. When the synchronization is enabled, the slave performs a slight adjustment of the moments when the speed/position loop control is performed to synchronize them with the moments when the master sends its position. This allows the slaves to always have a new master position before starting to use it. In order to:

- Enable the synchronization with the master, set TML variable `EFLEVEL = 0;`
- Disable the synchronization with the master, set TML variable `EFLEVEL = 0xFFFF;`

Remark: *The synchronization must be enabled only after the master starts sending its position and must be disabled before or immediately after the master stops sending its position. Do not leave a slave with the synchronization enabled while the master is disabled. During this period the motor control performance is slightly degraded*

5) Enable operation in one of the electronic camming slave modes. Depending on the control structure, the following four motion modes are possible for the slaves.

Table 2.9. *Electronic Cam Slave - Motion Modes*

Electronic Cam Slave Motion Modes	Controlled Loops		
	Position	Speed	Torque

CS3	√	√	√
CS2	√	√	–
CS1	√	–	√
CS0	√	–	–

Remarks:

- *The selection of one of the above electronic camming modes must match with the setup data like in the case of position and speed profiles (see par. 2.1.1 and 2.1.2 for details)*
- *As in most applications the current/torque control is needed, the IPM Motion Studio does not cover the setup options where current loop is not closed. Therefore, using IPM Motion Studio, you can chose only between 2 options: position loop with speed loop and current loop (`MODE CS3`) and position loop without speed loop and with current loop (`MODE CS1`).*

Related TML Parameters

SLAVEID the axis or group ID to which the master sends its position. When group ID is used, the `SLAVEID` is set with group ID value + 256 (int)

MREF Slave location where the master sends its position (long). Measured in **master position units**

CAMOFF Cam offset (long). The cam table X input `MPOS0` is computed by subtracting cam offset from the master position. Measured in **master position units**

MASTERRES Master resolution used by slave(s) (long) Set at extended address 0x81A. Can be read/written using indirect addressing commands. Measured in **master position units**

APOS2 Master position computed from 2nd encoder inputs on slave axes (long). Set at extended address 0x81C. Can be read/written using indirect addressing commands. Measured in **master position units**

MSPD Master speed computed from 2nd encoder inputs on slave axes (long). Set at extended address 0x820. Can be read/written using indirect addressing commands. Measured in **master speed units**

EFLEVEL Set to 0 enables and set to 0xFFFF disables the synchronization of the slave(s) with the master when master position is sent via communication (int)

Related TML Variables

MPOS0 Cam table X input (long). `MPOS0 = (MREF – CAMOFF) % MASTERRES`. Measured in **master position units**.

CAMSTART SRAM program memory start address for a cam table. When several cam tables are used, switching between them resumes to set `CAMSTART` to the right address i.e. the beginning of next the cam table to use. `CAMSTART` is automatically set by the `INITCAM` command, which copies the cam table from the EEPROM to the SRAM memory

TPOS Target position (long) – position reference computed by the reference generator at each slow loop (position/speed loop) sampling period when

	electronic camming slave modes are performed. Measured in **position units**
TSPD	Target speed (fixed) – speed reference computed by the reference generator at each slow loop sampling period when electronic camming slave modes are performed. Measured in **speed units**
TACC	Target acceleration (fixed) – acceleration/deceleration reference computed by the reference generator at each slow loop sampling period when electronic camming slave modes are performed. Measured in **acceleration units**
APOS	Actual position (long) – motor position measured in **position units**
ASPD	Actual speed (fixed) – motor speed measured in **speed units**

Related TML Instructions

SGM	Set electronic camming master mode
RGM	Reset electronic camming master mode
INITCAM LoadAddress, **RunAddress**	Copy cam table from E^2ROM starting with **LoadAddress** into SRAM starting at **RunAddress**
EXTREF 0	Receive master position via a communication channel
EXTREF 2	Read master position from second encoder input
MODE CSx	Set electronic camming slave mode x (x = 3, 2, 1, 0)
TUM1	Generate new trajectory starting from the actual values of position and speed reference (i.e. don't update the reference values with motor position and speed)
TUM0	Generate new trajectory starting from the actual values of motor position and speed (i.e. update the reference values with motor position and speed)
UPD	Update motion mode and parameters. Start motion

STOP0, **STOP1**, **STOP2** or **STOP3** – Stop motion using methods 0 to 3

Programming Example

```
// On slave axis (Axis ID = 1):
      INITCAM 0x4500,0xE500;// copy cam table from E2ROM at address
                        // 0x4500 to SRAM at address 0xE500
      EXTREF 0;         // receive master position via a
                        //communication channel
      EIR = 0x081A;     // set EIR variable with address of MASTERRES
      (EIR),dm = 2000L;// set MASTERRES = 2000
      MODE CS3;         // set cam slave mode 3
      UPD;              // update – activate cam slave mode. Slave
                        // starts following the master position
// On master axis:
      SLAVEID 1;        // slave axis has Axis ID = 1
      SGM;              // set electronic camming master mode
      UPD;              // update – activate new mode. Master starts
                        // sending its actual position (APOS)
```

In the electronic camming mode, the slave computes a position increment, which is added to its current position.

When the master moves in the positive direction, the slave position increment is:

- **DY = Y – Y_1, if in the cam**, where Y = f(X) is the actual cam table output and Y_1 = f(X_1) is the previous cam table output. In the cam condition is when both X and X_1 inputs are between the minimum (Xmin) and maximum (Xmax) input values
- **DY = Y – Ymin, on cam entry,** where Y = f(X) is the actual cam table output and Ymin = f(Xmin) is the first cam table output point. On cam entry condition is when actual X is inside cam table i.e. X > Xmin, but the previous X_1 was outside the cam table i.e. X_1 < Xmin
- **DY = Ymax – Y_1, on cam exit**, where Ymax = f(Xmax) is the last cam table output point and Y_1 = f(X_1) is the previous cam table output. On cam exit condition is when actual X is outside cam table i.e. X > Xmax, but previous X_1 was inside the cam i.e. X_1 < Xmax
- **DY = Ymax – Y_1 + Y – Ymin, if in the cam with master rollover**, where Y = f(X) is the actual cam table output, Y_1 = f(X_1) is the previous cam table output, Ymax = f(Xmax) is the last cam table output point, Ymin = f(Xmin) is the first cam table output point. In the cam with master rollover condition is when both X and X_1 inputs are inside the cam table, but X < X_1 because the master position has rolled over

When the master moves in the negative direction, the slave position increment is:

- **DY = Y – Y_1, if in the cam**, where Y = f(X) is the actual cam table output and Y_1 = f(X_1) is the previous cam table output. In the cam condition is when both X and X_1 inputs are between the minimum (Xmin) and maximum (Xmax) input values
- **DY = Ymin – Y_1, on cam exit**, where Ymin = f(Xmin) is the first cam table output point and Y_1 = f(X_1) is the previous cam table output. On cam exit condition is when actual X is outside cam table i.e. X < Xmin, but the previous X_1 was inside the cam table i.e. X_1 > Xmin
- **DY = Y – Ymax, on cam entry**, where Y = f(X) is the actual cam table output and Ymax = f(Xmax) is the last cam table output point. On cam entry condition is when actual X is inside cam table i.e. X < Xmax, but previous X_1 was outside the cam i.e. X_1 > Xmax
- **DY = Ymin – Y_1 + Y – Ymax, if in the cam with master rollover**, where Y = f(X) is the actual cam table output, Y_1 = f(X_1) is the previous cam table output, Ymax = f(Xmax) is the last cam table output point, Ymin = f(Xmin) is the first cam table output point. In the cam with master rollover condition is when both X and X_1 inputs are inside the cam table but X > X_1 because the master position has rolled over

If needed, the slave position may be modified before enabling the slave operation using the `SAP 0` TML command (see par. 2.1.8 for details)

2.1.8 Motor Commands. Stop Modes

You can apply one of following commands to the motor:

- Activate/deactivate the control loops and the power stage PWM output commands (`AXISON / AXISOFF`)
- Stop the motor in one of the four possible modes: `STOP3, STOP2, STOP1, STOP0`

- Issue an update command, immediate (UPD) or when a previously programmed event occurs (UPD!)
- Change the values of the motor position and the position reference

The **AXISON** command activates the control loops and the PWM output commands. After power on, the AXISON command has to be executed at least once, after the ENDINIT (end of initialization) command. During operation, AXISON command may be used to restore the normal drive operation following an AXISOFF command. Typically, the AXISON command can be used in the error treatment routines, to restore the normal operation after the error cause was detected and eliminated.

At first AXISON after power on, the reference generator starts from the initial conditions. However, when AXISON is set after an AXISOFF command, the reference generator resumes its calculations from the same conditions left when the AXISOFF command was executed. If the values for the speed reference were high when the AXISOFF command was issued, at next AXISON command, a still motor may suddenly face a large speed reference. This may lead to a high reaction, which may stress the motion system mechanical parts. In order to avoid this situation, it is recommended to reprogram the (remaining) motion, without using TUM1 (i.e. updating the target position and target speed with the actual values of the position and speed), and only then set the AXISON command.

Example: A motor controlled in speed, was stopped with an AXISOFF command. In order to resume the normal operation, the TML program can be:

```
CACC = 0.5; // only if you want to change the previous acceleration value
CSPD = 100; // only if you want to change the previous speed value
MODE SP1;   // set again the speed profile mode 1
UPD;   // update motion mode & parameters. Motion is prepared but will not start
// as the drive continues to be in the AXISOFF condition
AXISON;      // motion starts. The initial value for target speed is 0 because was
// updated with the actual motor speed which is 0 because the motor is still
```

Remarks:

- *During AXISON condition, the Motion Status Register bit 13 is set (MSR.13 = 1)*
- *In IPM Motion Studio, the AXISON command is automatically included in the motion programs, after the drive setup parameters and before the motion sequences you program using the Motion Wizard. Therefore it is not necessary to include it at the beginning of a motion programming sequence*

The **AXISOFF** command deactivates the control loops, the reference generator and the PWM output commands (all the switching devices are off). However, all the measurements remain active and therefore the motor currents, speed, position as well as the supply voltage continue to be updated and monitored. If the AXISOFF command is applied during motion, it leaves the motor free running. Typically, the AXISOFF command is used when an error condition is detected, for example when a protection is triggered.

Remark: *The AXISOFF command is automatically generated when the Enable input goes from enabled to disabled status. If the Enable input returns to the enabled status, no other command (like AXISON) is automatically generated. However, if needed, you can generate automatically the*

AXISON command when Enable input returns to the enable status, by setting the AXISON command in the TML interrupt service routine called each time when the Enable input status changes.

The TML offers you 4 ways to stop a motor. **Table 2.10** presents these stop modes.

Table 2.10. *Stop Modes*

Stop Modes	Action
STOP3	Set speed control and decelerate with the rate set in TML parameter CACC until speed is 0
STOP2	Set speed control and force speed reference to 0
STOP1	Set torque control and force current reference to 0
STOP0	Set voltage control and force motor voltage to 0

Select `STOP3` to stop the motor smoothly, with a deceleration rat set in TML parameter `CACC`. When this command is executed, the drive is automatically set in speed profile mode (`MODE SP1`) with jog speed command = 0. When the speed reference arrives at zero, the motion complete condition is set

Select `STOP2` to stop very abruptly the motor. When this command is executed, the drive is automatically set in speed external mode (`MODE SE1`) with on-line speed reference set to 0.

Remark: *STOP3 or STOP2 modes may not work correctly if in the setup data you have set your drive for position control without closing the speed loop. In this case, you'll close the speed loop using a speed controller whose parameters have not been properly set.*

Select `STOP1` to stop the motor when the drive performs torque control. When this command is executed, the drive is set in torque external mode (`MODE TES`) with on-line current reference set to 0.

Select `STOP0` to stop the motor when the drive performs voltage control. When this command is executed, the drive is set in voltage external mode (`MODE VES`) with on-line voltage reference set to 0. `STOP0` is foreseen only for test purposes. During normal operation, the drive performs at least torque control. Voltage control may occur only during setup tests or if you have specifically set the drive in voltage contouring, voltage external or voltage test modes.

Remarks:

- *In order to restart after a STOPx (x = 0,1,2,3) command, the motion mode has to be set again, even if it is not changed. Setting a motion mode disables the stop mode and allows the motor to move*
- *STOPx (x = 0,1,2,3) commands always set TUM0 mode to perform an update of the target/reference position and speed with the actual motor position and speed*
- *When a host sends via a communication channel a STOPx command, this stops the execution of any TML program from the local memory, in order to avoid the risk of overwriting the STOPx command from the TML program*
- *Use with caution STOP2, STOP1 and STOP0 commands. These cause abrupt stops that may generate an important energy towards the supply. If the power supply can't absorb*

the energy generated by the motor, it is necessary to foresee an adequate surge capacitor in parallel with the drive supply to limit the over voltage.

When an immediate update command **UPD** is executed, the last motion mode programmed together with the latest motion parameters are taken into consideration. During motion execution, you can freely change the motion mode and/or its parameters. These changes will have no effect until an update command is executed.

If you intend to perform an update when a specific condition occurs, you can set an event which monitors the condition, followed by an update on event command **UPD!.** When the monitored condition occurs, the update will be automatically performed. Once you have set an update on event UPD!, you can either wait for the monitored event to occur, or perform other operations.

The TML command **SAP** offers you the possibility to set / change the referential for position measurement by changing simultaneously the motor position APOS and the target position TPOS values, while keeping the same position error.

You can specify the new position either as an immediate value or via a 32-bit long variable. SAP command can be executed at any moment during motion. When SAP command is executed, the following operations are performed:

- Under TUM1, i.e. if TUM1 command has been executed after the last motion mode setting and before the last UPD, the target/reference position TPOS is set equal with the new position value and the actual motor position APOS is set equal with the new position reference minus the position error (POSERR)

```
TPOS = new_value;
APOS = TPOS – POSERR;
```

- Under TUM0, i.e. if TUM1 command has not been executed after the last motion mode setting and before the last UPD, the actual motor position APOS is set equal with the new position value and the target/reference position TPOS is set equal with the new position plus the position error (POSERR)

```
APOS = new_value;
TPOS = APOS + POSERR;
```

The TML command **STA** sets the target position equal with the actual position: TPOS = APOS.

Remark: *The target position update with the actual position is automatically performed each time a new motion mode is set without TUM1. Together with the target position the target speed is also updated with the actual speed*

Related Instructions

AXISON	Set axis ON. Activate control loops and PWM commands
AXISOFF	Set axis OFF. Deactivate control loops and PWM commands
STOPx	Set stop mode x (x = 3, 2, 1, 0)
UPD	Update immediate motion mode and parameters. Start motion
UPD!	Update the motion mode and parameters a programmed event occurs
SAP V32	Set V32 in the actual or target position. V32 is either a 32-bit immediate value or a long TML data (user variable) containing the value to set

STA Set target position TPOS equal with the actual position APOS

Programming Example

```
CACC = 1.5;        // command acceleration = 1.5
                   // encoder counts/sampling²
CSPD = 20.;        // command speed = 20 counts/sampling
CPOS = 20000;      // command position = 2000 counts
CPR;               // command position is relative
MODE PP3;          // set position profile mode 3
TUM1;              // keep the position and speed reference
UPD;               // update - start the motion
...
STOP3;             // stop smoothly with CACC = 1.5
!MC;               // set event on motion complete
WAIT!;             // wait for the event to occur
SAP 0;             // STOP3 disables TUM1. Hence APOS = 0 and
                   // TPOS = APOS + POSERR
...
MODE PP3;          // set again the position profile mode 3
UPD;               // update – restart motion after a STOP command
```

2.1.9 Torque/Voltage Test Modes

The torque and voltage test modes have been designed to facilitate the testing during the setup phase. In these test modes, either a voltage or a torque (current) command can be set using a test reference consisting of a limited ramp (see **Figure 2.6**).

For AC motors (like for example the brushless motors), the test mode offers also the possibility to rotate a voltage or current reference vector with a programmable speed (see **Figure 2.7**). As a result, these motors can be moved in an “open-loop” mode without using the position sensor. The main advantage of this test mode is the possibility to conduct in a safe way a series of tests, which can offer important information about the motor parameters, drive status and the integrity of the its connections.

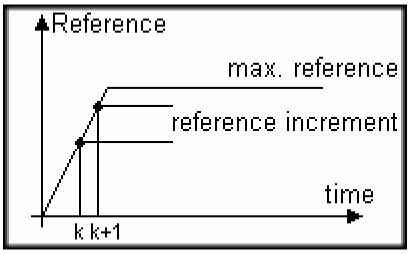

Figure 2.6. *Reference profile in test modes*

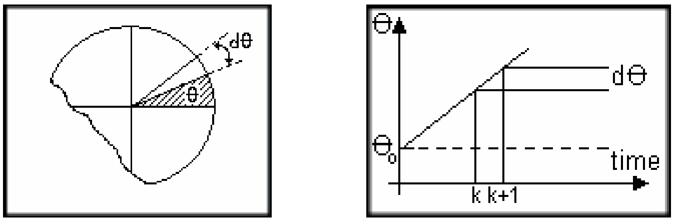

Figure 2.7. *Electrical angle setup in test modes with brushless AC motors*

***Remark**: The Motion test is a special test mode to be used only in some special cases for drives setup. The Motion Test mode is not supposed to be used during normal operation*

Related Parameters

REFTST	maximum value of the test reference in **torque** or **voltage units** (int)
RINCTST	reference increment at each slow-loop sampling period (int)
THTST	initial value for the electrical angle in **electrical angle** units (int)
TINCTST	electrical angle increment at each fast-loop sampling period (int)

Related Instructions

MODE TT	Set torque test mode
MODE VT	Set voltage test mode
UPD	Update motion mode and parameters. Start motion

2.1.10 Motion Mode Changing

The TML allows switching all motion modes on the fly, except for the test modes.

This feature is especially useful for position/speed control applications, where the target reference is provided by the internal trajectory generator using position/speed profile modes, position/speed contouring modes, electronic gearing, electronic cam and stop modes.

On the fly changes of the motion modes are possible because the target reference is updated each time the motion mode changes. Whenever a new motion mode is set, the target position and the target speed reference are set to the actual values of the motor position and motor speed i.e. `TPOS = APOS` and `TSPD = ASPD`.

This default target update mode (`TUM0`) is particularly useful to perform precise relative positioning triggered by an external event, because the input data for the relative position profile computation are the real motor position and speed.

There are however situations when the target reference update is not desired. In these cases you can overwrite the default target update mode by adding the TML instruction `TUM1` between the motion mode setting and the update commands.

The TUM1 command is particularly useful for open-loop applications, where there is no position/speed feedback. Here using TUM1 the target reference is preserved when motion modes are changed. As in the speed profile or speed contouring modes, the trajectory generator computes the target position by integrating the target speed, it is possible to do on the fly transitions from these modes to position profile or position contouring modes, even in the absence of motor feedback, under TUM1.

2.2 Program flow control

In the TML you can control the program flow in 3 ways:

- By setting an event to be monitored and waiting the event occurrence
- Through conditional or unconditional GOTO and CALL instructions
- Through the TML interrupts which can be triggered in certain conditions

2.2.1 Events

You can define an event (a condition) to be monitored and to perform one of the following actions:

- Change the motion mode and/or the motion parameters, when the programmed event occurs
- Stop the motion with one of the 4 possible stop modes, when the programmed event occurs
- Wait for the program event to occur

Remark: *Only a single event can be monitored at a time. The programmed event is automatically erased if the event is reached or if a new event is programmed*.

There are 18 events, which can be programmed, one at a time, for monitoring. **Table 2.11** presents them.

Table 2.11. *Programmable Event Triggers*

No.	Mnemonic	Event Description
1	`!MC`	When the actual motion is completed
2	`!APU value32` `!APU var32`	When the actual (motor) absolute position is equal or under a 32-bit long value or the value of a long variable
3	`!APO value32` `!APO var32`	When the actual (motor) absolute position is equal or over a 32-bit long value or the value of a long variable
4	`!RPU value32` `!RPU var32`	When the actual (motor) relative position is equal or under a 32-bit long value or the value of a long variable
5	`!RPO value32` `!RPO var32`	When the actual (motor) relative position is equal or over a 32-bit long value or the value of a long variable;
6	`!SU value32` `!SU var32`	When the actual (motor) speed is equal or under a 32-bit fixed value or the value of a fixed variable
7	`!SO value32` `!SO var32`	When the actual (motor) speed is equal or over a 32-bit fixed value or the value of a fixed variable
8	`!RT value32` `!RT var32`	After a wait time (measured from the event setting) equal with a 32-bit long value or the value of a long variable. The time unit is the slow-loop sampling period
9	`!AT value32` `!AT var32`	When absolute time is equal with a 32-bit long value or the value of a long variable. The time unit is the slow-loop sampling period
10	`!RU value32` `!RU var32`	When position or speed or torque or voltage target reference is equal or under a 32-bit value or the value of a long/fixed variable
11	`!RO value32` `!RO var32`	When position or speed or torque or voltage target reference is equal or over a 32-bit value or the value of a long/fixed variable
12	`!CAP`	When the selected capture input is triggered

13	`!LSP`	When positive limit switch input (LSP) is triggered
14	`!LSN`	When negative limit switch input (LSN) is triggered
15	`!IN#n 0`	When digital input #n goes low;
16	`!IN#n 1`	When digital input #n goes high;
17	`!VU var32a, value32` `!VU var32a, var32b`	When value of the long/fixed variable var32a is equal or under a 32-bit long/fixed value or the value of long/fixed variable var32b
18	`!VO var32a, value32` `!VO var32a, var32b`	When value of the long/fixed variable var32a is equal or over a 32-bit long/fixed value or the value of long/fixed variable var32b

You can combine the events with the motion programming in order to define the moment when a new motion mode and/or motion parameters must be updated (i.e. enabled) as the moment when a programmed event will occur. This involves the following operations:

- Definition of an event
- Programming of a new motion mode and/or new motion parameters
- Setting of an update on event (`UPD!`) command or one of the stop modes on event: `STOP0!, STOP1!, STOP2! Or STOP3!`
- Wait for the event to occur (`WAIT!`)

Remarks:

- *After you have programmed a new motion mode and/or new motion parameters with an update on event or a stop on event, it is recommended to introduce a wait until the programmed event occurs. Otherwise, the TML program will continue with the next instructions that may override the event set for monitoring*.
- *If the TML command* `WAIT!` *is executed and the programmed event doesn't occur, the TML program will remain in a loop. In order to get it out of the loop, you can send via a communication channel a* `GOTO` *command to a preset location, which will move the program execution outside the wait loop*
- *The TML command `WAIT!` is a **sequential** command. This means that the `WAIT!` command must be executed only as part of a TML program and not as a command sent on-line via a communication channel. If a host sends a `WAIT!` command on-line, the wait condition is disregarded*

Programming Examples:

1)
```
!IN#4 0       // set event when input IO#4 goes low
CPOS=2000;    // command position is 2000
CPR;          // command position is relative
MODE PP3      // set position profile mode 3
UPD!;         // when the event will occur, execute the move
WAIT!;        // wait the event to occur
```

2)
```
!CAP;         // set event when a capture input is triggered
STOP3!;       // smooth stop when event occurs
WAIT!;        // wait the event to occur
```

```
3)    !RT 100;    // set a wait time event of 100 slow-loop periods
                  // i.e. 100 ms for the default sampling values
      WAIT!;      // wait the event to occur
```

2.2.1.1 When the actual motion is completed

The motion complete condition is set in the following conditions:

- During position profiles execution, when the target position reference (computed by the reference generator, at each step) reaches the commanded position
- During a STOP3 command, when the target speed (computed by the reference generator) reaches zero

By setting a motion complete event and waiting for its occurrence, you can start the next move after the actual profile generation is completed.

Remark: *One way to execute successive position profiles where each move waits the previous one to finish is to start the first move, and then program all the other moves with update on event (UPD!) where the selected event is: when the actual motion is completed*.

2.2.1.2 Function of motor position

The monitored events are: when the absolute or the relative actual (motor) position is equal or over/under a 32-bit long value or the value of a long variable. The comparison value is expressed in **position units**

Remark: *The motor relative position is defined as the motor displacement from the beginning of the actual movement. For example if a position profile was started with the absolute motor position 50000 counts, when the absolute motor position reaches 60000 counts, the relative motor position is 10000 counts.*

2.2.1.3 Function of motor speed

The monitored events are when the actual (motor) speed is equal or over/under a 32-bit fixed value or the value of a fixed variable. The comparison value is expressed in **speed units**

2.2.1.4 After a wait time

The monitored event is when a 32-bit relative time counter is equal with a 32-bit long value or the value of a long variable. The comparison value is expressed in **time units**, i.e. in slow-loop sampling periods. When the wait time event is set, the 32-bit relative time counter is reset and restarts counting from zero.

Remark: *After setting a wait time event, in order to effectively execute the time delay, you need to wait for the event to occur, using for example the wait on event command `WAIT!`*

It is also possible to set an event when a 32-bit absolute time counter is equal with a 32-bit long value or the value of a long variable. Like in the relative case, the comparison value is expressed in **time units**

Remark:

- *Both the relative and the absolute time counters are started ONLY after the execution of the `ENDINIT` (end of initialization) command. Therefore you should not set wait events or absolute time events before executing this command*
- *In the case of an absolute time event, be aware that the 32-bit absolute time counter rolls over when it reaches the maximum value of 2^{32}-1*

2.2.1.5 Function of reference

The monitored event is when TML variable TREF is equal or over/under with a 32-bit value or the value of a 32-bit variable.

The TML variable TREF represents:

- The position reference, when position control is performed
- The speed reference, when speed control is performed
- The current/torque reference, when torque control is performed
- The voltage reference, when voltage control is performed

Depending on the reference type selection, the comparison value is a:

- 32-bit long integer value for position reference, expressed in **position units**
- 32-bit fixed value for speed reference, expressed in **speed units**
- 32-bit long integer value where the current reference is in the 16MSB part and the 16LSB part is 0, where the 16MSB value is expressed in **current units**
- 32-bit long integer value where the voltage reference is in the 16MSB part and the 16LSB part is 0, where the 16 MSB value is expressed in **voltage command units**

Remarks:

- *Setting an event based on the position or speed reference is particularly useful for open loop operation where motor position and speed is not available*
- *It is the user responsibility to know in which mode the drive operates when this event is set and to set the comparison value accordingly.*

2.2.1.6 Function of inputs status

You can define events function of the following inputs status:

- Capture inputs
- Limit switch inputs
- General purpose digital inputs

Capture inputs

The MotionChip II has two capture inputs: IN#5/Z1/CAPI and IN#34/H2/Z2/2CAPI. These can be programmed to sense either a low to high or high to low transition. Typically, on the IN#5/Z1/CAPI input is connected the motor encoder index and on the IN#34/H2/Z2/2CAPI input is connected the master encoder index (when available)

When the programmed transition occurs on IN#5/Z1/CAPI input, the actual (motor) position is captured and stored in a dedicated variable named `CAPPOS`. When the programmed transition occurs on IN#34/H2/Z2/2CAPI input, the master position `APOS2` is captured and stored in a dedicated variable named `CAPPOS2`.

When the position sensor is an incremental encoder, the captured position is very accurate as the whole process is done in less than 200 ns.

The master position can be captured only in the following conditions:

- The encoder signals from the master are connected to the 2nd encoder inputs
- The drive is set as slave either in electronic gearing or electronic camming with the option to read the master position from 2nd encoder inputs

In order to set an event on a capture input, you need to:

1) Enable the capture input for the detection of a low->high or a high-> low transition. The TML instructions for enabling the capture inputs are:

- To enable detection of a high to low transition

```
ENCAPI0;     //Activate CAPI input to detect a falling transition
EN2CAPI0;    //Activate 2CAPI input to detect a falling transition
```

- To enable detection of a low -> high transition

```
ENCAPI1;     //Activate CAPI input to detect a rising transition
EN2CAPI1;    //Activate 2CAPI input to detect a rising transition
```

2) Set a capture event, with the TML instruction: `!CAP;`

3) Wait for the event to occur, with the TML instruction: `WAIT!;`

Remarks:

- *If both capture inputs are activated in the same time, the capture event is set by the capture input that is triggered first.*
- *A capture input is automatically disabled, after the programmed transition was detected. In order to reuse a capture input, you need to enable it again.*

If you have a capture input enabled, and you want to disable it, before sensing the transition, use the following TML instructions:

```
DISCAPI;     //Deactivate CAPI input. Set CAPI pin as digital input.
DIS2CAPI;    //Deactivate 2CAPI input. Set 2CAPI pin as digital input.
```

Limit switch inputs

The MotionChip II has two limits switch inputs: IN#2/LSP and IN#24/LSN, first for the positive direction and the second for negative direction. Their goal is to protect against accidental moves outside the working area. Limit switches working mode is presented in detail par. 2.3.3

Like the capture inputs, the limit switch inputs can be programmed to sense either a low to high or high to low transition. When the programmed transition occurs, the actual (motor) position is captured and stored in the dedicated variable named `CAPPOS`. The position capture is done with a maximum delay of 5 μs.

In many applications, in order to determine the working area, the initialization procedure requires to move the motor until one or both limit switches are reached. You can program events on both positive or negative limit switches to detect when then these have been reached.

In order to set an event on a limit switch input, you need to:

1) Enable the limit switch input capability to detect a low->high or a high-> low transition. The TML instructions for enabling transition detection on the limit switch inputs are:

- To enable detection of a high to low transition

```
ENLSP0;     //Activate LSP input capability to detect a falling transition
ENLSN0;     //Activate LSN input capability to detect a falling transition
```

- To enable detection of a low -> high transition

```
ENLSP1;     //Activate LSP input capability to detect a rising transition
ENLSN1;     //Activate LSN input capability to detect a rising transition
```

2) Set a limit switch event, with the TML instructions:

```
!LSP;       // set event when transition is detected on positive limit switch
!LSN;       // set event when transition is detected on negative limit switch
```

3) Wait for the event to occur, with the TML instruction: `WAIT!;`

Remarks:

- *Both limit switch inputs can be set in the same time to detect transitions, as each input has its own event and TML interrupt*
- *A limit switch input capability to detect transitions is automatically disabled, after the programmed transition was detected. In order to reuse it, you need to enable it again.*

If you have a limit switch input enabled to detect transitions, and you want to disable this capability, before sensing the transition, use the following TML instructions:

```
DISLSP;     //Deactivate LSP input capability to detect transitions
DISLSN;     //Deactivate LSN input capability to detect transitions
```

Remark: *The main task of the limit switches is to protect against accidental moves outside the working area, by blocking moves in the wrong direction. For their main task, the limit switches are active on level, i.e. as long as a limit switch is activated, it will stop any move in the wrong* *direction. This task is always performed, independently of the fact if the limit switch is enabled or not to detect transitions.*

General purpose digital inputs

You can program an event on any general-purpose digital input. The event can be set when the input goes high (after a low to high transition) or low (after a high to low transition)

In order to set an event when the digital input IN#n goes high, use:

```
!IN#n 1;    //set event when input #n goes high
```

In order to set an event when the digital input IN#n goes low, use:

```
!IN#n 0;    //set event when input # goes low
```

where number "n" is the input number.

2.2.1.7 Function of a variable value

You can set an event function of the value of a selected variable. The selected variable for this event can be any 32-bit TML variable. The monitored events are:

- When variable `var_name` is equal or over a 32-bit `value` or the value of `variable`

```
!VU var_name, value;    // set event when var_name is equal or under value
!VU var_name, variable;//set event when var_name is equal or under variable
```

- When variable `var_name` is equal or over a 32-bit `value` or the value of `variable`

```
!VO var_name, value;    // set event when var_name is equal or over value
!VO var_name, variable;//set event when var_name is equal or over variable
```

2.2.2 GOTO, CALL

The TML offers the possibility to make unconditional or conditional jumps to a specific label and also unconditional or conditional calls of TML subroutines/functions.

The conditional instructions test the value of a variable for the following conditions: < 0, <= 0, >0, >=0, =0, |= 0. The `GOTO` or `CALL` is executed only if the test condition is true.

In all the cases, the jump location is defined via a label. A label can be any user-defined string of up to 32 characters, which starts from the first column of a text line and ends with a colon (`:`). A label contains the TML program address of the next TML instruction. In the case of the `CALL` instructions, the label name represents the TML subroutine called. This is because, in TML a subroutine or function is defined as follows:

```
TML_subroutine_name:    // Label with subroutine name. This is the subroutine start point
    ...                 // TML instructions. The subroutine body
    RET;                // Return from subroutine. Subroutine exit point
```

Programming Examples

```
      GOTO label1, var1, LT;        // jump to label1 if var1 < 0
      GOTO label2, var1, LEQ;       // jump to label2 if var1 <= 0
      GOTO label3, var1, GT;        // jump to label3 if var1 > 0
      GOTO label4;                  // unconditional jump to label4
      CALL fct1, var2, GEQ;         // call function fct1, if var2 >= 0
      CALL fct1, var2, EQ;          // call function fct1, if var2 = 0
      CALL fct1, var2, NEQ;         // call function fct1, if var2 != 0
      CALL fct1;                    // unconditional call of function fct1
fct1:
      ...
      ...
      RET;
```

Remarks:

- *All labels mentioned in the `GOTO` or `CALL` instructions must exist i.e. must be defined somewhere in the TML program*
- *The variable tested in the conditional `GOTO` and `CALL` can be of any type, 16 or 32-bit*
- *When you call a TML subroutine, the return address pointed by the IP (instruction pointer) is saved into the TML stack. When RET is executed, the IP is set with the last value from the TML stack, hence the TML program execution continues with the next instruction after the `CALL`. The TML stack dimension is 12 words. Each `CALL` and TML interrupt uses one word of the TML stack.*
- *The body of the TML subroutines, must be placed outside the main TML program i.e. after the `END` instruction (see* **Figure 1.1***)*

2.2.3 Interrupts

The TML interrupts offer the possibility of selecting up to 12 interrupt conditions that can be monitored in the same time. Unlike the events, where the programmed event is expected to occur and is waited for, the TML interrupts' main goal is to provide a way of reacting to unexpected events as are most of the conditions in **Table 2.12**

The TML interrupt mechanism is the following:

- Conditions that may generate TML interrupts are continuously monitored
- When an interrupt condition occurs, a flag (bit) is set in the Interrupt status register (ISR)
- If the interrupt condition is enabled i.e. the same bit (as position) is set in the Interrupt control register (ICR) and also if the interrupts are globally enabled (`EINT` instruction was executed), the interrupt condition is qualified and it generates an interrupt
- The interrupt causes a jump to the associated interrupt service routine. On entry in this routine, the TML interrupts are globally disabled (DINT) and the interrupt flag is reset
- The interrupt service routine ends with the TML instruction `RETI`, which returns to normal program execution and in the same time globally enables the TML interrupts (`EINT`)

The interrupt service routines (ISR) of the TML interrupts are similar with the TML subroutines: the starting point is a label and the ending point is the TML instruction `RETI` (return from interrupt). The use of the TML interrupts requires defining an interrupt table. This starts with a label whose value must be assigned in the dedicated TML variable `INITABLE`, and then is followed by the values of the labels (i.e. the starting points) of all the ISR. Like the TML functions, the TML interrupt service routines must be positioned after the end of the main program (see the programming example below).

Table 2.12. *TML Interrupt Conditions*

TML Interrupt No.	Condition Description
0	When ENABLE input changes. Both transitions are monitored
1	When power-stage hardware protection is triggered
2	When at least one software-monitored protection: over-current, I^2t, over temperature motor, over temperature drive, over-voltage or under-voltage is triggered
3	When control error protection is triggered i.e. the difference between the target reference and actual feedback value goes over a programmed limit
4	When a communication error occurs
5	When 32-bit actual (motor) position wraps-around
6	When positive limit switch input (LSP) has detected a programmed transition
7	When negative limit switch input (LSN) has detected a programmed transition
8	When a capture input (CAPI or 2CAPI) has detected a programmed transition
9	When motion is completed
10	When a new contour segment can be provided
11	When a programmed event has occurred

Remarks:

1. *By default, during the execution of the ISR, the TML interrupts are disabled. If you want to enable in this period some of the TML interrupts, set accordingly the interrupt mask in the ICR register and insert the `EINT` instruction that enables globally the interrupts*
2. *The interrupt conditions set the flags in the ISR register independently of the fact that the interrupts are disabled or enabled. If an interrupt flag is set while the interrupt is disabled, the flag remains set. If later on, the interrupt is enabled, due to the flag set by a previous condition, a TML interrupt is generated. In order to avoid this situation, before enabling an interrupt, it is recommended to reset the corresponding interrupt flag.*
3. *Use only the TML instruction `SRB` to set/reset bits in the interrupt control (ICR) and the interrupt status (ISR) registers. TML command `SRB` provides a safe mechanism which avoids errors when data of these registers is simultaneously modified by the user and internally due to a change in a monitored condition*

Related TML Parameters

INITABLE Must be initialized with the start address of the interrupt table

Related TML Instructions

EINT Globally enables the TML interrupts. Sets ICR.15 = 1
DINT Globally disables the TML interrupts. Sets ICR.15 = 0
SRB ICR, ANDm, ORm Individually enable/disable TML interrupts, by setting/resetting bits from ICR register according with AND mask **ANDm** and OR mask **ORm**
SRB ISR, ANDm, 0; Reset interrupt flags in the ISR register according with AND mask **ANDm**

RETI Return from a TML interrupt service routine

Programming Example

```
        BEGIN;                  // TML program start
         ...
        INTTABLE = InterruptTable;   // set interrupt table start address
        SRB ICR, 4095, 4;       // unmask INT2 Software Protection
         ...
        ENDINIT;                // end of initialization
         ...
        EINT;                   // globally enable the TML interrupts
         ...
        END;                    // end of the main section

InterruptTable:                 // start of the interrupt table
   @Int0_Axis_disable_ISR;
   @Int1_PDPINT_ISR;
   @Int2_Software_Protection_ISR;
   @Int3_Control_Error_ISR;
   @Int4_Communication_Error_ISR;
   @Int5_Wrap_Around_ISR;
   @Int6_Limit_Switch_Positive_ISR;
   @Int7_Limit_Switch_Negative_ISR;
   @Int8_Capture_ISR;
   @Int9_Motion_Complete_ISR;
   @Int10_Update_Contour_Segment_ISR;
   @Int11_Event_Reach_ISR;
Int0_Axis_disable_ISR:          // Int0_Axis_disable_ISR body
        ...
        RETI;                   // RETurn from TML ISR
        ...
Int2_Software_Protection_ISR;:  // Int11_Event_Reach_ISR body
        AXISOFF;                // set axis OFF if a protection is triggered
        RETI;                   // RETurn from TML ISR
        ...
Int11_Event_Reach_ISR:          // Int11_Event_Reach_ISR body
        ...
        RETI;                   // RETurn from TML ISR
```

2.3 I/O Programming

2.3.1 General I/O

The MotionChip II has a total of 40 pins that can be set as I/O lines. These pins are numbered from #0 to #39. All of them share the I/O function with an alternate function like: PWM output command, receive and transmit for serial and CAN-bus communication, encoder inputs, etc. Most of the 40 pins are set by default for the alternate functions and cannot be used as general-purpose I/O. Some of the remaining I/O lines are used for special functions like the Enable input and the Ready or Error output. Finally only 8 I/O lines remain available and may be used as general-purpose I/O. By default 4 are set as general-purpose inputs and the other 4 as general-purpose outputs.

