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SINUS PENTA

MULTIFUNCTION AC DRIVE

USER MANUAL FOR TRACTION APPLICATION

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ELETTRONICA
SANTERNO

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0. TABLE OF CONTENTS

0.1. Figures

0.2. Tables

1. OVERVIEW

Special software is supplied with the inverters of the Sinus Penta series, that can be used for particular applications. The menu structure, the programming mode and navigation mode of the Sinus Penta are used; parameters or menus will be added/(removed) whether required/(not required) for the application.
This manual covers the wiring diagrams and the parameters relating to the application; for any detail concerning option control boards and different parameters common to the Sinus Penta, refer to Sinus Penta's User Manuals.

2. SOFTWARE DOWNLOAD FOR APPLICATION PROGRAMMING

The Remote Drive software and the PXxxxxF0.mot, PXxxxxF1.mot files of the application are required to download the application to a Sinus Penta inverter. The download procedure is detailed in the following sections of this manual.
The PTxxxxF0.mot and PTxxxxF1.mot files are required for the TRACTION application.
For different applications, refer to the relevant manuals and to the updates available on Elettronica Santerno's website.

NOTE Refer to the User Manual of the Remote Drive software for more details.

The software of the Sinus Penta inverters consists of two files, one containing the firmware and one containing the MMI table for the keypad interface. Both files use hexadecimal files with the MOT format. The filenames ending with "F0" relate to the firmware; the filenames ending with "F1" relate to the MMI table.

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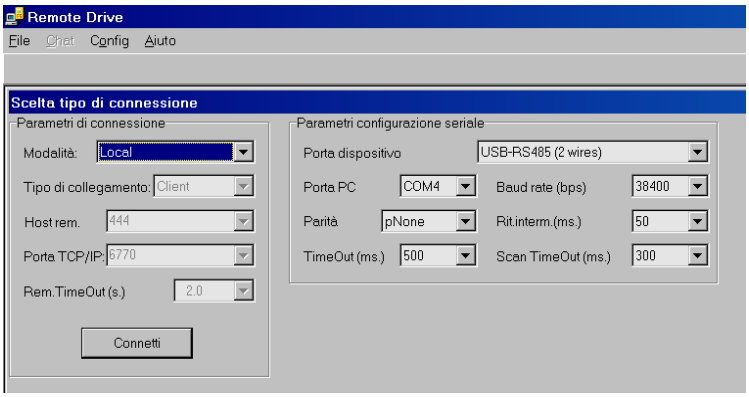
2.1. Firmware Upgrade for SINUS PENTA Inverters

This section covers firmware upgrade and application download.
In case of multidrop connection (RS485), only the equipment to be upgraded shall be connected to the network.

1	Launch Remote Drive.
2	Select the dialog language (click a flag) and press Next.
3	In the "Connection Parameters" window, select the Local mode. In the "Serial Configuration Parameters" window, set the interface device, the COM being used and the baud rate (38400bps); click "Connect", then click the "Next" button. In the example below, USB-RS485 converter is used. 
4	Select "Firmware Upgrade" from the "File" drop-down menu. Enter the path for the PXxxxxF0.mot and PXxxxxF1. files to be downloaded. If only one of the firmware files or MMI tables is to be updated, go to step 7. If an application shall be downloaded to a PXxxxx, select the PXxxxxF0.mot file and click the "Open" button.
5	Send the "Autodet." command to allow Remote Drive to detect the type of equipment. Once the product is detected, PXxxxx will appear in the Equipment Type window. Press the "Send" button; confirmation for the Flash clearing will appear. Click "Yes" to start downloading. Once download is over, go to step 6. 
6	Click "Browse" to select the PxxxxF1.mot file, then click "SendTab". Once this file is downloaded, the application download is complete (end of the download procedure).
7	Click "Browse" to select the file to be updated, PXxxxxF0.mot for the firmware and PxxxxF1.mot for the MMI table; first click "Open", then click "Send" or "SendTab". Confirm flash clearing. Procedure is over.

3. TRACTION APPLICATION

3.1. Introduction

The inverters of the SINUS PENTA series can be used in Traction mode even when handling Zebra batteries.

The main components forming the traction system of an electric vehicle are the following:

- The battery (the energy accumulator of the system);
- The electric motor, that converts electric energy into mechanical energy;
- The inverter, that delivers energy to the motor and that allows to control the vehicle and to adjust its speed;
- The DC/DC converter, that recharges the supply batteries for the auxiliary services.