The 4 general-purpose inputs are: #36, #37, #38 and #39. You can read their status with the TML command:

```
user_var = IN#n;           // read input #n in the user variable user_var
```

where `user_var` is a 16-bit integer user defined variable and n is the input number: 36 to 39. If the input is low (0 logic), `user_var` is set to 0, else `user_var` is set to a non-zero value.

Programming Example

```
user_var = IN#36;                 // read input #36 in user_var
GOTO label1, user_var, NEQ;       // go to label1 if input #36 is high (1 logic)
user_var = IN#39;                 // read input #39 in user_var
GOTO label2, user_var, EQ;        // go to label2 if input #39 is low (0 logic)
```

The 4 general-purpose outputs are: #28, #29, #30, #31. You can set them high (1 logic) or low (0 logic) with the following commands:

```
ROUT#n;          // Set low the output line #n
SOUT#n;          // Set high the output line #n
```

where n is the output number: 28-31.

You can also read simultaneously the 4 general-purpose inputs and set simultaneously the 4 general-purpose outputs, with the TML instructions:

```
user_var = INPORT, 0xF;       // user_var (bits 3-0)  = status of IN#39, 38, 37, 36
OUTPORT user_var;             // OUT#28,29,30,31 = user_var (bits 3-0)
```

In the first TML instruction, the status of the 4 inputs is saved in the 4LSB of the 16-bit user variable, while the 12MSB are set to 0. If an input line is low, the corresponding bit in the user variable is zero. If an input line is high, the corresponding bit in the user variable is one. The correspondence with the input lines is the following:

IN#36 -> bit 0, IN#37 -> bit 1, IN#38 -> bit 2, IN#39 -> bit 3 of the user variable

In the second TML instruction, you can set the 4 outputs according with the 4LSB from the user variable. The 12MSB of the user variable must be set to zero. If a bit in the user variable is zero, the corresponding output line is set low. If a bit in the user variable is one, the corresponding output line is set high. The correspondence with the output lines is the following:

User variable Bit 0 -> OUT#28, bit 1 -> OUT#29, bit 2 -> OUT#30, bit 3 -> OUT#31

Remark: *When reading inputs or setting outputs keep in mind that the I/O status refers to the MotionChip II pin. If your drive has either the inputs or outputs inverted, you must reverse the logic levels presented above. For example, if the general-purpose outputs are inverted, the `OUTPORT` command with the 4LSB bits at zero, sets the 4 output lines high. The command `SOUT#n` will set low the output line #n and the command `ROUT#n`, will set the same output high.*

If you application require more inputs or more outputs you have the possibility to change some of the general-purpose outputs into inputs and vice versa, using the following commands:

```
SETIO#n OUT;        //Set the I/O line #n as an input
SETIO#n IN;         //Set the I/O line #n as an output
```

where n is the I/O number.

Remark: *An I/O line status change must be done only after carefully checking if your drive was designed to support it.*

You can further extend the number of I/O in some special situations, by enabling the I/O function for some pins set by default with the alternate function. For example if your drive was designed to control only DC motors and uses just 4 PWM output commands, the remaining PWM output commands may be transformed into general-purpose I/O. This can be done with the command:

```
ENIO#n;      // Enable the use of pin #n as an I/O line
```

The reverse is also possible i.e. to disable the I/O function and activate the alternate function

```
DISIO#n;     // Disable the use of pin #n as an I/O line
```

Remark: *Enabling or disabling I/O lines must be done only after carefully checking if your drive was designed to support it*

2.3.2 Captures

The MotionChip II has two capture inputs: IN#5/Z1/CAPI and IN#34/H2/Z2/2CAPI. These can be programmed to sense either a low to high or high to low transition. Typically, on the IN#5/Z1/CAPI input is connected the motor encoder index and on the IN#34/H2/Z2/2CAPI input is connected the master encoder index (when available)

When the programmed transition occurs on IN#5/Z1/CAPI input, the actual (motor) position is captured and stored in a dedicated variable named `CAPPOS`. When the programmed transition occurs on IN#34/H2/Z2/2CAPI input, the master position `APOS2` is captured and stored in a dedicated variable named `CAPPOS2`.

When the position sensor is an incremental encoder, the captured position is very accurate as the whole process is done in less than 200 ns.

The master position can be captured only in the following conditions:

- The encoder signals from the master are connected to the 2nd encoder inputs
- The drive is set as slave either in electronic gearing or electronic camming with the option to read the master position from 2nd encoder inputs

You can set either an event or a TML interrupt on a capture input. In both cases you need to:

1) Enable the capture input for the detection of a low->high or a high-> low transition. The TML instructions for enabling the capture inputs are:

- To enable detection of a high to low transition

```
ENCAPI0;     //Activate CAPI input to detect a falling transition
EN2CAPI0;    //Activate 2CAPI input to detect a falling transition
```

- To enable detection of a low -> high transition

```
ENCAPI1;     //Activate CAPI input to detect a rising transition

EN2CAPI1;    //Activate 2CAPI input to detect a rising transition
```

2) Set:

- A capture event with `!CAP`, then wait until the event occurs with `WAIT!;`, or
- Enable the TML capture interrupt with `SRB ICR 0xFFFF,0x100;` which sets ICR.8 =1.

Remarks:

- *If both capture inputs are activated in the same time, the capture event and the TML capture interrupt flag is set by the capture input that is triggered first.*
- *A capture input is automatically disabled, after the programmed transition was detected. In order to reuse a capture input, you need to enable it again.*

If you have a capture input enabled, and you want to disable it, before sensing the transition, use the following TML instructions:

```
DISCAPI;     //Deactivate CAPI input. Set CAPI pin as digital input.
DIS2CAPI;    //Deactivate 2CAPI input. Set 2CAPI pin as digital input.
```

2.3.3 Limit switches

The MotionChip II has two limits switch inputs: IN#2/LSP and IN#24/LSN, first for the positive direction and the second for negative direction. Their goal is to protect against accidental moves outside the working area.

The limit switch inputs are active on level, more exactly when the input level is high. When a limit switch input is active, it stops the motor when it attempts to move towards the protected direction but allows the motor to move in the opposite direction. Therefore, with the positive limit switch active, movement is possible only in the negative direction; with the negative limit switch active, movement is possible only in the positive direction.

Like the capture inputs, the limit switch inputs can be programmed to sense either a low to high or high to low transition. When the programmed transition occurs, the actual (motor) position is captured and stored in the dedicated variable named `CAPPOS`. The position capture is done with a maximum delay of 5 μs.

In many applications, in order to determine the working area, the initialization procedure requires to move the motor until one or both limit switches are reached. You can set for each limit switch input, either an event or a TML interrupt to detect when it has been reached.

In order to set an event or a TML interrupt on a limit switch input, you need to:

1) Enable the limit switch input capability to detect a low->high or a high-> low transition. The TML instructions for enabling transition detection on the limit switch inputs are:

- To enable detection of a high to low transition

```
ENLSP0;     //Activate LSP input capability to detect a falling transition
ENLSN0;     //Activate LSN input capability yo detect a falling transition
```

- To enable detection of a low -> high transition

```
ENLSP1;     //Activate LSP input capability to detect a rising transition
ENLSN1;     //Activate LSN input capability to detect a rising transition
```

2) Set

- A limit switch event, with the TML instructions: `!LSP` or `!LSN`, then wait until the event occurs with `WAIT!;`, or
- Enable LSP or LSN TML interrupt with `SRB ICR 0xFFFF,0x40;` which sets ICR.6 =1 or with `SRB ICR 0xFFFF,0x80;` which sets ICR.7 =1

Remarks:

- *Both limit switch inputs can be set in the same time to detect transitions, as each input has its own event and TML interrupt*
- *A limit switch input capability to detect transitions is automatically disabled, after the programmed transition was detected. In order to reuse it, you need to enable it again.*

If you have a limit switch input enabled to detect transitions, and you want to disable this capability, before sensing the transition, use the following TML instructions:

```
DISLSP;     //Deactivate LSP input capability to detect transitions
DISLSN;     //Deactivate LSN input capability to detect transitions
```

Remarks:

- *The main task of the limit switches i.e. to protect against accidental moves outside the working area is performed, independently of the fact if the limit switches are enabled or not to detect transitions*
- *You can disable the limit switches by executing the following TML code, once at the beginning of the TML program:*

```
user_var = 0x0832;      // Set variable user_var with value 0x0832
(user_var),dm = 1;      // Write 1 at data memory address 0x0832
```

Following this command, the active levels on limit switch inputs will no longer block the movement in the wrong direction. The capability to detect transitions remains unchanged

- *You can read the status of the limit switches inputs like any other general purpose inputs using the TML instructions:*

```
var = IN#2;      // read status of the positive limit switch input
var = IN#24;     // read status of the negative limit switch input
```

2.4 Assignment & Data Transfer

2.4.1 Setup 16-bit variable

The TML instructions presented in this paragraph help you to program assignment operations involving the transfer of a 16-bit value from a source to a 16-bit destination.

The source can be:
- A 16-bit immediate value
- A 16-bit TML data: TML register, parameter, variable or user variable (direct or negate)
- The high or low part of a 32-bit TML data: TML parameter, variable or user variable
- A memory location indicated through a pointer variable

The destination can be:
- A 16-bit TML data: TML register, TML parameter or user variable
- A memory location indicated through a pointer variable

Programming Examples

1) Source: 16-bit immediate value, Destination: 16-bit TML data. The immediate value can be decimal or hexadecimal

```
user_var = 100;       // set user variable user_var with value 100
user_var = 0x100;     // set user variable user_var with value 0x100 (256)
```

2) Source: 16-bit TML data, Destination: 16-bit TML data.

```
var_dest = var_source; // copy value of var_source in var_dest
var_dest = -var_source;// copy negate value of var_source in var_dest
```

3) Source: high or low part of a 32-bit TML data, Destination: 16-bit TML data. The 32-bit TML data can be either long or fixed

```
int_var = long_var(L);     // copy low part of long_var in int_var
int_var = fixed_var(H);    // copy high part of fixed_var in int_var
```

4) Source: a memory location indicated through a pointer variable, Destination: 16-bit TML data. The memory location can be of 3 types: SRAM data memory (dm), SRAM memory for TML programs (pm), EEPROM SPI-connected memory for TML programs (spi). If the pointer variable is followed by a + sign, after the assignment, the pointer variable is incremented by 1

```
p_var = 0x4500;        //  set 0x4500 in pointer variable p_var
var1 = (p_var),spi;    // var1 = value of  the EEPROM memory location 0x4500
var1 = (p_var+),spi;   // var1 = value of  the EEPROM memory location 0x4500
                       // p_var = 0x4501
p_var = 0x8200;        //  set 0x8200 in pointer variable p_var
var1 = (p_var),pm;     // var1 = value of  the SRAM program memory location 0x8200
var1 = (p_var+),pm;    // var1 = value of  the SRAM program memory location 0x8200
                       // p_var = 0x8201
p_var = 0xA00;         //  set 0xA00 in pointer variable p_var
```

```
var1 = (p_var),dm;   // var1 = value of  the SRAM data memory location 0xA00
var1 = (p_var+),dm;  // var1 = value of  the SRAM data memory location 0xA00
                     // p_var = 0xA01
```

***Remark:** Check the memory map (par. 1.8) for the valid address ranges of the 3 memory types: EEPROM memory for TML programs, SRAM memory for TML programs, SRAM data memory.*

5) Source: 16-bit immediate value (decimal or hexadecimal) or 16-bit TML data. Destination: a memory location indicated through a pointer variable. The memory location can be of 3 types: SRAM data memory (dm), SRAM memory for TML programs (pm), EEPROM SPI-connected memory for TML programs (spi). If the pointer variable is followed by a + sign, after the assignment, the pointer variable is incremented by 1

```
p_var = 0x4500;          //  set 0x4500 in pointer variable p_var
(p_var),spi = -5;        // write value –5 in the EEPROM memory location 0x4500
(p_var+),spi = var1;     // write var1 value in the EEPROM memory location 0x4500
                         // p_var = 0x4501
p_var = 0x8200;          //  set 0x8200 in pointer variable p_var
(p_var),pm = 0x10;       // write value 0x10 in SRAM program memory location 0x8200
(p_var+),pm = var1;      // write var1 value in SRAM program memory location 0x8200
                         // p_var = 0x8201
p_var = 0xA00;           //  set 0xA00 in pointer variable p_var
(p_var),dm = 50;         // write value 50 in the SRAM data memory location 0xA00
(p_var+),dm = var1;      // write var1 value in the SRAM data memory location 0xA00
                         // p_var = 0xA01
```

***Remark:** When the source is either an immediate value or another TML data and the destination is a TML data, the destination address must be between 0x200 and 0x3FF. This happens for most of the TML data, including all the user-defined variables, which take addresses between 0x3B0 to 0x3FF. There are however a limited number of TML parameters and variables having an **extended address** situated between 0x800 and 0x9FF. For these TML data, you should use either indirect addressing via a pointer variable, or the following commands that support extended addressing:*

```
int_var,dm = 100;          // write 100 in int_var using extended addressing

int_var,dm = 0x100;        // with 0x100(256) in int_var using extended addressing

var_dest,dm = var_source;       // copy value of var_source in var_dest using
```

// extended addressing

2.4.2 Setup 32-bit variable

The TML instructions presented in this paragraph help you to program assignment operations involving the transfer of a 16 or 32-bit value from a source to a 32-bit destination.

The source can be:

- A 32-bit immediate value

- A 32-bit TML data: TML parameter, variable or user variable (direct or negate)
- A 16-bit immediate value or a 16-bit TML data: TML register, parameter, variable or user variable to be set in the high or low part of the destination: a 32-bit TML data
- A 16-bit TML data: TML register, parameter, variable or user variable left shifted by 0 to 16
- A memory location indicated through a pointer variable

The destination can be:

- A 32-bit TML data: TML parameter or user variable
- A memory location indicated through a pointer variable

Programming Examples

1) Source: 32-bit immediate value, Destination: 32-bit TML data. The immediate value can be decimal or hexadecimal. The destination can be either a long or a fixed variable

```
long_var = 100000;       // set user variable long_var with value 100000
long_var = 0x100000;     // set user variable long_var with value 0x100000
fixed_var = 1.5;         // set user variable fixed_var with value 1.5 (0x18000)
fixed_var = 0x14000;     // set user variable fixed_var with value 1.25 (0x14000)
```

2) Source: 32-bit TML data, Destination: 32-bit TML data.

```
var_dest = var_source; // copy value of var_source in var_dest
var_dest = -var_source;// copy negate value of var_source in var_dest
```

Remark: *source and destination must be of the same type i.e. both long or both fixed*

3) Source: 16-bit immediate value (decimal or hexadecimal) or 16-bit TML data, Destination: high or low part of a 32-bit TML data. The 32-bit TML data can be either long or fixed

```
long_var(L) = -1;            // write value –1 (0xFFFF) into low part of long_var
fixed_var(H) = 0x2000;       // write value 0x2000 into high part of fixed_var
long_var(L) = int_var;       // copy int_var into low part of long_var
fixed_var(H) = int_var;      // copy int_var into high part of fixed_var
```

4) Source: 16-bit TML data left shifted 0 to 16. Destination: 32-bit TML data. The 32-bit TML data can be either long or fixed

```
long_var = int_var << 0;       // copy int_var left shifted by 0 into long_var
fixed_var(H) = int_var << 16;// copy int_var left shifted by 16 fixed_var
```

Remarks:

- *The left shift operation is done with sign extension. If you intend to copy the value of an integer TML data into a long TML data preserving the sign use this operation with left shift 0*
- *If you intend to copy the value of a 16-bit unsigned data into a 32-bit long variable, assign the 16-bit data in low part of the long variable and set the high part with zero.*

Examples:

```
var = 0xFFFF;        // As integer, var = 1, as unsigned integer var = 65535
lvar = var << 0;  //  lvar = -1 (0xFFFFFFFF), the 16MSB of lvar are all set to 1 the
```

```
                         // sign bit of var
lvar(L) = var;       // lvar(L) = 0xFFFF
lvar(H) = 0;         // lvar(H) = 0. lvar = 65535 (0x0000FFFF)
```

5) Source: a memory location indicated through a pointer variable, Destination: 32-bit TML data. The memory location can be of 3 types: SRAM data memory (dm), SRAM memory for TML programs (pm), EEPROM SPI-connected memory for TML programs (spi). If the pointer variable is followed by a + sign, after the assignment, the pointer variable is incremented by 2. The destination can be either a long or a fixed TML data

```
p_var = 0x4500;          // set 0x4500 in pointer variable p_var
var1 = (p_var),spi;      // var1 = value of the EEPROM memory location 0x4500
var1 = (p_var+),spi;     // var1 = value of the EEPROM memory location 0x4500
                         // p_var = 0x4502
p_var = 0x8200;          // set 0x8200 in pointer variable p_var
var1 = (p_var),pm;       // var1 = value of the SRAM program memory location 0x8200
var1 = (p_var+),pm;      // var1 = value of the SRAM program memory location 0x8200
                         // p_var = 0x8202
p_var = 0xA00;           // set 0xA00 in pointer variable p_var
var1 = (p_var),dm;       // var1 = value of the SRAM data memory location 0xA00
var1 = (p_var+),dm;      // var1 = value of the SRAM data memory location 0xA00
                         // p_var = 0xA02
```

Remark: *Check the memory map (par. 1.8) for the valid address ranges of the 3 memory types: EEPROM memory for TML programs, SRAM memory for TML programs, SRAM data memory.*

6) Source: 32-bit immediate value (decimal or hexadecimal) or a 32-bit TML data. Destination: a memory location indicated through a pointer variable. The memory location can be of 3 types: SRAM data memory (dm), SRAM memory for TML programs (pm), EEPROM SPI-connected memory for TML programs (spi). If the pointer variable is followed by a + sign, after the assignment, the pointer variable is incremented by 2

```
p_var = 0x4500;          // set 0x4500 in pointer variable p_var
(p_var),spi = 200000;    // write 200000 in the EEPROM memory location 0x4500
(p_var+),spi = var1;     // write var1 value in the EEPROM memory location 0x4500
                         // p_var = 0x4502
p_var = 0x8200;          // set 0x8200 in pointer variable p_var
(p_var),pm = 3.5;        // write value 3.5 in SRAM program memory location 0x8200
(p_var+),pm = var1;      // write var1 value in SRAM program memory location 0x8200
                         // p_var = 0x8202
p_var = 0xA00;           // set 0xA00 in pointer variable p_var
(p_var),dm = -1L;        // write –1 (0xFFFFFFFF) in the SRAM data memory 0xA00
(p_var+),dm = var1;      // write var1 value in the SRAM data memory location 0xA00
                         // p_var = 0xA02
```

When this operation is performed having as source an immediate value, the TML compiler checks the type and the dimension of the immediate value and based on this generates the binary code for a 16-bit or a 32-bit data transfer. Therefore if the immediate value has a decimal point, it is automatically considered as a fixed value. If the immediate value is outside the 16-bit integer range (-32768 to +32767), it is automatically considered as a long value. However, if the immediate value is inside the integer range, in order to execute a 32-bit data transfer it is necessary to add the suffix **L** after the value, for example: **200L** or **–1L**.

Examples:

```
user_var = 0x29E;     // write CPOS address in pointer variable user_var
(user_var),dm = 1000000;  // write 1000000 (0xF4240) in the CPOS parameter i.e
                          // 0x4240 at address 0x29E and 0xF at next address 0x29F
(user_var+),dm = -1;// write -1 (0xFFFF) in CPOS(L). CPOS(H) remains unchanged
                    // CPOS value is (0xFFFFF) i.e. 1048575, user_var is
                    // incremented by 1

user_var = 0x29E;     // write again CPOS address in pointer variable user_var
(user_var+),dm = -1L;// write –1L long value (0xFFFFFFFF) in CPOS i.e.
                     // CPOS(L) = 0xFFFF and  CPOS(H) = 0xFFFF, user_var is
                     // incremented by 2
user_var = 0x2A0;  // write CSPD address in pointer variable user_var

(user_var),dm = 1.5;  // write 1.5 (0x18000) in the CSPD parameter i.e
                 // 0x8000 at address 0x2A0 and 0x1 at next address 0x2A1
```

Remark: *When the source is either an immediate value or another TML data and the destination is a TML data, the destination address must be between 0x200 and 0x3FF. This happens for most of the TML data, including all the user-defined variables, which take addresses between 0x3B0 to 0x3FF. There are however a limited number of TML parameters and variables having an* ***extended address*** *situated between 0x800 and 0x9FF. For these TML data, you should use either indirect addressing via a pointer variable, or the following commands that support extended addressing:*

```
long_var,dm = 100000;   // write 100000 in long_var using extended addressing
long_var,dm = 0x100000;// with 0x100000 in TMLparam using extended addressing
var_dest,dm = var_source;     // copy value of var_source in var_dest using
                              // extended addressing
```

2.5 Arithmetic & Logic Operations

The TML offers the possibility to perform the following operations with the TML data:

- Addition
- Subtraction
- Multiplication
- Left and right shift
- Logic AND and OR

In all the cases, except the multiplication, the result of the operation is saved into the left side operand. For the multiplication, the result is saved in a dedicated 48-bit register named PROD.

For all the operations, except the logic AND and OR, the left side operand can be any 16 or 32-bit TML data. The logic AND and OR are performed only with 16-bit data.

Addition: The right-side operand is added to the left-side operand

The left side operand can be:

- A 16-bit TML data: TML parameter or user variable
- A 32-bit TML data: TML parameter or user variable

The right side operand can be:

- A 16-bit immediate value
- A 16-bit TML data: TML parameter, variable or user variable
- A 32-bit immediate value, if the left side operand is a 32-bit TML data
- A 32-bit TML data: TML parameter, variable or user variable, if the left side operand is a 32-bit data too

Programming Examples

```
int_var += 10;          // int_var1 = int_var1 + 10
int_var += int_var2;    // int_var = int_var + int_var2
long_var += -100;       // long_var = long_var + (-100) = long_var – 100
long_var += long_var2; // long_var = long_var + long_var2
fixed_var += 10.;       // fixed_var = fixed_var + 10.0
fixed_var += fixed_var2;  // fixed_var = fixed_var + fixed_var2
```

Subtraction: The right-side operand is subtracted from the left-side operand

The left side operand can be:

- A 16-bit TML data: TML parameter or user variable
- A 32-bit TML data: TML parameter or user variable

The right side operand can be:

- A 16-bit immediate value
- A 16-bit TML data: TML parameter, variable or user variable
- A 32-bit immediate value, if the left side operand is a 32-bit TML data

- A 32-bit TML data: TML parameter, variable or user variable, if the left side operand is a 32-bit data too

Programming Examples

```
int_var -= 10;          // int_var1 = int_var1 - 10
int_var -= int_var2;    // int_var = int_var - int_var2
long_var -= -100;       // long_var = long_var - (-100) = long_var + 100
long_var -= long_var2;  // long_var = long_var - long_var2
fixed_var -= 10.;       // fixed_var = fixed_var - 10.0
fixed_var -= fixed_var2; // fixed_var = fixed_var - fixed_var2
```

Multiplication: The 2 operands are multiplied and the result is saved in a dedicated 48-bit register named PROD. The result of the multiplication can be left or right-shifted with 0 to 15 bits, before being stored in the PROD register. At right shifts, high order bits are sign-extended and the low order bits are lost. At left shifts, high order bits are lost and the low order bits are zeroed. The result is preserved in the PROD register until the next multiplication.

The first (left) operand can be:

- A 16-bit TML data: TML parameter, variable or user variable
- A 32-bit TML data: TML parameter, variable or user variable

The second (right) operand can be:

- A 16-bit immediate value
- A 16-bit TML data: TML parameter, variable or user variable

Programming Examples

```
long_var * -200 << 0;      // PROD = long_var * (-200)
fixed_var * 10 << 5;       // PROD = fixed_var * 10 * 2^5 i.e. fixed_var *320
int_var1 * int_var2 >> 1;  // PROD = (int_var1 * int_var2) / 2
long_var * int_var >> 2;   // PROD = (long_var * int_var) / 4
long_var = PROD;           // save 32LSB of PROD in long_var
long_var = PROD(H);        // save 32MSB of PROD in long_var i.e. bits 47-15
```

Left and right shift: The operand is left or right shifted with 0 to 15. The result is saved in the same operand. At right shifts, high order bits are sign-extended and the low order bits are lost. At left shifts, high order bits are lost and the low order bits are zeroed.

The right shift is performed with sign-extension.

The operand can be:

- A 16-bit TML data: TML parameter, variable or user variable
- A 32-bit TML data: TML parameter, variable or user variable
- The 48-bit PROD register with the result of the last multiplication

Programming Examples

```
long_var << 3;     //  long_var = long_var * 8
int_var = -16;     //  int_var = -16 (0xFFF0)
int_var >> 3;      //  int_var = int_var / 8 = -2 (0xFFFE)
PROD << 1;         //  PROD = PROD * 2
```

Logic AND and OR: A logic AND is performed between the operand and a 16-bit data (the AND mask), followed by a logic OR between the result and another 16-bit data (the OR mask).

The operand is a 16-bit TML data: TML register, TML parameter or user variable

The AND and OR masks are 16-bit immediate values, decimal or hexadecimal.

Programming Examples

```
int_var = 13;                   // int_var = 13 (0xD)
SRB int_var, 0xFFFE, 0x2;       //  set int_var bit 0 = 0 and bit 1 = 1
                                // int_var = 12 (0xC)
```

The SRB instruction modifies the TML data in specific conditions that avoid the interference with changes done in parallel by the MotionChip II firmware. This is particularly useful for the TML registers, which have bits that can be manipulated both at firmware level and at TML level by the user. A typical example is the interrupt flag register (IFR) where the interrupt flags set and reset by both the firmware and the user. The SRB instruction allows you to set/reset bits in a “safe” way without the risk of altering the settings done in parallel by the firmware.

Remark: *In the SRB instruction, the address of the operand must be between 0x200 and 0x3FF. This happens for most of the TML data, including all the user-defined variables, which take addresses between 0x3B0 to 0x3FF. There are however a limited number of TML parameters and variables having an* ***extended address*** *situated between 0x800 and 0x9FF. For these TML data, you should use the* ***SRBL*** *instruction, for setting and resetting bits:*

```
SRBL TMLvar, 0xFFFE, 0x2;       //  set bit 0 = 0 and bit 1 = 1 in TMLvar with
                                // extended address
```

2.6 Multi-axis control

This group of instructions includes:

- Data transfer operations between drives connected in a network
- Remote control commands through which a drive which acts like a host, effectively controls one or more drives operation

2.6.1 Axis ID. Group ID

In multiple-axis configurations, each axis (drive) needs to be identified through a unique number – the **axis ID**. This is a number between 1 and 255. The axis ID is initially set at power on by reading the MotionChip II analogue input lines ADCIN10 to ADCIN14, as follows:

- Axis ID = 255 if all the analogue inputs ADCIN10 to ADCIN14 are high;
- Axis ID = 1 to 31, if at least one of the ADCIN10 to ADCIN14 inputs is low. The axis ID value depends on the analogue inputs combination (see **Table 3.1**)

Later on, you can change the axis ID to any of the 255 possible values, using the TML instruction `AXISID`, followed by an integer value between 1 and 255.

Apart from the Axis ID, each drive has also a **group ID**. The group ID represents a way to identify a group of drives, for a multicast transmission. Each drive can be programmed to be member of one or several of the 8 possible groups. When a TML command is sent to a group, all the axes members of this group, will receive the command. For example, if the drive is member of group 1 and group 3, he will receive all the messages that in the group ID include group 1 and group 3. This feature allows a host to send a command simultaneously to several axes, for example to start or stop the axes motion in the same time.

The group ID is like the axis ID an 8-bit value. A TML command can be sent to 8 different groups. Each group is defined as having one of the 8 bits of the group ID value set to 1 (see **Table 3.2**)

The group ID of an axis can have any value between 0 and 255. If for example the group ID is 11 (1011b) this means that the axis will receive all messages sent to groups 1, 2 and 4. You can set a drive to be member of one group using the TML instruction `GROUPID`, followed by an integer value between 1 and 8. You can add/remove an axis to group using the TML instructions `ADDGRID` / `REMGRID` followed by an integer value between 1 and 8.

***Remark**: By default all the drives are set as members of group 1.*

2.6.2 Data transfers between axes

There are 2 categories of data transfer operations between axes:

1. Read data from a remote axis. A variable or a memory location from the remote axis is saved into a local variable
2. Write data to a remote axis. A variable or a memory location of a remote axis or group of axes is written with the value of a local variable

In a read data from a remote axis operation:

- The source is placed on a remote axis and can be:
  - A 16-bit TML data: TML register, parameter, variable or user variable
  - A memory location indicated through a pointer variable
- The destination is placed on the local axis and can be:
  - A 16-bit TML data: TML register, parameter or user variable

Programming Examples

1) Source: remote 16-bit TML data, Destination: local 16-bit TML data.

```
local_var = [2]remote_var;    // set local_var with value of remote_var from axis 2
```

Remark: *If remote_var is a user variable, it has to be declared in the local axis too. Moreover, for correct operation, remote_var must have the same address in both axes, which means that it must be declared on each axis on the same position. Typically, when working with data transfers between axes, it is advisable to establish a block of user variables that may be the source, destination or pointer of data transfers, and to declare these data on all the axes as the first user variables. This way you can be sure that these variables have the same address on all the axes.*

2) Source: remote memory location pointed by a remote pointer variable, Destination: 16-bit TML data. The remote memory location can be of 3 types: SRAM data memory (dm), SRAM memory for TML programs (pm), EEPROM SPI-connected memory for TML programs (spi). If the pointer variable is followed by a + sign, after the assignment, the pointer variable is incremented by 1 if the destination is a 16-bit integer or by 2 if the destination is a 32-bit long or fixed

```
local_var = [2](p_var),spi;  // local_var = value of EEPROM program memory
                             // location from axis 2, pointed by p_var from axis 2
long_var = [3](p_var+),dm;   // local long_var = value of SRAM data memory
                             // locations from axis 3, pointed by p_var from axis
                        3
                             // p_var is incremented by 2
int_var = [4](p_var+),pm;    // local int_var = value of SRAM program memory
                             // location from axis 4, pointed by p_var from axis 4;
                             // p_var is incremented by 1
```

Remark: *When the remote source is a TML data, its address must be between 0x200 and 0x3FF. This happens for most of the TML data, including all the user-defined variables, which take addresses between 0x3B0 to 0x3FF. There are however a limited number of TML parameters and variables having an* ***extended address*** *situated between 0x800 and 0x9FF. For these TML data, you should use either indirect addressing via a pointer variable, or the following command that supports extended addressing:*

```
local_var = [2]remote_var,dm;      // set local_var with value of remote_var
                                   // from axis 2 using extended addressing
```

In a write data to a remote axis or group of axes operation:

- The source is placed on the local drive and can be:
  - A 16-bit TML data: TML register, parameter, variable or user variable

- The destination is placed on the remote axis or group of axes and can be:
  - A 16-bit TML data: TML register, parameter or user variable
  - A memory location indicated through a pointer variable

Programming Examples

1) Source: local 16-bit TML data, Destination: remote 16-bit TML data.

```
[2]remote_var = local_var;    // set remote_var from axis 2 with local_var value
[G2]remote_var = local_var;   // set remote_var from group 2 with local_var value
```

2) Source: 16-bit TML data, Destination: remote memory location pointed by a remote pointer variable. The remote memory location can be of 3 types: SRAM data memory (dm), SRAM memory for TML programs (pm), EEPROM SPI-connected memory for TML programs (spi). If the pointer variable is followed by a + sign, after the assignment, the pointer variable is incremented by 1 if the source is a 16-bit integer or by 2 if the source is a 32-bit long or fixed

```
[2](p_var),spi = local_var;   // set local_var value in EEPROM program memory
                              // location from axis 2, pointed by p_var from axis 2
[G3](p_var+),dm = long_var;   // set local long_var value in SRAM data memory
                              // location from group 3 of axes, each location being
                              // pointed its own p_var, which is incremented by 2
[4](p_var+),pm = int_var;     // set local int_var value in SRAM program memory
                              // location from axis 4, pointed by p_var from axis 4;
                              // p_var is incremented by 1
```

Remark: *When the remote destination is a TML data, its address must be between 0x200 and 0x3FF. This happens for most of the TML data, including all the user-defined variables, which take addresses between 0x3B0 to 0x3FF. There are however a limited number of TML parameters and variables having an* ***extended address*** *situated between 0x800 and 0x9FF. For these TML data, you should use either indirect addressing via a pointer variable, or the following command that supports extended addressing:*

```
[G2]remote_var,dm = local_var; // set remote_var from group 2 with
                               // local_var value, using extended addressing
```

2.6.3 Remote control

The TML includes 2 powerful instructions through which you can program a drive to issue TML commands to another drive or group of drives. You can include these instructions in the TML program of a drive, which can act like a host and can effectively control the operation of the other drives from the network. These TML instructions are:

```
[axis]{TML command;};
[group]{TML command;};
```

where TML command can be any single axis TML instructions whose instruction code can be represented in maximum 4 words (1 operation code + 3 data words). A single axis TML instruction is defined as an instruction which does not transfer data or send TML commands to other axes i.e. it is not one of the TML instructions presented in this paragraph.

Remark: *Most of the TML instructions, enter in the category of those that can be sent to another axis or group of axes.*

Programming Examples

```
[G1]{CPOS=2000;};        // send a new CPOS command to all axes from group 1
[G1]{UPD};               // send an UPDate command to all the axes from group 1
                         // all axes from group 1 will start to move simultaneously
[5]{STOP3;};             // send an STOP3 command to axis 5
```

2.7 Miscellaneous commands

In this category enter the following TML instructions:

```
NOP;          // No operation
BEGIN;        // first instruction in the main section of a TML program.
END;          // marks the end of a TML program
SCIBR value;  // change RS-232/RS-485 baudrate. Value specifies the new baudrate as
              // follows: 0 – 9600, 1 – 19200, 2 – 38400, 3 – 56000, 4 – 115200
SPIBR value;  // change SPI baudrate with the EEPROM. Value specifies the new
              // baudrate as: 0 for 1 MHz, 2 for 2MHz, 3 for 5MHz
CANBR value;  // change CANbus baudrate Value specifies the new baudrates as:
              // 0xF36C for 125 kHz, 0x736C for 250 kHz, 0x3273 for 500 kHz,
              // 0x412A for 800 kHz and 0x1273 for 1MHz
CHECKSUM, dm start, stop, user_var; // compute the sum modulo 65535 of
              // SRAM data memory locations from addresses start to stop
CHECKSUM, pm start, stop, user_var; // compute the sum modulo 65535 of
              // SRAM TML program memory locations from addresses start to stop
CHECKSUM, spi start, stop, user_var; // compute the sum modulo 65535 of
              // EEPROM TML program memory locations from addresses start to stop
```

Remarks:

1. It is mandatory to end the main section of a TML program with an `END` command. This stops the execution of the TML program resident in the memory. All ML subroutines and interrupt service routines should be added after the `END` command. **IPM Motion Studio** automatically handles these requirements when it generates the TML program to compile and download into the drive.
2. The `END` commands is also useful when you intend to change the TML program from the EEPROM of a drive set in AUTORUN mode (i.e. which starts to execute automatically after reset the TML program from the EEPROM memory) you should do the following:
   - Send to the drive the command `END`, to stop the current program execution. In order to disable the power stage, send also an `AXISOFF` command
   - Download the new program
   - Reset the drive. The new program will start to execute
3. When a drive is set in AUTORUN mode, it checks the first EEPROM memory location at address 0x4000 to contain the binary code of the TML instruction `BEGIN`. If this is true, the drive continues to execute the next TML instructions from the EEPROM, otherwise it

puts the drive in a wait. Therefore, for correct operation in AUTORUN mode, it is important to have the TML program downloaded in EEPROM starting with first address 0x4000 and having the first TML instruction `BEGIN`.

2.8 Internal units and scaling factors

This paragraph describes the MotionChip II internal units (IU) and their correspondence with the international standard units (SI).

The values you set in the TML parameters must be always in internal units. As the TML parameters may represent various signals: position, speed, current, voltage, etc. in order to correctly identify each category of internal units, these have been named after their category. For example the **position units** are the internal units for position, the **speed units** are the internal units for speed, etc.

Position units

In the TML environment the internal position units (IU) are encoder counts.

The correspondence with the international standard (SI) units is:

$$\text{Position[rad]} = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines}} \cdot \text{Position[i.u.]}$$

where:

No_encoder_lines – is the number of encoder lines per revolution

Speed units

In TML environment the internal speed units (IU) are encoder counts/slow loop sampling period i.e. the position variation over one position/speed loop sampling period

The correspondence with the international standard (SI) units is:

$$\text{Speed[rad/s]} = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines} \times \text{Ts\_S}} \cdot \text{Speed[i.u.]}$$

where:

No_encoder_lines – is the number of encoder lines per revolution

Ts_S – is the slow loop sampling period [s]

Acceleration units

In TML environment the internal acceleration units (IU) are encoder counts/slow loop sampling^2

The correspondence with the international standard (SI) units is:

$$\text{Acceleration[rad/s\^{}2]} = \frac{2 \times \pi}{4 \times \text{No\_encoder\_lines} \times \text{Ts\_S\^{}2}} \cdot \text{Acceleration[i.u.]}$$

where:

No_encoder_lines – is the number of encoder lines per revolution

Ts_S – is the speed loop sampling period [s]

Current units

The correspondence with the international standard (SI) units is:

$$\text{Current}[A] = \frac{2\text{ImaxPS}}{65472} \cdot \text{Current}[i.u.]$$

where:

ImaxPS – is the power stage peak current i.e. the maximum measurable current [A]

Typically, a motor phase current is measured through transducers that provide a voltage proportional with the current value. This is connected to a MotionChip II analogue input. The currents are both positive and negative, therefore the current transducer output is offset by half in order to get zero current at half A/D input scale. The power stage peak current is the current corresponding to half of the maximum value for the analogue input i.e. half of 3.3V. After A/D conversion 3.3V is 65472.

Voltage command units

The significance of the voltage commands as well as the scaling factors, depend on the motor technology and the control method used.

For a brushed DC motor the voltage command is the voltage to apply between the motor phases.