The wiring block diagram for the connected SINUS PENTA inverter is shown below:

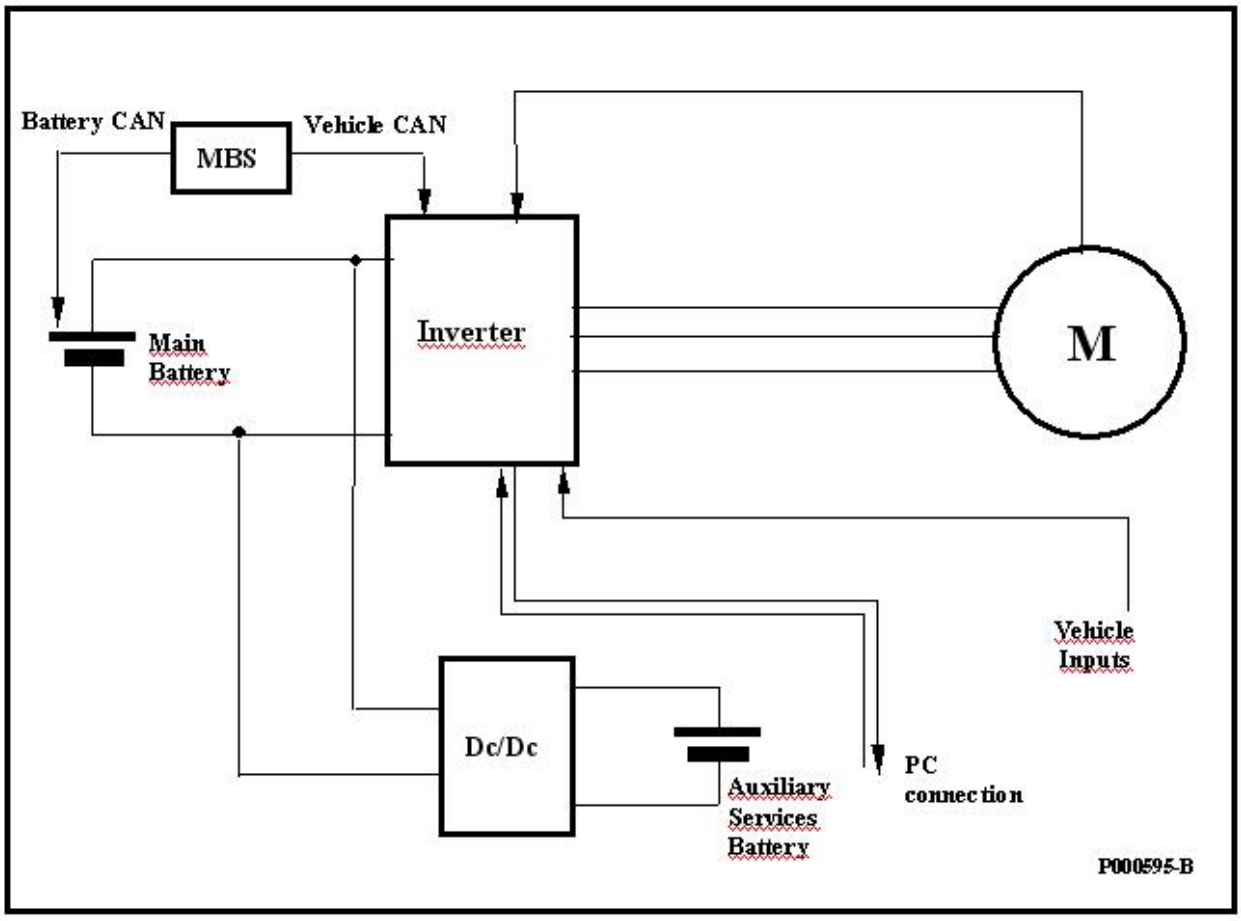


Figure 1: Block-diagram of the traction system

NOTE The TRACTION application for SINUS PENTA inverters MUST be activated only after performing the first startup for the FOC motor control.

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3.1.1. WIRING

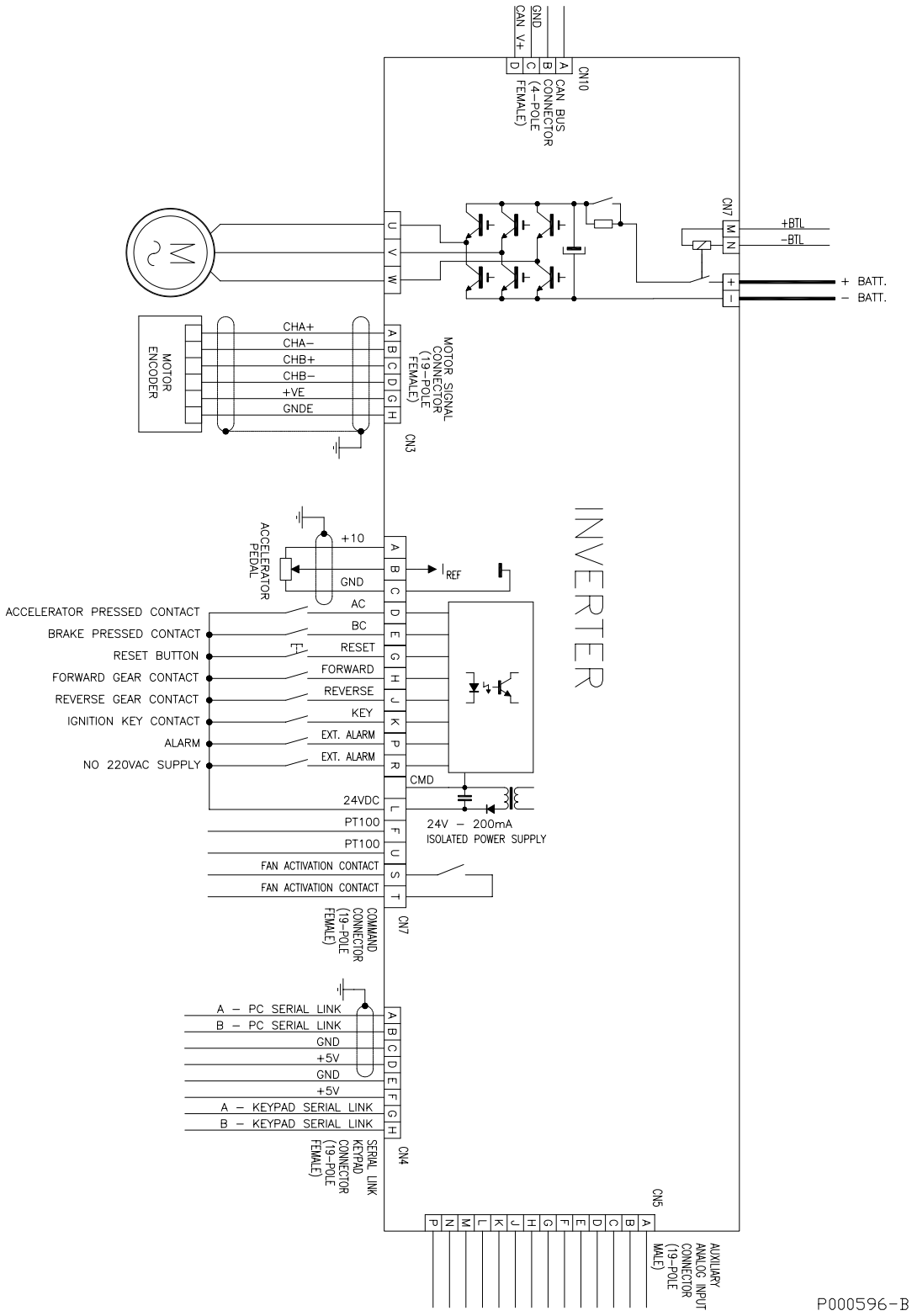

Figure 2: Inverter wiring

CAUTION Connect the main battery to the relevant connector only; do not reverse polarities.

CAUTION Do not change the sequence of the motor winding phases.

CAUTION After connecting the equipment, check the following:
- all wires must be properly connected;
- no link is missing;
- no short-circuit is occurring between the terminals and between the terminals and the ground.

CAUTION When wiring the equipment, the thermal/magnetic circuit breaker installed on the inverter must be kept in the "open" position.

3.1.2. CONTROL CONNECTORS

NOTE To avoid accidental activation of the round connectors, one pole is used as a safety key.

3.1.2.1. CN3: MOTOR SIGNAL CONNECTOR

19-pole round connector F is installed on the inverter.

Name	Connection
CHA +	CN3-A
CHA -	CN3-B
CHB +	CN3-C
CHB -	CN3-D
+VE	CN3-G
GNDE	CN3-H
Safety key	CN3-L

3.1.2.2. CN4 KEYPAD AND SERIAL LINK 485 CONNECTION

19-pole round connector F is installed on the inverter.

Function	Connection
1-Aser	CN4-A
2-Bser	CN4-B
3-gndser	CN4-C
4-+5Vser	CN4-D
Keypad ground	CN4-E
Keypad power supply	CN4-F
Keypad serial link	CN4-G
Keypad serial link	CN4-H
Safety key	CN4-K

3.1.2.3. CN5 AUXILIARY ANALOG INPUT CONNECTION

19-pole round connector F is installed on the inverter.

Function	Range/full-scale value	Connection
Spare analog input 1 +	+/-10V	CN5-A
Spare analog input 1 -		CN5-B
Spare analog input 2 +	+/-10V	CN5-C
Spare analog input 2 -		CN5-D
Spare analog input 3 +	+/-10V	CN5-E
Spare analog input 3 -		CN5-F
Spare analog input 4 +	+/-10V	CN5-G
Spare analog input 4 -		CN5-H
Spare current analog input 5 Rin=33.3Ohm	+/_150mA	CN5-J
Ground for spare analog input 5		CN5-L
Spare current analog input 6 Rin=33.3Ohm	+/_150mA	CN5-M
Ground for spare analog input 6		CN5-N
Spare current analog input 7 Rin=33.3Ohm	+/_150mA	CN5-K
Ground for spare analog input 7		CN5-P
Safety key		CN5-U

3.1.2.4. CN7 COMMAND CONNECTOR

19-pole round connector F is installed on the inverter.