For a brushless DC motor (BLDC) i.e. a brushless motor with trapezoidal control (more exactly with commutation on Hall sensors causing trapezoidal BEMF), the voltage command is the voltage to apply between 2 of the 3 motor phases. These are the 2 phases that are supplied at one moment.

For a brushless AC motor (PMSM) i.e. a brushless motor with sinusoidal control (field oriented vector control generating sinusoidal currents and voltages), the voltage commands are the amplitude of the sinusoidal phase voltages.

For the brushed DC and brushless DC motors, the correspondence with the international standard (SI) units is:

$$\text{Voltage command}[V] = \frac{\text{Vdc}}{32767} \cdot \text{Voltage command}[i.u.]$$

where:

Vdc – is the rated DC-link/supply voltage [V]

In MotionChip II, the output voltage of each inverter is leg is set via a command in the range (-32767, + 32767). The minimum value means that that lower transistor is all the time ON and upped one is OFF, hence the inverter output voltage is 0. The maximum value means that the upper transistor is all the time ON and the lower one is OFF, hence the inverter output voltage is equal with the DC link/supply voltage (minus a slight voltage drop).

In the case of a brushed DC or brushless DC motor, a voltage command for of let's say 16384 (half of positive scale), means that on one leg the command is +16384 and on the other leg it is negated that is –16384. This means that one motor leg is connected to a potential of ¾ of the DC link/supply voltage, while the other motor leg is connected to ¼ of the DC-link/supply voltage. The difference i.e. the motor voltage is half of the inverter supply.

For the brushless AC motor, the correspondence with the international standard (SI) units is:

$$\text{Voltage command}[V] = \frac{1.1 \times \text{Vdc}}{65534} \cdot \text{Voltage command}[i.u.]$$

In the case of a brushless AC motor, the voltage commands are sinusoidal with mid point and amplitude equal with ½ of the DC-link/supply voltage. The 1.1 factor comes from a MotionChip II advanced PWM control technique which add another 10% on the voltages applied on the motor

DC-link/supply voltage units

The correspondence with the international standard (SI) units for DC-link/supply voltage is:

$$\text{Voltage}[V] = \frac{\text{VdcMaxMeasurable}}{65472} \cdot \text{Voltage}[i.u.]$$

where:

VdcMaxMeasurable – is the maximum measurable DC-link/supply voltage [V]

Typically, the DC-link/supply voltage is measured through a voltage divisor connected to an analogue input of the MotionChip II. The maximum measurable DC-link/supply voltage is the DC-link/supply voltage that corresponds to the MotionChip II maximum value for the analogue input i.e. 3.3V, which after A/D conversion is 65472.

Time units

In TML environment the internal time units (IU) are expressed in slow loop sampling periods.

The correspondence with the international standard (SI) units is:

$$\text{Time}[s] = \text{Ts\_S} \cdot \text{Time}[i.u.]$$

where:

Ts_S – is the speed loop sampling period

For example, if Ts_S is 1ms, one second is 1000 in internal time units.

Current increment units

The correspondence with the international standard (SI) units for current increment is:

$$\text{Current Increment}[A/s] = \frac{2\text{ImaxPS}}{65472 \times \text{Ts\_S}} \cdot \text{Current Increment}[i.u.]$$

where:

ImaxPS – is the power stage maximum current [A]
Ts_S – is the speed loop sampling period [s]

Voltage (command) increment units

Like in the case of the voltage command units, the correspondence with the international standard (SI) units of the voltage increment units depends on the on the motor technology and the control method used.

For the brushed DC and brushless DC motors, the correspondence with the international standard (SI) units is:

$$\text{Voltage Increment}[V/s] = \frac{Vdc}{32767 \times Ts\_S} \quad \text{Voltage Increment}[i.u.]$$

For the brushless AC motor, the correspondence with the international standard (SI) units is:

$$\text{Voltage increment}[V/s] = \frac{1.1 \times Vdc}{65534 \times Ts\_S} \quad \text{Voltage increment}[i.u.]$$

where:

Vdc – is the DC-link/supply voltage [V]
Ts_S – is the speed loop sampling period [s]

Electrical angle units

The correspondence with the international standard (SI) units is:

$$\text{Electrical angle}[rad] = \frac{\pi}{32768} \quad \text{Electrical angle}[i.u.]$$

The electrical angle is the mechanical angle divided by the number of pole pairs. For example when a brushless motor with 2 pairs does half of revolution (i.e. 180 mechanical degrees) this corresponds to 360 electrical degrees

Electrical angle increment units

The correspondence with the international standard (SI) units is:

$$\text{Motor speed}[rad/s] = \frac{\pi}{32767 \times Ts\_C \times pp} \quad \text{Electrical angle increment}[i.u.]$$

where:

pp – is the number of pair poles
Ts_C – is the current loop sampling period [s]

Temperature units

The correspondence with the international standard (SI) units is:

$$\text{Temperature}[^{\circ}C] = \frac{3.3V}{\text{TempSensorGain}[V/^{o}C] \times 65472} \left(\text{Temperature}[i.u.] - \text{TempOffset}[i.u.]\right)$$

where:

TemperatureSensorGain – expresses the sensor output voltage variation when the temperature modifies with one degree Celsius.

TempOffset – is the temperature sensor voltage output at 0°C expressed in internal units [V]

$$TempOutputAt0oC[V] = \frac{3.3}{65472} \cdot TempOffset[i.u.]$$

Master Position units

When the master position is sent via a communication channel, the master position units depend on the type of position sensor present on the master axis.

When the master position is an encoder the correspondence with the international standard (SI) units is:

$$Master\_position[rad] = \frac{2 \times \pi}{4 \times No\_encoder\_lines} \quad Master\_position[i.u.]$$

where:

No_encoder_lines – is the master number of encoder lines per revolution

Master Speed units

The master speed is computed in internal units (IU) as master position units /slow loop sampling period i.e. the master position variation over one position/speed loop sampling period.

When the master position is an encoder, the correspondence with the international standard (SI) units is:

$$Master\_speed[rad/s] = \frac{2 \times \pi}{4 \times No\_encoder\_lines \times Ts\_S} \quad Master\_speed[i.u.]$$

where:

No_encoder_lines – is the master number of encoder lines per revolution

Ts_S – is the slave slow loop sampling period [s]

3. Communication Channels and Protocols

3.1 Communication channels

The Motion Chip II accepts two types of communication channels:

- Serial RS-232 or RS-485
- CAN-bus

The serial RS-232 communication channel can be used to connect a host with a single MotionChip II based drive (see **Figure 3.1**). The serial RS-485 and the CAN-bus communication channels can be used to create a distributed control network with a host and up to 255 MotionChip II based drives (see **Figure 3.2** and **Figure 3.3**).

When CAN-bus communication is used, any MotionChip II based drive from the network may also be connected through RS-232 with a host (see **Figure 3.4**). In this structure, the axis connected to the host, apart from executing the commands received from host or other axes acts also as a retransmission relay which:

- Receives through RS-232, commands from host for another axis and retransmits them to the destination through CAN-bus
- Receives through CAN-bus data requested by host from another axis and retransmits them to the host through RS-232

This flexibility enables a host to program and monitor a CAN-bus network using only one RS-232 connection, without the need to have a CAN-bus interface. In this case the CAN-bus protocol is completely transparent for the host.

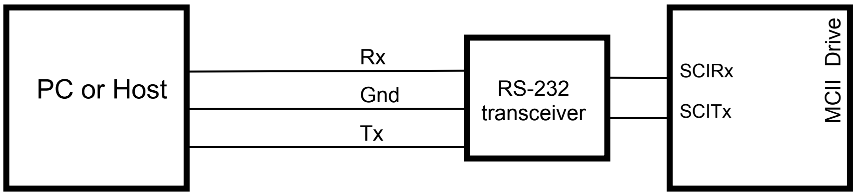

Figure 3.1. *Serial RS-232 communication between a host and the MotionChip II*

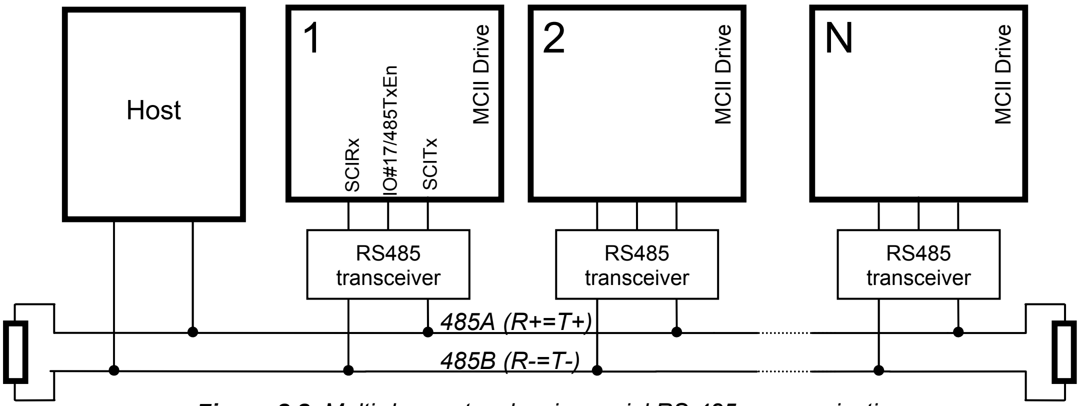

Figure 3.2. *Multi-drop network using serial RS-485 communication*

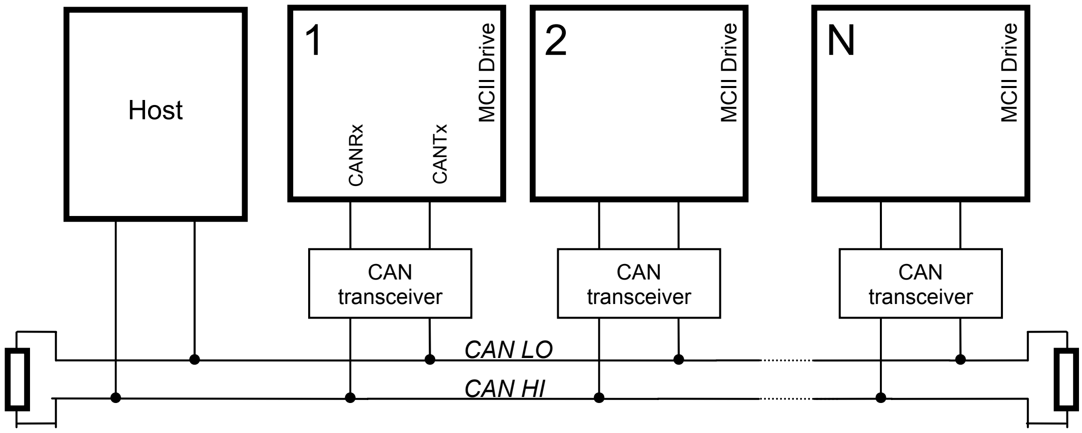

Figure 3.3. *Multi-drop network using CAN-bus communication*

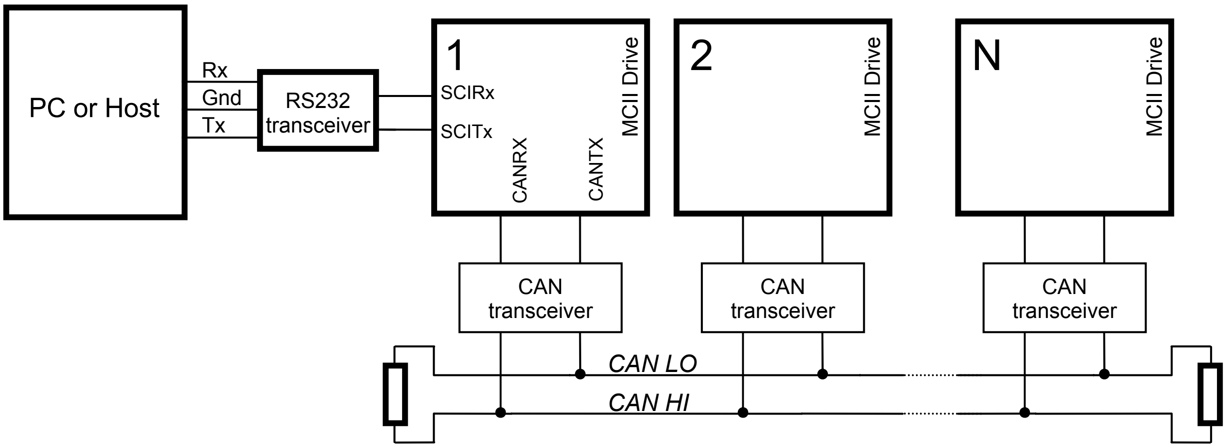

Figure 3.4.*Multi-drop network using CAN-bus communication with host connected through RS-232 to an axis used as communication relay*

3.2 Communication protocols

3.2.1 Axis Identification in a Multiple-axis Network

In multiple-axis configurations, each axis (drive) needs to be identified through a unique number – the **axis ID**. This is a number between 1 and 255. The axis ID is initially set at power on by reading the MotionChip II analogue input lines ADCIN10 to ADCIN14, as follows:

- Axis ID = 255 if all the analogue inputs ADCIN10 to ADCIN14 are high;
- Axis ID = 1 to 31, if at least one of the ADCIN10 to ADCIN14 inputs is low. The axis ID value depends on the analogue inputs combination (see **Table 3.1**)

Later on, you can change the axis ID to any of the 255 possible values, using the TML instruction `AXISID`, followed by an integer value between 1 and 255.

Table 3.1 *Axis ID values*

ADCIN10	ADCIN11	ADCIN12	ADCIN13	ADCIN14	AXISID
HIGH	HIGH	HIGH	HIGH	HIGH	255
HIGH	HIGH	HIGH	HIGH	LOW	1
HIGH	HIGH	HIGH	LOW	HIGH	2
HIGH	HIGH	LOW	HIGH	LOW	3
HIGH	HIGH	LOW	HIGH	HIGH	4
HIGH	HIGH	LOW	HIGH	LOW	5
HIGH	HIGH	LOW	LOW	HIGH	6
HIGH	HIGH	LOW	LOW	LOW	7
HIGH	LOW	HIGH	HIGH	HIGH	8
HIGH	LOW	HIGH	HIGH	LOW	9
HIGH	LOW	HIGH	LOW	HIGH	10
HIGH	LOW	HIGH	LOW	LOW	11
HIGH	LOW	LOW	HIGH	HIGH	12
HIGH	LOW	LOW	HIGH	LOW	13
HIGH	LOW	LOW	LOW	HIGH	14
HIGH	LOW	LOW	LOW	LOW	15
LOW	HIGH	HIGH	HIGH	HIGH	16
LOW	HIGH	HIGH	HIGH	LOW	17
LOW	HIGH	HIGH	LOW	HIGH	18
LOW	HIGH	HIGH	LOW	LOW	19
LOW	HIGH	LOW	HIGH	HIGH	20
LOW	HIGH	LOW	HIGH	LOW	21
LOW	HIGH	LOW	LOW	HIGH	22
LOW	HIGH	LOW	LOW	LOW	23
LOW	LOW	HIGH	HIGH	HIGH	24
LOW	LOW	HIGH	HIGH	LOW	25
LOW	LOW	HIGH	LOW	HIGH	26
LOW	LOW	HIGH	LOW	LOW	27
LOW	LOW	LOW	HIGH	HIGH	28
LOW	LOW	LOW	HIGH	LOW	29
LOW	LOW	LOW	LOW	HIGH	30
LOW	LOW	LOW	LOW	LOW	31

Apart from the Axis ID, each drive has also a **group ID**. The group ID represents a way to identify a group of drives, for a multicast transmission. Each drive can be programmed to be member of one or several of the 8 possible groups. When a TML command is sent to a group, all the axes members of this group, will receive the command. For example, if the drive is member of group 1 and group 3, he will receive all the messages that in the group ID include group 1 and group 3. This feature allows a host to send a command simultaneously to several axes, for example to start or stop the axes motion in the same time.

The group ID is like the axis ID an 8-bit value. A TML command can be sent to 8 different groups. Each group is defined as having one of the 8 bits of the group ID value set to 1 (see **Table 3.2**)

Table 3.2. *Definition of the groups*

Group No.	Group ID value
1	1 (0000 0001b)
2	2 (0000 0010b)
3	4 (0000 0100b)
4	8 (0000 1000b)
5	16 (0001 0000b)
6	32 (0010 0000b)
7	64 (0100 0000b)
8	128 (1000 0000b)

The group ID of an axis can have any value between 0 and 255. If for example the group ID is 11 (1011b) this means that the axis will receive all messages sent to groups 1, 2 and 4. You can set a drive to be member of one group using the TML instruction `GROUPID`, followed by an integer value between 1 and 8. You can add/remove an axis to group using the TML instructions `ADDGRID` / `REMGRID` followed by an integer value between 1 and 8.

Remark*: By default all the drives are set as members of group 1.*

When a TML Instruction is send through the serial or CAN-bus channel, the message consists of the axis or group ID followed by the instruction code (see **Figure 3.5**.).

.

Axis/Group ID
Operation Code
Data (1)
…
Data (4)

Figure 3.5. *Message Structure*

In a serial or CAN message, the axis or group ID is 16-bit word with the following structure:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	G	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0	0	0	0	H
				7	6	5	4	3	2	1	0				

Where:

- Bit 0 – HOST bit. In a network configuration the HOST bit indicates the destination axis for messages received by the relay axis: 0 – relay axis, 1 – host. Messages received by the relay axis with HOST bit set to 1, will be retransmitted through RS-232 to the host. Messages received by the relay axis with HOST bit set to 0, will be interpreted as commands for this axis and will be executed. On RS-485, the host and the drives have different axis ID, the HOST bit has as no significance and must be set to 0.
- Bits 11-8 – ID7-ID0: the 8-bit value of an axis or group ID
- Bit 12 – GROUP bit: 0 – ID7-ID0 value is an axis ID, 1 – ID7-ID0 value is a group ID

3.2.2 Serial communication protocol

Serial settings and message packaging

The RS-232/RS-485 serial communication is done using 8 data bits, 2 stop bits, no parity at the following baud rates: 9600 (default after reset), 19200, 38400, 56600 and 115200. The messages exchanged through serial communication are packed in the following format:

Byte 1: Message length
Byte 2: Axis/Group ID – high byte
Byte 3: Axis/Group ID – low byte
Byte 4: Operation code – high byte
Byte 5: Operation code – low byte
Byte 6: Data (1) – high byte
Byte 7: Data (1) – low byte
Byte 8: Data (2) – high byte
…
Byte13: Data (4) – low byte
Last byte: Checksum

Figure 3.6. *Serial communication message format*

The message length byte contains the total number of bytes of the message minus 2. Put in other words, the length byte value is the number of bytes of the: axis/group ID (2bytes), the operation code (2 bytes) and the data words (variable from 0 to 8 bytes). The checksum byte is the sum modulo 256 of all the bytes of the message except the checksum byte itself.

Message types on serial communication

The serial communication protocol is based on two types of messages:

- Type A: Messages that don't require an answer (a return message). In this category enter for example the messages containing commands for parameter settings, commands that start or stop motion execution, etc.
- Type B: Messages that require an answer. In this category enter the messages containing commands that ask to return data, for example the value of TML parameters, registers, or variables.

The type B message has two components:

- A request message sent through the TML command "Give Me Data".
- An answer message sent through the TML command "Take Data"

The "Give Me Data" request message includes the following information:

"Give Me Data" Message Contents

Axis ID (destination axis)
Operation Code: B004h for 16-bit data **B005h for 32-bit data**
Data(1): Sender Axis ID
Data(2): Requested Data Address

The “Take Data” answer message includes the following information:

Axis ID (destination axis)
Operation Code: B404h for 16-bit data **B405h for 32-bit data**
Data(1): Sender Axis ID
Data(2): Requested Data Address
Data(3): Data Requested 16LSB
Data(4): Data Requested 16MSB (for 32-bit data)

Example 1:

A host is connected to a drive via RS-232 and sends a type A message with the TML instruction “kpp = 5” (set proportional part of the position controller with value 5).

The axis ID of host and of the drive are 255 = 0FFh. The TML instruction code is:

Operation Code = 205Eh
Data (1) = 0005h

The serial message package must have the following contents:

Byte 1: 06h – length: ID=2,Opcode=2,Data=2
Byte 2: 0Fh – high byte of ID = 0FF0h
Byte 3: F0h – low byte of ID = 0FF0h
Byte 4: 20h – high byte of OpCode = 205Eh
Byte 5: 5Eh – low byte of OpCode = 205Eh
Byte 6: 00h – high byte of Data(1) = 0005h
Byte 7: 05h – low byte of Data(1) = 0005h)
Byte 8: 88h – checksum

Figure 3.7. *Serial message contents when TML instruction “kpp = 5” is sent*

The host receives from the drive a byte 0x4F as confirmation that the message was received OK.

Remarks:

1. *If the host wants to sent the same TML instruction “kpp = 5” to another drive with axis ID=1, drive connected via CAN-bus with the drive having axis ID=255, the destination ID becomes 0010h instead of 0FF0h. Hence the modifications are: byte 2: 00h, byte 3: 10h, checksum byte adjusted accordingly (99h).*
2. *If the host is connected via RS-485 with a drive, the two devices must have different axis ID values. For example if the host ID = 255 and the drive ID = 1, the message is the same as in the previous remark.*

Example 2:

A host is connected to a drive via RS-232 and wants to get the value of the kpp parameter from the drive. The ID of host and drive are 255 = 0FFh.

Let’s suppose that the kpp value returned by the drive is 288 (120h). The host has to send a “Give Me Data” TML command with the following instruction code:

Operation Code = B004h (16-bit value)
Data(1) = 0FF1h (sender ID = destination ID + HOST bit set)
Data(2) = 025Eh (kpp variable address)

The" Take Data" answer will have the following instruction code:

Operation Code = B404h (16-bit value)
Data(1) = 0FF0h (sender ID)
Data(2) = 025Eh (kpp variable address)
Data(3) = 0120h (kpp variable value)

The serial message send by the host with "Give Me Data" TML command must have the following contents:

Byte 1: 08h – length ID=2,Opcode=2,Data=4
Byte 2: 0Fh – high byte of ID = 0FF0h
Byte 3: F0h – low byte of ID = 0FF0h
Byte 4: B0h – high byte of OpCode = B004h
Byte 5: 04h – low byte of OpCode = B004h
Byte 6: 0Fh – high byte of Data(1) = 0FF1h
Byte 7: F1h – low byte of Data(1) = 0FF1h
Byte 8: 02h – high byte of Data(2) = 025Eh
Byte 9: 5Eh – low byte of Data(2) = 025Eh
Byte 8: 1Bh – checksum

Figure 3.8. *Serial message contents for "Give Me Data" value of kpp*

The host receives from the drive a byte 0x4F as confirmation that the message was received OK.

The serial message received by the host with "Take Data" TML command must have the following contents:

Byte 1: 0Ah – length ID=2,Opcode=2,Data=6
Byte 2: 0Fh – high byte of ID = 0FF1h
Byte 3: F1h – low byte of ID = 0FF1h
Byte 4: B4h – high byte of OpCode = B404h
Byte 5: 04h – low byte of OpCode = B404h
Byte 6: 0Fh – high byte of Data(1) = 0FF0h
Byte 7: F0h – low byte of Data(1) = 0FF0h
Byte 8: 02h – high byte of Data(2) = 025Eh
Byte 9: 5Eh – low byte of Data(2) = 025Eh
Byte 10: 01h – high byte of Data(3) = 0120h
Byte 11: 20h – low byte of Data(3) = 0120h
Byte 12: 42h – checksum

Figure 3.9. *Serial message contents for "Take Data" value of kpp*

Remarks:

1. *If the host wants to get the value of the kpp parameter from another drive with axis ID=1, connected via CAN-bus with the drive having axis ID=255, the destination ID becomes 0010h in instead of 0FF0h in the "Give Me Data" message. "Take Data" message also will have 0010h in instead of 0FF0h as sender ID. Hence the modifications are:*
   - *"Give Me Data": byte 2: 00h, byte 3: 10h, checksum byte adjusted accordingly;*
   - *"Take Data": byte 6: 00h, byte 7: 10h, checksum byte adjusted accordingly;*
2. *If the host is connected via RS-485 with a drive, the 2 devices must have different axis ID values. For example if the host ID = 255 and the drive ID = 1, the modifications compared with the above examples are:*
   - *"Give Me Data": byte 2: 00h, byte 3: 10h, byte 7: F0h (in sender ID the host bit = 0) and the checksum byte adjusted accordingly;*
   - *"Take Data": byte 3: F0h, byte 6: 00h, byte 7: 10h and the checksum byte adjusted accordingly.*

RS-232 communication protocol

The RS-232 protocol is full duplex, allowing simultaneous transmission in both directions. After each command (Type A or B) sent by the host, the drive will confirm the reception by sending one acknowledge-Ok byte. This byte is: 'O' (ASCII code of capital letter "o", 0x4F). If the host receives the 'O' byte, this means that the drive has received correctly (checksum verification was passed) the last message sent, and now is ready to receive the next message.

Remark: *If the destination axis for the message is not the axis connected with the host via RS-232 (e.g. the relay axis), but another axis connected with the relay axis via CAN-bus, the reception of the acknowledge-Ok byte from the relay axis doesn't mean that the message was received by the destination axis, but just by the relay axis. Depending on the CAN-bus baud rate and the amount of traffic on this bus, the host may need to consider introducing a delay before sending the next message to an axis connected on the CAN-bus. This delay must provide the relay axis the time necessary to retransmit the message via CAN-bus.*

If any error occurs during the message reception, for example the checksum computed by the drive axis doesn't match with the one sent by the host, the drive will not send the acknowledge-**O**k byte. If the host doesn't receive any acknowledge byte for at least 2ms after the end of the checksum byte transmission, this means that at some point during the last message transmission, one byte was lost and the synchronization between the host and the relay axis is gone. In order to restore the synchronization the host should do the following:

1. Send a SYNC byte having value 0x0D (higher values are also accepted)
2. Wait a programmed timeout (typically 2ms) period for an answer;
3. If the drive sends back the same SYNC byte, the synchronization is restored and the host can send again the last message, else go to step 1

Repeat steps 1 to 3 until the drive answers with a SYNC byte or until 15 SYNC bytes are sent. If after 15 SYNC bytes the drive still doesn't answer, then there is a serious communication problem and the serial link must be checked.

When a host sends a type A message through RS-232 it has to:

- Send the message;
- Wait the acknowledge-OK byte 'O' from the drive;

When a host sends a type B message through RS-232 it has to:

- Send a message with "Give Me Data" command;
- Wait the acknowledge-OK byte 'O' from the drive connected via RS-232 (relay axis);
- Wait the response message from the drive to which the message is addressed. The answer contains the command "Take Data".

When the relay axis returns a "Take Data" message it doesn't expect to receive an acknowledge byte from the host. It is the host task to monitor the communication. If the host gets the response message with a wrong checksum, it is the host duty to send again the "Give Me Data" request.

RS-485 communication protocol

The RS-485 protocol is half duplex. If two devices start by mistake to transmit in the same time, both transmissions are corrupted. Therefore for a correct operation, in an RS-485 network it is mandatory to have a master, which controls the transmission. This means that only the master can initiate a transmission, while all the other devices from the network may transmit only when the master asks them to provide some data. Usually you should set as master your host.

After each command (Type A or B) sent by the host to one drive, the drive will confirm the reception by sending one acknowledge-Ok byte. This byte is: 'O' (ASCII code of capital letter "o", 0x4F). If the host receives the 'O' byte, this means that the drive has received correctly (checksum verification was passed) the last message sent, and now is ready to receive the next message.

The acknowledge-Ok byte is not sent when the host broadcasts a message to a group of drives.

If any error occurs during the message reception, for example if the checksum computed by the drive axis doesn't match with the one sent by the host, the drive will not send the acknowledge-Ok byte. If the host doesn't receive any acknowledge byte for at least 2ms after the end of the checksum byte transmission, this means that at some point during the last message transmission, one byte was lost and the synchronization between the host and the relay axis is gone. In order to restore the synchronization the host should do the following:

1. Send a 15 SYNC byte having value 0x0D (higher values are also accepted)
2. Wait a programmed timeout (typically 2ms) period for an answer;
3. If the drive sends back the same SYNC byte, the synchronization is restored and the host can send again the last message, else go to step 1

If the drive still doesn't answer, then there is a serious communication problem and the serial link must be checked

When a host sends a type A message through RS-485 it has to:

- Send the message;
- Wait the acknowledge-OK byte 'O' from the drive, only if the message destination was a single drive;

When a host sends a type B message through RS-485 it has to:

- Send a message with "Give Me Data" command;
- Wait the acknowledge-OK byte 'O' from the drive;
- Wait the response message from the drive, which contains the command "Take Data".

Remark: *it is not possible to send a "Give Me Data" command to a group of axes.*

When the drive returns a “Take Data” message it doesn’t expect to receive an acknowledge byte from the host. It is the host task to monitor the communication. If the host gets the response message with a wrong checksum, it is the host duty to send again the “Give Me Data” request.

3.2.3 CAN-bus Communication Protocol

CAN-bus communication settings and message packaging

The Technosoft drives implements the CAN 2.0B protocol that uses 29 bits for the identifier. Below you can see how the information to be sent is packed in a CAN-bus message:

CAN message identifier:

28 **0**

Operation Code (7MSB)	**Group bit**	**Axis/Group ID**	**0**	**0**	**0**	**Host bit**	**Operation code (9LSB)**

CAN message data bytes:

CAN Message Data Byte No.	TML Data Word
0	Data word (1) – low byte
1	Data word (1) – high byte
2	Data word (2) – low byte
3	Data word (2) – high byte
4	Data word (3) – low byte
5	Data word (3) – high byte
6	Data word (4) – low byte
7	Data word (4) – high byte

Figure 3.10. *CAN message structure*

Where G is the group bit and H is the host bit.

The CAN-bus communication offers the possibility to work on a semi-duplex network like in a full-duplex one. The CAN controller automatically solves the conflicts that occur while two axes try to transmit messages in the same time. In an RS-485 network, such an event usually corrupts both messages, while in a CAN-bus the higher priority message always wins. The lower priority message is automatically sent after the transmission of the first message ends. Hence, in a CAN-bus network, all the limitations mentioned for RS-485 are eliminated.

Message types on CAN-bus communication

The CAN-bus communication protocol is based on two types of messages:

- Type A: Messages that don’t require an answer (a return message). In this category enter for example the messages containing commands for parameter settings, commands that start or stop motion execution, etc.
- Type B: Messages that require an answer. In this category enter the messages containing commands that ask to return data, for example the value of TML parameters, registers, or variables.

The type B message has two components:

- A request message sent through the TML command “Give Me Data”.
- An answer message sent through the TML command “Take Data”

The “Give Me Data” request message includes the following information:

CAN Identifier: **Operation Code** and **Axis ID** (destination axis)
Data word (1): Sender Axis ID
Data word (2): Request Data Address

The Operation Code for the “Give Me Data” request is B004h for 16-bit data and B005h for 32-bit data.

The “Take Data” answer message includes the following information:

CAN Identifier: **Operation Code** and **Axis ID** (destination axis)
Data word (1): Sender Axis ID
Data word (2): Request Data Address
Data word (3): Data Requested 16 LSB
Data word (4): Data Requested 16 MSB (for 32-bit data)

The Operation Code for the “Take Data” request is B404h for 16-bit data and B405h for 32-bit data.

Example 1:

A host is directly connected on a CAN-bus network with Technosoft drives and wants to send to the drive with the axis ID=5 the TML instruction “kpp = 0x1234” (set proportional part of the position controller with value 1234 hexa).

The code of the TML instruction is:

Operation Code = 205Eh
Data word (1) = 1234h

The CAN Message Identifier have the following content:

28 0

Operation Code (7MSB of 205Eh)	**Group bit**	**Axis/Group ID**	**0**	**0**	**0**	**Host bit**	**Operation code (9LSB of 205Eh)**	
0 0 1 0 0 0 0	0	0 0 0 0 0 1 0 1	0	0	0	0	0 0 1 0 1 1 1 1 0	0400A05Eh

Consequently, the CAN message for “kpp = 0x1234” is:

	Value	**Description**
Identifier	**0400A05E**	**CAN Message Identifier**
Byte 0	**34**	**low byte of Data word (1) = 1234h**
Byte 1	**12**	**high byte of Data word (1) = 1234h**

Figure 3.11. *CAN message contents when TML instruction “kpp = 0x1234” is sent*

Example 2:

A host is directly connected on a CAN-bus network of Technosoft drives and wants to get the value of the position error from the drive with the axis ID=5. The host ID=3.

The position error is a 16-bit TML variable named POSERR situated at the memory address 0x022A

The code of the TML instruction for “Give Me Data” is:

Operation Code = B004h
Data word (1) = 0031h
Data word (2) = 022Ah

The CAN Message Identifier for request command “Give Me Data” have the following content:

28 0

Operation Code (7MSB of B004h)	**Group bit**	**Axis/Group ID**	**0**	**0**	**0**	**Host bit**	**Operation code (9LSB of B004h)**	
1 0 1 1 0 0 0	0	0 0 0 0 0 1 0 1	0	0	0	0	0 0 0 0 0 0 1 0 0	1600A004h

Consequently, the CAN message for the TML instruction “?POSERR” (e.g. “Give Me Data of POSERR) is:

	Value	**Description**
Identifier	**1600A004**	**CAN Message Identifier**
Byte 0	**31**	**low byte of Data word (1) = 0031h**
Byte 1	**00**	**high byte of Data word (1) = 0031h**
Byte 2	**2A**	**low byte of Data word (2) = 022Ah**
Byte 3	**02**	**high byte of Data word (2) = 022Ah**

Figure 3.12. *CAN message contents when TML instruction “?POSERR” is sent*

Supposing that the position error value is 2, the code of the TML instruction ”Take Data” is:

Operation Code = B404h
Data word (1) = 0050h
Data word (2) = 022Ah
Data word (3) = 0002h

The CAN message Identifier for command “Take Data” will have the following content:

28 0

Operation Code (7MSB of B004h)	**Group bit**	**Axis/Group ID**	**0**	**0**	**0**	**Host bit**	**Operation code (9LSB of B004h)**	
1 0 1 1 0 1 0	0	0 0 0 0 0 0 1 1	0	0	0	1	0 0 0 0 0 0 1 0 0	16806204h

Consequently, the CAN message for the answer to the “?POSERR” request is:

	Value	Description
Identifier	16806204	CAN Message Identifier
Byte 0	50	low byte of Data word (1) = 0050h
Byte 1	00	high byte of Data word (1) = 0050h
Byte 2	2A	low byte of Data word (2) = 022Ah
Byte 3	02	high byte of Data word (2) = 022Ah
Byte 4	02	low byte of Data word (2) = 0002h
Byte 5	00	high byte of Data word (2) = 0002h

Figure 3.13. CAN message contents for “Take Data” value of POSERR

Remark: *A “Give Me Data” command can’t be sent to a group of axes.*

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4. TML instruction set

The chapter describes the complete set of TML instructions, grouped by functionality. In each group the instructions are ordered alphabetically, mnemonic, syntax and description are given for each instruction.