Function	Connection
10V Torque reference	CN7-A
Torque reference [0-10V/Max. torque]	CN7-B
Torque reference ground	CN7-C
Accelerator contact	CN7-D
Brake contact	CN7-E
Coolant PT100	CN7-F
RESET	CN7-G
FORWARD	CN7-H
REVERSE	CN7-J
Ignition KEY	CN7-K
Digital input power supply [24Vdc]	CN7-L
+BOBTL Command for power supply internal contactor	CN7-M
-BOBTL Command for power supply internal contactor	CN7-N
No 220Vac power supply	CN7-O
External alarm	CN7-P
Fan 1 activation	CN7-Q
Fan 2 activation	CN7-R
Coolant PT100	CN7-U
Safety key	CN7-V

3.1.2.5. CN10 CAN BUS CONNECTOR

A 4-pole female connector is installed on the inverter.

Name	Function	Connection
CAN H		CN10-A
CAN L		CN10-B
GND	CAN ground	CN10-C
CAN V+	External power supply (if any)	CN10-D

3.1.3. CONTROL OF THE MOTOR TORQUE

FOC (Field Oriented Control) is the implemented control algorithm. This is a closed-chain control requiring a speed transducer to detect the position of the motor shaft instant by instant. Where the speed reference and torque (accelerator) are used, it is used as the torque limit.
The position of the accelerator is directly proportional to the torque generated by the motor. Nevertheless, limitations exist, to avoid exceeding the limits set by the electric and mechanical features of the equipment components and to obtain the best driving comfort. The torque limit produced by the inverter never exceeds a certain limit torque model based on rpm, as shown in the figure below. The maximum value of the torque limit is equal to parameter C048 (percentage with respect to the motor rated torque).

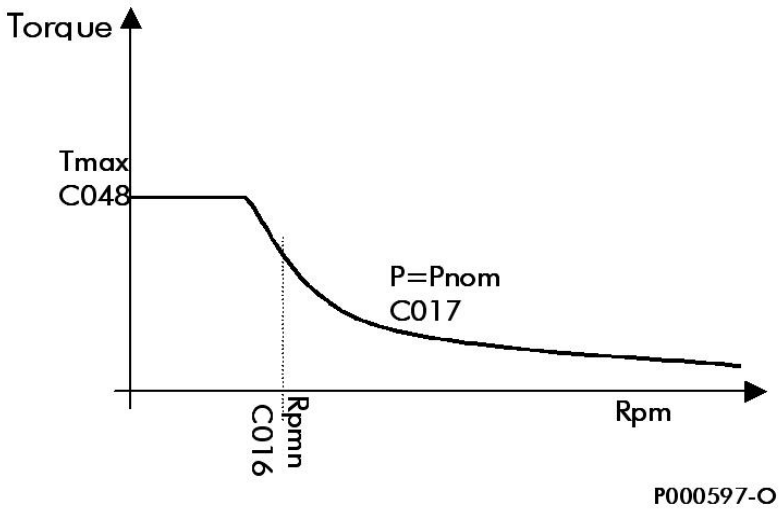

Figure 3: Max. torque pattern based on rpm

When you release the accelerator, a decelerating torque (P355) is automatically produced, which is equal to a percentage of the rated torque, allowing the battery to recover the kinetic energy of the vehicle. If you press the brake pedal, the torque attains a higher value with respect to the decelerating torque (equal to parameter P356, computed as a percentage of the motor rated torque).

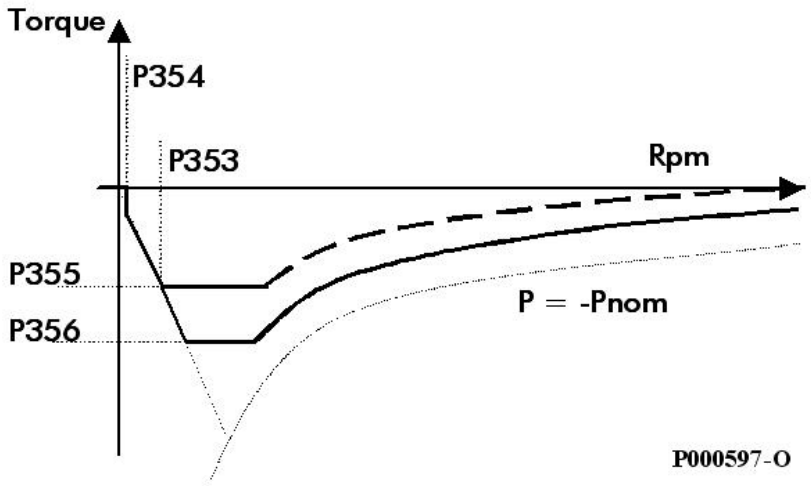

Figure 4: Limit pattern of the braking torque based on rpm

If the braking torque drops below the value set in parameter **P353**, it is proportional to rpm. In case of even lower rpm (**P354**), the braking torque is reset to avoid reversing the direction of rotation of the motor.

Torque variations should be adjusted through special ramps, as they avoid uneven operation of the motor due to sudden variations of the torque delivered to the motor.

Parameter **P026** allows to set the time the acceleration ramp takes to change the reference from 0 to its max. value. Parameter **P027** allows to set the time the deceleration ramp takes to change the reference from its max. value to zero.

For the systems provided with "smart" ZEBRA batteries, which detecting the internal status of the equipment and send signals about operation limits, parameter **P364** allows to dynamically adjust the activation thresholds of the control system.

The following parameters can be used:

- **P368:** Maximum recovery current of the batteries
- **P369:** Maximum discharge current of the batteries
- **P370:** Voltage value for the traction torque decrease
- **P371:** Voltage value for the traction torque neutralisation.

The max. current for discharge and recovery is limited from the values sent from the battery diagnostics. The maximum limit for recovery voltage is the limit which is dynamically set from the vehicle batteries.

If voltage ranges between the two limits set via parameters **P370-P371**, the traction torque is limited with a proportional pattern, and it drops to 0 when the battery voltage value is the same as the value set in parameter **P371**.

If parameter **P364** is set up to avoid using dynamic parameters, the max. discharge current and the max. recovery current is computed as stated above.

When only one battery is operating, all variables relating to torque and power—i.e. parameters *Tmax, Pnom*—are decreased by a value percent based on the values set in parameters **P366-P367**.

3.2. Measures Menu

3.2.1. DESCRIPTION

The Measures Menu contains all the variables measured by the inverter.
In the RemoteDrive software, all measures are divided into submenus, one for each type of measures.
The measure submenus are the following:

- Menu – General Measures

It includes current measures, voltage measures, power measures, the inverter digital inputs, the status measures for the digital/analog outputs of the inverter, the ambient temperature measures and IGBT temperature measures, the inverter status measure and the active alarm.

- Menu – Traction Measures

It includes measures concerning the traction application: currents, motor voltage, battery voltage, unit speed, battery warnings.

- Menu – CAN Measures

It includes the words sent from the CAN interface via ZEBRA batteries through the MBS. This menu is available only if ZEBRA batteries are fitted. (It is available provided that the ENGINEERING access level is selected.)

- Menu – Battery Measures

It includes the measures relating to the MBS batteries. This menu is available only if ZEBRA batteries are fitted.

3.3. Motor Control Menu

3.3.1. DESCRIPTION

The control algorithm used for the Sinus Penta Traction application is **FOC** (Field Oriented Control), a closed-chain control requiring a speed transducer to detect the position of the motor shaft instant by instant with a speed reference.

The characteristic parameter set for the connected motor is contained in the Motor Control Menu (see Sinus Penta's Programming Instructions manual) and is set up when tuning the motor. Check parameters in Table in particular.

Table 1: Description of the motor parameters and values to be set for the Traction application.

Parameter	FUNCTION	Access Level	MODBUS Address	Values for Sinus Penta-Traction application
C008	Mains rated voltage	BASIC	1008	Regen (2T-4T)
C010	Control algorithm being used	BASIC	1010	2: FOC
C011	Type of reference being used (speed/torque)	ADVANCED	1011	0: Speed
C012	Speed feedback from encoder	BASIC	1012	1: Yes
C015 ÷ C025	Characteristic electric ratings for the connected motor	BASIC/ ADVANCED	1015÷1025	
C028	Minimum speed to be obtained	ADVANCED	1028	-6000
C029	Maximum speed to be obtained	ADVANCED	1029	6000
C030	Speed for the beginning of flux weakening	ENGINEERING	1030	From tuning
C031	Max. speed alarm threshold and enable	ADVANCED	1031	6200

CAUTION **DO NOT** change parameters C010 to C012 for the Traction application!

NOTE For the Traction application, parameteres C028 to C031 set the speed limits that can be adjusted based on the speed performance to be obtained.
Avoid altering parameter C030.

3.4. Control Method Menu

3.4.1. DESCRIPTION

NOTE Refer to the **Installation Instructions manual** for the hardware description of the digital inputs (COMMANDS) and the analog inputs (REFERENCES).

The parameters in the Control Method menu allow to select the following items:

- The source of the **inverter commands** (digital inputs) from **three signal sources** (through parameters **C140, C141, C142**) which are matched together to obtain **M031** (active command set). For each of the **3 parameters** above, you can select the source of the command signals from **5 different sources**.
- The source of the **speed reference** from **4 different sources** (that can be selected through parameters **C143, C144, C145, C146)**. They can be **summed up.**
- For each of the **4 parameters** above, you can select the reference source from **9 different sources**.
- The source of the **torque limit** reference (through parameter **C147**). This **parameter** allows to select the reference source from **9 different sources.**

In that way, you can select and activate different **command sources** (hardware or virtual sources), different speed **references** (hardware or virtual references) and you can activate an external torque **limit.**
The inverter **commands** can be sent via:

- Hardware terminal board (terminals in control board ES821), which is logically divided into terminal board A and terminal board B;
- Virtual remote terminal board: through serial link with MODBUS communication protocol.

Multiple reference sources can be activated at a time (up to 3 sources through parameters **C140**, **C141**, **C142**): in that case, the inverter will apply **OR** / **AND** logic functions to the different terminals to obtain the active terminal board.

The **references** and the torque limit signal can be sent from:

- Three analog inputs acquired on the hardware terminal board (REF, AIN1, AIN2)
- FIN frequency input
- Encoder input
- Keypad
- Serial link with MODBUS communication protocol
- Field bus (for option board)
- Traction (from traction machine processing).