TML instructions are divided in groups as follows:

- Motion mode setting group (**Table 4.1**)
- Event group (**Table 4.2**)
- Program flow (decision) group (**Table 4.3**)
- I/O group (**Table 4.4**)
- Assignment group (**Table 4.5**)
- Arithmetic and logic group (**Table 4.6**)
- Configuration and command group (**Table 4.7**)
- Multiple axis group (**Table 4.8**)
- Miscellaneous group (**Table 4.9**).
- On-line group (**Table 4.10**)

Table 4.1. *Motion mode setting group*

Mnemonic	Syntax	Description
MODE	MODE CS0	Set MODE Cam Slave 0 ()
	MODE CS1	Set MODE Cam Slave 1 (T)
	MODE CS2	Set MODE Cam Slave 2 (S)
	MODE CS3	Set MODE Cam Slave 3 (S, T)
	MODE GS0	Set MODE Gear Slave 0 ( )
	MODE GS1	Set MODE Gear Slave 1 (T)
	MODE GS2	Set MODE Gear Slave 2 (S)
	MODE GS3	Set MODE Gear Slave 3 (S,T)
	MODE PC0	MODE Position Contouring 0 ( )
	MODE PC1	MODE Position Contouring 1 (T)
	MODE PC2	MODE Position Contouring 2 (S)
	MODE PC3	MODE Position Contouring 3 (S,T)
	MODE PE0	MODE Position External 0 ( )
	MODE PE1	MODE Position External 1 (T)
	MODE PE2	MODE Position External 2 (S)
	MODE PE3	MODE Position External 3 (S,T)
	MODE PP0	MODE Position Profile 0 ( )
	MODE PP1	MODE Position Profile 1 (T)
	MODE PP2	MODE Position Profile 2 (S)
	MODE PP3	MODE Position Profile 3 (S,T)

	MODE PPD0	MODE Position Pulse & Dir 0 ( )
	MODE PPD1	MODE Position Pulse & Dir 1 (T)
	MODE PPD2	MODE Position Pulse & Dir 2 (S)
	MODE PPD3	MODE Position Pulse & Dir 3 (S,T)
	MODE SC0	MODE Speed Contouring 0 ( )
	MODE SC1	MODE Speed Contouring 1 (T)
	MODE SE0	MODE Speed External 0 ( )
	MODE SE1	MODE Speed External 1 (T)
	MODE SP0	MODE Speed Profile 0 ( )
	MODE SP1	MODE Speed Profile 1 (T)
	MODE SPD0	MODE Speed Pulse & Dir 0 ( )
	MODE SPD1	MODE Speed Pulse & Dir 1 (T)
	MODE TC	MODE Torque Contouring
	MODE TEF	MODE Torque External Fast loop
	MODE TES	MODE Torque External Slow loop
	MODE TT	MODE Torque Test
	MODE VC	MODE Voltage Contouring
	MODE VEF	MODE Voltage External Fast loop
	MODE VES	MODE Voltage External Slow loop
	MODE VT	MODE Voltage Test

Table 4.2. *Event group*

Mnemonic	**Syntax**	**Description**
!APO	!APO V32	! if Relative Position Over V32
	!APO val32	! if Relative Position Over val32
!APU	!APU V32	! if Relative Position Under V32
	!APU val32	! if Relative Position Under val32
!AT	!AT V32	! if Absolute Time >= V32
	!AT val32	! if Absolute Time >= val32
!CAP	!CAP	! if Capture triggered
!IN	!IN#n 0	! if Input #n is 0
	!IN#n 1	! if Input #n is 1
!LSN	!LSN	! if Limit Switch Negative active
!LSP	!LSP	! if Limit Switch Positive active
!MC	!MC	!(set event) if Motion Complete
!RO	!RO V32	! if Reference Over V32
	!RO val32	! if Reference Over val32
!RPO	!RPO V32	! if Relative Position Over V32
	!RPO val32	! if Relative Position Over val32
!RPU	!RPU V32	! if Relative Position Under V32
	!RPU val32	! if Relative Position Under val32

!RT	!RT V32	! if Relative Time >= V32
	!RT val32	! if Relative Time >= val32
!RU	!RU V32	! if Reference Under V32
	!RU val32	! if Reference Under val32
!SO	!SO V32	! if Speed Over V32
	!SO val32	! if Speed Over val32
!SU	!SU V32	! if Speed Under V32
	!SU val32	! if Speed Under val32
!VO	!VO V32A, V32B	! if V32A Over V32B
	!VO V32A, val32	! if V32A Over val32
!VU	!VU V32A, V32B	! if V32A Under V32B
	!VU V32A, val32	! if V32A Under val32
WAIT!	WAIT!	Wait until event occurs

Table 4.3. *Program flow (decision) group*

Mnemonic	Syntax	Description
CALL	CALL Label	Unconditional CALL of a function
	CALL Label, V16, Flag	CALL function if V16 Flag 0
	CALL Label, V32, Flag	CALL function if V32 Flag 0
GOTO	GOTO Label	Unconditional GOTO to label
	GOTO Label, V16, Flag	GOTO label if V16 Flag 0
	GOTO Label, V32, Flag	GOTO label if V32 Flag 0
RET	RET	Return from TML function
RETI	RETI	Return from TML Interrupt Service Routine

Table 4.4. I/O group

Mnemonic	Syntax	Description
DIS2CAPI	DIS2CAPI	Disable 2nd CAPI capture input
DISCAPI	DISCAPI	Disable CAPI capture input
DISIO#n	DISIO#n	Disable IO#n
DISLSN	DISLSN	Disable LSN limit switch
DISLSP	DISLSP	Disable LSP limit switch
EN2CAPI0	EN2CAPI0	Enable 2nd CAPI capture for 1->0
EN2CAPI1	EN2CAPI1	Enable 2nd CAPI capture for 0->1
ENCAPI0	ENCAPI0	Enable CAPI capture for 1->0
ENCAPI1	ENCAPI1	Enable CAPI capture for 0->1
ENIO#n	ENIO#n	Enable IO#n
ENLSN0	ENLSN0	Enable LSN limit switch for 1->0
ENLSN1	ENLSN1	Enable LSN limit switch for 0->1
ENLSP0	ENLSP0	Enable LSP limit switch for 1->0

ENLSP1	ENLSP1	Enable LSP limit switch for 0->1
OUTPORT	OUTPORT V16	Set OUT#28-31 with V16 value (4LSB)
ROUT#n	ROUT#n	Reset IO#n output to 0
SETIO#n	SETIO#n IN	Set IO#n as input
	SETIO#n OUT	Set IO#n as output
SOUT#n	SOUT#n	Set IO#n output to 1
=	V16D = IN#n	Read input #n
	V16D = IN1/IN2,ANDm	Read IN#4 to IN#11 with ANDm
	V16D = INPUT1, ANDm	Read IN#25 to IN#32 with ANDm
	V16D = INPUT2, ANDm	Read IN#33 to IN#39 with ANDm
	V16D = INPORT#n	Read one input from IN#33 to 39
	V16D = INPORT,ANDm	Read IN#36-39 in V16D (4LSB)

Table 4.5. *Assignment group*

Mnemonic	Syntax	Description
=	(V16D), TM = V16S	(V16D) from TM = V16S
	(V16D), TM = V32S	(V16D) from TM = V32S
	(V16D), TM = val16	(V16D) from TM = val16
	(V16D), TM = val32	(V16D) from TM = val32
	(V16D+), TM = V16S	(V16D) from TM = V16S then V16D += 1
	(V16D+), TM = V32S	(V16D) from TM = V32S then V16D += 2
	(V16D+), TM = val16	(V16D) from TM = val16 then V16D += 1
	(V16D+), TM = val32	(V16D) from TM = val32 then V16D += 2
	V16 = label	V16 = address of a TML label
	V16 = val16	V16 = val16
	V16D = (V16S), TM	V16D = (&V16S) from TM
	V16D = (V16S+), TM	V16D = (&V16S) from TM then V16S += 1
	V16D = V16S	V16D = V16S
	V16D = -V16S	V16D = -V16S
	V16D = V32S(H)	V16D = V32S(H)
	V16D = V32S(L)	V16D = V32S(L)
	V16D, dm = V16S	V16D from dm = V16S (la)
	V16D, dm = val16	V16 from dm = val16 (la)
	V32 = val32	V32 = val32
	V32(H) = val16	V32(H) = val16
	V32(L) = val16	V32(H) = val16
	V32D = (V16S), TM	V32D = (V16S) from TM
	V32D = (V16S+), TM	V32D = (V16S) from TM then V16D += 2
	V32D = V32S	V32D = V32S
	V32D = -V32S	V32D = -V32S
	V32D =V16S << N	V32D = V16S left-shifted by N

	V32D(H) = V16S	V32D(H) = V16
	V32D(L) = V16S	V32D(L) = V16
	V32D, dm = V32S	V32D from dm = V32S (la)
	V32D, dm = val32	V32 from dm = val32 (la)

Table 4.6. *Arithmetic & Logic group*

Mnemonic	Syntax	Description
+=	V16 += val16	Add val16 to V16
	V16D += V16S	Add V16S to V16D
	V32 += val32	Add val32 to V32
	V32D += V32S	Add V32S to V32D
-=	V16 -= val16	Subtract val16 from V16
	V16D -= V16S	Subtract V16S from V16D
	V32 -= val32	Subtract val32 from V32
	V32D -= V32S	Subtract V32S from V32D
*	V16 * val16 << N	PROD = (V16 * val16) >> N
	V16 * val16 >> N	PROD = (V16 * val16) >> N
	V16A * V16B << N	PROD = (V16A * V16B) << N
	V16A * V16B >> N	PROD = (V16A * V16B) >> N
	V32 * V16 << N	PROD = (V32 * V16) << N
	V32 * V16 >> N	PROD = (V32 * V16) >> N
	V32 * val16 << N	PROD = (V32 * val16) << N
	V32 * val16 >> N	PROD = (V32 * val16) >> N
<<=	PROD <<= N	Left shift PROD by N
	V16 <<= N	Left shift V16 by N
	V32 <<= N	Left shift V32 by N
>>=	PROD >>= N	Right shift PROD by N
	V16 >>= N	Right shift V16 by N
	V32 >>= N	Right shift V32 by N
SRB	SRB V16,ANDm,ORm	Set / Reset Bits of a V16
	SRBL V16,ANDm,ORm	Set / Reset Bits of a V16 (la)

Table 4.7. *Configuration and Command group*

Mnemonic	Syntax	Description
AXISOFF	AXISOFF	AXIS is OFF (deactivate control)
AXISON	AXISON	AXIS is ON (activate control)
CPA	CPA	Command Position is Absolute
CPR	CPR	Command Position is Relative
DINT	DINT	Disable TML Interrupts
EINT	EINT	Enable TML Interrupts

ENDINIT	ENDINIT	END of Initialization
EXTREF	EXTREF 0	External Reference read from variable EREF updated on-line
	EXTREF 1	External Reference read from REFERENCE input
	EXTREF 2	External Reference read from second encoder input
RAOU	RAOU	Reset Automatic Origin Update
RESET	RESET	RESET DSP controller
RGM	RGM	Reset axis as Gear/Cam Master
SAOU	SAOU	Set Automatic Origin Update
SAP	SAP V32	Set Actual Position = V32
	SAP val32	Set Actual Position = val32
SEG	SEG D_time, D_ref	Segment D_time, D_ref
	SEG V16, V32	Segment V16, V32
SGM	SGM	Set axis as Gear/Cam Master
STA	STA	Set Target position = Actual position
STOP0	STOP0	STOP motion in mode 0
STOP0!	STOP0!	STOP0 when ! (event occurs)
STOP1	STOP1	STOP motion in mode 1
STOP1!	STOP1!	STOP1 when ! (event occurs)
STOP2	STOP2	STOP motion in mode 2
STOP2!	STOP2!	STOP2 when ! (event occurs)
STOP3	STOP3	STOP motion in mode 3
STOP3!	STOP3!	STOP3 when ! (event occurs)
TUM0	TUM0	Set Target Update Mode 0
TUM1	TUM1	Set Target Update Mode 1
UPD	UPD	Update motion immediate
UPD!	UPD!	Update when ! (event occurs)

Table 4.8. *Communication & Multiple axis group*

Mnemonic	**Syntax**	**Description**
=	[A/G] { Instr1; Instr2; …}	Send a series of TML instructions to [A/G]
	[A/G] (V16D),TM = V16S	[A/G] (V16D),TM = local V16S
	[A/G] (V16D),TM = V32S	[A/G] (V16D),TM = local V32S
	[A/G] (V16D+),TM = V16S	[A/G] (V16D),TM = local V16S then V16D += 1
	[A/G] (V16D+),TM = V32S	[A/G] (V16D),TM = local V32S then V16D += 2
	[A/G] V16D = V16S	[A/G] V16D = local V16S
	[A/G] V16D,dm = V16S	[A/G] V16D,dm = local V16S (la)
	[A/G] V32D = V32S	[A/G] V32D = local V32S
	[A/G] V32D,dm = V32S	[A/G] V32D,dm= local V32S (la)
	V16D = [A] (V16S),TM	Local V16D = [A] (V16S), dm
	V16D = [A] (V16S+),TM	Local V16D = [A] (V16S), dm then V16S += 1
	V16D = [A] V16S	Local V16D = [A] V16S

	V16D = [A] V16S,dm	Local V16D = [A] V16S, dm (la)
	V32D = [A] V32S,dm	Local V32D = [A] V32S, dm (la)
	V32D = [A] (V16S),TM	Local V32D = [A] (V16S),TM
	V32D = [A] (V16S+),TM	Local V32D = [A] (V16S),TM then V16S += 2
	V32D = [A] V32S	Local V32D = [A] V32S
ADDGRID	ADDGRID V16	Add Group ID = V16
	ADDGRID val16	Add Group ID = val16
AXISID	AXISID val16	AXIS ID = val16
	AXISID V16	AXIS ID = V16
CANBR	CANBR val16	Set CAN-bus Baud-Rate
GROUPID	GROUPID val16	GROUP ID = val16
REMGRID	REMGRID V16	Remove Group ID = V16
	REMGRID val16	Remove Group ID = val16

Table 4.9. *Miscellaneous group*

Mnemonic	Syntax	Description
BEGIN	BEGIN	BEGIN of a TML program
CHECKSUM	CHECKSUM, TM Start, Stop, V16D	V16D=Checksum between Start and Stop addresses from TM
INITCAM	INITCAM addrS, addrD	Copy CAM table from SPI (addrS address) to RAM (addrD address)
END	END	END of a TML program
NOP	NOP	No Operation
SCIBR	SCIBR V16	Set SCI Baud Rate
	SCIBR val16	Set SCI Baud Rate
SPIBR	SPIBR V16	Set SPI Baud Rate
	SPIBR val16	Set SPI Baud Rate

Table 4.10 *On line group*

Mnemonic	**Syntax**	**Description**
?	?V16	**GiveMeData** - 16-bit from SRAM data memory
	?V32	**GiveMeData** - 32-bit from SRAM data memory
		GiveMeData - 16-bit from SRAM program memory
		GiveMaData - 32-bit from SRAM program memory
		GiveMeData - 16-bit from EEPROM program memory
		GiveMeData - 32-bit from EEPROM program memory
		TakeData requested with **GiveMeData** - 16-bit data
		TakeData requested with **GiveMeData** - 32-bit data
		Get a 16-bit TML data (address range 200-3FFh)
		Get a 32-bit TML data (address range 200-3FFh)
		Take the 16-bit TML data requested with **Get a 16-bit TML**
		Take the 32-bit TML data requested with **Get a 32-bit TML**

		Take a 32-bit TML data (address range 200-3FFh)
		Get version
		Answer to Get version

4.1 TML instruction set description

This paragraph presents for each TML instruction: mnemonic, arguments, binary code and programming examples. TML instructions are ordered alphabetically. Instructions descriptions may contain specific symbols. Their significance is presented in Table 4.11. The information is grouped as follows:

- instruction name
- syntax
- operands
- type
- binary code
- description
- execution
- example

Table 4.11 *TML Instructions Code Symbols*

Symbols	Description
&Label	Address of TML program label
&V16	Address of a 16-bit integer variable
&V32	Address of a 32-bit long or fixed variable
(V16)	Memory location at address equal with V16 value
(la)	Long addressing. Source/destination operand provided with 16-bit address. Some TML instructions using 9-bit short addressing are doubled with their long addressing equivalent
9LSB(&V16)	The 9 LSB (less significant bits) of the address of a 16-bit integer
9LSB(&V32)	The 9 LSB (less significant bits) of the address of a 32-bit long or fixed
A	Axis ID
A/G	Axis ID or Group ID
ANDdis	16-bit AND mask. See Table MCRx & AND/OR masks for DISIO#n and Table MCRx & PxDIR addresses
ANDen	16-bit AND mask. See Table MCRx & AND/OR masks for ENIO#n and Table MCRx & PxDIR addresses
ANDin	16-bit AND mask. See Table AND/OR masks for SETIO#n IN
ANDm	16-bit user-defined AND mask
ANDout	16-bit AND mask. See Table AND/OR masks for SETIO#n OUT
ANDrst	16-bit AND mask. See Table AND/OR masks for ROUT#n

ANDset	16-bit AND mask. See Table AND/OR masks for SOUT#n
Bit_mask	16-bit AND mask. See Tables PxDIR & Bit_mask for V16=IN#n and table MCRx & PxDIR addresses
D_ref	32-bit fixed value
D_time	16-bit value
Flag	Condition Flag for GOTO/CALL
LengthMLI	Length of a TML instruction code in words – 1
MCRx	See Tables MCRx & AND/OR masks for ENIO#n / DISIO#n and Table MCRx & PxDIR addresses
ORdis	16-bit OR mask. See Table MCRx & AND/OR masks for DISIO#n and Table MCRx & PxDIR addresses
ORen	16-bit OR mask. See Table MCRx & AND/OR masks for ENIO#n and Table MCRx & PxDIR addresses
ORin	16-bit OR mask.. See Table AND/OR masks for SETIO#n IN
ORm	16-bit user-defined OR mask
ORout	16-bit OR mask. See Table AND/OR masks for SETIO#n OUT
ORrst	16-bit OR mask. See Table AND/OR masks for ROUT#n
ORset	16-bit OR mask. See Table AND/OR masks for SOUT#n
PxDIR	See Table PxDIR & Bit_msk for V16=IN#n and Table MCRx & PxDIR addresses
PM	Data memory space: 200 – 3FFh/800 – 9FFh (internal), 8000 – FFFFh (external)
DM	Program memory space: 8000 – FFFFh (external)
SPI	SPI-E2ROM memory space: 4000h – 7FFFh (external)
TM	Type of memory. When used in syntax TM should be replaced by *DM* or *PM* or *SPI*. When used in code, see Table TM values.
VAR16	16-bit integer variable
VAR16D	16-bit integer variable used as destination
VAR16S	16-bit integer variable used as source
VAR32	32-bit long or fixed variable
VAR32(L)	16LSB of a 32-bit long or fixed variable (seen as a 16-bit integer)
VAR32(H)	16MSB of a 32-bit long or fixed variable (seen as a 16-bit integer)
VAR32D	32-bit long or fixed variable used as destination
VAR32S	32-bit long or fixed variable used as source
value16	16-bit integer value
value32	32-bit long or fixed value
value32(L)	16LSB of a 32-bit long or fixed value
value32(H)	16MSB of a 32-bit long or fixed value

Name	**?**	Get data - On line commands send by a host + the answers *(On-line group)*

Syntax

?VAR16	**GiveMeData -** 16-bit from SRAM data memory
?VAR32	**GiveMeData** - 32-bit from SRAM data memory
	GiveMeData - 16-bit from SRAM program memory
	GiveMaData - 32-bit from SRAM program memory
	GiveMeData - 16-bit from EEPROM program memory
	GiveMeData - 32-bit from EEPROM program memory
	TakeData requested with **GiveMeData** - 16-bit data
	TakeData requested with **GiveMeData** - 32-bit data
	Get a 16-bit TML data (address range 200-3FFh)
	Get a 32-bit TML data (address range 200-3FFh)
	Take the 16-bit TML data requested with **Get a 16-bit TML**
	Take the 32-bit TML data requested with **Get a 32-bit TML**
	Get version
	Answer to Get version request

Operands *VAR16*: integer variable
VAR32: long/fixed variable

Type

TML program	On-line
–	**X**

Binary code

?VAR16 – GiveMeData – 16-bit from SRAM data memory

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Expeditor AxisID															
Data memory address from where to read data requested (&VAR16)															

?VAR32 - GiveMeData – 32-bit from SRAM data memory

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
Expeditor AxisID															
Data memory address from where to read data requested (&VAR32)															

GiveMeData – 16-bit from SRAM TML program memory

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Expeditor AxisID															
SRAM program memory address from where to read data requested															

GiveMeData – 32-bit from SRAM TML program memory

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Expeditor AxisID															
SRAM program memory address from where to read data requested															

GiveMeData – 16-bit from EEPROM TML program memory

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
Expeditor AxisID															
EEPROM program memory address from where to read data requested															

GiveMeData – 32-bit from EEPROM TML program memory

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1
Expeditor AxisID															
EEPROM program memory address from where to read data requested															

TakeData requested with GiveMeData – 16-bit data

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0
Expeditor AxisID															
SRAM data, SRAM program or EEPROM memory address of data requested															
Data requested															

TakeData requested with GiveMeData – 32-bit data

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	0	1	0	0	0	0	0	0	0	1	0	1
Expeditor AxisID															
SRAM data, SRAM program or EEPROM memory address of data requested															
Data requested – 16LSB															
Data requested – 16MSB															

Get a 16-bit TML data (the TML data address must be in range 200-3FFh)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	0	0	(9LSBs of &*VAR16D*)								
Expeditor AxisID															

Get a 32-bit TML data (the TML data address must be in range 200-3FFh)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	0	1	0	(9LSBs of &*VAR32D*)								
Expeditor AxisID															

Take the 16-bit TML data requested with Get 16-bit TML data

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	1	0	0	(9LSBs of &*VAR16D*)								
Expeditor AxisID															
Data requested															

Take the 32-bit TML data requested with Get 32-bit TML data

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	0	1	1	0	(9LSBs of &*VAR32D*)								
Expeditor AxisID															
Data requested – 16 LSB															
Data requested – 16 MSB															

Get version

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1
Expeditor AxisID															

Answer to get version request

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1
Expeditor AxisID															
ASCII code of first 2 digits of the firmware ID															
ASCII code of last digit + revision letter of the firmware ID															

Description These instructions allow a host to interrogate a MotionChip II based drive in order to find the contents of any TML data as well as the value of any memory location from the TML program space (EEPROM or SRAM) or from the SRAM data space. The Get version command offers the possibility to check find which is the firmware version of the drive. The firmware version has the form: FxyzA, where xyz is the firmware number (3 digits) and A is a letter for the revision

Execution Return the answer messages

Name	!APO	Set event when motor absolute position is over a given value *(Event group)*

Syntax

!APO *value32* — **!** if **A**bs**P**osition**O**ver *value32*
!APO *VAR32* — **!** if **A**bs**P**osition**O**ver *VAR32*

Operands *VAR32*: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	X

Binary code

!APO value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	1	0	0	1	0
0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!APO VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	1	0	0	1	0
0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0
&*VAR32*															

Description Program the detection of the event when the motor position is greater than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when motor position >= value32 or VAR32, respectively.
The bits 14 and 11 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 1.5;      //Acceleration command for speed profile
                 //(counts/sampling^2)
CSPD = 20;       //Speed command (counts/sampling)
MODE SP1;        //Set Speed Profile Mode 1
UPD;             //Update immediate
CSPD = 40;       //New speed command (counts/sampling)
!APO 60000;      //Set event when absolute position >= 60000
                 //(counts)
UPD!;            //Update on event
```

Name	**!APU**	Set event when motor absolute position is under a given value *(Event group)*

Syntax

!APU *value32* — **!** if **A**bs**P**osition**U**nder *value32*
!APU *VAR32* — **!** if **A**bs**P**osition**U**nder *VAR32*

Operands *VAR32*: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	**X**

Binary code

!APU value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!APU VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	0	0	0	1	1
0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0
&*VAR32*															

Description Program the detection of the event when the motor position is smaller than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when motor position <= value32 or VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 1.5;       //Acceleration command for speed profile
                  //(counts/sampling²)
CSPD = -20;       //Speed command (counts/sampling)
MODE SP1;         //Set Speed Profile Mode 1
UPD;              //Update immediate
CSPD = -40;       //New speed command (counts/sampling)
!APU -60000;      //Set  event  when  absolute  position  =<  -
60000
                  //(counts)
UPD!;             //Update on event
```

Name	!AT	Set event when absolute time is greater than a given value *(Event group)*

Syntax

!AT *value32*	**!** if **A**bsolute**T**ime >= *value32*
!AT *VAR32*	**!** if **A**bsolute**T**ime >= *VAR32*

Operands *VAR32*: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	X

Binary code

!AT value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	1	1	0	0	0
0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!AT VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	1	1	0	0	0
0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
&*VAR32*															

Description Program the detection of the event when the system absolute time is greater than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when system absolute time >= value32 OR VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 1.5;        //Acceleration command for speed profile
                   //(counts/sampling^2)
CSPD = 20;         //Speed command (counts/sampling)
MODE SP1;          //Set Speed Profile Mode 1
UPD;               //Update immediate
CSPD = 40;         //New speed command (counts/sampling)
!AT 10000;         //Set event when absolute time is bigger
                   //than 10000 samplings
UPD!;              //Update on event
```

Name	!CAP	Set event when a capture is triggered *(Event group)*

Syntax

!CAP   **!** if **CAP**ture triggered

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**

Description Program the detection of the event when one of the external captures (from encoder index – CAPI, or from second encoder – 2CAPI) was detected and triggered by the DSP. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation, when the monitored event occurs.

Execution Activate the setting of an event when an external capture was triggered. The bits 15 and 14 of the TML motion status register (**MSR**) are reset.

This operation erases a previous programmed event that has occurred.

Example

```
CACC = 1.5;      //Acceleration command for speed profile
                 //(counts/sampling²)
CSPD = 20;       //Speed command (counts/sampling)
MODE SP1;        //Set Speed Profile Mode 1
UPD;             //Update immediate
ENCAPI0;         //Activate CAPI input to trigger a falling
                 //transitions.
CSPD = 40;       //New speed command (counts/sampling)
!CAP;            //Set event when capture is triggered
UPD!;            //Update on event
```

Name	**!IN#n**	Set event when data from input #n is 0 or 1 *(Event group)*

Syntax

!IN#*n* 0 — **!** if **In**put#*n* is **0**
!IN#*n* 1 — **!** if **In**put#*n* is **1**

Operands *n*: bit-port number (0<=n<=39)

Type

TML program	On-line
X	**X**

Binary code

!IN#*n* 0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	1	0	1	1	0	1	1
PxDATDIR															
Bit_mask															

!IN#*n* 1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	1	0	1	1	0	1	0
PxDATDIR															
Bit_ mask															

Description Program the detection of the event once the data read from input bit-port #n becomes 0, respectively 1. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event, when the data read from input bit-port #n becomes 0 (!IN#n 0) or 1 (!IN#n 1), respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 1.5;      //Acceleration command for speed profile
                 //(counts/sampling²)
CSPD = 20;       //Speed command (counts/sampling)
MODE SP1;        //Set Speed Profile Mode 1
UPD;             //Update immediate
CSPD = 40;       //New speed command (counts/sampling)
!IN#38 1;        //Set event if INput#38 is high
UPD!;            //Update on event
```

PxDAT & Bit_mask for !IN#n 0 and !IN#n 1		
#n	PxDATDIR	Bit_mask
#0	0x7098	0x0001
#1	0x7098	0x0002
#2	0x7098	0x0004
#3	0x7098	0x0008
#4	0x7098	0x0010
#5	0x7098	0x0020
#6	0x7098	0x0040
#7	0x7098	0x0080
#8	0x709A	0x0001
#9	0x709A	0x0002
#10	0x709A	0x0004
#11	0x709A	0x0008
#12	0x709A	0x0010
#13	0x709A	0x0020
#14	0x709A	0x0040
#15	0x709A	0x0080
#16	0x709C	0x0001
#17	0x709C	0x0002
#18	0x709C	0x0004
#19	0x709C	0x0008

#n	PxDATDIR	Bit_mask
#20	0x709C	0x0010
#21	0x709C	0x0020
#22	0x709C	0x0040
#23	0x709C	0x0080
#24	0x709E	0x0001
#25	0x7095	0x0001
#26	0x7095	0x0002
#27	0x7095	0x0004
#28	0x7095	0x0008
#29	0x7095	0x0010
#30	0x7095	0x0020
#31	0x7095	0x0040
#32	0x7095	0x0080
#33	0x7096	0x0001
#34	0x7096	0x0002
#35	0x7096	0x0004
#36	0x7096	0x0008
#37	0x7096	0x0010
#38	0x7096	0x0020
#39	0x7096	0x0040

Name	!LSN	Set event when negative limit switch becomes active *(Event group)*

Syntax

!LSN **!** if **L**imit**S**witch**N**egative active

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0

Description Program the detection of the event once the negative limit switch is reached and becomes active. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when the negative limit switch becomes active. The bits 15 and 14 of the TML motion status register (**MSR**) are reset. This operation erases a previous programmed event that has occurred.

Example

```
CACC = 1.5;      //Acceleration command for speed profile
                 //(counts/sampling²)
CSPD = -20;      //Speed command (counts/sampling)
MODE SP1;        //Set Speed Profile Mode 1
UPD;             //Update immediate
ENLSN1;          //Negative  Limit  Switch  triggers  rising
edge
CSPD = 20;       //New speed command (counts/sampling)
!LSN;            //Set event if Negative Limit Switch is
                 //reached
UPD!;            //Update on event
```

Name	**!LSP**	Set event when positive limit switch becomes active *(Event group)*

Syntax

!LSP — **!** if **L**imit**S**witch**P**ositive active

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	1

Description Program the detection of the event once the positive limit switch is reached and becomes active. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when the positive limit switch becomes active.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 1.5;          //Acceleration command for speed
                     //profile (counts/sampling²)
CSPD = 20;           //Speed command (counts/sampling)
MODE SP1;            //Set Speed Profile Mode 1
UPD;                 //Update immediate
ENLSP1;              //Positive Limit Switch triggers
                     //rising edge
CSPD = -20;          //New speed command (counts/sampling)
!LSP;                //Set event if Positive LimitSwitch is
                     //reached
UPD!;                //Update on event
```

Name	!MC	Set event when the actual motion is completed *(Event group)*

Syntax

!MC — **!**(set event) if **M**otion**C**omplete

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1

Description Program the detection of the event once the actual motion sequence is completed. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when the actual motion sequence is completed. The bits 15 and 14 of the TML motion status register (**MSR**) are reset. This operation erases a previous programmed event that has occurred.

Example

```
CACC = 1.5;           //Acceleration command for position
                      //profile (counts/sampling^2)
CSPD = 40;            //Speed command for position profile
                      //(counts/sampling)
CPOS = 50000;         //Position command (counts)
CPA;                  //Position command is Absolute
MODE PP3;             //Set Position Profile Mode 3
UPD;                  //Update immediate
CPOS = 100000;        //New position command (counts);
!MC;                  //Set event when MotionComplete
UPD!;                 //Update on event
```

Name	!RO	Set event when the reference is grater than a given value *(Event group)*

Syntax

!RO *value32* — **!** if **R**eference**O**ver *value32*
!RO *VAR32* — **!** if **R**eference**O**ver *VAR32*

Operands *VAR32*: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	**X**

Binary code

!RO value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0
0	0	0	0	0	0	1	0	1	0	1	0	1	1	1	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!RO VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	1	0	0	0	0
0	0	0	0	0	0	1	0	1	0	1	0	1	1	1	0
&*VAR32*															

Description Program the detection of the event when the reference value is greater than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.
The reference value can be:

- a position reference
- a speed reference
- a torque reference
- a voltage reference

Execution Activate the setting of an event when the reference value is >= value32 or VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Examples :

a) In case of a position reference:

```
CACC = 1.5;              //Acceleration command for position
                         //profile (counts/sampling²)
CSPD = 20;               //Speed command for position profile
                         //(counts/sampling)
CPOS = 100000;           //Position command (counts)
CPA;                     //Position command is Absolute
MODE PP3;                //Set Position Profile Mode 3
UPD;                     //Update immediate
CSPD = 40;               //New speed command for position
                         //profile (counts/sampling)
!RO 20000;               //Set event if Reference >= 20000
                         //(counts) - position reference
UPD!;                    //Update on event
```

b) In case of a speed reference:

```
CACC = 0.005;            //Acceleration command for speed
                         //profile (counts/sampling²)
CSPD = 20;               //Speed command (counts/sampling)
MODE SP1;                //Set Speed Profile Mode 1
UPD;                     //Update immediate
CACC = 0.5;              //New acceleration command for speed
                         //profile (counts/sampling²)
!RO 10.;                 //Set event if Reference >= 10.
                         //(counts/sampling) - speed reference
UPD!;                    //Update on event
```

c) In case of a torque reference:

```
MODE TT;                 //Set Torque Test Mode
REFTST = 3968;           //Reference saturation value in test
                         //mode
RINCTST = 10;            //Reference increment value in test
                         //mode
UPD;                     //Update immediate
CACC = 0.005;            //Acceleration command for speed
                         //profile (counts/sampling²)
CSPD = 20;               //Speed command (counts/sampling)
MODE SP1;                //Set Speed Profile Mode 1
!RO 2500;                //Set event if Reference >= 2500
                         //(bits) – torque reference
UPD!;                    //Update on event
```

d) In case of a voltage reference:

```
MODE VT;              //Set Voltage Test Mode
REFTST = 19353;       //Reference saturation value in test
                      //mode
RINCTST = 194;        //Reference increment value in test
                      //mode
UPD;                  //Update immediate
CACC = 0.05;          //Acceleration command for position
                      //profile (counts/sampling²)
CSPD = 20;            //Speed command for position profile
                      //(counts/sampling)
CPOS = 80000;         //Position command (counts)
CPA;                  //Position command is Absolute
MODE PP3;             //Set Position Profile Mode 3
!RO 15000;            //Set event if Reference >= 15000
                      //(bits) – voltage reference
UPD!;                 //Update on event
```

Name	!RPO	Set event when the relative position is greater than a given value *(Event group)*

Syntax

!RPO *value32* — **!** if **R**el**P**osition**O**ver *value32*
!RPO *VAR32* — **!** if **R**el**P**osition**O**ver *VAR32*

Operands *VAR32*: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	X

Binary code

!RPO value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	1	0	1	0	0
0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!RPO VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	1	0	1	0	0
0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0
&*VAR32*															

Description Program the detection of the event when the relative position value is greater than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when the relative position value is >= value32 or VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 0.5;            //Acceleration command for position
                       //profile (counts/sampling²)
CSPD = 20;             //Speed command for position profile
                       //(counts/sampling)
CPOS = 100000;         //Position command (counts0
CPR;                   //Position command is Relative
MODE PP3;              //Set Position Profile Mode 3
```

```
UPD;                      //Update immediate
CSPD = 40;                //New speed command (counts/sampling)
!RPO 60000;               //Set event when relative position
                          //>= 60000 (counts)
UPD!;                     //Update on event
```

Name	**!RPU**	Set event when the relative position is smaller than a given value *(Event group)*

Syntax

!RPU *value32* — **!** if **R**el**P**osition**U**nder *value32*
!RPU *VAR32* — **!** if **R**el**P**osition**U**nder *VAR32*

Operands *VAR32*: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	**X**

Binary code

!RPU value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	0	0	1	0	1
0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!RPU VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	0	0	1	0	1
0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	0
&*VAR32*															

Description Program the detection of the event when the relative position value is smaller than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event, when the relative position value is <= value32 or VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 0.5;     //Set acceleration command
 CSPD = -20;     //Set speed command
CPOS = -100000; //Position command (counts)
CPR;            //Position command is Relative
MODE PP3;       //Set Position Profile Mode 3
UPD;            //Update immediate
CSPD = -40;     //New speed command (counts/sampling)
!RPU -60000;    //Set event when relative position =< -60000
```

```
UPD!;           //Update on event
```

Name	!RT	Set event when relative time is greater than a given value *(Event group)*

Syntax

!RT *value32* — **!** if **R**elative**T**ime >= *value32*
!RT *VAR32* — **!** if **R**elative**T**ime >= *VAR32*

Operands *VAR32*: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	X

Binary code

!RT value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	1	1	1	0	0	1
0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!RT VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	1	1	1	0	0	1
0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0
&*VAR32*															

Description Program the detection of the event when the system relative time is greater than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when system relative time >= value32 or VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 0.5;         //Set acceleration command)
CSPD = 20;          //Set speed command
CPOS = 100000;      //Position command (counts)
CPR;                //Position command is Relative
MODE PP3;           //Set Position Profile Mode 3
UPD;                //Update immediate
CSPD = 30;          //New speed command
!RT 2000;           //Set event if Relative Time >= 2000
 UPD!;              //Update on event
```

Name	!RU	Set event when the reference is smaller than a given value *(Event group)*

Syntax

!RU *value32* **!** if **R**eference**U**nder *value32*
!RU *VAR32* **!** if **R**eference**U**nder *VAR32*

Operands *VAR32*: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	**X**

Binary code

!RU value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1
0	0	0	0	0	0	1	0	1	0	1	0	1	1	1	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!RU VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	1
0	0	0	0	0	0	1	0	1	0	1	0	1	1	1	0
&*VAR32*															

Description Program the detection of the event when the reference value is smaller than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.
The reference value can be:

- a position reference
- a speed reference
- a torque reference
- a voltage reference

Execution Activate the setting of an event when the reference value is <= value32 or VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Examples :

a) In case of a position reference:

```
CACC = 1.5;         //Acceleration command for position
                    //profile (counts/sampling^2)
CSPD = -20;         //Speed command for position
                    //profile (counts/sampling)
CPOS = -100000;     //Position command (counts)
CPR;                //Position command is Relative
MODE PP3;           //Set Position Profile Mode 3
UPD;                //Update immediate
CSPD = -40;         //New speed command for position
                    //profile (counts/sampling)
!RU -20000;         //Set event if Reference <= -20000
                    //(counts) - position reference
UPD!;               //Update on event
```

b) In case of a speed reference:

```
CACC = 0.005;       //Acceleration command for speed
                    //profile counts/sampling^2)
CSPD = -20;         //Speed command (counts/sampling)
MODE SP1;           //Set Speed Profile Mode 1
UPD;                //Update immediate
CACC = 0.5;         //New acceleration command for speed
                    //profile (counts/sampling^2)
!RU -10.;           //Set event if Reference <=-10.
                    //(counts/sampling) - speed reference
UPD!;               //Update on event
```

c) In case of a torque reference:

```
MODE TT;            //Set Torque Test Mode
REFTST = -3968;     //Reference saturation value in test
                    //mode
RINCTST = -10;      //Reference increment value in test
                    //mode
UPD;                //Update immediate
CACC = 0.005;       //Acceleration command for speed
                    //profile (counts/sampling^2)
CSPD = -20;         //Speed command (counts/sampling)
MODE SP1;           //Set Speed Profile Mode 1
!RU -2500;          //Set event if Reference <= -2500
                    //(bits) – torque reference
UPD!;               //Update on event
```

d) In case of a voltage reference:

```
MODE VT;            //Set Voltage Test Mode
REFTST = -19353;    //Reference saturation value in test
                    //mode
```

```
RINCTST = -194;        //Reference  increment  value  in  test
                       //mode
UPD;                   //Update immediate
CACC = 0.05;           //Acceleration command for position
                       //profile (counts/sampling²)
CSPD = 20;             //Speed command for position profile
                       //(counts/sampling)
CPOS = 80000;          //Position command (counts)
CPA;                   //Position command is Absolute
MODE PP3;              //Set Position Profile Mode 3
!RU -15000;            //Set event if Reference <= -15000
                       //(bits) – voltage reference
UPD!;                  //Update on event
```

Name	**!SO**	Set event when speed is over a given value *(Event group)*

Syntax

!SO *value32* — **!** if **S**peed**O**ver *value32*
!SO *VAR32* — **!** if **S**peed**O**ver *VAR32*

Operands *VAR32*: fixed variable
value32: 32-bit fixed immediate value

Type

TML program	On-line
X	**X**

Binary code

!SO value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	1	0	1	1	0
0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!SO VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	1	0	1	1	0
0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0
&*VAR32*															

Description Program the detection of the event when the motor speed is bigger than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when motor speed >= value32 or VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 0.005;          //Set acceleration command
CSPD = 20;             //Set speed command
CPOS = 100000;         //Position command (counts)
CPA;                   //Position command is Absolute
MODE PP3;              //Set Position Profile Mode 3
UPD;                   //Update immediate
 CACC = 1;             //Set new acceleration
!SO 15;                //Set event if speed >= 15
UPD!;                  //Update on event
```

Name	**!SU**	Set event when speed is under a given value *(Event group)*

Syntax

!SU *value32* — **!** if **S**peed**U**nder *value32*
!SU *VAR32* — **!** if **S**peed**U**nder *VAR32*

Operands *VAR32*: fixed variable
value32: 32-bit fixed immediate value

Type

TML program	On-line
X	**X**

Binary code

!SU value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	0	0	1	1	1
0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0
LOWORD(*value32*)															
HIWORD(*value32*)															

!SU VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	0	0	1	1	1
0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0
&*VAR32*															

Description Program the detection of the event when the motor speed is smaller than the specified value. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution Activate the setting of an event when motor speed <= value32 or VAR32, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 0.005;        //Set acceleration command
CSPD = -20;          //Set speed command
CPOS = -100000;      //Position command (counts)
CPA;                 //Position command is Absolute
MODE PP3;            //Set Position Profile Mode 3
UPD;                 //Update immediate
CACC = 1;            //Set new acceleration
!SU -15;             //Set event if speed <= -15
UPD!;                //Update on event
```

Name	**!VO**	Set event when a selected variable is equal or over a given value *(Event group)*

Syntax

!VO VAR32A, *value32* — **!** if **V**ar32A**O**ver *value32*
!VO VAR32A, *VAR32B* — **!** if **V**ar32A**O**ver *VAR32B*

Operands

VAR32A: long variable
VAR32B: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	**X**

Binary code

!VO VAR32A, value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0
&*VAR32A*															
LOWORD(*value32*)															
HIWORD(*value32*)															

!VO VAR32A, VAR32B

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	1	0	0	0	0
&*VAR32A*															
&*VAR32B*															

Description

Program the detection of the event when the selected variable (any 32-bit TML variable) is greater than the specified value or the value of another 32-bit variable. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution

Activate the setting of an event when the selected variable (VAR32A) >= value32, or VAR32B, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 0.5;      //Set acceleration command
CSPD = 20;       //Set speed command
CPOS = 100000;   //Position command (counts)
CPA;            //Position command is Absolute
MODE PP3;        //Set Position Profile Mode 3
UPD;            //Update immediate
CSPD = 30;      //Set new speed command
!VO APOS, 50000;//Set event when APOS is equal or over 50000
UPD!;           //Update on event
```

Name	**!VU**	Set event when a selected variable is equal or under a given value *(Event group)*

Syntax

!VU VAR32A, *value32* — **!** if **V**ar32A**U**nder *value32*
!VU VAR32A, *VAR32B* — **!** if **V**ar32A**U**nder *VAR32B*

Operands

VAR32A: long variable
VAR32B: long variable
value32: 32-bit long immediate value

Type

TML program	On-line
X	**X**

Binary code

!VU VAR32A, value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1
&*VAR32A*															
LOWORD(*value32*)															
HIWORD(*value32*)															

!VU VAR32A, VAR32B

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	1
&*VAR32A*															
&*VAR32B*															

Description

Program the detection of the event when the selected variable (any 32-bit TML variable) is smaller than the specified value or the value of another 32-bit variable. An *update on event* command (**UPD!**) must be used in these cases, in order to activate an *update* operation when the monitored event occurs.

Execution

Activate the setting of an event when the selected variable (VAR32A) <= value32 or VAR32B, respectively.
The bits 15 and 14 of the TML motion status register (**MSR**) are reset.
This operation erases a previous programmed event that has occurred.

Example

```
CACC = 0.5;          //Acceleration command for
                     //position profile (counts/sampling²)
CSPD = 20;           //Speed command for position
                     //profile (counts/sampling)
CPOS = -50000;       //Position command (counts)
```

```
CPA;                    //Position command is Absolute
MODE PP3;               //Set Position Profile Mode 3
UPD;                    //Update immediate
CSPD = 30;              //New speed command for position
                        //profile (counts/sampling2)
!VU APOS, -10000;       //Set event when APOS is equal or
                        //under -10000 (counts)
UPD!;                   //Update on event
```

Name	**=**	Assignment instruction for 16 bits TML variables *(Assignment group)*

Syntax

VAR16D = *label*	set *VAR16D* to value of a *label*
VAR16D = *value16*	set *VAR16D* to *value16*
VAR16D = *VAR16S*	set *VAR16D* to *VAR16S* value
VAR16D = *VAR32S(L)*	set *VAR16D* to *VAR32S*(L) value
VAR16D = *VAR32S(H)*	set *VAR16D* to *VAR32S*(H) value
VAR16D, dm = *value16*	set *VAR16D* from *dm* to value16
VAR16D, dm = *VAR16S*	set *VAR16D* from *dm* to *VAR16S*
VAR16D = *(VAR16S), TypeMem*	set *VAR16D* to &(*VAR16S*) from *TM*
VAR16D = *(VAR16S+), TypeMem*	set *VAR16D* to &(*VAR16S*) from *TM, then VAR16S += 1*
(VAR16D), TypeMem = *value16*	set &(*VAR16D*) from *TM* to *value16*
(VAR16D), TypeMem = *VAR16S*	set &(*VAR16D*) from *TM* to *VAR16S*
(VAR16D+), TypeMem = *value16*	set &(*VAR16D*) from *TM* to *value16, then VAR16D += 1*
(VAR16D+), TypeMem = *VAR16S*	set &(*VAR16D*) from *TM* to *VAR16S, then VAR16D += 1*
VAR32D(L) = *value16*	set *VAR32D* low word to *value16*
VAR32D(L) = *VAR16S*	set *VAR32D* (L) to *VAR16* value
VAR32D(H) = *value16*	set *VAR32D* high word to *value16*
VAR32D(H) = *VAR16S*	set *VAR32D* (H) to *VAR16* value

Legend: D (destination), S (source).

Operands

label: 16-bit address of a TML instruction label
value16: 16-bit integer immediate value
VAR16x: integer variable
VAR32x(*L*): the low word of VAR32x long variable
VAR32x(H): the high word of VAR32x long variable
Dm: data memory operand
TypeMem: memory operand.
(*VAR16x*): contents of variable VAR16x, representing a 16-bit address of another variable

Type

TML program	On-line
X	**X**

Binary code

VAR16D = label

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**0**	**1**	**0**	**0**	**0**	**0**	(9LSBs of &*VAR16D*)								
&label															

VAR16D = value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**0**	**1**	**0**	**0**	**0**	**0**	(9LSBs of &*VAR16D*)								
value16															

VAR16D = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**0**	**1**	**0**	**1**	**0**	**0**	(9LSBs of &*VAR16D*)								
&*VAR16S*															

VAR16D = VAR32S(L)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**0**	**1**	**0**	**1**	**0**	**0**	(9LSBs of &*VAR16D*)								
&*VAR32S*															

VAR16D = VAR32S(H)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**0**	**1**	**0**	**1**	**0**	**0**	(9LSBs of &*VAR16D*)								
&*VAR32S* + 1															

VAR16D,dm = value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
&*VAR16D*															
value16															

VAR16D, dm = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**
&*VAR16D*															
&*VAR16S*															

VAR16D = (VAR16S), TypeMem

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	*TypeMem*		**0**	**0**
&*VAR16S*															
&*VAR16D*															

VAR16D = (VAR16S+), TypeMem

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	1	0	0	0	0	*TypeMem*		0	0
&*VAR16S*															
&*VAR16D*															

(VAR16D), TypeMem = value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	0	1	0	1	0	*TypeMem*		0	0
&*VAR16D*															
value16															

(VAR16D), TypeMem = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	0	1	0	1	1	*TypeMem*		0	0
&*VAR16D*															
&*VAR16S*															

(VAR16D+), TypeMem = value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	0	0	0	1	0	*TypeMem*		0	0
&*VAR16D*															
value16															

(VAR16D+), TypeMem = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	0	0	0	1	1	*TypeMem*		0	0
&*VAR16D*															
&*VAR16S*															

VAR32D(L) = value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	0	0	(9LSBs of &*VAR32D*)								
value16															

VAR32D(L) = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	1	0	0	(9LSBs of &*VAR32D*)								
&*VAR16S*															

VAR32D(H) = value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	0	0	(9LSBs of &*VAR32D*+1)								
value16															

VAR32D(H) = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

0	0	1	0	1	0	0	(9LSBs of &*VAR32D*+1)
&*VAR16S*							

Description This command allows you to generate assignment TML instruction for a specified 16-bit variable. All possible 16-bit assignment instruction forms are covered.

Execution (destination variable) = source value

TypeMem	
DM	01
PM	00
SPI	10

Example1

```
int Var1;
Label1      …
...
Var1 = Label1;
```

Before instruction		**After instruction**	
Label1	0x1234	Label1	0x1234
Var1	x	Var1	0x1234

Example2

```
int Var1;
...
Var1 = 26438;
```

Before instruction		**After instruction**	
Var1	x	Var1	26438

Example3

```
int Var1, Var2;
...
Var2 = Var1;
```

Before instruction		**After instruction**	
Var2	0x56AB	Var2	0x56AB
Var1	x	Var1	0x56AB

Example4

```
int Var1;
long Var3;
...
Var1 = Var3(L);
```

Before instruction		**After instruction**	
Var3	0x56ABCD98	Var3	0x56ABCD98
Var1	x	Var1	0xCD98

Example5

```
int Var1;
```

```
long Var3;
...
Var1 = Var3(H);
```

Before instruction

Var3	0x56ABCD98
Var1	x

After instruction

Var3	0x56ABCD98
Var1	0x56AB

Example6

```
int Var1;
...
Var1, dm = 3321;
```

Before instruction

Var1	x

After instruction

Var1	3321

Example7

```
int Var1, Var2;
...
Var1, dm = Var2;
```

Before instruction

Var1	0x0A01
Var2	x

After instruction

Var1	0x0A01
Var2	0x0A01

Example8

```
int Var1, pVar2;
...
Var1 = (pVar2), dm;
```

Before instruction

pVar2	0x0A01
Data memory	
0x0A01	0x1234
Var1	x

After instruction

pVar2	0x0A01
Data memory	
0x0A01	0x1234
Var1	0x1234

Example9

```
int Var1, pVar2;
...
Var1 = (pVar2+), dm;
```

Before instruction

pVar2	0x0A01
Data memory	
0x0A01	0x1234
Var1	x

After instruction

pVar2	0x0A02
Data memory	
0x0A01	0x1234
Var1	0x1234

Example10

```
int pVar1;
```

```
...
(pVar1), spi = 0x5422;
```

Before instruction		**After instruction**	
pVar1	0x5100	pVar1	0x5100
SPI memory		*SPI memory*	
0x5100	x	0x5100	0x5422

Example11

```
int pVar1;
...
(pVar1+), spi = 0x5422;
```

Before instruction		**After instruction**	
pVar1	0x5100	pVar1	0x5101
SPI data memory		*SPI data memory*	
0x5100	x	0x5100	0x5422

Example12

```
int pVar1, Var2;
...
(pVar1), pm = Var2;
```

Before instruction		**After instruction**	
pVar1	0x8200	pVar1	0x8200
Var2	0xA987	Var2	0xA987
program memory		*program memory*	
0x8200	x	0x8200	0xA987

Example13

```
int pVar1, Var2;
...
(pVar1+), pm = Var2;
```

Before instruction		**After instruction**	
pVar1	0x8200	pVar1	0x8201
Var2	0xA987	Var2	0xA987
program memory		*program memory*	
0x8200	x	0x8200	0xA987

Example14

```
long Var5;
...
Var5(H) = 0xAA55 ;
```

Before instruction		**After instruction**	
Var5	0x12344321	Var5	0xAA554321

Example15

```
long Var5;
```

```
...
Var5(L) = 0xAA55;
```

Before instruction		**After instruction**	
Var5	0x12344321	Var5	0x1234AA55

Example16

```
int Var1;
long Var5;
...
Var5(H) = Var1;
```

Before instruction		**After instruction**	
Var1	0x7711	Var1	0x7711
Var5	0x12344321	Var5	0x77114321

Example17

```
int Var1;
long Var5;
...
Var5(L) = Var1;
```

Before instruction		**After instruction**	
Var1	0x7711	Var1	0x7711
Var5	0x12344321	Var5	0x12347711

Name	**=**	Assignment instruction for 16 bits TML variables *(IO group)*

Syntax

VAR16D = IN#n	read input #n into VAR16D
VAR16D = INPUT1, ANDm	read inputs IN#25 to IN#32 into *VAR16D* with *ANDm*
VAR16D = INPUT2, ANDm	read input IN#33 to IN#39 into *VAR16D* with *ANDm*
VAR16D = INPORT, 0xF	read IN#36 to IN#39 into *VAR16D with 0xF as ANDm*

Operands

Var16D: integer variable
IN#n : the source is input bit-port number n (0=<n<=39)
INPUT1: the source is 8 input lines status of IO inputs #25 to #32
INPUT2: the source is 8 input lines status of IO inputs #33 to #39
ANDm: a 16-bit mask used to indicate which bits are read from the input ports
INPORT: the source is 4 input lines status of IO inputs #39, #38, #37 and #36

The variable VAR16D must be a valid variable name, defined in the current TML application. The selection of the IN#n line is specific for each Technosoft drive.

Type

TML program	On-line
X	**X**

Binary code

VAR16D = IN#n

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**1**	**0**	**0**	**0**	**0**	(9LSBs of &*VAR16D*)								
PxDATDIR															
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	*Bit_mask*							

VAR16D = INPUT1, ANDm

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**1**	**0**	**0**	**0**	**0**	(9LSBs of &*VAR16D*)								
0	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**1**
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	*ANDm*							

VAR16D = INPUT2, ANDm

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**1**	**0**	**0**	**0**	**0**	(9LSBs of &*VAR16D*)								
0	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**1**	**1**	**0**
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	*ANDm*							

VAR16D = INPORT, ANDm

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	0	0	(9LSBs of &*VAR16D*)								
ANDm															

Description Assign the value (status) of input #n or groups of input to the 16-bit destination variable.

Execution (destination variable) = source input (input lines) status

PxDATDIR & Bit_mask		
#n	**PxDATDIR**	**Bit_mask**
#0	0x7098	0x0001
#1	0x7098	0x0002
#2	0x7098	0x0004
#3	0x7098	0x0008
#4	0x7098	0x0010
#5	0x7098	0x0020
#6	0x7098	0x0040
#7	0x7098	0x0080
#8	0x709A	0x0001
#9	0x709A	0x0002
#10	0x709A	0x0004
#11	0x709A	0x0008
#12	0x709A	0x0010
#13	0x709A	0x0020
#14	0x709A	0x0040
#15	0x709A	0x0080
#16	0x709C	0x0001
#17	0x709C	0x0002
#18	0x709C	0x0004
#19	0x709C	0x0008

#n	PxDATDIR	Bit_mask
#20	0x709C	0x0010
#21	0x709C	0x0020
#22	0x709C	0x0040
#23	0x709C	0x0080
#24	0x709E	0x0001
#25	0x7095	0x0001
#26	0x7095	0x0002
#27	0x7095	0x0004
#28	0x7095	0x0008
#29	0x7095	0x0010
#30	0x7095	0x0020
#31	0x7095	0x0040
#32	0x7095	0x0080
#33	0x7096	0x0001
#34	0x7096	0x0002
#35	0x7096	0x0004
#36	0x7096	0x0008
#37	0x7096	0x0010
#38	0x7096	0x0020
#39	0x7096	0x0040

Example1

```
int Var1;
…
Var1 = IN#14;
```

Before instruction

IN#14 logic state	1
Var1	x

After instruction

IN#14 logic state	1
Var1	0x0040

Bit#6 of Var1 has logic value of IN#14. Remaining bits are set *to 0.*

Example2

```
int Var1;
…
Var1 = INPUT1, 0x00E7;
```

Before instruction

IN#	32	31	30	29	28	27	26	25
Logic state	0	1	1	0	1	1	0	1
Var1	x							

After instruction

IN#	32	31	30	29	28	27	26	25
Logic state	0	1	1	0	1	1	0	1
Var1	0x0065							

IN#	32	31	30	29	28	27	26	25	
Port state	0	1	1	0	1	1	0	1	Bitwise operation
And_Mask	1	1	1	0	0	1	1	1	
Var1	0	1	1	0	0	1	0	1	

Example3

```
int Var1;
…
Var1 = INPUT2, 0x00E7;
```

Before instruction

IN#	39	38	37	36	35	34	33
Input state	1	0	0	1	1	0	1
Var1	x						

After instruction

IN#	39	38	37	36	35	34	33
Input state	1	0	0	1	1	0	1
Var1	0x0045						

IN#	39	38	37	36	35	34	33	
Input state	1	0	0	1	1	0	1	Bitwise operation
And_Mask	1	1	0	0	1	1	1	
Var1	1	0	0	0	1	0	1	

Example4

```
int Var1;
…
Var1 = INPORT, 0xF;
```

Before instruction

IN#	39	38	37	36
Input state	1	0	1	1
Var1	x			

After instruction

IN#	39	38	37	36
Logic state	1	0	1	1
Var1	0x000B			

The inputs status (IN#39 to IN#36) is saved in the 4LSB of the variable while the 12MSB are set to 0. If an input line is low, the corresponding bit in the variable is zero. If an input line is high, the corresponding bit in the variable is one.

Name =	Assignment instruction for 32 bits TML variables *(Assignment group)*

Syntax

VAR32D = *value32*	set *VAR32D* to *value32*
VAR32D = *VAR32S*	set *VAR32D* to *VAR32S* value
VAR32D = *VAR16S << N*	set *VAR32D* to *VAR16S << N*
VAR32D, DM = *value32*	set long *VAR32D* from *DM* to *value32*
VAR32D, DM = *VAR32S*	set long *VAR32D* from *DM* to *VAR32S*
VAR32D = *(VAR16S), TypeMem*	set *VAR32D* to &(*VAR16S*) from *TM*
VAR32D = *(VAR16S+), TypeMem*	set *VAR32D* to &(*VAR16S*) from *TM, then VAR16S += 2*
(VAR16D), TypeMem = *value32*	set &(*VAR16D*) from *TM* to *value32*
(VAR16D), TypeMem = *VAR32S*	set &(*VAR16D*) from *TM* to *VAR32S*
(VAR16D+), TypeMem = *value32*	set &(*VAR16D*) from *TM* to *value32, then VAR16D += 2*
(VAR16D+), TypeMem = *VAR32S*	set &(*VAR16D*) from *TM* to *VAR32S, then VAR16D += 2*

Operands

value32: 32-bit long immediate value
VAR32x: long variable
DM: data memory operand
TypeMem: memory operand
(*VAR16x*): contents of variable VAR16x, representing a 16-bit address of a variable

Type

TML program	On-line
X	**X**

Binary code

VAR32D = value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**0**	**1**	**0**	**0**	**1**	**0**	(9LSBs of &*VAR32D*)								
LOWORD(*value32*)															
HIWORD(*value32*)															

VAR32D = VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**0**	**1**	**0**	**1**	**1**	**0**	(9LSBs of &*VAR32D*)								
&*VAR32S*															

VAR32D =VAR16S << N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**1**	**1**	*N (0≤N≤16)*				
&*VAR32D*															
&*VAR16S*															

VAR32D, dm = value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
&*VAR32D*															
LOWORD(*value32*)															
HIWORD(*value32*)															

VAR32D, dm = VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**1**
&*VAR32D*															
&*VAR32S*															

VAR32D = (VAR16S), TypeMem

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	*TypeMem*		**0**	**1**
&*VAR16S*															
&*VAR32D*															

VAR32D = (VAR16S+), TypeMem

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	*TypeMem*		**0**	**1**
&*VAR16S*															
&*VAR32D*															

(VAR16D), TypeMem = value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	*TypeMem*		**0**	**1**
&*VAR16D*															
LOWORD(*value32*)															
HIWORD(*value32*)															

(VAR16D), TypeMem = VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

1	0	0	1	0	0	0	0	1	0	1	1	*TypeMem*	0	1
&*VAR16D*														
&*VAR32S*														

(VAR16D+), TypeMem = value32

15	14	13	12	11	10	9	8	7	6	5	4	3 2	1	0
1	0	0	1	0	0	0	0	0	0	1	0	*TypeMem*	0	1
&*VAR16D*														
LOWORD(*value32*)														
HIWORD(*value32*)														

(VAR16D+), TypeMem = VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3 2	1	0
1	0	0	1	0	0	0	0	0	0	1	1	*TypeMem*	0	1
&*VAR16D*														
&*VAR32S*														

Description Assign the 32-bit value of the source operand to the 32-bit destination variable

Execution (destination variable) = source value

TypeMem	
DM	01
PM	00
SPI	10

Example1

```
long Var1;
...
Var1 = 0x1122AABB;
```

Before instruction		**After instruction**	
Var1	x	Var1	0x1122AABB

Example2

```
long Var1, Var2;
...
Var1 = Var2;
```

Before instruction		**After instruction**	
Var2	0xAABC1234	Var2	0xAABC1234
Var1	x	Var1	0xAABC1234

Example3

```
int Var1;
long Var2;
...
```

```
Var2 = Var1 << 4;
```

Before instruction		After instruction	
Var1	0x9876	Var1	0x9876
Var2	x	Var2	0x00098760

Example4

```
long Var1;
...
Var1, dm = 0x1122AABB;
```

Before instruction		After instruction	
Var1	x	Var1	0x1122AABB

Example5

```
long Var1, Var2;
...
Var1, dm = Var2;
```

Before instruction		After instruction	
Var2	0xAABC1234	Var2	0xAABC1234
Var1	x	Var1	0xAABC1234

Example6

```
long Var1;
int pVar2;
...
Var1 = (pVar2), dm;
```

Before instruction		After instruction	
pVar2	0x96AB	pVar2	0x96AB
Data memory		*Data memory*	
0x96AB	0x1234	0x96AB	0x1234
0x96AC	0xABCD	0x96AC	0xABCD
Var1	x	Var1	0xABCD1234

Example7

```
long Var1;
int pVar2;
...
Var1 = (pVar2+), dm;
```

Before instruction		After instruction	
pVar2	0x0A02	pVar2	0x0A04
Data memory		*Data memory*	
0x0A02	0x1234	0x0A02	0x1234
0x0A03	0xABCD	0x0A03	0xABCD
Var1	x	Var1	0xABCD1234

Example8

```
int pVar1;
...
(pVar1), spi = 0x5422AFCD;
```

Before instruction		After instruction	
pVar1	0x5100	pVar1	0x5100
SPI memory		*SPI memory*	
0x5100	x	0x5100	0xAFCD
0x5101	x	0x5101	0x5422

Example9

```
int pVar1;
long Var2;
...
(pVar1), pm = Var2;
```

Before instruction		After instruction	
pVar1	0x8200	pVar1	0x8200
Var2	0xA98711EF	Var2	0xA98711EF
program memory		*program memory*	
0x8200	x	0x8200	0x11EF
0x8201	x	0x8201	0xA987

Example10

```
int pVar1;
...
(pVar1+), pm = 0x5422AFCD;
```

Before instruction		After instruction	
pVar1	0x8200	pVar1	0x8202
program memory		*program memory*	
0x8200	x	0x8200	0xAFCD
0x8201	x	0x8201	0x5422

Example11

```
int pVar1;
long Var2;
...
(pVar1+), pm = Var2;
```

Before instruction		After instruction	
pVar1	0x8200	pVar1	0x8202
Var2	0xA98711EF	Var2	0xA98711EF
program memory		*program memory*	
0x8200	x	0x8200	0x11EF

0x8201	x	0x8201	0xA987

Name	**=** Assignment instruction for a 16 bits TML local variable with data from another axis – *multiple axis instruction (get data from another axis)* *(Multiple axis group)*

Syntax

VAR16D = [Axis] VAR16S	local *VAR16D* = [*Axis*] *VAR16S*
VAR16D = [Axis] VAR16S, DM	local *VAR16D* = [*Axis*] *VAR16S*, *DM*
VAR16D = [Axis] (VAR16S), TypeMem	local *VAR16D* = [*Axis*] &(*VAR16S*), *TM*
VAR16D = [Axis] (VAR16S+), TypeMem	local *VAR16D* = [*Axis*] &(*VAR16S*), *TM, then V16S+=1*

Operands *VAR16x*: integer variable
Axis: 8-bit ID for source axis
DM: data memory operand
TypeMem: memory operand. One of dm (0x1), pm (0x0) or spi (0x2) values
(*VAR16x*): contents of variable VAR16x, representing a 16-bit address of a variable

Type

TML program	On-line
X	–

Binary code

VAR16D = [Axis] VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	0	0	(9LSBs of &*VAR16S*)								
0	0	0	0	*Axis*								0	0	0	0
&*VAR16D*															

VAR16D = [Axis] VAR16S, dm

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0
0	0	0	0	*Axis*								0	0	0	0
&*VAR16S*															
&*VAR16D*															

VAR16D = [Axis] (VAR16S), TypeMem

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	1	0	1	1	0	0	0	*TypeMem*		0	0
0	0	0	0	*Axis*								0	0	0	0
&*VAR16S*															
&*VAR16D*															

VAR16D = [Axis] (VAR16S+), TypeMem

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	*TypeMem*		**0**	**0**
0	**0**	**0**	**0**	*Axis*								**0**	**0**	**0**	**0**
&VAR16S															
&VAR16D															

Description Bring the 16-bit value of the source operand from an external axis and assign it to the 16-bit destination local variable.

Execution (local 16-bit destination variable) = external source 16-bit value, from another axis

TypeMem	
DM	01
PM	00
SPI	10

Example1

```
int VarLoc, VarExt;
...
VarLoc = [15]VarExt;
```

Before instruction		After instruction	
VarLoc on local axis	x	VarLoc on local axis	0x1234
VarExt on axis 15	0x1234	VarExt on axis 15	0x1234

Example2

```
int VarLoc, VarExt;
...
VarLoc = [15]VarExt, dm;
```

Before instruction		After instruction	
VarLoc on local axis	x	VarLoc on local axis	0x1234
VarExt on axis 15	0x1234	VarExt on axis 15	0x1234

Example3

```
int VarLoc, pVarExt;
...
VarLoc = [15](pVarExt), dm;
```

Before instruction		After instruction	
pVarExt on axis 15	0x1234	pVarExt on axis 15	0x1234
At dm address 0x1234 on axis 15	0xFEDC	At dm address 0x1234 on axis 15	0xFEDC
VarLoc on local axis	x	VarLoc on local axis	0xFEDC

Example4

```
int VarLoc, pVarExt;
...
VarLoc = [15](pVarExt+), dm;
```

Before instruction			**After instruction**	
pVarExt on axis 15	0x1234		pVarExt on axis 15	0x1235
At dm address 0x1234 on axis 15	0xFEDC		At dm address 0x1234 on axis 15	0xFEDD
VarLoc on local axis	x		VarLoc on local axis	0xFEDC

Name	**=** Assignment instruction for a 32 bits TML local variable with data from another axis – *multiple axis instruction (get data from another axis))* *(Multiple axis group)*

Syntax

VAR32D = *[Axis] VAR32S*	local *VAR32D* = [*A*] *VAR32S*
VAR32D = *[Axis] VAR32S, DM*	local *VAR32D* = [*A*] *VAR32S*, *DM*
VAR32D = *[Axis] (VAR16S), TypeMem*	local *VAR32D* = [*A*] &(*VAR16S*), *TM*
VAR32D = *[Axis] (VAR16S+), TypeMem*	local *VAR32D* = [*A*] &(*VAR16S*), *TM, then V16S+=2*

Operands *VAR32x*: long variable VAR32x
Axis: 8-bit ID for source axis
DM: data memory operand
TypeMem: memory operand. One of dm (0x1), pm (0x0) or spi (0x2) values
(*VAR16x*): contents of variable VAR16x, representing a 16-bit address of a variable

Type

TML program	On-line
X	**–**

Binary code

VAR32D = [Axis] VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	1	0	0	1	0	(9LSBs of &*VAR32S*)								
0	0	0	0	*Axis*								0	0	0	0
&*VAR32D*															

VAR32D = [Axis] VAR32S, dm

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1
0	0	0	0	*Axis*								0	0	0	0
& *VAR32S*															
& *VAR32D*															

VAR32D = [Axis] (VAR16S), TypeMem

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	1	0	1	1	0	0	0	*TypeMem*		0	1
0	0	0	0	*Axis*								0	0	0	0
& *VAR16S*															
& *VAR32D*															

VAR32D = [Axis] (VAR16S+), TypeMem

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	1	0	1	0	0	0	0	*TypeMem*		0	1
0	0	0	0	*Axis*								0	0	0	0
& *VAR16S*															
& *VAR32D*															

Description Bring the 32-bit value of the source operand from an external axis and assign it to the 32-bit destination local variable

Execution (local 32-bit destination variable) = external source 32-bit value, from another axis

TypeMem	
DM	01
PM	00
SPI	10

Example1

```
long VarLoc, VarExt;
…
VarLoc = [15]VarExt;
```

Before instruction		After instruction	
VarLoc on local axis	x	VarLoc on local axis	0x1234ABCD
VarExt on axis 15	0x1234ABCD	VarExt on axis 15	0x1234ABCD

Example2

```
long VarLoc, VarExt;
...
VarLoc = [15]VarExt, dm;
```

Before instruction		After instruction	
VarLoc on local axis	x	VarLoc on local axis	0xF0E1A2B3
VarExt on axis 15	0xF0E1A2B3	VarExt on axis 15	0xF0E1A2B3

Example3

```
long VarLoc;
int pVarExt;
...
VarLoc = [15](pVarExt), dm;
```

Before instruction		After instruction	
pVarExt on axis 15	0x1234	pVarExt on axis 15	0x1234
At dm address 0x1234 on axis 15	0xFEDC	At dm address 0x1234 on axis 15	0xFEDC
At dm address 0x1235 on axis 15	0x2233	At dm address 0x1235 on axis 15	0x2233
VarLoc on local axis	x	VarLoc on local axis	0x2233FEDC

Example4

```
long VarLoc;
```

```
int pVarExt;
...
VarLoc = [15](pVarExt+), dm;
```

Before instruction

pVarExt on axis 15	0x1234
At dm address 0x1234 on axis 15	0xFEDC
At dm address 0x1235 on axis 15	0x2233
VarLoc on local axis	x

After instruction

pVarExt on axis 15	0x1236
At dm address 0x1234 on axis 15	0xFEDF
At dm address 0x1235 on axis 15	0x2233
VarLoc on local axis	0x2233FEDC

Name	**=**	Assignment instruction for a 16 bits TML external variable with data sent from the local axis – *multiple axis instruction (send data to another axis)* *(Multiple axis group)*

Syntax

[Axis/Group] VAR16D = *VAR16S*	[*A/G*] *VAR16D* = local *VAR16S*
[Axis/Group] VAR16D,dm = *VAR16S*	[*A/G*] *VAR16D*, *dm* = local *VAR16S*
[Axis/Group] (VAR16D), TypeMem = *VAR16S*	[*A/G*] &(*VAR16D*), *TM* = local *VAR16S*
[Axis/Group] (VAR16D+), TypeMem = *VAR16S*	[*A/G*] &(*VAR16D*), *TM* = local *VAR16S, then V16D+=1*

Operands *VAR16x*: integer variable
Axis/Group: 8-bit ID for source axis or group of axes
dm: data memory operand
TypeMem: memory operand. One of dm (0x1), pm (0x0) or spi (0x2) values
(*VAR16x*): contents of variable VAR16x, representing a 16-bit address of a variable

Type

TML program	On-line
X	**–**

Binary code

[Axis/Group] VAR16D = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**1**	**1**	**1**	**0**	**0**	(9LSBs of &*VAR16D*)								
0	**0**	**0**	**0**	*Axis/Group*								**0**	**0**	**0**	**0**
&*VAR16S*															

[Axis/Group] VAR16D,dm = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**
0	**0**	**0**	**0**	*Axis/Group*								**0**	**0**	**0**	**0**
&*VAR16D*															
&*VAR16S*															

[Axis/Group] (VAR16D), TypeMem = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	*TypeMem*		**0**	**0**
0	**0**	**0**	**0**	*Axis/Group*								**0**	**0**	**0**	**0**
&*VAR16D*															
&*VAR16S*															

[Axis/Group] (VAR16D+), TypeMem = VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	*TypeMem*		**0**	**0**
0	**0**	**0**	**0**	*Axis/Group*								**0**	**0**	**0**	**0**
&*VAR16D*															
&*VAR16S*															

Description Send the 16-bit local value of the source operand to an external axis and assign it to the 16-bit destination external variable

Execution (external 16-bit destination variable from another axis) = local source 16-bit value

TypeMem	
DM	01
PM	00
SPI	10

Example1

```
int VarLoc, VarExt;
...
[G8]VarExt = VarLoc;
```

Before instruction		**After instruction**	
VarLoc on local axis	0x1234	VarLoc on local axis	0x1234
VarExt on all axes belonging to group 8	x	VarExt on all axes from group 8	0x1234

Example2

```
int VarLoc, VarExt;
...
[15]VarExt, dm = VarLoc;
```

Before instruction		**After instruction**	
VarLoc on local axis	0x1234	VarLoc on local axis	0x1234
VarExt on axis 15	x	VarExt on axis 15	0x1234

Example3

```
int VarLoc, pVarExt;
...
[G8](pVarExt), dm = VarLoc;
```

Before instruction		**After instruction**	
VarLoc on local axis	0xFEDC	VarLoc on local axis	0xFEDC
pVarExt on all axes belonging to group 8	0x1234	pVarExt on all axes belonging to group 8	0x1234
At dm address 0x1234 on all axes belonging to group 8	x	At dm address 0x1234 on all axes belonging to group 8	0xFEDC

Example4

```
int VarLoc, pVarExt;
...
[G8](pVarExt+), dm = VarLoc;
```

Before instruction

VarLoc on local axis	0xFEDC
pVarExt on all axes belonging to group 8	0x1234
At dm address 0x1234 on all axes belonging to group 8	x

After instruction

VarLoc on local axis	0xFEDC
pVarExt on all axes belonging to group 8	0x1235
At dm address 0x1234 on all axes belonging to group 8	0xFEDC

Name	**=**	Assignment instruction for a 32 bits TML external variable with data sent from the local axis – *multiple axis instruction (send data to another axis)* *(Communication & Multiple axis group)*

Syntax

[Axis/Group] VAR32D = VAR32S	[*A/G*] long *VAR32D* = local *VAR32S*
[Axis/Group] VAR32D, DM = VAR32S	[*A/G*] long *VAR32D*, *DM* = local *VAR32S*
[Axis/Group] (VAR16D), TypeMem = VAR32S	[*A/G*] &(*VAR16D*), *TM* = local *VAR32S*
[Axis/Group] (VAR16D+), TypeMem = VAR32S	[*A/G*] &(*VAR16D*), *TM* = local *VAR32S, then V1DS+=2*

Operands *VAR32x*: long variable VAR32x
Axis: 8-bit ID for source axis or group of axes
dm: data memory operand
TypeMem: memory operand
(*VAR16x*): contents of variable VAR16x, representing a 16-bit address of a variable

Type

TML program	On-line
X	**–**

Binary code

[Axis/Group] VAR32D = VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	1	1	1	1	0	(9LSBs of &*VAR32D*)								
0	0	0	0	*Axis/Group*								0	0	0	0
&*VAR32S*															

[Axis/Group] VAR32D, dm = VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	0	0	0	0	0	1	0	1	0	1
0	0	0	0	*Axis/Group*								0	0	0	0
& *VAR32D*															
& *VAR32S*															

[Axis/Group] (VAR16D), TypeMem = VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	0	0	1	0	1	1	*TypeMem*		0	1
0	0	0	0	*Axis/Group*								0	0	0	0
& *VAR16D*															
& *VAR32S*															

[Axis/Group] (VAR16D+), TypeMem = VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	1	0	0	0	0	0	1	1	*TypeMem*		0	1
0	0	0	0	*Axis/Group*								0	0	0	0
& *VAR16D*															
& *VAR32S*															

Description Send the 32-bit local value of the source operand to an external axis and assign it to the 32-bit destination external variable

TypeMem	
DM	01
PM	00
SPI	10

Execution (external 32-bit destination variable from another axis) = local source 32-bit value

Example1

```
long VarLoc, VarExt;
...
[15]VarExt = VarLoc;
```

Before instruction		After instruction	
VarLoc on local axis	0x1234ABCD	VarLoc on local axis	0x1234ABCD
VarExt on axis 15	x	VarExt on axis 15	0x1234ABCD

Example2

```
long VarLoc, VarExt;
...
[15]VarExt, dm = VarLoc;
```

Before instruction		After instruction	
VarLoc on local axis	0xF0E1A2B3	VarLoc on local axis	0xF0E1A2B3
VarExt on axis 15	x	VarExt on axis 15	0xF0E1A2B3

Example3

```
long VarLoc;
int pVarExt;
...
[15](pVarExt), dm = VarLoc;
```

Before instruction		After instruction	
VarLoc on local axis	0x2233FEDC	VarLoc on local axis	0x2233FEDC
pVarExt on axis 15	0x1234	pVarExt on axis 15	0x1234
At dm address 0x1234 on axis 15	x	At dm address 0x1234 on axis 15	0xFEDC
At dm address 0x1235 on axis 15	x	At dm address 0x1235 on axis 15	0x2233

Example4

```
long VarLoc;
int pVarExt;
...
[15](pVarExt+), dm = VarLoc;
```

Before instruction

VarLoc on local axis	0x2233FEDC
pVarExt on axis 15	0x1234
At dm address 0x1234 on axis 15	x
At dm address 0x1235 on axis 15	x

After instruction

VarLoc on local axis	0x2233FEDC
pVarExt on axis 15	0x1236
At dm address 0x1234 on axis 15	0xFEDC
At dm address 0x1235 on axis 15	0x2233

Name	**–**	Get data from memory (16-bit/32-bit) with direct addressing *(On-line group)*

Syntax –

Operands –

Type

TML program	On-line
–	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	*TypeMem*		**0**	**0**
Destination Address															
16-bit value															

Description The instructions request, via a communication channel, from a remote drive the value contained in the memory location(s) with address specified directly in the code. The address can be in data memory, program memory or SPI memory.

TypeMem	
DM	01
PM	00
SPI	10

Execution Request from the remote drive, the remote drive sends the value requested.

Name	**–**	Get data from memory (16-bit/32-bit) with indirect addressing *(On-line group)*

Syntax –

Operands –

Type

TML program	On-line
–	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	1	0	0	0	0	1	0	0	0	*TypeMem*		0	0
Destination Address															
LOWORD(*value32*)															
HIWORD(*value32*)															

Description The instructions request, via a communication channel, from a remote drive the value contained in the memory location(s) with address specified in *VAR16* variable. The address contained in *VAR16* can be in data memory, program memory or SPI memory.

TypeMem	
DM	01
PM	00
SPI	10

Execution Request from the remote drive, the remote drive sends the requested value.

Name	**–**	Send a TML instruction to another axis *(Communication & Multiple axis group)*

Syntax **[***Axis/Group***] {***TML Instruction;***}**

Operands *Axis/Group ID*: the ID of the destination axis or group
TML Instruction: any of the single axis TML instruction codes, to be send to the destination axis/group

Type

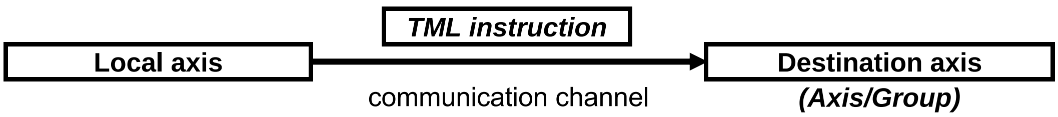
TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**1**	**0**	**1**	**0**	**length(***MLI***) – 1**								
0	**0**	**0**	**A/G**	*Axis/Group*								**0**	**0**	**0**	**0**
TML instruction word 1 (operation code)															
TML instruction word 2 (data)															
…															
TML instruction word (**length(***MLI***)**) (data)															

Description This multiple axis operation allows one to send TML commands from one axis to another one. When this code is encountered, the TML instruction included in it is sent to the destination axis, and will be executed as an on-line TML command received by that axis.

Execution



Send the "*TML Instruction*" through the multiple-axis communication channel.

Example

```
[G8] {STOP3;}//Send to all axes that belong to group 8 the command
             //to execute a motion stop of type 3.
```

Name	=-	Set inverse value for TML variables *(Assignment group)*

Syntax

VAR16D **= -** *VAR16S* set *VAR16D* to –*VAR16S* value
VAR32D **= -** *VAR32S* set *VAR32D* to –*VAR32S* value

Operands *VAR16x*: integer variable
VAR32x: long variable VAR32x

Type

TML program	On-line
X	**–**

Binary code

VAR16D = -VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	0	0	0	(9LSBs of &*VAR16D*)								
&*VAR16S*															

VAR32D = -VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	1	0	1	0	(9LSBs of &*VAR32D*)								
&*VAR32S*															

Description Assign to the variable its inverse value

Execution variable = - variable

Example