Up to 4 reference sources can be activated through parameters **C143**, **C144**, **C145**, **C146**: in that case, the inverter will consider the sum of all active references as the main reference.

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3.4.2. COMMAND SOURCES

For the Sinus Penta-Traction application, the **inverter commands** are sent from the following sources:
1: Terminals
2: Serial link (with MODBUS communication protocol)
Because multiple command sources are activated at a time, the logic function of the inverter for the terminals of all active command sources is as follows:

- **AND** for the terminals allocated to the **ENABLE, External alarms n.1, n.2, n.3** functions.
- **OR** for the remaining terminals.

3.4.3. SPEED REFERENCE SOURCE

The "**main reference**" is the speed value to be attained at constant speed (**M000**).
This reference is acquired by the inverter only if the **START** command and the **ENABLE** command are active, otherwise it is ignored.
When the main reference is acquired from the inverter (the **START** & **ENABLE** commands are active), it becomes the input handled by the "time ramps" that produce the current speed setpoint for the connected motor.

The speed reference in the Sinus Penta-Traction application is sent from:
9: Traction *(traction machine processing)*

TRACTION

The source derives from the TRACTION machine processing. The machine sets a different speed setpoint (that can be user-defined) based on the preset running direction.

3.4.4. TORQUE LIMIT SOURCE

Parameter **C147** allows to select the source of the Torque Limit value. The Torque Limit function is a limit of the absolute value of the torque required from the motor.
(– Torque Limit) ≤ torque demand ≤ (+ Torque Limit)

The reference to be selected for the torque limit in Penta-Traction mode is:
9: Traction *(traction machine processing)*

3.4.5. CONFIGURATION OF THE COMMAND SOURCE PARAMETERS IN THE SINUS PENTA-TRACTION APPLICATION

Table 2: List of parameters C140 to C148 to be selected for the Sinus Penta-Traction setting

Parameter	FUNCTION	Access Level	MODBUS Address	Values for Sinus Penta Traction application
C140	Command digital input n. 1	ADVANCED	1140	1: Terminals
C141	Command digital input n. 2	ADVANCED	1141	2: Serial link
C142	Command digital input n. 3	ENGINEERING	1142	0: Disable
C143	Reference input n.1	ADVANCED	1143	9: Traction
C144	Reference input n.2	ADVANCED	1144	0: Disable
C145	Reference input n.3	ENGINEERING	1145	0: Disable
C146	Reference input n.4	ENGINEERING	1146	0: Disable
C147	Torque limit input	ENGINEERING	1147	9: Traction
C148	Remote control to Local control	ENGINEERING	1148	0: StandBy or Flux weakening

CAUTION **DO NOT** change parameters C140 to C148 for the Traction application!

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3.5. Limits Menu

3.5.1. DESCRIPTION

The parameters included in the Limits menu for the standard SINUS PENTA series set the maximum torque pattern that can be obtained from the vehicle, unless reducers are installed, and they limit both traction pattern and braking pattern.

3.5.2. PARAMETER C048

PARAMETER DESCRIPTION

Parameter **C048** is used for control purposes in the Sinus Penta Traction application.

C048 Maximum Torque Limit

C048	Range	–5000 ÷ 5000 (*)	–500.0% ÷ +500.0%
	Default	1200	120.0%
	Level	ADVANCED	
	Address	1048	
	Control	VTC and FOC	
	Function	This parameter sets the maximum limit of the torque demand. It is expressed as a percentage of the rated torque of the connected motor. The traction torque pattern (see Figure 3) is defined based on parameter C048.). It also sets the maximum allowable value required while braking.	

(*) *The max. value depends on the inverter size.*

3.5.3. CONFIGURATION OF DIGITAL INPUT PARAMETERS IN THE SINUS PENTA-TRACTION APPLICATION

Table 3: Description of parameter C048

Parameter	FUNCTION	Access Level	MODBUS Address	Values for Sinus Penta Traction application
C048	Maximum torque	ADVANCED	1048	200.0%

3.6. Digital Inputs Menu

3.6.1. DESCRIPTION

NOTE Refer to Sinus Penta's **Installation Instructions** manual for the hardware description of the digital inputs.

The parameters contained in this menu assign particular digital control functions to each digital input on the terminal board. Each parameter has a particular function, which is assigned to a given terminal on the terminal board.

The full processing of the digital inputs also includes the selection of other remote/virtual terminal boards (see The Control Method Menu on the standard Programming Instruction Manual) and the possibility of delaying input digital signal enable/disable by means of software timers (see The Timers Menu on the standard Programming Instruction Manual).

The input status is displayed in **M031**, **M032**, **M033**.
Measure **M033** indicates the **current** status of the 8 inputs in the local hardware terminal board.
Measure **M032** shows the **current** status of the virtual terminal board obtained by processing all active terminal boards. It includes 10 signals, with two additional signals with respect to the local hardware terminal board:

- Inputs **MDI1** to **MDI8** are obtained with the **logic OR** of the input signals for all active terminal boards;
- The **ENABLE** input is obtained with the logic **AND** of the input signals for terminal **MDI2** in all active terminal boards.

Measure **M031** is similar to **M032**, but it displays the status of the terminal board obtained after delaying input signals **M032** (where required) through special timers.
The inverter uses this terminal board to acquire digital commands.
Some functions cannot be programmed, but they are assigned to special terminals:

Table 4: Sinus Penta-Traction functions for digital inputs

Function	*Terminal*
FORWARD GEAR (START)	MDI1
KEY (ENABLE)	MDI2
RESET	MDI3
REVERSE GEAR	MDI4
ACCELERATOR CONTACT	MDI5
BRAKE CONTACT	MDI6
EXTERNAL ALARM	MDI7
NO 220Vac POWER SUPPLY	MDI8

3.6.2. START (TERMINAL 14: MDI1)

This input only sets the *FORWARD GEAR* of the vehicle; the forward gear is not enabled.
It cannot be activated when the *REVERSE GEAR* input is active.
If both inputs are active (*REVERSE GEAR* and *START-FORWARD GEAR*), the vehicle **RUN** is disabled.

3.6.3. ENABLE (TERMINAL 15: MDI2)

CAUTION If the **ENABLE** input signal is disabled for one of the active terminals, the inverter is instantly disabled and the motor starts idling! The mechanical load could then accelerate/brake the motor in an uncontrolled way.

CAUTION If a protection/alarm trips, the inverter deactivates and the motor starts idling!

NOTE The activation of the **ENABLE** command enables particular alarms which control the configuration consistency of certain parameters.

NOTE When the **ENABLE** contact is closed, C parameters cannot be altered (factory-setting). Set **P003** as = Standby+Fluxing to allow C parameter alteration even when the inverter is enabled but the motor is not running.

The **ENABLE** input function is assigned to terminal **MDI2**. It **enables the inverter operation**. It cannot be programmed for other terminals, although additional functions may be assigned to the **ENABLE** terminal.
To enable the inverter operation, the ENABLE **input is to be always active (for all active terminal boards), regardless of the control mode being used.**
If the **ENABLE** input is disabled, the inverter output voltage is always cut off, so the connected motor starts **idling** (the motor idles and stops due to friction or the mechanical load).
If the **ENABLE** command is already active when the inverter is powered on, the inverter starts only when terminal **MDI2** is opened and closed again.
If the **ENABLE** input is disabled when the inverter is controlling the motor, it is closed with a delay time depending on the inverter size. This **ENABLE** delay starts from the instant when the input is disabled regardless of the enabling delay (if any) set through a software timer in **MDI2**.
For safety reasons, if the ignition key is fitted when the accelerator is pressed and the run selector switch is on, the vehicle does not start.

NOTE The vehicle run is enabled only if the key is fitted when the run selector switch is off.

3.6.4. RESET (TERMINAL 16: MDI3)

The **RESET** function is assigned to input terminal **MDI3**. It resets the alarms to unlock the inverter.
If a protection trips, the inverter locks, the motor starts idling (the motor idles and stops due to friction or the mechanical load) and an alarm message is displayed (see ALARMS AND WARNINGS).

Reset procedure

To unlock the inverter, activate the **RESET** input for an instant, or press the **RESET** key on the keypad. When the inverter unlocks and the cause for the alarm has been removed, "Inverter OK" comes up on the screen, otherwise, the alarm persists and cannot be reset.
Factory-setting: activate and deactivate the **ENABLE** command (see parameter **C181**) to restart the inverter.

NOTE

Factory-setting: the inverter power off does not reset the alarm tripped, which is stored to memory and is displayed at next power on to lock the inverter. Perform a reset procedure to unlock the inverter.
The alarms stored may be automatically reset at power on by setting special parameters (see Sinus Penta's Programming Instructions manual).

CAUTION

If an alarm trips, refer to the Sinus Penta's Programming Instructions manual (diagnostics). Reset the equipment after the cause responsible for the alarm has been removed.

DANGER!!!

Electrical shock hazard exists on output terminals (U, V, W) and resistive braking module terminals (+, –, B) even when the inverter is locked.

3.6.5. REVERSE GEAR (TERMINAL 17: MDI4)

This input only sets the *REVERSE GEAR* of the vehicle; the reverse gear is not enabled.
It cannot be activated when the *START-FORWARD GEAR* input is active.
If both inputs are active (*REVERSE GEAR* and *START-FORWARD GEAR*), the vehicle **RUN** is disabled.

3.6.6. ACCELERATOR CONTACT (TERMINAL 18: MDI5)

This input activates the "accelerator pressed" signal. If this signal is active when the BRAKE CONTACT is active, the ACCELERATOR CONTACT signal is ignored, and the BRAKE CONTACT signal has priority. it stops the vehicle through a torque-controlled stop. When RUNNING, the deactivation of this signal stops the vehicle through a controlled stop of the system following the deceleration characteristic (Figure 4).