```
int Var1;
long Var2;
...
Var1 = - Var1;
Var2 = - Var1;
```

Before instruction

Var1	1256
Var2	-22450

After instruction

Var1	-1256
Var2	1256

Name	**+=**	Add a value to a TML variable *(Arithmetic&Logic group)*

Syntax

VAR16 **+=** *value16*	add to *VAR16 value16*
VAR16D **+=** *VAR16S*	add to *VAR16D VAR16S* value
VAR32 **+=** *value32*	add to *VAR32 value32*
VAR32D **+=** *VAR32S*	add to *VAR32D VAR32S* value

Operands

VAR16x: integer variable
VAR32x: long variable
value16: 16-bit immediate integer value
value32: 32-bit immediate long value

Type

TML program	On-line
X	**X**

Binary code

VAR16 += value16

15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	**0**	**1**	**1**	**1**	**0**	**0**	(9LSBs of &*VAR16*)								
value16															

VAR16D += VAR16S

15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	**1**	**0**	**0**	**0**	**0**	**0**	(9LSBs of &*VAR16D*)								
&*VAR16S*															

VAR32 += value32

15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	**0**	**1**	**1**	**1**	**1**	**0**	(9LSBs of &*VAR32*)								
LOWORD(*value32*)															
HIWORD(value32)															

VAR32D += VAR32S

15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	**1**	**0**	**0**	**0**	**1**	**0**	(9LSBs of &*VAR32D*)								
&*VAR32S*															

Description Add to the destination variable the value of the source variable or value. Store the result in the destination variable.

Execution destination variable = destination variable + source variable / value

Example

```
int Var1, Var2, Var3;
long Var10, Var11, Var12;
...
Var1 +=  125;
Var3 += Var2;
Var10 += 128000;
Var12 += Var11;
```

Before instruction

Var1	1256
Var2	-22450
Var3	22500
Var10	-1201
Var11	25
Var12	12500

After instruction

Var1	1381
Var2	-22450
Var3	50
Var10	126799
Var11	25
Var12	12525

Name	**-=**	Subtract a value from a TML variable *(Arithmetic&Logic group)*

Syntax

VAR16 **-=** *value16*	subtract from *VAR16 value16*
VAR16D **-=** *VAR16S*	subtract from *VAR16D VAR16S* value
VAR32 **-=** *value32*	subtract from *VAR32 value32*
VAR32D **-=** *VAR32S*	subtract from *VAR32D VAR32S* value

Operands
VAR16x: integer variable
VAR32x: long variable
value16: 16-bit immediate integer value
value32: 32-bit immediate long value

Type

TML program	On-line
X	**X**

Binary code

VAR16 -= value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**0**	**0**	**1**	**0**	**0**	(9LSBs of &*VAR16*)								
value16															

VAR16D -= VAR16S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**0**	**1**	**0**	**0**	**0**	(9LSBs of &*VAR16D*)								
&*VAR16S*															

VAR32 -= value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**0**	**0**	**1**	**1**	**0**	(9LSBs of &*VAR32*)								
LOWORD(*value32*)															
HIWORD(*value32*)															

VAR32D -= VAR32S

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**0**	**1**	**0**	**1**	**0**	(9LSBs of &*VAR32D*)								
&*VAR32S*															

Description Subtract from the destination variable the value of the source variable or value. Store the result in the destination variable.

Execution destination variable = destination variable – source variable / value

Example

```
int Var1, Var2, Var3;
long Var10, Var11, Var12;
...
Var1 -=  125;
Var3 -= Var2;
Var10 -= 128000;
Var12 -= Var11;
```

Before instruction

Var1	1256
Var2	-22450
Var3	22500
Var10	-1201
Var11	25
Var12	12500

After instruction

Var1	1131
Var2	-22450
Var3	44950
Var10	-129201
Var11	25
Var12	12475

Name	*****	Multiplication operation *(Arithmetic&Logic group)*

Syntax

VAR16 ***** *VALUE16* >> *N*	PROD = (*VAR16******value16*) >> *N*
VAR16 ***** *VALUE16* << *N*	PROD = (*VAR16******value16*) << *N*
VAR16A ***** *VAR16B* >> *N*	PROD = (*VAR16A*******VAR16B*) >> *N*
VAR16A ***** *VAR16B* << *N*	PROD = (*VAR16A*******VAR16B*) << *N*
VAR32 ***** *VALUE16* >> *N*	PROD = (*VAR32******value16*) >> *N*
VAR32 ***** *VALUE16* << *N*	PROD = (*VAR32******value16*) << *N*
VAR32 ***** *VAR16* >> *N*	PROD = (*VAR32*******VAR16*) >> *N*
VAR32 ***** *VAR16* << *N*	PROD = (*VAR32*******VAR16*) << *N*

Operands

VAR16x: integer variable
VAR32x: long variable
value16: 16-bit immediate integer value
value32: 32-bit immediate long value
N: result shift factor

Type

TML program	On-line
X	**X**

Binary code

VAR16 * VALUE16 >> N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	1	0	0	0	0	0	0	*N (0≤N≤15)*			
&*VAR16*															
VALUE16															

VAR16 * VALUE16 << N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	1	0	0	0	0	1	0	*N (0≤N≤15)*			
&*VAR16*															
VALUE16															

VAR16A * VAR16B >> N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	1	0	0	1	0	0	0	*N (0≤N≤15)*			
&*VAR16A*															
&*VAR16B*															

VAR16A * VAR16B << N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	1	0	0	1	0	1	0	*N (0≤N≤15)*			
&*VAR16A*															
&*VAR16B*															

VAR32 * VALUE16 >> N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	1	0	1	0	0	0	0	*N (0≤N≤15)*			
&*VAR32*															
VALUE16															

VAR32 * VALUE16 << N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	1	0	1	0	0	1	0	*N (0≤N≤15)*			
&*VAR32*															
VALUE16															

VAR32 * VAR16 >> N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	1	0	1	1	0	0	0	*N (0≤N≤15)*			
&*VAR32*															
&*VAR16*															

VAR32 * VAR16 << N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	1	0	1	1	0	1	0	*N (0≤N≤15)*			
&*VAR32*															
&*VAR16*															

Description Multiply two values and store the result (eventually shifted) in the PROD (product) register of the TML environment.

Execution PROD register = (first operand * second operand) shifted to left or right with a specified number of bits

Example1

```
int Var1;
long var2;
...
Var1 * 0x125;
Var2 = PROD;
```

Before instruction

Var1	0x1256
PROD	x
Var2	x

After instruction

Var1	0x1256
PROD	0x00000014FC6E
Var2	0x0014FC6E

Example2

```
int Var1;
long Var2;
...
Var1 *  0x125 << 12;
Var2 = PROD(H);
```

Before instruction

Var1	0x1256
PROD	x
Var2	X

After instruction

Var1	0x1256
PROD	0x00014FC6E000
Var2	0x00014FC6

Example3

```
int Var2, Var3;
long Var4;
...
Var2 *  Var3 >> 4;
Var4 = PROD;
```

Before instruction

Var2	0x1256
Var3	0x125
PROD	x
Far4	x

After instruction

Var2	0x1256
Var3	0x125
PROD	0x000000014FC6
Var4	0x00014FC6

Example4

```
int Var2, Var3;
long Var7;
...
Var2 * Var3 << 8;
Var7 = PROD(H);
```

Before instruction

Var2	0x1256
Var3	0x125
PROD	x
Var7	x

After instruction

Var2	0x1256
Var3	0x125
PROD	0x000014FC6E00
Var7	0x000014FC

Example5

```
long Var1, Var2;
...
Var1 * 0x125;
Var2 = PROD;
```

Before instruction

Var1	0x001256AB
PROD	x
Var2	x

After instruction

Var1	0x1256
PROD	0x000014FD31B7
Var2	0x14FD31B7

Example6

```
long Var1, Var2;
...
Var1 * 0x125 << 12;
Var2 = PROD(H);
```

Before instruction		**After instruction**	
Var1	0x001256AB	Var1	0x001256AB
PROD	x	PROD	0x014FD31B7000
Var2	x	Var2	0x014FD31B

Example7

```
long Var2, Var9;
int Var3;
...
Var2 * Var3 >> 4;
Var9 = PROD(H);
```

Before instruction		**After instruction**	
Var2	0x001256AB	Var2	0x001256AB
Var3	0x125	Var3	0x125
PROD	x	PROD	0x0000014FD31B
Var9	x	Var9	0x0000014F

Example8

```
long Var2, Var9;
int Var3;
...
Var2 *  Var3 << 8;
Var9 = PROD;
```

Before instruction		**After instruction**	
Var2	0x001256AB	Var2	0x001256AB
Var3	0x125	Var3	0x125
PROD	x	PROD	0x0014FD31B700
Var9	X	Var9	0xFD31B700

Name	**>>=** Shift right
	(Arithmetic & Logic group)

Syntax

VAR16 **>>=** *N* — shift *VAR16* right by *N*
VAR32 **>>=** *N* — shift *VAR32* right by *N*
PROD **>>=** *N* — shift *PROD* (product reg.) right by *N*

Operands

VAR16: integer variable
VAR32: long variable
PROD: product register
N: shift factor

Type

TML program	On-line
X	**X**

Binary code

VAR16 >>= N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	0	0	0	0	0	0	0	*N (0≤N≤15)*			
&*VAR16*															

VAR32 >>= N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	0	0	1	0	0	0	0	*N (0≤N≤15)*			
&*VAR32*															

PROD >>= N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	0	0	0	1	0	0	0	*N (0≤N≤15)*			

Description Right shift the source operand with the specified number of bits (N). Fill the most significant bits with the sign bit (sign extension mode applied, all values are considered as signed values).

Execution Value = Value shifted to right with N bits

Example1

```
int Var1;
...
Var1 >>= 4;
```

	Before instruction		**After instruction**
Var1	0x1256	Var1	0x0125

Example2 long Var1;

…

Var1 >>= 12;

Before instruction		**After instruction**	
Var1	0x1256ABAB	Var1	0x0001256A

Example3 **PROD >>= 4;**

Before instruction		**After instruction**	
PROD	0x12560000ABCD	PROD	0x012560000ABC

Name	**<<=** Shift left *(Arithmetic & Logic group)*

Syntax

VAR16 **<<=** *N*	shift *VAR16* left by *N*
VAR32 **<<=** *N*	shift *VAR32* left by *N*
PROD **<<=** *N*	shift *PROD* (product reg.) right by *N*

Operands
VAR16: integer variable
VAR32: long variable
PROD: product register
N: shift factor

Type

TML program	On-line
X	**X**

Binary code

VAR16 <<= N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	0	0	0	0	0	1	0	*N (0<N<15)*			
&*VAR16*															

VAR32 <<= N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	0	0	1	0	0	1	0	*N (0<N<15)*			
&*VAR32*															

PROD <<= N

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	0	0	0	1	0	0	0	1	0	1	0	*N (0<N<15)*			

Description Left shift the source operand, with the specified number of bits (N). Fill the least significant bits with 0.

Execution Value = Value shifted to left with N bits

Example1

```
int Var1;
…
Var1 <<= 4;
```

Before instruction		**After instruction**	
Var1	0x1256	Var1	0x2560

Example2

```
long Var1;
…
Var1 <<= 12;
```

	Before instruction		After instruction
Var1	0x1256ABAB	Var1	0x6AABAB000

Example3

```
PROD <<= 4;
```

	Before instruction		After instruction
PROD	0x12560000ABCD	PROD	0x2560000ABCD0

Name	**ADDGRID**	Add group ID *(Multiple axis group)*

Syntax

ADDGRID *value16*	Add value16 to **GROUP ID**
ADDGRID *VAR16*	Add value of VAR16 to **GROUP ID**

Operands *value16*: 16-bit integer immediate value
VAR16: integer variable

Type

TML program	On-line
X	**X**

Binary code

ADDGRID value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Value16															

ADDGRID VAR16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
&VAR16															

Description In multiple axis structures, this command allows one to add a new group ID to the local axis.
After the execution of this command, the new group ID value is recognized by the axis and is used by the communication drivers in order to accept or reject messages addressed to groups of axes.
Only the lower 8 bits of the *value16* or *VAR16* parameters are used for group coding. Each bit corresponds to a group.
Up to 8 groups (1 to 8) can be defined/added/removed in a multiple axis structure. An axis can belong to any of the groups. A multiple-axis message can be addressed to one axis or to a group of axes.

Execution Group_ID = Group_ID + *value16 (or value of VAR16)*.

Example

```
GROUPID  1;      //local axis belongs to group 1
ADDGRID  2;      //from now on, the local axis belongs
                 //to groups 1 and 2 GROUPID = 3)
 ADDGRID  4;     //from now on, the local axis belongs
                 //to groups 1, 2 and 4
                 //(GROUPID 11)
...
 [G4] {STOP3;}   //send stop motion command to all axes
                 //belonging to group 4
```

Name	**AXISID**	Set axis ID value *(Multiple axis group)*

Syntax

AXISID *value16*	Set **AXIS ID** address
AXISID *VAR16*	Set **AXIS ID** with value of VAR16

Operands *value16*: 16-bit integer immediate value
VAR16: integer variable

Type

TML program	On-line
X	**X**

Binary code

AXISID *value16*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Value16															

AXISID *VAR16*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1
&VAR16															

Description In multiple axis structures, these commands allows changing the ID of the axis. After the execution of these commands, the new ID value is recognized by the axis. The ID *value16* or the ID value of VAR16 has the range from 0 to 255.

Execution Axis_ID is set to value16 or value of VAR16.

Example

```
AXISID 10;       // from now on, the local axis ID is 10
...
[10] {AXISID 9;} // change the ID of axis 10 to 9 (this
                  //instruction is send and executed on
                  //the actual axis 10)
...
[9] {CSPD = 30;} // send a command to axis 9 (previous axis
                 //10)
```

Name	AXISOFF	Set the axis OFF *(Configuration and command group)*

Syntax

AXISOFF — **AXIS** is **OFF** (deactivate control)

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Description This command deactivates the control loops (current, speed and position) and the reference generator module. The PWM outputs are also deactivated (put in the high impedance status).
The real-time kernel continues to be active, both slow and high frequency sampling loops are active. Only acquisition of measured data (currents, position, Vdc, etc) continues to be performed.

Execution Sets the axis OFF, and deactivates the control.

Example

```
BEGIN;
#include "dc_epc.ini" //includes the setup file
ENDINIT;   //end of setup file
Loop:AXISON;     //start program
     MODE SP1 ;       //work mode ;
     CSPD = 20.;      //setup reference speed
     UPD;             //update
     !RT 1000;        //Set event  if RelativeTime >= 1000
     WAIT!;           //WAIT until event occurs
     AXISOFF;         //deactivate the control
     !RT 20000;       //Set event  if RelativeTime >= 20000
     WAIT!;           //WAIT until event occurs
     GOTO loop;       // restart the motion
END;             //end of program
```

Name	AXISON	Set the axis ON *(Configuration and command group)*

Syntax

AXISON — **AXIS** is **ON** (activate control)

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0

Description This command activates the control loops (current, speed and position) and the reference generator module. The PWM outputs are also activated.

Execution Sets the axis ON, and activates the control.

Example

```
 BEGIN;
 #include "dc_epc.ini" //includes the setup file
ENDINIT;   //end of setup file
 Loop:AXISON;    //start program
      MODE SP1 ;       //work mode ;
      CSPD = 20.;      //setup reference speed
      UPD;             //update
      !RT 1000;        //Set event  if RelativeTime >= 1000
      WAIT!;           //WAIT until event occurs
      AXISOFF;         //deactivate the control
      !RT 20000;       //Set event  if RelativeTime >= 20000
      WAIT!;           //WAIT until event occurs
      GOTO loop;       // restart the motion
END;             //end of program
```

Name	BEGIN	Begin a TML program sequence *(Miscellaneous group)*

Syntax

BEGIN — **Begin**ning of a TML program

Operands –

Type

TML program	On-line
X	**–**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	0	1	0	0	1	0	0	1	1	1	0	0

Description This command is used at the beginning of an independent sequence of TML instructions.
The TML instruction decoding section will recognize the BEGIN instruction as the first valid instruction of a TML program.

Execution Begin a sequence of TML instructions.

Example

```
BEGIN;
#include “dc_epc.ini” //includes the setup file
ENDINIT;   //end of setup file
Loop:AXISON;    //start program
     MODE SP1 ;       //work mode ;
     CSPD = 20.;      //setup reference speed
     UPD;             //update
END;             //end of program
```

Name	**CALL**	Call a TML function *(Decision group)*

Syntax

CALL *Label*	Unconditional **CALL** of a TML function
CALL *Label, VAR16, Flag*	**CALL** if *VAR16 Flag* 0
CALL *Label, VAR32, Flag*	**CALL** if *VAR32 Flag* 0

Operands

Label: 16-bit program memory address
VAR16: integer variable
VAR32: long variable
Flag: one of '=', '!=', '>', '>=', '<', '<=' relational factors.

Type

TML program	On-line
X	**X**

Binary code

CALL Label

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1
&*Label*															

CALL Label, VAR16, Flag

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	1	0	0	*Flag*							1
&*VAR16*															
&*Label*															

CALL Label, VAR32, Flag

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	1	0	1	*Flag*							1
&*VAR32*															
&*Label*															

Description

This instruction allows the execution of a TML function (subroutine).

A TML function starts with a label and ends with RET instruction. The function can contain any TML instruction. When a conditional CALL instruction is encountered, the condition is checked and, if it is true (i.e. the tested variable is in the specified relation with 0), a call of to the specified label is executed. If condition is false, the next TML instruction is executed.

Specific sequences can be called from different points of the TML program. Use a RET instruction to end the execution of a function and to continue the TML sequence following the CALL instruction.

Execution Calls a TML function (subroutine) located at the address *Label*.

Unconditional call.

IP -> TOS
Label -> IP

Conditional call.

If VarXX Flag 0 then
IP -> TOS
Label -> IP

The label must be an existing label name, defined in the TML program (a 16-bit program memory address), otherwise an error will occur. The variable must be an existing TML variable name (an integer or long variable), defined in the TML program, otherwise an error will occur. The flag imposes the test condition for the variable var.

In case of a conditional decision instruction **(CALL Label, VAR16/32, Flag)** the variable specified is compared to 0, using one of the following test conditions:

variable.EQ.0 // variable = 0 (EQUAL)
variable.NEQ.0 // variable != 0 (NON EQUAL)
variable.LT.0 // variable < 0 (LESS THAN)
variable.LEQ.0 // variable <= 0 (LESS OR EQUAL)
variable.GT.0 // variable > 0 (GREATER THAN)
variable.GEQ.0 // variable >= 0 (GREATER OR EQUAL)

The CALL instruction is executed only if the test condition is satisfied.

Flag	
LT	0x0090
LEQ	0x0088
EQ	0x00C0
NEQ	0x00A0
GT	0x0084
GEQ	0x0082

Example1

```
CALL fct1, i_var1, GEQ; //call function fct1, if i_var1 >= 0
CALL fct1, i_var1, EQ;   //call function fct1, if i_var1 = 0
CALL fct1, i_var1, NEQ; //call function fct1, if i_var1 != 0
CALL fct1;              //unconditional call of function fct1
fct1:
...
...
RET;
```

Example2

```
int my_pos;
```

```
my_pos = 2000;
CALL MOVEP;      // execute a first motion of 2000
                 //counts
My_pos = 4000;
CALL MOVEP, ASPD, GT;  // execute a second motion of 4000
                       //counts, if motor speed > 0
 ...
MOVEP:     // function to move up to a specified position
      CACC = 1.5;      // acceleration = 1.5counts/sampling2
      CSPD = -20.;     // slew speed = -20counts/sampling
      CPOS = my_pos;   // position command (input argument)
      UPD;             // start the motion
      RET;             // exit from function MOVEP

 ...
 END;
```

Name	**CANBR**	Set the baud rate *(Multiple axis group)*

Syntax

CANBR *value16* Set the baud rate for CAN-bus

Operands *value16*: 16-bit integer immediate value

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Value16															

Description This command is used to setup the baud rate for CAN communication parameters channel. It also sets the CBR register.

Baud rate [kb]	***Value 16***
125	0xF36C
250	0x736C
500	0x3273
800	0x412A
1000	0x1273

Execution CBR register = value16. Program the CAN controller accordingly.

Example In order to configure the baud rate at 1 Mb for the CAN communication channel use the following assignment instruction:

```
CANBR 0x1273;
```

Name	**CHECKSUM**	Assignment instruction for a 16 bits TML variable with the result of the checksum operation *(Miscellaneous group)*

Syntax

CHECKSUM, TypeMem Start, Stop, V16D V16D=Checksum data from TM Start address to TM Stop address-1

Operands *TypeMem*: memory operand.
Start: Start addresses from TypeMem
Stop: Stop addresses from TypeMem
VAR16D: integer variable (destination)

Type

TML program	On-line
X	**X**

Binary code

CHECKSUM, TypeMem Start, Stop, V16D

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	1	0	*TypeMem*		0	0	0	0	0
& *VAR16D*															
Start address															
Stop address															

Description The selected 16-bit variable is assigned with checksum operation performed on the all memory locations situated in TypeMem between Start address and Stop address –1.

Execution (16-bit destination variable) = checksum of data located in TypeMem between Start address and Stop address - 1.

TypeMem	
DM	01
PM	00
SPI	10

Example

```
int Var1;
…
CHECKSUM, SPI 0x5000, 0x5007, VAR1;
```

Before instruction

Var1	x
TypeMem start address	0xB004

After instruction

Var1	0xD45F
TypeMem start address	0xB004

0x5000	
TypeMem address 0x5001	0x0FF1
TypeMem address 0x5002	0x0366
TypeMem address 0x5003	0x0404
TypeMem address 0x5004	0x0C09
TypeMem address 0x5005	0x0010
TypeMem address 0x5006	0x00E7
TypeMem address 0x5007	0x0008

0x5000	
TypeMem address 0x5001	0x0FF1
TypeMem address 0x5002	0x0366
TypeMem address 0x5003	0x0404
TypeMem address 0x5004	0x0C09
TypeMem address 0x5005	0x0010
TypeMem address 0x5006	0x00E7
TypeMem address 0x5007	0x0008

Name	CPA	Absolute command position *(Configuration and command group)*

Syntax

CPA — **C**ommand **P**osition is **A**bsolute

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Description After the execution of this instruction, all position commands will be considered as absolute values. So, position references will be compared with the absolute position of the motor (stored in the APOS variable).

Execution Subsequent position commands are considered as absolute.

Example

```
...
CACC = 1.5;         //Acceleration command for position profile
                    //(counts/sampling²)
CSPD = 40;          //Speed command for position profile
                    //(counts/sampling)
CPOS = 50000;       //Position command (counts)
CPA;                //Position command is Absolute
MODE PP3;           //Set Position Profile Mode 3
UPD;                //Update immediate
```

Name	CPR	Relative command position *(Configuration and command group)*

Syntax

CPR **C**ommand **P**osition is **R**elative

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description After the execution of this instruction, all position commands will be considered as relative values. Depending on the target update mode setting (using instructions `TUM0` or `TUM1`), the position value will be relative to the actual and respectively target motor position.

Execution Subsequent position commands are considered as relative.

Example

```
...
CACC = 0.5;       //Acceleration command for position
                  //profile (counts/sampling²)
CSPD = 20;        //Speed command for position profile
                  //(counts/sampling)
CPOS = 40000;     //Position command (counts)
CPA;              //Position command is Absolute
MODE PP3;         //Set Position Profile Mode 3
UPD;              //Update immediate
CPOS = 80000;     //New Position command (counts)
CPR;              //Position command is Relative
TUM0;             //Target update mode 0
!IN#38 1;         //Set event if INput#38 is high
UPD!;             //Update on event
WAIT!;            //WAIT until event occurs
```

Name	**DINT**	Disable TML interrupts *(Configuration and command group)*

Syntax

DINT — **D**isable TML **INT**errupts

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0

Description After the execution of this instruction, further TML interrupts are disabled. Use the EINT instruction to re-enable TML interrupts.

Execution Disable TML interrupts.

Name	**DIS2CAPI**	Disable Index2 capture *(I/O group)*

Syntax

DIS2CAPI **DIS**able **2**nd **CAP**ture **I**ndex

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0

Description After the execution of this instruction the index2 capture connected to 2CAPI pin is disabled.
Use the EN2CAPI0 or EN2CAPI1 instructions to re-enable this capture.
In the disabled mode, the index2 capture is reprogrammed and can be used as a general purpose I/O pin. By default, it is re-programmed as an input pin.

Index2Capture captures the master position. The master position can be captured only in the following conditions:

- The encoder signals from the master system are connected to the 2nd encoder input of the drive
- The drive is set as slave either in electronic gearing or electronic camming with option Read master position from 2nd encoder input activated

In order to enable the index2 capture input, specify the type of transition to look for: index2 Capture transition low->high or index2 Capture transition high-> low. Normally, you don't need to disable the index2 capture input as this is automatically done when the programmed transition occurs. Use Disable only if you want to disable on purpose the index2 capture input, before sensing the transition.

Execution Disable index2 input capture.

Name	DISCAPI	Disable index capture *(I/O group)*

Syntax

DISCAPI — **DIS**able **CAP**ture **I**ndex

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1

Description After the execution of this instruction, the index capture, connected to CAPI pin, is disabled.

Use the ENCAPI0 or ENCAPI1 instructions to re-enable this capture.

In the disabled mode, the index capture is reprogrammed and can be used as a general purpose I/O pin. By default, it is re-programmed as an input pin.

Index capture captures the motor position.

In order to enable a capture input, specify the type of transition to look for: Capture transition low->high or Capture transition high-> low. Normally, you don't need to disable a capture input as this is automatically done when the programmed transition occurs. Use Disable only if you want to disable on purpose a capture input, before sensing the transition.

Execution Disable index input capture.

Name	**DISIO**	Disable input bit-port *(I/O group)*

Syntax

DISIO#*n* **DIS**able **IO#n**

Operands *n*: the input/output bit-port number (0<=n<=39)

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
MCRx															
ANDdis															
ORdis															

Description After the execution of this instruction, the I/O bit-port #n is disabled. Use the ENIO#n instruction to re-enable this I/O bit-port. In the disabled mode, the associated pin is reprogrammed and can be used for its primary function on the DSP.

Execution Disable I/O bit-port number n (0<=n<=39).

MCRx & AND/OR masks for DISIO#n			
#n	MCRx	ANDdis	ORdis
#0	0x7090	0xFFFF	0x0001
#1	0x7090	0xFFFF	0x0002
#2	0x7090	0xFFFF	0x0004
#3	0x7090	0xFFFF	0x0008
#4	0x7090	0xFFFF	0x0010
#5	0x7090	0xFFFF	0x0020
#6	0x7090	0xFFFF	0x0040
#7	0x7090	0xFFFF	0x0080
#8	0x7090	0xFFFF	0x0100
#9	0x7090	0xFFFF	0x0200
#10	0x7090	0xFFFF	0x0400
#11	0x7090	0xFFFF	0x0800
#12	0x7090	0xFFFF	0x1000
#13	0x7090	0xFFFF	0x2000
#14	0x7090	0xFFFF	0x4000
#15	0x7090	0xFFFF	0x8000
#16	0x7092	0xFFFF	0x0001
#17	0x7092	0xFFFF	0x0002
#18	0x7092	0xFFFF	0x0004
#19	0x7092	0xFFFF	0x0008

#n	MCRx	ANDdis	ORdis
#20	0x7092	0xFFFF	0x0010
#21	0x7092	0xFFFF	0x0020
#22	0x7092	0xFFFF	0x0040
#23	0x7092	0xFFFF	0x0080
#24	0x7092	0xFFFF	0x0100
#25	0x7094	0xFFFF	0x0001
#26	0x7094	0xFFFF	0x0002
#27	0x7094	0xFFFF	0x0004
#28	0x7094	0xFFFF	0x0008
#29	0x7094	0xFFFF	0x0010
#30	0x7094	0xFFFF	0x0020
#31	0x7094	0xFFFF	0x0040
#32	0x7094	0xFFFF	0x0080
#33	0x7094	0xFFFF	0x0100
#34	0x7094	0xFFFF	0x0200
#35	0x7094	0xFFFF	0x0400
#36	0x7094	0xFFFF	0x0800
#37	0x7094	0xFFFF	0x1000
#38	0x7094	0xFFFF	0x2000
#39	0x7094	0xFFFF	0x0000

Name	DISLSN	Disable negative limit switch *(I/O group)*

Syntax

DISLSN — **DIS**able **L**imit **S**witch **N**egative

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description After the execution of this instruction, the negative limit switch is deactivated. Use the ENLSN0 or ENLSN1 instructions to re-enable the negative limit switch detection.
In the disabled mode, the negative limit switch pin is re-programmed and can be used as an input pin, usable to get the status of the limit switch signal. Use the LSN variable in order to examine the status of this pin.

Execution Disable negative limit switch.

Name	**DISLSP**	Disable positive limit switch *(I/O group)*

Syntax

DISLSP **DIS**able **L**imit **S**witch **P**ositive

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description After the execution of this instruction, the positive limit switch is deactivated. Use the ENLSP0 or ENLSP1 instructions to re-enable the positive limit switch detection.
In the disabled mode, the positive limit switch pin is re-programmed and can be used as an input pin, usable to get the status of the limit switch signal. Use the LSP variable in order to examine the status of this pin.

Execution Disable positive limit switch.

Name	**EINT**	Enable TML interrupts *(Configuration and command group)*

Syntax

EINT — **E**nable TML **INT**errupts

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0

Description After the execution of this instruction, the TML interrupts will be enabled. If an interrupt flag is set by a specific event, and the corresponding interrupt enable bit from the ICR register is active, the corresponding TML interrupt service routine will be called and executed. The TML interrupts can be de-activated using the DINT instruction.

Execution Enable TML interrupts.

Name	**EN2CAPI0**	Enable index2 capture on falling-edge front *(I/O group)*

Syntax

EN2CAPI0 **En**able **2**nd**CAP**ture **I**ndex 1->**0**

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0

Description After the execution of this instruction, the DSP will detect the first transition from 1 to 0 on the index2 capture input (pin 2CAPI) for drives where the second encoder input is available. Index2 Capture captures the master position.

The master position can be captured only in the following conditions:

- The encoder signals from the master are connected to the second encoder input of the drive
- The drive is set as slave either in electronic gearing or electronic camming with option Read master position from second encoder input activated

When the programmed transition occurs, the following happens:

- The value of the master position will be stored in the CAPPOS2 system variable;
- An event is detected, and the *update event* and the *wait event bits* of the MSR register are set if a capture triggered (!CAP) instruction was executed prior the occurrence of the capture;
- If an update on event was programmed, a motion update is performed;
- The corresponding status bit in the MSR register (Bit 8, position capture) is set
- The corresponding interrupt bit in the ISR register (Bit 8, position capture) is set, and will determine the execution of the associated interrupt service routine if the corresponding mask bit from the ICR register is set.
- The DSP index capture pin is programmed as a general input data pin(bit-port #34 in TML).

A capture input is automatically disabled after the programmed transition was detected and the position was captured. In order to reuse a capture input, you need to enable it again.

Execution Enable index2 capture on falling-edge front (transition from 1 to 0).

Example

```
CACC = 0.5;     //Acceleration command for speed profile
                //(counts/sampling2)
CSPD = 20;      //Speed command (counts/sampling)
MODE SP1;       //Set Speed Profile Mode 1
UPD;            //Update immediate
EN2CAPI0;       //Activate 2CAPI input to trigger a falling
                //transition
CSPD = 30;      //New acceleration command for speed profile
                //(counts/sampling2)
!CAP;           //Set event if CAPture is triggered
UPD!;           //Update on event
```

Name	EN2CAPI1	Enable index2 capture on rising-edge front *(I/O group)*

Syntax

EN2CAPI1 **En**able **2**nd**CAP**ture **I**ndex 0->**1**

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0

Description After the execution of this instruction, the DSP will detect the first transition from 0 to 1 on the index2 capture input (pin 2CAPI) for drives where the second encoder input is available.
Index2 Capture captures the master position.

The master position can be captured only in the following conditions:

- The encoder signals from the master are connected to the second encoder input of the drive
- The drive is set as slave in electronic gearing or electronic camming with option Read master position from second encoder input activated

When the programmed transition occurs, the following happens:

- The value of the master position will be stored in the CAPPOS2 system variable;
- An event is detected, and the *update event* and the *wait event bits* of the MSR register are set if a capture triggered (!CAP) instruction was executed prior the occurrence of the capture;
- If an update on event was programmed, a motion update is performed;
- The corresponding status bit in the MSR register (Bit 8, position capture) is set
- The corresponding interrupt bit in the ISR register (Bit 8, position capture) is set, and will determine the execution of the associated interrupt service routine if the corresponding mask bit from the ICR register is set.
- The DSP index capture pin is programmed as a general input data pin(bit-port #34 in TML).

A capture input is automatically disabled after the programmed transition was detected and the position was captured. In order to reuse a capture input, you need to enable it again.

Execution Enable index2 capture on rising-edge front (transition from 0 to 1).

Example

```
CACC = 0.5;        //Acceleration command for speed profile
                   //(counts/sampling^2)
CSPD = 20;         //Speed command (counts/sampling)
MODE SP1;          //Set Speed Profile Mode 1
UPD;               //Update immediate
EN2CAPI1;          //Activate 2CAPI input to trigger a rising
                   //transitions.
CSPD = 30;         //New acceleration command for speed profile
                   //(counts/sampling^2)
!CAP;              //Set event if CAPture is triggered
UPD!;              //Update on event
```

Name	ENCAPI0	Enable index capture on falling-edge front *(I/O group)*

Syntax

ENCAPI0 **En**able **CAP**ture **I**ndex 1->**0**

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1

Description After the execution of this instruction, the DSP will detect the first transition from 1 to 0 on the index capture input (CAPI pin).
Index capture captures the motor actual position.

On capture, the following happens:

- the value of the motor position will be stored in the CAPPOS system variable;
- an event is detected, and the *update event* and the *wait event bits* of the MSR register are set if a capture triggered (!CAP) instruction was executed prior the occurrence of the capture;
- if an update on event was programmed, a motion update is performed;
- the corresponding status bit in the MSR register (Bit 8, position capture) is set
- the corresponding interrupt bit in the ISR register (Bit 8, position capture) is set, and will determine the execution of the associated interrupt service routine if the corresponding mask bit from the ICR register is set.
- the DSP index capture pin is programmed as a general input data pin(bit-port #5 in TML).

Execution Enable index capture on falling-edge front (transition from 1 to 0).

Example

```
CACC = 0.5;      //Acceleration command for speed profile
                 //(counts/sampling²)
CSPD = 20;       //Speed command (counts/sampling)
MODE SP1;        //Set Speed Profile Mode 1
UPD;             //Update immediate
ENCAPI0;         //Activate CAPI input to trigger a falling
                 //transitions.
CSPD = 50;       //New acceleration command for speed profile
                 //(counts/sampling²)
!CAP;            //Set event if CAPture is triggered
```

```
UPD!;            //Update on event
```

Name	ENCAPI1	Enable index capture on rising-edge front (I/O group)

Syntax

ENCAPI1 **En**able **CAP**ture **I**ndex 0->**1**

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1

Description After the execution of this instruction, the DSP will detect the first transition from 0 to 1 on the index capture input (CAPI pin). Index capture captures the motor actual position.

On capture, the following happens:

- The value of the motor position will be stored in the CAPPOS system variable;
- An event is detected, and the *update event* and the *wait event bits* of the MSR register are set if a capture triggered (!CAP) instruction was executed prior the occurrence of the capture;
- If an update on event was programmed, a motion update is performed;
- The corresponding status bit in the MSR register (Bit 8, position capture) is set
- The corresponding interrupt bit in the ISR register (Bit 8, position capture) is set, and will determine the execution of the associated interrupt service routine if the corresponding mask bit from the ICR register is set.
- The DSP index capture pin is programmed as a general input data pin (bit-port #5 in TML).

Execution Enable index capture on rising-edge front (transition from 0 to 1).

Example

```
CACC = 0.5;      //Set acceleration command
CSPD = 20;       //Ser speed command (counts/sampling)
MODE SP1;        //Set Speed Profile Mode 1
UPD;             //Update immediate
ENCAPI1;         //Activate CAPI input to trigger a rising
                 //transitions.
CSPD = 50;       //Set new acceleration command
!CAP;            //Set event if CAPture is triggered
```

```
UPD!;           //Update on event
```

Name	END	End of TML program *(Miscellaneous group)*

Syntax

END — **END** of a TML program

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Description The END instruction will indicate the end of a TML program sequence. After the execution of this instruction, the TML kernel will enter in a wait loop, and no other TML instruction is executed (this stops the execution of the motion program resident in the drive memory). A RESET, a TML interrupt or an on-line GOTO or CALL instructions are needed to change this status, and to start the execution of another TML program sequence.

Please note that after the execution of the END instruction, the control, PWM outputs and real-time section of the system continue to operate as before the execution of this instruction. Use commands as AXISOFF in order to stop the controllers and to de-activate the PWM outputs.

Remarks:

1. It is mandatory to end the motion program (main routine) with an END command. All the TML subroutines and interrupt service routines should be added after the END command.
2. If you intend to change the program of a drive set for stand-alone operation (e.g. which starts to execute automatically after reset the TML program from the E2ROM memory) you should do the following:
   a. Send to the drive the command END, to stop the current program execution. In order to disable the power stage, send also an AXISOFF command
   b. Compile the new program
   c. Download the new program
   d. Reset the drive. The new program will start to execute

Execution End a TML program.

Name	ENDINIT	End of the initialization part of a TML program *(Configuration and command group)*

Syntax

ENDINIT — **END** of **INIT**ialization

Operands –

Type

TML program	On-line
X	**–**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Description The ENDINIT instruction will indicate the end of the initialization part of the TML program. This instruction must be preceded by all the initializations (TML instructions) needed to setup the motion system configuration structure and parameters.

When executed, this instruction uses these parameters and settings in order to setup the operating environment of the motion system (real-time sampling periods, PWM parameters, sensor-related parameters, etc.).

The following settings must be done before executing the ENDINIT instruction.

Category	Name	Remarks
Registers	SCR	
	OSR	
Parameters	PWMPER	
	DBT	
	CLPER	
	SLPER	

Remarks:

1. Only one ENDINIT instruction may be executed in a TML program.
2. The ENDINIT instruction activates the real-time interrupts and the measurement from A/D channels, but no PWM outputs or controllers. Use the AXISON command in order to activate them, too.

   The AXISON command must be executed <u>after</u> the ENDINIT command!

Execution End the initialization part of the TML program.

Name	**ENIO**	Enable input bit-port *(I/O group)*

Syntax

ENIO#*n* **En**able **IO#n**

Operands *n*: the input/output bit-port number (0<=n<=39)

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
MCRx															
ANDen															
ORen															

Description After the execution of this instruction, the I/O bit-port #n is enabled.

Use the DISIO#n instruction to disable this I/O bit-port.

In the enabled mode, the associated pin is programmed and can be used as a general-purpose I/O bit. The ENIO#n instruction does not change the bit-port type (input or output). By default, after reset, the bit-port is set as an input port.

Use the SETIO#n OUT instruction to change it to an output bit-port or, alternatively, the SETIO#n IN to change it to an input bit-port.

Execution Enable the use of the IO#n signal as an I/O line (0<=n<=39).

Example

```
ENIO#5     // enable port 5
```

MCRx & AND/OR masks for ENIO#n			
#n	**MCRx**	**ANDen**	**ORen**
#0	0x7090	0xFFFE	0x0000
#1	0x7090	0xFFFD	0x0000
#2	0x7090	0xFFFB	0x0000
#3	0x7090	0xFFF7	0x0000
#4	0x7090	0xFFEF	0x0000
#5	0x7090	0xFFDF	0x0000
#6	0x7090	0xFFBF	0x0000
#7	0x7090	0xFF7F	0x0000
#8	0x7090	0xFEFF	0x0000
#9	0x7090	0xFDFF	0x0000
#10	0x7090	0xFBFF	0x0000
#11	0x7090	0xF7FF	0x0000
#12	0x7090	0xEFFF	0x0000
#13	0x7090	0xDFFF	0x0000
#14	0x7090	0xBFFF	0x0000
#15	0x7090	0x7FFF	0x0000
#16	0x7092	0xFFFE	0x0000
#17	0x7092	0xFFFD	0x0000
#18	0x7092	0xFFFB	0x0000
#19	0x7092	0xFFF7	0x0000

#n	MCRx	ANDen	ORen
#20	0x7092	0xFFEF	0x0000
#21	0x7092	0xFFDF	0x0000
#22	0x7092	0xFFBF	0x0000
#23	0x7092	0xFF7F	0x0000
#24	0x7092	0xFEFF	0x0000
#25	0x7094	0xFFFE	0x0000
#26	0x7094	0xFFFD	0x0000
#27	0x7094	0xFFFB	0x0000
#28	0x7094	0xFFF7	0x0000
#29	0x7094	0xFFEF	0x0000
#30	0x7094	0xFFDF	0x0000
#31	0x7094	0xFFBF	0x0000
#32	0x7094	0xFF7F	0x0000
#33	0x7094	0xFEFF	0x0000
#34	0x7094	0xFDFF	0x0000
#35	0x7094	0xFBFF	0x0000
#36	0x7094	0xF7FF	0x0000
#37	0x7094	0xEFFF	0x0000
#38	0x7094	0xDFFF	0x0000
#39	0x7094	0xFFFF	0x0000

Name	ENLSN0	Enable falling-edge front detection on negative limit switch *(I/O group)*

Syntax

ENLSN0 **En**able **L**imit **S**witch **N**egative 1->**0**

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Description After the execution of this instruction, the DSP will detect the first transition from 1 to 0 on the negative limit switch input.
In this case, the following happens:

- the *update event* and the *wait event bits* of the MSR register are set if a negative limit switch triggered (!LSN) instruction was executed prior the occurrence of the transition;
- if an update on event was programmed, a motion update is performed;
- the corresponding status bit in the MSR register (Bit 7) is set;
- the corresponding interrupt bit in the ISR register (Bit 7) is set, and will determine the execution of the associated interrupt service routine if the corresponding mask bit from the ICR register is set;
- the negative limit switch pin is reprogrammed in the disabled mode and can be used as an input pin, usable to get the status of the limit switch signal.

Use the DISLSN instruction to disable this function.
Use the LSN variable in order to examine the status of the negative limit switch pin.

Execution Enable falling-edge front detection on negative limit switch.

Example

```
CACC = 1.5;   //Set acceleration command
CSPD = -20;   //Speed command (counts/sampling)
MODE SP1;     //Set Speed Profile Mode 1
UPD;          //Update immediate
ENLSN0;       //Negative Limit Switch triggers falling edge
CSPD = 20;    //Set new speed command (counts/sampling)
!LSN;         //Set event if Negative LimitSwitch is reached
UPD!;        //Update on event
```

Name	**ENLSN1**	Enable rising-edge front detection on negative limit switch *(I/O group)*

Syntax

ENLSN1 **En**able **L**imit **S**witch **N**egative 0->**1**

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

Description After the execution of this instruction, the DSP will detect the first transition from 0 to 1 on the negative limit switch input.
In this case, the following happens:

- the *update event* and the *wait event bits* of the MSR register are set if a negative limit switch triggered (!LSN) instruction was executed prior the occurrence of the transition;
- if an update on event was programmed, a motion update is performed;
- the corresponding status bit in the MSR register (Bit 7) is set;
- the corresponding interrupt bit in the ISR register (Bit 7) is set, and will determine the execution of the associated interrupt service routine if the corresponding mask bit from the ICR register is set;
- the negative limit switch pin is reprogrammed in the disabled mode and can be used as an input pin, usable to get the status of the limit switch signal.

Use the DISLSN instruction to disable this function.
Use the LSN variable in order to examine the status of the negative limit switch pin.

Execution Enable rising-edge front detection on negative limit switch.

Example

```
CACC = 1.5;    //Set acceleration command
CSPD = -20;    //Set speed command (counts/sampling)
MODE SP1;     //Set Speed Profile Mode 1
UPD;          //Update immediate
ENLSN1;       //Negative Limit Switch triggers rising edge
CSPD = 20;    //Set new speed command (counts/sampling)
!LSN;         //Set event if Negative LimitSwitch is reached
UPD!;         //Update on event
```

Name	ENLSP0	Enable falling-edge front detection on positive limit switch *(I/O group)*

Syntax

ENLSP0 **En**able **L**imit **S**witch **P**ositive 1->**0**

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Description After the execution of this instruction, the DSP will detect the first transition from 1 to 0 on the positive limit switch input.
In this case, the following happens:

- The *update event* and the *wait event bits* of the MSR register are set if a positive limit switch triggered (!LSP) instruction was executed prior the occurrence of the transition;
- If an update on event was programmed, a motion update is performed;
- The corresponding status bit in the MSR register (Bit 6) is set;
- The corresponding interrupt bit in the ISR register (Bit 6) is set, and will determine the execution of the associated interrupt service routine if the corresponding mask bit from the ICR register is set;
- The positive limit switch pin is reprogrammed in the disabled mode and can be used as an input pin, usable to get the status of the limit switch signal.

Use the DISLSP instruction to disable this function.
Use the LSP variable in order to examine the status of the positive limit switch pin.

Execution Enable falling-edge front detection on positive limit switch.

Example

```
CACC = 1.5;    //Set acceleration command
CSPD = 20;     //Set speed command (counts/sampling)
MODE SP1;      //Set Speed Profile Mode 1
UPD;           //Update immediate
ENLSP0;        //Positive Limit Switch triggers falling edge
CSPD = -20;    //Set new speed command (counts/sampling)
!LSP;          //Set event if Positive LimitSwitch is reached
```

```
UPD!;         //Update on event
```

Name	**ENLSP1**	Enable rising-edge front detection on positive limit switch *(I/O group)*

Syntax

ENLSP1 **En**able **L**imit **S**witch **P**ositive 0->**1**

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

Description After the execution of this instruction, the DSP will detect the first transition from 0 to 1 on the positive limit switch input.
In this case, the following happens:

- the *update event* and the *wait event bits* of the MSR register are set if a positive limit switch triggered (!LSP) instruction was executed prior the occurrence of the transition;
- if an update on event was programmed, a motion update is performed;
- the corresponding status bit in the MSR register (Bit 6) is set;
- the corresponding interrupt bit in the ISR register (Bit 6) is set, and will determine the execution of the associated interrupt service routine if the corresponding mask bit from the ICR register is set;
- the positive limit switch pin is reprogrammed in the disabled mode and can be used as an input pin, usable to get the status of the limit switch signal.

Use the DISLSP instruction to disable this function.
Use the LSP variable in order to examine the status of the positive limit switch pin.

Execution Enable rising – edge front detection on positive limit switch.

Example

```
CACC = 1.5;  //Acceleration command for speed profile
CSPD = 20;   //Speed command (counts/sampling)
MODE SP1;   //Set Speed Profile Mode 1
UPD;         //Update immediate
ENLSP1;      //Positive Limit Switch triggers rising edge
CSPD = -20;  //New speed command (counts/sampling)
!LSP;        //Set event if Positive LimitSwitch is reached
```

```
UPD!;        //Update on event
```

Name	**EXTREF**	Set external reference type *(Configuration and command group)*

Syntax

EXTREF *value* — Set **EXT**ernal **REF**erence type

Operands *value*: two bits value

Type

TML program	On-line
X	**X**

Binary code

EXTREF 0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

EXTREF 1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

EXTREF 2

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Description This instruction sets the type of external references depending on the parameter *value*:

- *value* = 0: external reference read from EREF system variable (integer or long variable) updated on-line
- *value* = 1: external reference read from REFERENCE input
- *value* = 2: external reference read from second encoder input

Execution Sets the external reference type based on *value's* value (0, 1 or 2)

Example

```
EXTREF 1;    // the reference will be read from the analogue
             //reference A/D channel (REFERENCE input)
```

Name	**GOTO**	Jump to a TML address *(Decision group)*

Syntax

GOTO *Label*	Unconditional **GOTO** to label
GOTO *Label, VAR16, Flag*	**GOTO** if *VAR16 Flag* 0
GOTO *Label, VAR32, Flag*	**GOTO** if *VAR32 Flag* 0

Operands *Label*: 16-bit program memory address
VAR16: integer variable
VAR32: long variable
Flag: one of '=', '!=', '>', '>=', '<', '<=' relational factors.

Type

TML program	On-line
X	**X**

Binary code

GOTO Label

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0
&*Label*															

GOTO Label, VAR16, Flag

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	1	0	0	*Flag*							0
&*VAR16*															
&*Label*															

GOTO Label, VAR32, Flag

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	0	1	0	1	*Flag*							0
&*VAR32*															
&*Label*															

Description This instruction allows the jump to a TML instruction located at the address *Label*. When a conditional GOTO instruction is encountered, the condition is checked and, if it is true (i.e. the tested variable is in the specified relation with 0), a jump to the specified label is executed. If condition is false, the next TML instruction is executed.

Execution Jumps to a TML instruction located at the address *Label*.
Unconditional jump.
Label -> IP
Conditional jump.
If VarXX Flag 0 then
Label -> IP

The label must be an existing label name, defined in the TML program (a 16-bit program memory address), otherwise an error will occur. The *VAR16*/*VAR32* must be an existing TML variable name (an integer or long variable), defined in the TML program, otherwise an error will occur. The flag imposes the test condition for the variable *VAR16*/*VAR32*.

In case of a conditional decision instruction **(GOTO Label, VAR16/32, Flag)** the variable specified is compared to 0, using one of the following test conditions:

```
variable.EQ.0       // variable = 0 (EQUAL)
variable.NEQ.0      // variable != 0 (NON EQUAL)
variable.LT.0       // variable < 0 (LESS THAN)
variable.LEQ.0      // variable <= 0 (LESS OR EQUAL)
variable.GT.0       // variable > 0 (GREATER THAN)
variable.GEQ.0      // variable >= 0 (GREATER OR EQUAL)
```

The GOTO instruction is executed only if the test condition is satisfied.

Example1

```
GOTO label1, i_var2, LT;    // jump to label1 if i_var2 < 0
GOTO label2, i_var2, LEQ;   // jump to label2 if i_var2 <= 0
GOTO label3, i_var2, GT;    // jump to label3 if i_var2 > 0
GOTO label4;                // unconditional jump to label4
```

Example2

```
...
GOTO MOVEP;            // jump unconditionally
...
GOTO MOVEP, ASPD, GT;  // jump if motor speed > 0
...
MOVEP:                 // program sequence to move to a
                       //specified position
CACC = 1.5;            // acceleration = 1.5
                       //(counts/sampling^2)
CSPD = -20.;           // slew speed = -20 (counts/sampling)
CPOS = my_pos;         // position command
UPD;                   // start motion
GOTO Exit;             // exit
...
Exit:                  //label
```

Name	**GROUPID**	Set group ID value *(Multiple axis group)*

Syntax

GROUPID *value16* Set **GROUP ID** address

Operands *value16*: 16-bit integer immediate value

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Value16															

Description In multiple axis structures, this command allows one to change the group ID of the local axis.

After the execution of this command, the new ID value is recognized by the axis and is used by the communication drivers in order to accept or reject messages addressed to groups of axes.

Only the lower 8 bits of the *value16* parameter are used for group coding. Each bit corresponds to a group. Up to 8 groups can be defined in a multiple axis structure.

An axis can belong to any of the 8 groups.
A multiple-axis message can be addressed to one or more of the axes.

Execution Group_ID = *value16*.

Example

```
GROUPID 1;  // local axis belongs to groups 1
GROUPID 3;  // from now on, the local axis belongs to group 3
...
[G3] {STOP3;}    //  stop  the  motion  for  all  axes  belonging
to
                 //group 3
```

Name	INITCAM	Init CAM table for electronic camming mode operation *(Miscellaneous group)*

Syntax

INITCAM LoadAddress, RunAddress — **InitCam** table from **LoadAddress** to **RunAddress**

Operands

LoadAddress: SPI drive memory, type E^2PROM
RunAddress: RAM drive memory

Type

TML program	On-line
X	**–**

Binary code

INITCAM LoadAddress, RunAddress

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0
Load address															
Run address															

Description

The INITCAM instruction copies the selected CAM Table from the drives' E2ROM memory to the drives' RAM memory where the CAM Table must reside while electronic camming is enabled.

The LoadAddress represents the address (decimal number) of E^2ROM memory where the selected CAM Table was loaded.

The RunAddress parameter (decimal number) specifies address in the RAM memory of the Technosoft drive where the CAM profile Table resides at run-time.
Note that in order to copy a CAM table using this instruction, the following steps must be done:

- The cam must be created or imported before;
- The cam must be selected as an active cam;
- The cam must be downloaded to the drive. The *Download CAM files* command downloads into the drives' E^2ROM memory all the active cams selected;
- The cam must be selected from the Use Table list of cams available into the E^2ROM memory.

Execution

Copy CAM table from drive's SPI memory to drive's RAM memory.

Example

```
INITCAM 18864,2560;    //Copy CAM table from SPI memory
                       //(address 0x49B0) to RAM memory
                       //(address 0xA00)
UPD;                   // Update immediate
```

Name	**MODE CS**	Set cam slave mode *(Motion mode group)*

Syntax

MODE CS0	Set axis in **MODE C**amming **S**lave **0** ()
MODE CS1	Set axis in **MODE C**amming **S**lave **1** (T)
MODE CS2	Set axis in **MODE C**amming **S**lave **2** (S)
MODE CS3	Set axis in **MODE C**amming **S**lave **3** (S,T)

Operands –

Type

TML program	On-line
X	**X**

Binary code

MODE CS0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	0	0	1	1	0	0	0	1	1	0
1	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0

MODE CS1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	0	1	1	1	0	0	0	1	1	0
1	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0

MODE CS2

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	1	0	1	1	0	0	0	1	1	0
1	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0

MODE CS3

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	1	1	1	1	0	0	0	1	1	0
1	0	0	0	0	1	1	1	0	0	0	0	0	1	1	0

Description **MODE CS0/CS1/CS2/CS3** instruction set the axis to operate in the slave camming mode.

In this mode, the reference values received from the master are differentiated and used to obtain the position reference for the slave axis based on the active CAM Table.

See Motion Programming chapter for details about camming reference parameters and implementation.

Depending on the selected option (CS0, CS1, CS2 or CS3), some of the internal control loops – speed and current – are activated or not (depending on the system structure) – see below table.

Note that for all the control loops needed to implement the selected mode (position [, speed] [, current]), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the slave camming mode operation for the axis (reference type). Four cases are possible:

MODE	Position controller	Speed controller	Current controller
CS0	√	-	-
CS1	√	-	√
CS2	√	√	-
CS3	√	√	√

Example

```
EXTREF 0;
EIR = 0x081A;
(EIR),dm = 2000;
EIR = 0x081B;
(EIR),dm = 0;
MODE CS3;        //Set as slave, position mode 3
TUM1;            //Set Target Update Mode 1
UPD;             //Update immediate
EFLEVEL = 0;     //Activate synchronization
```

Name	MODE GS	Set gear slave mode
		(Motion mode group)

Syntax

MODE GS0	Set axis in **MODE G**ear **S**lave **0** ()
MODE GS1	Set axis in **MODE G**ear **S**lave **1** (T)
MODE GS2	Set axis in **MODE G**ear **S**lave **2** (S)
MODE GS3	Set axis in **MODE G**ear **S**lave **3** (S,T)

Operands –

Type

TML program	On-line
X	X

Binary code

MODE GS0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	0	0	1	1	0	0	0	1	0	1
1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1

MODE GS1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	0	1	1	1	0	0	0	1	0	1
1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1

MODE GS2

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	1	0	1	1	0	0	0	1	0	1
1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1

MODE GS3

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	1	1	1	1	1	0	0	0	1	0	1
1	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1

Description **MODE GS0/GS1/GS2/GS3** instruction set the axis to operate in the slave gear mode. In this mode, the reference values must be sent from the master and stored into the variable `MREF`. Multiplied with the parameter `GEAR`, these values will be used as position reference for the axis.

See Motion Programming chapter for details about gearing reference parameters and implementation.

Depending on the selected option (GS0, GS1, GS2 or GS3), some of the internal control loops – speed and current – are activated or not (depending on the system structure).

Note that for all the control loops needed to implement the selected mode (position [, speed] [, current]), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the slave gear mode operation for the axis (reference type). Four cases are possible:

MODE	Position controller	Speed controller	Current controller
GS0	√	-	-
GS1	√	-	√
GS2	√	√	-
GS3	√	√	√

Example

```
GEAR = 2.00000;
GEARMASTER = 1;       //Gearing factor for master axis
GEARSLAVE = 2;        //Gearing factor for slave axis
EXTREF 0;         //Set axis as Gear Slave without read
                  //master position from 2nd Encoder Input
EIR = 0x081A;
(EIR),dm = 2000;
EIR = 0x081B;
(EIR),dm = 0;
MODE GS3;             //Set as slave, position mode 3
UPD;                  //Update immediate (enable gear mode)
EFLEVEL = 0xFFFF;     //Deactivate synchronization
```

Name	MODE PC	Position contouring motion mode *(Motion mode group)*

Syntax

MODE PC0	**MODE P**osition **C**ontouring **0** ( )
MODE PC1	**MODE P**osition **C**ontouring **1** (T)
MODE PC2	**MODE P**osition **C**ontouring **2** (S)
MODE PC3	**MODE P**osition **C**ontouring **3** (S,T)

Operands –

Type

TML program	On-line
X	X

Binary code

MODE PC0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	0	0	1	1	0	0	0	0	1	0
1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0

MODE PC1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	0	1	1	1	0	0	0	0	1	0
1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0

MODE PC2

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	0	1	1	0	0	0	0	1	0
1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0

MODE PC3

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	1	1	1	0	0	0	0	1	0
1	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0

Description **MODE PC0/PC1/PC2/PC3** instruction defines the position control operating in the contouring reference motion mode.

In this mode, the reference module will perform linear interpolation based on motion segments, described using the SEG instruction.

The reference will represent a position reference value in position control structures. The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about contouring reference parameters and implementation.

Depending on the selected option (PC0, PC1, PC2 or PC3), some of the internal control loops – speed and current – are activated or not (depending on the system structure).

Note that for all the control loops needed to implement the selected mode (position [, speed] [, current]), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the position contouring motion mode. Four cases are possible:

MODE	Position / User controller	Speed controller	Current controller
PC0	√	-	-
PC1	√	-	√
PC2	√	√	-
PC3	√	√	√

Example

```
MODE PC3;               //Set Position Contouring Mode 3
SEG 100U, 5.00000;      //Set 1st motion segment. Increment
                        //position reference with 5 counts for
                        //the next 100 sampling periods
UPD;                    //Update immediate
SEG 100U, 5.00000;      //Set 2st motion segment.
SEG 100U, -20.00000;    //Set 3st motion segment.
SEG 100U, 10.00000;     //Set 4st motion segment.
SEG 0, 0.;              //End of contouring mode
```

Name	**MODE PE**	Position external motion mode *(Motion mode group)*

Syntax

MODE PE0	**MODE P**osition **E**xternal **0** ( )
MODE PE1	**MODE P**osition **E**xternal **1** (T)
MODE PE2	**MODE P**osition **E**xternal **2** (S)
MODE PE3	**MODE P**osition **E**xternal **3** (S,T)

Operands –

Type

TML program	On-line
X	**X**

Binary code

MODE PE0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0
1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

MODE PE1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	0
1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0

MODE PE2

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	0	1	1	0	0	0	0	0	0
1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0

MODE PE3

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0

Description **MODE PE0/PE1/PE2/PE3** instruction defines the position control operating in the external reference motion mode.

In this mode, the reference module will use an external reference, as previously defined by the EXTREF instruction.

The reference will represent a position reference value, in position control structures. The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about external reference parameters and implementation.

Depending on the selected option (PE0, PE1, PE2 or PE3), some of the internal control loops – speed and current – are activated or not (depending on the system structure).

Note that for all the control loops needed to implement the selected mode (position [, speed] [, current]), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the position external motion mode (reference type). Four cases are possible:

MODE	Position controller	Speed controller	Current controller
PE0	√	-	-
PE1	√	-	√
PE2	√	√	-
PE3	√	√	√

Example

```
MODE PE3;   // set position external mode, with speed and
            // current loops active
TUM1;       // set target update mode 1
UPD;        // update immediate
```

Name	**MODE PP**	Position profile motion mode *(Motion mode group)*

Syntax

MODE PP0	**MODE P**osition **P**rofile **0** ( )
MODE PP1	**MODE P**osition **P**rofile **1** (T)
MODE PP2	**MODE P**osition **P**rofile **2** (S)
MODE PP3	**MODE P**osition **P**rofile **3** (S,T)

Operands –

Type

TML program	On-line
X	**X**

Binary code

MODE PP0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	0	0	1	1	0	0	0	0	0	1
1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1

MODE PP1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	0	1	1	1	0	0	0	0	0	1
1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1

MODE PP2

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	0	1	1	0	0	0	0	0	1
1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1

MODE PP3

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	1
1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1

Description **MODE PP0/PP1/PP2/PP3** instructions define the position control operating in the profile reference motion mode. In this mode, the reference module will generate a position value with a trapezoidal speed profile.

The reference will represent a position reference value. The reference will be generated in the slow control loop (position/speed loop). See Motion Programming chapter for details about profile reference parameters and implementation.

Depending on the selected option (PP0, PP1, PP2 or PP3), some of the internal control loops – speed and current – are activated or not (depending on the system structure) – see below table.

Note that for all the control loops needed to implement the selected mode (position [, speed] [, current]), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the position profile motion mode (reference type). Four cases are possible:

MODE	Position controller	Speed controller	Current controller
PP0	√	-	-
PP1	√	-	√
PP2	√	√	-
PP3	√	√	√

Example

```
CACC = 0.5;           //Acceleration command for position
                      //profile (counts/sampling²)
CSPD = 20;            //Speed command for position profile
                      //(counts/sampling)
CPOS = 100000;        //Position command (counts)
CPA;                  //Position command is Absolute
MODE PP3;             //Set Position Profile Mode 3
TUM1;                 //Set Target Update Mode 1
UPD;                  //Update immediate
```

Name	**MODE PPD**	Position pulse&direction motion mode *(Motion mode group)*

Syntax

MODE PPD0	**MODE P**osition **E**xternal **0** ( )
MODE PPD1	**MODE P**osition **E**xternal **1** (T)
MODE PPD2	**MODE P**osition **E**xternal **2** (S)
MODE PPD3	**MODE P**osition **E**xternal **3** (S,T)

Operands –

Type

TML program	On-line
X	**X**

Binary code

MODE PPD0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	0	0	1	1	0	0	0	1	0	0
1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0

MODE PPD1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	0	1	1	1	0	0	0	1	0	0
1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0

MODE PPD2

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	0	1	1	0	0	0	1	0	0
1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0

MODE PPD3

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	0
1	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0

Description **MODE PPD0/PPD1/PPD2/PPD3** instruction defines the position control operating in the pulse and direction reference motion mode.

In this mode, the reference module will get the reference values from the specific pulse and direction interface of the DSP.

The reference will represent a position reference value, in position control structures. The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about pulse and direction reference parameters and implementation.

Depending on the selected option (PPD0, PPD1, PPD2 or PPD3), some of the internal control loops – speed and current – are activated or not (depending on the system structure) – see below table.

Note that for all the control loops needed to implement the selected mode (position [, speed] [, current]), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the position / user pulse & direction motion mode (reference type). Four cases are possible:

MODE	Position controller	Speed controller	Current controller
PPD0	√	-	-
PPD1	√	-	√
PPD2	√	√	-
PPD3	√	√	√

Example

```
MODE PPD3;      //Set   Position   mode   3   with   Pulse   &
Direction
                //reference
UPD;            //Update immediate
```

Name	**MODE SC**	Speed contouring motion mode *(Motion mode group)*

Syntax

MODE SC0	**MODE S**peed **C**ontouring **0** ( )
MODE SC1	**MODE S**peed **C**ontouring **1** (T)

Operands –

Type

TML program	On-line
X	**X**

Binary code

MODE SC0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	0	1	0	1	1	0	0	0	0	1	0
1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0

MODE SC1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	0	1	1	1	1	0	0	0	0	1	0
1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0

Description **MODE SC0/SC1** instruction defines the speed control operating in the contouring reference motion mode.

In this mode, the reference module will perform linear interpolation based on motion speed segments described using the SEG instruction. The reference will represent a speed reference value, in speed control structures. The reference is generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about contouring reference parameters and implementation.

Depending on the selected option (SC0, SC1), the internal current control loop – is activated/deactivated (depending on the system structure).

Note that if the current control loop is needed to implement the selected mode (MODE SC1), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the speed contouring motion mode (reference type). Two cases are possible:

MODE	Current controller
SC0	**-**
SC1	√

Example

```
MODE SC1;              //Set Speed Contouring Mode 1
TUM1;                  //Set Target Update Mode 1
 SEG 100U, 5.00000;    //Set 1st motion segment. Increment
                   //speed reference with 5 counts/sampling
                   //for the next 100 sampling periods
 UPD;                  //Update immediate
 SEG 100U, 5.00000;    //Set 2st motion segment.
 SEG 200U, -10.00000;  //Set 3st motion segment.
 SEG 100U, -10.00000;  //Set 4st motion segment.
 SEG 200U, 10.00000;   //Set 5st motion segment.
 SEG 0, 0.;             //End of contouring mode
```

Name	**MODE SE**	Speed external motion mode *(Motion mode group)*

Syntax

MODE SE0	**MODE S**peed **E**xternal **0** ( )
MODE SE1	**MODE S**peed **E**xternal **1** (T)

Operands –

Type

TML program	On-line
X	**X**

Binary code

MODE SE0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0
1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

MODE SE1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0
1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0

Description **MODE SE0/SE1** instruction defines the speed control operating in the external reference motion mode.

In this mode, the reference module will use an external reference, as previously defined by the EXTREF instruction. The reference will represent a speed reference value, in speed control structures. The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about external reference parameters and implementation.

Depending on the selected option (SE0, SE1), the internal current control loop is activated or not (depending on the system structure).

Note that if the current control loop is needed to implement the selected mode (MODE SE1), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the speed external motion mode (reference type). Two cases are possible:

MODE	Current controller
SE0	–
SE1	√

Example

```
MODE SE1 ;       //Set Speed External Mode 1
UPD;             //Update immediate
```

Name	**MODE SP**	Speed profile motion mode *(Motion mode group)*

Syntax

MODE SP0 — **MODE S**peed **P**rofile **0** ( )
MODE SP1 — **MODE S**peed **P**rofile **1** (T)

Operands –

Type

TML program	On-line
X	X

Binary code

MODE SP0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	0	1	0	1	1	0	0	0	0	0	1
1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1

MODE SP1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	0	1	1	1	1	0	0	0	0	0	1
1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1

Description **MODE SP0/SP1** instruction defines the speed control operating in the profile reference motion mode.

In this mode, the reference module will generate a ramp speed profile. The reference will represent a speed reference value, in speed control structures. The reference is generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about speed profile reference parameters and implementation.

Depending on the selected option (SP0, SP1), the internal current control loop is activated or not (depending on the system structure).

Note that if the current control loop is needed to implement the selected mode (MODE SP1), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the speed profile motion mode (reference type). Two cases are possible:

MODE	Current controller
SP0	-
SP1	√

Example:

```
CACC = 0.5;       //Acceleration command for speed profile
                  //(counts/sampling²)
CSPD = -20;       //Speed command (counts/sampling)
MODE SP1;         //Set Speed Profile Mode 1
UPD;              //Update immediate
```

Name	**MODE SPD**	Speed pulse & direction motion mode *(Motion mode group)*

Syntax

MODE SPD0	**MODE S**peed **E**xternal **0** ( )
MODE SPD1	**MODE S**peed **E**xternal **1** (T)

Operands –

Type

TML program	On-line
X	X

Binary code

MODE SPD0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	0	1	0	1	1	0	0	0	1	0	0
1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0

MODE SPD1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	0	1	1	1	1	0	0	0	1	0	0
1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0

Description **MODE SPD0/SPD1** instruction defines the speed control operating in the pulse and direction reference motion mode.

In this mode, the reference module will get the reference values from the specific pulse and direction interface of the DSP.
The reference will represent a speed reference value, in speed control structures.
The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about pulse and direction reference parameters and implementation.

Depending on the selected option (SPD0, SPD1), the internal current control loop is activated or not (depending on the system structure).

Note that if the current control loop is needed to implement the selected mode (MODE SPD1), one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the speed pulse & direction motion mode (reference type). Two cases are possible:

MODE	Current controller
SPD0	**-**
SPD1	√

Example

```
MODE SPD1;       //Set Speed mode 1 with Pulse & Direction
                 //reference
UPD;             //Update immediate
```

Name	MODE TC	Torque contouring motion mode *(Motion mode group)*

Syntax

MODE TC — **MODE T**orque **C**ontouring

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	1	1	1	0	0	0	0	1	1
1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1

Description **MODE TC** instruction defines the torque control operating in the contouring reference motion mode.

In this mode, the reference module will perform linear interpolation based on motion speed segments, described using the SEG instruction. The reference will represent a torque reference value, in torque control structures.

The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about contouring reference parameters and implementation.

Note that the current control loop is needed to implement the selected mode, thus one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the torque contouring motion mode (reference type).

Example

```
MODE TC;                //Set Torque Contouring Mode 1
REF0 = 0.00000;         //Initial reference
SEG 200U, 2.00000;;     //Set 1st motion segment. Increment
                        //torque reference with 2 bits for the
                        //next 200 sampling periods
 UPD;                   //Update immediate
 SEG 100U, -1.00000;    //Set 2st motion segment.
 SEG 200U, 0.00000;     //Set 3st motion segment.
 SEG 100U, -1.00000;    //Set 4st motion segment.
```

```
SEG 0, 0.;              //End of contouring mode
```

Name	MODE TEF, TES	Torque external motion mode *(Motion mode group)*

Syntax

MODE TEF **MODE T**orque **E**xternal **F**ast
MODE TES **MODE T**orque **E**xternal **S**low

Operands –

Type

TML program	On-line
X	**X**

Binary code

MODE TEF

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	1	1	1	1	0	0	0	0	0
1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0

MODE TES

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	1	1	1	0	0	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Description **MODE TEF/TES** instruction defines the torque control operating in the external reference motion mode.

If **MODE TEF** is set, the reference module will always use only the analogue reference input. In **MODE TES** there are also possible the other external modes as previously defined by the EXTREF instruction. The reference will represent a torque reference value, in torque control structures.

See Motion Programming chapter for details about external reference parameters and implementation.

Depending on the selected option (TEF or TES), the reference is generated in the fast control loop or in the slow control loop. This is based to the fact that normally, an external torque reference needs to be updated in the fast control loop (where the current controllers are activated).

Note that the current control loop is needed to implement the selected mode, thus one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the torque external motion mode (reference type). Two cases are possible:

MODE	Reference location
TEF	In the fast loop
TES	In the slow loop

Example

```
MODE TEF;        //Set Torque External reference in
                 //fast loop
UPD;             //Update immediate
```

Name	**MODE TT**	Torque test motion mode *(Motion mode group)*

Syntax

MODE TT — **MODE T**orque **T**est

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	1	1	1	0	0	1	0	0	0
1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0

Description **MODE TT** instruction defines the torque test operating motion mode. In this mode, the reference module will use the values of specific variables, allowing the generation of a saturated ramp or a constant value for the amplitude of the torque / current and for the electric angle of the motor.

Thus, one can apply a constant or a rotating current vector to the motor, for test or control loops tuning purposes.
The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about test reference parameters and implementation.

Note that the current control loop is needed to implement the selected mode, thus one must define the corresponding parameters.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the torque test motion mode (reference type).

Example

```
MODE TT;          //Set Torque Test Mode
REFTST = 40;      //Reference saturation value in test mode
                  //(bits)
RINCTST = 1;      //Reference increment value in test mode
                  //(bits/sampling)
UPD;              //Update immediate
```

Name	MODE VC	Voltage contouring motion mode *(Motion mode group)*

Syntax

MODE VC **MODE V**oltage **C**ontouring

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	0	1	1	0	0	0	0	1	1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Description **MODE VC** instruction defines the voltage control operating in the contouring reference motion mode.

In this mode, the reference module will perform linear interpolation based on motion speed segments described using the SEG instruction.

The reference will represent a voltage reference value, in voltage control structures. The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about contouring reference parameters and implementation.

Note that no control loop is needed to implement the selected mode.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the voltage contouring motion mode (reference type).

Example

```
MODE VC;               //Set Voltage Contouring
REF0 = 0.00000;        //Initial reference
SEG 100U, 12.00000;    //Set 1st motion segment. Increment
                       //voltage reference with 12 bits for
                       //the next 100 sampling periods
UPD;                   //Update immediate
SEG 100U, 3.00000;     //Set 2st motion segment.
SEG 100U, -15.00000;   //Set 3st motion segment.
SEG 0, 0.;             //End of contouring mode
```

Name	**MODE VEF, VES**	Voltage external motion mode *(Motion mode group)*

Syntax

MODE VEF	**MODE V**oltage **E**xternal **F**ast
MODE VES	**MODE V**oltage **E**xternal **S**low

Operands –

Type

TML program	On-line
X	**X**

Binary code

MODE VEF

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

MODE VES

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description **MODE VEF/VES** instructions define the voltage control operating in the external reference motion mode.

If **MODE VEF** is set, the reference module will always use only the analogue reference input. In **MODE VES** there are also possible the other external modes as previously defined by the EXTREF instruction.

The reference will represent a voltage reference value, in voltage control structures. See Motion Programming chapter for details about external reference parameters and implementation.

Depending on the selected option (VEF or VES), the reference is generated in the fast control loop or in the slow control loop.

Note that no control loop is needed to implement the selected mode.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the voltage external motion mode (reference type). Two cases are possible:

MODE	Reference location
VEF	In the fast loop
VES	In the slow loop

Example

```
MODE VES;  //MODE Voltage External reference in slow loop
UPD;       //Update immediate
```

Name	**MODE VT**	Voltage test motion mode *(Motion mode group)*

Syntax

MODE VT — **MODE V**orque **T**est

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	0	0	0	0	1	1	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Description **MODE VT** instruction defines the voltage test operating motion mode. In this mode, the reference module will use the values of specific variables, allowing the generation of a saturated ramp or a constant value for the amplitude of the voltage and for the electric angle of the motor.

Thus, one can apply a constant or a rotating voltage vector to the motor, for test purposes.
The reference will be generated in the slow control loop (position/speed loop).

See Motion Programming chapter for details about test reference parameters and implementation.

Note that no control loop is needed to implement the selected mode.

The selected motion mode will become effective at the first motion update command (immediate update – UPD, or update on event, UPD!).

Execution Sets the voltage test motion mode (reference type).

Example

```
MODE VT;          //Set Voltage Test Mode
REFTST = 15;      //Reference saturation value in test mode
                  //(bits)
RINCTST = 4;      //Reference increment value in test mode
                  //(bits/sampling)
UPD;              //Update immediate
```

Name	**NOP**	No operation *(Miscellaneous group)*

Syntax

NOP **N**o **O**peration

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description **NOP** instruction can be used to introduce a delay between two instructions. It also can be used as a labeled instruction for GOTO instructions.

Execution No operation is executed. The TML program will continue with the next instruction.

Example

```
CACC = 0.5;      //Acceleration command for speed profile
                 //(counts/sampling²)
CSPD = -20;      //Speed command (counts/sampling)
MODE SP1;        //Set Speed Profile Mode 1
UPD;             //Update immediate
CSPD = 30.;      //  New  jog  speed  command  for  the  next
update
UPD;             // on-the-fly change of jog speed, during
                 //motion
LOOP:
NOP;             // no operation
GOTO LOOP;       // infinite loop, exit only by RESET or a
                 //TML interrupt
```

Name	**OUTPORT**	Output to user port *(I/O group)*

Syntax

OUTPORT *VAR16* — **OUT**put *VAR16* value to IO**PORT**

Operands *VAR16*: integer variable

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	0	1	1	0	(9LSBs of &*VAR16*)								

Description The **OUTPORT** instruction sends a 16-bit value to the user output port. *VAR16* variable can be any of the TML or user variables.

See details about user output I/O port according to the drive.

Execution The 16-bit value of *Var16* is send to the user output port.

Example

```
int Var1;
Var1 = 0x1255;   // setup Var1 variable
OUTPORT Var1;    // output Var1 value to user port
```

Name	**RAOU**	Reset automatic origin update *(Configuration and command group)*

Syntax

RAOU **R**eset **A**utomatic **O**rigin **U**pdate

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description The **RAOU** instruction resets the automatic origin update mode. In this case, the variable POS0 is not changed at event occurrence, and needs to be initialized by the user. For successive motions, the event tests for relative position will be based on the same value of the POS0 parameter. Use instruction SAOU in order to automatically update variable POS0 after each detected event.

Execution Resets the automatic origin update.

Example

```
CACC = 0.5;      //Acceleration command for position profile
                 //(counts/sampling²)
CSPD = 20;       //Speed command for position profile
                 //(counts/sampling)
CPOS = 80000;    //Position command (counts)
CPA;             //Position command is Absolute
MODE PP3;        //Set Position Profile Mode 3
UPD;             //Update immediate
RAOU ;           // Reset automatic update mode
POS0 = APOS;     //Store the actual position as reference
UPD;             //Update immediate
CSPD = 40;       //New speed command for position profile
                 //(counts/sampling)
!RPO 20000;      //Set event when relative position >= 20000
                 //(bits)
UPD!;            //Update on event
```

Name	REMGRID	Remove group ID *(Multiple axis group)*

Syntax

REMGRID *value16* Remove value16 from **GROUP ID**
REMGRID *VAR16* Remove value of VAR16 from **GROUP ID**

Operands *value16*: 16-bit integer immediate value
VAR16: integer variable

Type

TML program	On-line
X	**X**

Binary code

REMGRID value16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Value16															

REMGRID VAR16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0
&VAR16															

Description In multiple axis structures, this command allows one to remove a group ID of the local axis.

After the execution of this command, the group ID value removed is no more recognized by the axis and the communication drivers will reject messages addressed to the removed group ID.

Only the lower 8 bits of the *value16* or *VAR16* parameters are used for group coding. Each bit corresponds to a group. Up to 8 groups can be defined/added/removed in a multiple axis structure.

An axis can belong to any of the 8 groups.
A multiple-axis message can be addressed to one axis or to a group of axes.

Execution Delete Group_ID with the specified value from the Group_Ids of the local axis.

Example

```
GROUPID 1;       //local axis belongs to groups 1
ADDGRID 2;       //local axis belongs to groups 1 and 2
ADDGRID 5;       //local axis belongs to groups 1, 2 and 5
REMGRID 2;       //from now on, the local axis belongs only
                 //groups 1 and 5
```

Name	**RESET**	Reset the DSP processor *(Configuration and command group)*

Syntax

RESET — **R**eset DSP processor

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0

Description The **RESET** instruction resets the DSP processor. After this instruction the complete TML environment is reinitialized. The following basic initializations are performed:

- The TML registers and parameters are initialized with their default values;
- Based on these values, and some hardware tests, the basic hardware initializations are also performed;
- The TML environment detects if an external memory is installed on the SPI interface, by identifying a valid TML command at the start address of this memory;
- If such a program is detected, it is executed; otherwise, an infinite loop is executed and only an on-line TML command will change this status.

Execute such a command in order to exit from a malfunctioning situation, when the system does not operate correspondingly.

This instruction can be used also from a TML interrupt or when detecting an error in the motion system operation (protections, control error, etc.).

Execution Resets the DSP processor.

Example

```
CACC = 0.5;      //Acceleration command for position profile
                 //(counts/sampling^2)
CSPD = 20;       //Speed command for position profile
                 //(counts/sampling)
CPOS = 70000;    //Position command (counts)
CPA;             //Position command is Absolute
MODE PP3;        //Set Position Profile Mode 3
UPD;             //Update immediate
!MC;             //Set event when MotionComplete
WAIT!;           //WAIT until event occurs
RESET;           //After motion complete, reset the system
```

Name	RET	Return from a TML function *(Decision group)*

Syntax

RET Unconditional **RET**urn from a TML function

Operands –

Type

TML program	On-line
X	**–**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0

Description This instruction allows the return from a TML function (subroutine). Specific sequences can be called from different points of the TML program. The RET instruction may be used to end the execution of a function and to continue the TML sequence following the CALL instruction.

Execution Returns from a TML function.

TOS -> IP

Example

```
int my_pos;
my_pos = 2000;
CALL MOVEP;                    //Execute a first motion of 2000
                               //counts
my_pos = 4000;

CALL MOVEP, ASPD, GT;   //Execute a second motion of 4000
                        //counts, if motor speed > 0
. . .

MOVEP:            //Function to move up to a specified
                        //position
      CACC = 1.5;      //Acceleration command for position
                       //profile (counts/sampling^2)
      CSPD = -20;      //Speed command for position profile (
                       //counts/sampling)
      CPOS = my_pos;   //Position command (counts)
      UPD;             //Update immediate
      RET;             //Exit from function MOVEP
```

Name	**RETI**	Return from a TML interrupt function *(Decision group)*

Syntax

RETI **RET**urn from a TML **I**nterrupt function

Operands –

Type

TML program	On-line
X	**–**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0

Description This instruction allows the return from a TML interrupt service routine.
When a TML interrupt service routine is entered, a specific TML sequence is executed.
The return from interrupt instruction will be used to end the execution of the interrupt function and to continue the TML sequence that was interrupted.

Execution Returns from a TML interrupt function.
Enables TML interrupts (they were disabled at the start of the TML interrupt service routine);
TOS -> IP;

Example

```
// test TML interrupts
int u_var, dt ;
fixed dp;

BEGIN;                          // start the TML program
INTTABLE = InterruptTable;      // locate the interrupt vector
ENDINIT;                        // global system settings
AXISON;                         // activate control
SAP 0;                          // set actual position value
u_var = 19;

SRB ICR, 4095, 4095;            // set interrupt masks
CACC = 0.5;                     // set acceleration
CSPD = 30.;                     // set speed
SP1                             //Set Speed Profile Mode 1
UPD;                            // start the motion
EINT ;                          // enable interrupts
lb1 :
GOTO lb1, u_var, GT;            // loop while u_var > 0
```

```
My_flag = u_var;            // this instruction is executed
                            //after an interrupt
GOTO lb1, u_var, GT;        // again in the infinite loop if
                            //u_var > 0
END;                        // end the TML program after
                            //motion complete

Int0_Disable:               // [level 0: disable] interrupt
                            //function
     u_var = 100;
     RETI;
Int1_PDPINT:                // [level 1: PDPINT] interrupt
                            //function
     u_var = 101;
     RETI;
Int2_SoftProtection:        // [level 2: Software
                            //protection] interrupt function
     u_var = 102;
     RETI;
Int3_ControlError:          // [level 3: Control error]
                            //interrupt function
     u_var = 103;
     RETI;
Int4_CommError:       // [level 4: Communication error]
                      //interrupt function
     u_var = 104;
     RETI;
Int5_WrapAround:      // [level 5: Wrap Around] interrupt
                      //function
     u_var = 105;
     RETI;
Int6_LimitSwitchP:          // [level 6: Positive limit
                            //switch] interrupt function
     u_var = 106;
     RETI;
Int7_LimitSwitchM:          // [level 7: Negative limit
                            //switch] interrupt function
     u_var = 107;
     RETI;
Int8_Capture:               // [level 8: Capture] interrupt
                            //function
     CPOS = CAPPOS;
     UPD;
     u_var = 108;
     RETI;
Int9_MotionComplete:        // [level 9: Motion complete]
                            //interrupt function
     UPD;
     u_var = -109 ;
     RETI ;
```

```
Int10_UpdateContourSeg:  //[level   10:   Update   contour
                         //segment] interrupt function
     dp = -dp;
     SEG dt, dp;
     u_var = 110;
     RETI;
Int11_EventReached:        // [level 11: Event reached]
                           //interrupt function
     CPOS = -20000;
     UPD;
     u_var = 111;
     RETI;

IntVect:                   // interrupt vector table
     @Int0_Disable;        // pointer to level 0 interrupt
     @Int1_PDPINT;         // pointer to level 1 interrupt
     @Int2_SoftProtection; // pointer to level 2 interrupt
     @Int3_ControlError;   // pointer to level 3 interrupt
     @Int4_CommError;      // pointer to level 4 interrupt
     @Int5_WrapAround;     // pointer to level 5 interrupt
     @Int6_LimitSwitchP;   // pointer to level 6 interrupt
     @Int7_LimitSwitchM;   // pointer to level 7 interrupt
     @Int8_Capture;        // pointer to level 8 interrupt
     @Int9_MotionComplete; // pointer to level 9 interrupt
     @Int10_UpdateContourSeg; // pt. To level 10 interrupt
     @Int11_EventReached; // pointer to level 11 interrupt
```

Name	**RGM**	Reset gear/cam master mode *(Configuration and Command group)*

Syntax

RGM — **R**eset axis as **G**ear/Cam **M**aster

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description **RGM** instruction resets the axis from the electronic gearing/camming master operation mode. In this mode, the reference values will be generated only locally.

The axis does not send its position information to the slave axes, but use it only locally.

See Motion Programming chapter for details about gearing reference parameters and implementation.

Execution Resets the axis from the gear/cam master operation mode.

Example

```
RGM;     //exit from master mode; enter in local mode
```

Name	**ROUT**	Reset output bit-port *(I/O group)*

Syntax

ROUT#n **R**eset **OUT#***n to low state (0)*

Operands *n*: number of output bit-port 0<=n<=39)

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
PxDATDIR															
ANDrst															
ORrst															

Description **ROUT#n** instruction resets the output status of the bit-port (IO line) number *n*. Note that the bit-port must be defined as an output port (using the SETIO#n OUT instruction).

Execution Resets the output bit-port number *n*.

Example

```
SETIO#13 OUT;          //Set IO line 13 as output
ROUT#13;               //Reset the IO line 13
```

AND/OR masks for ROUT#n

PxDATDIR	#n	ANDrst	ORrst
0X7098	#0	0xFFFE	0x0000
0X07098	#1	0xFFFD	0x0000
0X7098	#2	0xFFFB	0x0000
0X7098	#3	0xFFF7	0x0000
0X7098	#4	0xFFEF	0x0000
0X7098	#5	0xFFDF	0x0000
0X7098	#6	0xFFBF	0x0000
0X7098	#7	0xFF7F	0x0000
0X709A	#8	0xFFFE	0x0000
0X709A	#9	0xFFFD	0x0000
0X709A	#10	0xFFFB	0x0000
0X709A	#11	0xFFF7	0x0000
0X709A	#12	0xFFEF	0x0000
0X709A	#13	0xFFDF	0x0000
0X709A	#14	0xFFBF	0x0000
0X709A	#15	0xFF7F	0x0000
0X709C	#16	0xFFFE	0x0000
0X709C	#17	0xFFFD	0x0000
0X709C	#18	0xFFFB	0x0000
0X709C	#19	0xFFF7	0x0000

PxDATDIR	#n	ANDrst	ORrst
0X709C	#20	0xFFEF	0x0000
0X709C	#21	0xFFDF	0x0000
0X709C	#22	0xFFBF	0x0000
0X709C	#23	0xFF7F	0x0000
0X709E	#24	0xFFFE	0x0000
0X7095	#25	0xFFFE	0x0000
0X7095	#26	0xFFFD	0x0000
0X7095	#27	0xFFFB	0x0000
0X7095	#28	0xFFF7	0x0000
0X7095	#29	0xFFEF	0x0000
0X7095	#30	0xFFDF	0x0000
0X7095	#31	0xFFBF	0x0000
0X7095	#32	0xFF7F	0x0000
0X7096	#33	0xFFFE	0x0000
0X7096	#34	0xFFFD	0x0000
0X7096	#35	0xFFFB	0x0000
0X7096	#36	0xFFF7	0x0000
0X7096	#37	0xFFEF	0x0000
0X7096	#38	0xFFDF	0x0000
0X7096	#39	0xFFBF	0x0000

Name	SAOU	Set automatic origin update *(Configuration and command group)*

Syntax

SAOU **R**eset **A**utomatic **O**rigin **U**pdate

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Description The **SAOU** instruction sets the automatic origin update mode. In this case, the variable POS0 is changed at an UPDATE event occurrence, and needs not to be initialized by the user. For successive motions, the event tests for relative position will be based on the updated values of the POS0 parameter. Use instruction RAOU in order to manually update variable POS0.

Execution Sets the automatic origin update.

Example

```
CACC = 0.5;       //Acceleration command for position profile
                  //(counts/sampling²)
CSPD = 20;        //Speed   command   for   position   profile
                  //(counts/sampling)
CPOS = 90000;     //Position command (counts)
CPR;              //Position command is Relative
MODE PP3;         //Set Position Profile Mode 3
SAOU ;            //Set automatic update mode
UPD;              //Update immediate
CSPD = 40;        //New speed command for position profile
                  //(counts/sampling)
!RPO 20000;       //Set event when relative position >= 20000
                  //i.e.  when  motor  position  has  done  20000
                  // counts
UPD!;             //Update on event
WAIT!;            //Wait event to occur
```

Name	SAP	Set actual position *(Configuration and command group)*

Syntax

SAP *value32* — **S**et **A**ctual **P**osition to *value32*
SAP *VAR32* — **S**et **A**ctual **P**osition to *VAR32*

Operands *value32*: 32-bit long immediate value
VAR32: long variable

Type

TML program	On-line
X	**X**

Binary code

SAP value32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
LOWORD(*value32*)															
HIWORD(*value32*)															

SAP VAR32

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**0**	**0**	**0**	**0**	**0**	**0**	(9LSBs of &VAR32)								

Description Sets the value of variable APOS (absolute position) with the value *value32* or *VAR32*. Also corrects the reference value, so that the difference between the position reference and the actual position before the setting will be preserved after the change of the absolute position value.

Execution

Depending on the target update mode bit:

If TUM1 is set:

***value32*:**

value32 - old reference + old APOS -> new APOS
value32 -> new reference

***VAR32*:**

VAR32 - old reference + old APOS -> new APOS
VAR32 -> new reference

If TUM0 is set:

***value32*:**

value32 + old reference – old APOS-> new reference
value32 -> new APOS

***VAR32*:**

VAR32 + old reference – old APOS -> new reference
VAR32 -> new APOS

Example

```
CACC = 1.5;     //Acceleration command for speed profile
                //(counts/sampling2)
CSPD = 20;      //Speed command (counts/sampling)
MODE SP1;       //Set Speed Profile Mode 1
UPD;            //Update immediate
SAP 0;          //Set the actual position to 0 (counts)
!APO 60000;     //Set event when absolute position >= 60000
                //(counts)
UPD!;           //Update on event
```

Name	**SCIBR**	Set SCI serial communication baud rate *(Miscellaneous group)*

Syntax

SCIBR *value16* — **S**et **SCI** **B**aud **R**ate to *value16*
SCIBR *VAR16* — **S**et **SCI** **B**aud **R**ate to *VAR16*

Operands *value16*: 16-bit integer immediate value. (0<=*value32*<=4)
VAR16: integer variable

Type

TML program	On-line
X	**X**

Binary code

SCIBR *value16*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Value16															

SCIBR *VAR16*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
&VAR16															

Description Sets the value of SCI serial communication baud rate, based on the value of the input parameter *value16*.
Baud rates range from 9600 to 115200 baud. The default baud rate value of the drive is 9600.

Execution Sets the SCI serial communication baud rate, based on *value16* value:

Value16	**SCI baud rate**
0	9600
1	19200
2	38400
3	56600
4	115200

Example

```
SCIBR 4;          // sets the SCI baud rate to 115200 baud
```

Name	**SEG**	Define a segment for contouring motion mode *(Configuration and command group)*

Syntax

SEG *D_time, D_ref* **SEG**ment *D_time, D_ref*
SEG *VAR16, VAR32* **SEG**ment *VAR16, VAR32*

Operands *D_time*: 16-bit integer immediate value
D_ref: 32-bit long immediate value
VAR32: long variable
VAR16: integer variable

Type

TML program	On-line
X	**–**

Binary code

SEG *D_time, D_ref*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
D_time															
LOWORD(*D_ref*)															
HIWORD(*D_ref*)															

SEG *VAR16, VAR32*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	1	1	1	1	0	(9LSBs of &VAR16)								
&*VAR32*															

Description The **SEG** instruction is used in the contouring mode to generate the reference, describing one of the segments of the contour.

Its parameters represent the number of sampling periods over which that segment will be generated, respectively the value of reference increment added to the actual value of the reference at each sampling moment.

The reference is updated in the slow sampling interrupt routine (position/speed control loop). See Motion Programming chapter for details about contouring reference mode and its parameters.

Execution Generate a segment for the next D_time [VAR16] time samplings, at each sampling increment the reference with D_ref [VAR32].

Example

```
MODE PC3;              //Set Position Contouring Mode 3
SEG 100U, 5.00000;;    //Set 1st motion segment.
UPD;                   //Update immediate
SEG 100U, 5.00000;     //Set 2st motion segment.
SEG 100U, -20.00000;   //Set 3st motion segment.
SEG 100U, 10.00000;    //Set 4st motion segment.
SEG 0, 0.;              //End of contouring mode.
```

Name	**SETIO**	Set bit-port as input or output port *(I/O group)*

Syntax

SETIO#n IN	**SETIO#***n* as **In**put port
SETIO#n OUT	**SETIO#***n* as **OUT**put port

Operands *n*: number of output bit-port 0<=n<=39)

Type

TML program	On-line
X	**X**

Binary code

SETIO#n IN

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
PxDATDIR															
ANDin															
ORin															

SETIO#n OUT

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
PxDATDIR															
ANDout															
ORout															

Description **SETIO#n** instruction defines the operating mode of bit-port number #*n*. Each of the bit-ports can thus be individually defined and used as an input (in assignment instructions having the source operant IN#*n*) or output (in instruction SOUT#*n*) bit-port.

Execution Define the operating mode for bit-port number *n*.

Example

```
int v1;
SETIO#13 OUT;   //Set IO line 13 as output
ROUT#13;        //Reset IO line 13 as output
SETIO#14 IN;    //Set IO line 14 as input
v1 = IN#14;     //Read I/O line 14 data into variable v1
```

	AND/OR masks for SETIO#n IN			AND/OR masks for SETIO#n OUT		
PxDATDIR	**#n**	**ANDin**	**ORin**	**#n**	**ANDout**	**ORout**
0X7098	#0	0xFEFF	0x0000	#0	0xFFFF	0x0100
0X7098	#1	0xFDFF	0x0000	#1	0xFFFF	0x0200
0X7098	#2	0xFBFF	0x0000	#2	0xFFFF	0x0400
0X7098	#3	0xF7FF	0x0000	#3	0xFFFF	0x0800

	AND/OR masks for SETIO#n IN			AND/OR masks for SETIO#n OUT		
PxDATDIR	#n	ANDin	ORin	#n	ANDout	ORout
0X7098	#4	0xEFFF	0x0000	#4	0xFFFF	0x1000
0X7098	#5	0xDFFF	0x0000	#5	0xFFFF	0x2000
0X7098	#6	0xBFFF	0x0000	#6	0xFFFF	0x4000
0X7098	#7	0x7FFF	0x0000	#7	0xFFFF	0x8000
0X709A	#8	0xFEFF	0x0000	#8	0xFFFF	0x0100
0X709A	#9	0xFDFF	0x0000	#9	0xFFFF	0x0200
0X709A	#10	0xFBFF	0x0000	#10	0xFFFF	0x0400
0X709A	#11	0xF7FF	0x0000	#11	0xFFFF	0x0800
0X709A	#12	0xEFFF	0x0000	#12	0xFFFF	0x1000
0X709A	#13	0xDFFF	0x0000	#13	0xFFFF	0x2000
0X709A	#14	0xBFFF	0x0000	#14	0xFFFF	0x4000
0X709A	#15	0x7FFF	0x0000	#15	0xFFFF	0x8000
0X709C	#16	0xFEFF	0x0000	#16	0xFFFF	0x0100
0X709C	#17	0xFDFF	0x0000	#17	0xFFFF	0x0200
0X709C	#18	0xFBFF	0x0000	#18	0xFFFF	0x0400
0X709C	#19	0xF7FF	0x0000	#19	0xFFFF	0x0800
0X709C	#20	0xEFFF	0x0000	#20	0xFFFF	0x1000
0X709C	#21	0xDFFF	0x0000	#21	0xFFFF	0x2000
0X709C	#22	0xBFFF	0x0000	#22	0xFFFF	0x4000
0X709C	#23	0x7FFF	0x0000	#23	0xFFFF	0x8000
0X709E	#24	0xFEFF	0x0000	#24	0xFFFF	0x0100
0X7095	#25	0xFEFF	0x0000	#25	0xFFFF	0x0100
0X7095	#26	0xFDFF	0x0000	#26	0xFFFF	0x0200
0X7095	#27	0xFBFF	0x0000	#27	0xFFFF	0x0400
0X7095	#28	0xF7FF	0x0000	#28	0xFFFF	0x0800
0X7095	#29	0xEFFF	0x0000	#29	0xFFFF	0x1000
0X7095	#30	0xDFFF	0x0000	#30	0xFFFF	0x2000
0X7095	#31	0xBFFF	0x0000	#31	0xFFFF	0x4000
0X7095	#32	0x7FFF	0x0000	#32	0xFFFF	0x8000
0X7096	#33	0xFEFF	0x0000	#33	0xFFFF	0x0100
0X7096	#34	0xFDFF	0x0000	#34	0xFFFF	0x0200
0X7096	#35	0xFBFF	0x0000	#35	0xFFFF	0x0400
0X7096	#36	0xF7FF	0x0000	#36	0xFFFF	0x0800
0X7096	#37	0xEFFF	0x0000	#37	0xFFFF	0x1000
0X7096	#38	0xDFFF	0x0000	#38	0xFFFF	0x2000
0X7096	#39	0xBFFF	0x0000	#39	0xFFFF	0x4000

Name	**SGM**	Set gear master mode *(Configuration and Command group)*

Syntax

SGM **S**et axis as **G**ear/Cam **M**aster

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Description **SGM** instruction sets the axis in the gear/cam master operation mode.

In those modes, the position reference values computed for the master axis (the local axis) will also be sent to the slave axes. The master will use the `SLAVEID` parameter in order to generate the address of slave axes toward which the gearing/camming value is sent.

Depending on the "*Electronic gearing/camming mode*" bit of OSR register (bit 15), the value sent to the slaves is the *master actual position* – `APOS` (if bit 15 of OSR is 0), or the *master target position* – `TPOS` (if bit 15 of OSR is 1).

See Motion Programming chapter for details about gearing reference parameters and implementation.

Execution Sets the axis in the gear/cam master operation mode.

Example

```
SLAVEID = 2;           //ID of the slave axis referenced
SGM;            //Enable Master in Electronic Gearing mode
SRB OSR,0xFFFF,0x8000;  //Set OSR register, 15 bit to send
                       //reference position to slave axis 2
UPD;                   //Update immediate
```

Name	**SOUT**	Set output bit-port *(I/O group)*

Syntax

SOUT#n — **S**et **OUT#***n to high state (1)*

Operands *n*: number of output bit-port 0<=n<=39)

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
PxDATDIR															
ANDset															
ORset															

Execution Sets the output bit-port number *n* to high state.

Description **SOUT#n** instruction sets the output status of the bit-port number *n*.
Note that the bit-port must be defined as an output port (using the SETIO#n OUT instruction).

Example

```
SETIO#13 OUT;   //Set IO line 13 as output
SOUT#13;   //Set High to I/O line 13
```

AND/OR masks for SOUT#n			
PxDATDIR	**#n**	**ANDset**	**ORset**
0X7098	#0	0xFFFF	0x0001
0X7098	#1	0xFFFF	0x0002
0X7098	#2	0xFFFF	0x0004
0X7098	#3	0xFFFF	0x0008
0X7098	#4	0xFFFF	0x0010
0X7098	#5	0xFFFF	0x0020
0X7098	#6	0xFFFF	0x0040
0X7098	#7	0xFFFF	0x0080
0X709A	#8	0xFFFF	0x0001
0X709A	#9	0xFFFF	0x0002
0X709A	#10	0xFFFF	0x0004
0X709A	#11	0xFFFF	0x0008
0X709A	#12	0xFFFF	0x0010
0X709A	#13	0xFFFF	0x0020
0X709A	#14	0xFFFF	0x0040
0X709A	#15	0xFFFF	0x0080
0X709C	#16	0xFFFF	0x0001
0X709C	#17	0xFFFF	0x0002
0X709C	#18	0xFFFF	0x0004
0X709C	#19	0xFFFF	0x0008

PxDATDIR	#n	ANDset	ORset
0X709C	#20	0xFFFF	0x0010
0X709C	#21	0xFFFF	0x0020
0X709C	#22	0xFFFF	0x0040
0X709C	#23	0xFFFF	0x0080
0X709E	#24	0xFFFF	0x0001
0X7095	#25	0xFFFF	0x0001
0X7095	#26	0xFFFF	0x0002
0X7095	#27	0xFFFF	0x0004
0X7095	#28	0xFFFF	0x0008
0X7095	#29	0xFFFF	0x0010
0X7095	#30	0xFFFF	0x0020
0X7095	#31	0xFFFF	0x0040
0X7095	#32	0xFFFF	0x0080
0X7096	#33	0xFFFF	0x0001
0X7096	#34	0xFFFF	0x0002
0X7096	#35	0xFFFF	0x0004
0X7096	#36	0xFFFF	0x0008
0X7096	#37	0xFFFF	0x0010
0X7096	#38	0xFFFF	0x0020
0X7096	#39	0xFFFF	0x0040

Name	**SPIBR**	Set SPI serial communication baud rate *(Miscellaneous group)*

Syntax

SPIBR *value16* — **S**et **SPI B**aud **R**ate to *value16*
SPIBR *VAR16* — **S**et **SPI B**aud **R**ate to *VAR16*

Operands *value16*: 16-bit integer immediate value. (0<=*value32*<=2)
VAR16: integer variable

Type

TML program	On-line
X	**X**

Binary code

SPIBR *value16*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Value16															

SPIBR *VAR16*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
&VAR16															

Description Sets the value of SPI serial communication baud rate, based on the value of the input parameter *value16* or *VAR16*.
Baud rates range from 1 to 5 Mbaud. The default baud rate value is 1 Mb.

Execution Sets the SPI serial communication baud rate, based on *value16* value:

Value16	**SPI baud rate**
0	1 Mb
1	2 Mb
2	5 Mb

Example

```
SPIBR 1;         // sets the SPI baud rate to 2 Mbaud
```

Name	**SRB, SRBL**	Set/reset bits of a variable *(Arithmetic & Logic group)*

Syntax

SRB *VAR16*, *ANDmask, ORmask*	**S**et/**R**eset **B**its of *VAR16*
SRBL *VAR16*, *ANDmask, ORmask*	**S**et/**R**eset **B**its of *VAR16* (long addressing)

Operands

VAR16: integer variable
ANDmask: 16-bit mask for AND operation
ORmask: 16-bit mask for OR operation

Type

TML program	On-line
X	**X**

Binary code

SRB *VAR16*, *ANDmask, ORmask*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**0**	**1**	**1**	**0**	**0**	(9LSBs of &*VAR16*)								
ANDm															
ORm															

SRBL *VAR16*, *ANDmask, ORmask*

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	**1**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
&*VAR16*															
ANDm															
ORm															

Description

This special instruction allows setting and resetting individually each of the bits of a 16-bit variable.

The instruction must be used when needing to perform such operations on TML variables that can be changed during the execution of the real-time motion program. The **SRB** instruction will perform the modification of the bits of variable *VAR16* such that no interference between this modification and possible real-time modification occurs.

Execution

Reset in *VAR16* all the bits that are 0 in the corresponding position of *ANDmask*.
Set in *VAR16* all the bits that are 1 in the corresponding position of *ORmask*.

Example

```
int var1;
...
SRB var1, 0xFF0F, 0x0003;    //Reset bits 4 to 7, set bits 0
                             //and 1 of var1
```

Name	**STA**	Set target position to actual position *(Configuration and command group)*

Syntax

STA **S**et **T**arget position = **A**ctual position

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	1	1	0	0	1	0	1	1	0	0	1	0
0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0

Description **STA** instruction sets the value of the target position (the position reference) to the value of the actual motor position.

This can be useful for example for actualization of the reference during the execution of a given reference profile, when changing "on-the-fly" the reference value allows one to re-start from a 0-error point, the reference generation and motion execution.

Execution APOS -> TPOS

Example

```
MODE PC2;              //Set Position Contouring Mode 2
TUM1;                  //Set target update mode 1
SEG 100U, 5.00000;     //Set 1st motion segment
UPD;                   //Update immediate
SEG 100U, 5.00000;     //Set 2st motion segment.
SEG 100U, -20.00000;   //Set 3st motion segment.
SEG 100U, 10.00000;    //Set 4st motion segment.
SEG 0, 0.;             //End of contouring mode
STA;                   //Set target position value equal to
                       //the actual position value
```

Name	STOP	Stop the motion
		(Configuration and command group)

Syntax

STOP0	**STOP** motion in mode **0**
STOP1	**STOP** motion in mode **1**
STOP2	**STOP** motion in mode **2**
STOP3	**STOP** motion in mode **3**

Operands –

Type

TML program	On-line
X	**X**

Binary code

STOP0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0

STOP1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0

STOP2

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0

STOP3

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0

Description **STOP[0/1/2/3]** instruction imposes a motor stop.
Four different stop modes can be used, as presented in the table bellow.

Execution Stops the motion by applying a specific reference.

When a **STOP** instruction sent on-line is executed it will also contain an **END** instruction after the initialization of the stop mode! The **END** instruction will stop the execution of any current TML program!

If a **STOP** instruction is executed from a TML program, it will only stop the motor.

Four cases are possible:

Stop	Stop method
STOP0	Impose a voltage reference equal to 0 to the motor
STOP1	Impose a current reference equal to 0 to the motor
STOP2	Impose a speed reference equal to 0 to the motor
STOP3	Impose a speed reference equal to 0 to the motor, using the profiles acceleration value to brake

Example

```
CACC = 1.5;      //Acceleration command for position
                  //profile (counts/sampling^2)
CSPD = -20;      //Speed command for position profile
                  //(counts/sampling)
CPOS = -100000;  //Position command (counts)
CPR;              //Position command is Relative
MODE PP3;        //Set Position Profile Mode 3
UPD;             //Update immediate
CSPD = -40;      //New speed command for position profile
                  //(counts/sampling)
!RU -20000;       //Set event if Reference =< -20000
                  //(counts)
WAIT!;           //Wait until event occurs
STOP0;            //Apply 0 voltage reference to the motor
```

Name	**STOP!**	Stop the motion on event *(Configuration and command group)*

Syntax

STOP0!	**STOP** motion in mode **0** on event
STOP1!	**STOP** motion in mode **1** on event
STOP2!	**STOP** motion in mode **2** on event
STOP3!	**STOP** motion in mode **3** on event

Operands –

Type

TML program	On-line
X	**X**

Binary code

STOP0!

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

STOP1!

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0

STOP2!

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0

STOP3!

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0

Description **STOP[0/1/2/3]!** Instruction imposes a motor stop when an event occurs during the motion. Four different stop modes can be used, as presented in the table bellow.

Execution Stops the motion by applying a specific reference, at the occurrence of a programmed event. Four cases are possible:

Stop	**Stop method when event occurs**
STOP0!	Impose a voltage reference equal to 0 to the motor
STOP1!	Impose a current reference equal to 0 to the motor
STOP2!	Impose a speed reference equal to 0 to the motor
STOP3!	Impose a speed reference equal to 0 to the motor, using the profiles acceleration value to brake

Example:

```
CACC = 1;        //Acceleration  command  for  speed  profile
                 //(counts/sampling²)
CSPD = 25.5;     // Speed command (counts/sampling)
MODE SP1;    //Set Speed Profile Mode 1
UPD;             //Update immediate
!SO 10;          //Set     event     if     speed     >=     10
(counts/sampling)
...
STOP2!;          //Stop mode 2 when event occurs
WAIT!;           //Wait until event occurs
```

Name	TUM	Target update mode *(Configuration and command group)*

Syntax

TUM0	Set **T**arget **U**pdate **M**ode **0**
TUM1	Set **T**arget **U**pdate **M**ode **1**

Operands –

Type

TML program	On-line
X	X

Binary code

TUM0

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TUM1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description **TUM0** and **TUM1** (target update mode 0 or 1) let the user to choose how to consider the origin for relative positioning commands.

After a **TUM0** command, the origin is considered as the actual motor position (default). This option is useful in applications where, for example, the motor should move a specified distance after it reaches a contact (event that can be signaled by setting an input event).

After a **TUM1** command, the origin is considered as the target position. In this case, successive relative moves can be commanded and the final target represents the exact sum of the individual commands. In the example below, 2nd update command occurs when the motion commanded by the 1st update is complete, i.e. when target position reaches the command value 3000. Hence, due to **TUM1** mode, the next absolute position command is 3000+3000 = 6000.

It is important to note that the event motion complete refers to the target position and not to the actual motor position, which follows the target usually with a certain delay. If in the example below, **TUM1** command is replaced with **TUM0**, the next position command will not be 6000, but 6000 – the position error from the moment when target position reaches 3000.

Another difference between **TUM0** and **TUM1** modes is related to the treatment of the target speed and position, when the motion mode is changed.
Under **TUM0** mode, each time the motion mode is changed, the target speed takes the value of the actual motor speed and the target position takes the value of the actual motor position.

Under **TUM1** mode, the target speed and position remain unchanged providing a smoother, glitch-free transition of the target speed and position, when motion modes are changed.

However it should be noted that the target speed and position are computed only in the speed/position profile and speed/position contouring modes.

If the system operates in other motion modes, all motion mode changes must be done under **TUM0** mode.

Execution After a **TUM0** command, the origin is considered as the actual motor position (default). After a **TUM1** command, the origin is considered as the target position.

Example

```
CACC = 0.5;   //Acceleration command for position profile
CSPD = 10;   //Speed command for position profile
CPOS = 3000;   //Position command
CPR;   //Position command is Relative
MODE PP3;   //Set Position Profile Mode 3
TUM1;   //Set Target Update Mode 1
UPD;   //Update immediate

!MC;   //Set event when MotionComplete
CSPD = 30;   //Speed command for position profile
CPOS = 3000;   //Position command
CPR;   //Position command is Relative
MODE PP3;   //Set Position Profile Mode 3
TUM1;   //Set Target Update Mode 1
UPD!;   //Update on event
WAIT!;   //WAIT until event occurs
```

Name	**UPD**	Update the motion immediate *(Configuration and command group)*

Syntax

UPD **UPD**ate motion immediate

Operands –

Type

TML program	On-line
X	**X**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0

Description All motion parameters are buffered. Consequently, when a motion parameter is changed, the new value is placed into a buffer. This operation doesn't affect the reference generator, which continues to generate the target reference using the previous motion parameters.

In order to activate the new motion parameters an *update* command must be issued. The update command **UPD** transfers all motion parameters from buffers into the active registers, which are used for reference computation.

The same principle applies also to the **MODE** commands, which set the motion modes.

The update command can be issued at any time. If it is issued during motion, it determines a motion mode and/or motion parameter change on the fly. If it is issued after the motion was completed, it acts like a start motion command.

Execution Transfer all motion parameters from buffers into the active registers, which are used for reference computation.

Example

```
CACC = 0.5;           //Acceleration   command   for   speed
                      //profile(counts/sampling^2)
CSPD = 40;            //Speed command (counts/sampling)
MODE SP1;             //Set Speed Profile Mode 1
UPD;                  //Update immediate
CSPD = -40;           //Speed command (counts/sampling)
UPD;                  //Update immediate
```

Name	UPD!	Update the motion on event *(Configuration and command group)*

Syntax

UPD! — **UPD**ate motion on event **!**

Operands –

Type

TML program	On-line
X	X

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Description All motion parameters are buffered.
Consequently, when a motion parameter is changed, the new value is placed into a buffer. This operation doesn't affect the reference generator, which continues to generate the target reference using the previous motion parameters.
In order to activate the new motion parameters an *update* command must be issued. The update command **UPD!** Transfers all motion parameters from buffers into the active registers, which are used for reference computation, when one of the possible events occurs in the motion system.
There are 18 events, which can be programmed, one at a time, for monitoring:

!MC	When the actual motion is completed
!APO	When motor absolute position is equal or over a value or the value of a variable
!APU	When motor absolute position is equal or under a value or the value of a variable
!RPO	When motor relative position is equal or over a value or the value of a variable
!RPU	When motor relative position is equal or under a value or the value of a variable
!SO	When motor speed is equal or over a value or the value of a variable
!SU	When motor speed is equal or under a value or the value of a variable
!AT	After a wait absolute time equal with a value or the value of a variable
!RT	After a wait relative time equal with a value or the value of a variable
!RO	When position/speed/torque/voltage reference is equal or over a value or the value of a variable

!RU	When position/speed/torque/voltage reference is equal or under a value or the value of a variable
!CAP	When the selected capture input is triggered
!LSP	When the positive limit switch is triggered
!LSN	When the negative limit switch is triggered
!IN#n 1	When a digital input goes high
!IN#n 0	When a digital input goes low
!VO	When value of a variable is equal or over a value or the value of another variable
!VU	When value of a variable is equal or under a value or the value of another variable

Only one event can be monitored at a time.

Execution Transfer all motion parameters from buffers into the active registers, which are used for reference computation, when a monitored event occurs.

Example

```
CACC = 1.5;      //Acceleration command for speed profile
                 //(counts/sampling^2)
CSPD = 20;       //Speed command (counts/sampling)
MODE SP1;        //Set Speed Profile Mode 1
UPD;            //Update immediate
ENLSP1;          //Positive  Limit  Switch  triggers  rising
edge
CSPD = -20;      //New speed command (counts/sampling)
!LSP;            //Set event if Positive LimitSwitch is
                 //reached
UPD!;           //Update on event
```

Name	**WAIT!**	Wait a motion event to occur *(Event group)*

Syntax

WAIT! **WAIT** motion event **!**

Operands –

Type

TML program	On-line
X	**–**

Binary code

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0

Description **WAIT!** holds the execution of the following TML instructions from the TML program sequence, until the monitored event occurs.

There are 18 events, which can be programmed, one at a time, for monitoring:

!MC	When the actual motion is completed
!APO	When motor absolute position is equal or over a value or the value of a variable
!APU	When motor absolute position is equal or under a value or the value of a variable
!RPO	When motor relative position is equal or over a value or the value of a variable
!RPU	When motor relative position is equal or under a value or the value of a variable
!SO	When motor speed is equal or over a value or the value of a variable
!SU	When motor speed is equal or under a value or the value of a variable
!AT	After a wait absolute time equal with a value or the value of a variable
!RT	After a wait relative time equal with a value or the value of a variable
!RO	When position/speed/torque/voltage reference is equal or over a value or the value of a variable
!RU	When position/speed/torque/voltage reference is equal or under a value or the value of a variable
!CAP	When the selected capture input is triggered
!LSP	When the positive limit switch is triggered
!LSN	When the negative limit switch is triggered
!IN#n 1	When a digital input goes high
!IN#n 0	When a digital input goes low

!VO	When value of a variable is equal or over a value or the value of another variable
!VU	When value of a variable is equal or under a value or the value of another variable

Only one event can be monitored at a time.

Execution Hold up execution of the following instructions until the monitored event occurs.

Example:

```
CACC = 1;         //Acceleration command for speed profile
                  //(counts/sampling²)
CSPD = 25.5;      // Speed command (counts/sampling)
MODE SP1;         //Set Speed Profile Mode 1
UPD;              //Update immediate
!SO 10;           //Set    event    if    speed    >=    10
(counts/sampling)
. . .
STOP2!;           //Stop mode 2 when event occurs
WAIT!;            //Wait until event occurs
```

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