3.6.7. BRAKE CONTACT (TERMINAL 19: MDI6)

This input activates the "brake pedal pressed" signal. When RUNNING, the deactivation of this signal stops the vehicle through a controlled stop of the system following the deceleration characteristic (Figure 4).
If the BRAKE CONTACT signal is active when the ACCELERATOR CONTACT signal is active, the BRAKE CONTACT has priority and stops the vehicle through a torque-controlled stop.

3.6.8. CONFIGURATION OF THE DIGITAL INPUT PARAMETERS IN THE SINUS PENTA-TRACTION APPLICATION

Make sure that the digital parameters are set up as follows:

Table 5: List of parameters C150 to C187

Parameter	FUNCTION	Access Level	MODBUS Address	Values for Sinus Penta Traction application
C150	**STOP** input	ADVANCED	1150	0: None
C151	**REVERSE** input	ADVANCED	1151	0: None
C152	**ENABLE–S** input	ADVANCED	1152	0: None
C153	**DISABLE** input	ADVANCED	1153	0: None
C154	Disable alarm RESET in **MDI3**	ADVANCED	1154	0: No
C155	**MULTISPEED 0** input	ADVANCED	1155	0: None
C156	**MULTISPEED 1** input	ADVANCED	1156	0: None
C157	**MULTISPEED 2** input	ADVANCED	1157	0: None
C158	**MULTISPEED 3** input	ADVANCED	1158	0: None
C159	**CW/CCW** input	ADVANCED	1159	4: MDI4
C160	**DCB** input	ADVANCED	1160	0: None
C161	**UP** input	ADVANCED	1161	0: None
C162	**DOWN** input	ADVANCED	1162	0: None
C163	**RESET UP/DOWN** input	ADVANCED	1163	0: None
C164	**External alarm 1** input	ADVANCED	1164	7: MDI7
C164a	**External alarm 1** activation delay	ADVANCED	1305	Instantaneous
C165	**External alarm 2** input	ADVANCED	1165	8: MDI8
C165a	**External alarm 2** activation delay	ADVANCED	1306	Instantaneous
C166	**External alarm 3** input	ADVANCED	1166	0: None
C166a	**External alarm 3** activation delay	ADVANCED	1307	Instantaneous
C167	**MultiRamp 0** input	ENGINEERING	1167	0: None
C168	**MultiRamp 1** input	ENGINEERING	1168	0: None
C169	**JOG** input	ADVANCED	1169	0: None
C170	**SLAVE** input	ADVANCED	1170	0: None
C171	**PID DISABLE** input	ADVANCED	1171	0: None
C172	**KEYPAD LOCK** input	ADVANCED	1172	0: None
C173	**MOTOR n.2 SEL.** input	ENGINEERING	1173	0: None
C174	**MOTOR n.3 SEL.** input	ENGINEERING	1174	0: None
C175	**SPEED VARIATION 0** input	ENGINEERING	1175	0: None
C176	**SPEED VARIATION 1** input	ENGINEERING	1176	0: None
C177	**SPEED VARIATION 2** input	ENGINEERING	1177	0: None
C178	**PID RESET UP/DOWN** input	ADVANCED	1178	0: None
C179	**SOURCE SELECTION** input	ADVANCED	1179	0: None
C180	**LOC/REM** input	ADVANCED	1180	0: None
C180a	Type of contact for **LOC/REM**	ADVANCED	1303	Button+Storage
C181	Start safety enable	ADVANCED	1181	0: Disable
C182	Multiprogramming enable	ENGINEERING	1182	0: Disable
C183	Max. fluxing time before inverter disabling	ADVANCED	1183	Disabled
C184	Fluxing at start only when START closed	ADVANCED	1184	0: No
C185	Stop mode	ADVANCED	1185	0: Deceleration ramp
C186	Input for Fire Mode enable	ENGINEERING	1186	0: None
C187	Input for torque limit reference source disable	ADVANCED	1187	0: None

CAUTION **DO NOT** change parameters C150 to C187 for the Traction application!

3.7. Traction Application Menu

3.7.1. DESCRIPTION

The Traction menu contains user-defined parameters concerning the max. speed of the vehicle, the traction torque pattern and the braking torque pattern, the wheel ratio, the full-scale values for temperature and current measures.

3.7.2. LIST OF PARAMETERS P350 TO P362

PARAMETER DESCRIPTION

Table 6: List of parameters P350 to P362

Parameter	FUNCTION	Access Level	MODBUS Address	Default Values
P350	Traction machine enable	ENGINEERING	950	0:No
P351	Flux weakening enable from traction machine	ENGINEERING	951	0:No
P352	Reversal of positive running direction	ADVANCED	952	0:No
P353	Linear decrease speed for braking torque	ADVANCED	953	400rpm
P354	Null braking torque speed	ADVANCED	954	100rpm
P355	Limit torque while decelerating	ADVANCED	955	10%
P356	Limit torque while braking	ADVANCED	956	20%
P357	Forward gear speed setpoint	ADVANCED	957	6000rpm
P358	Reverse gear speed setpoint	ADVANCED	958	2000rpm
P359	Wheel ratio	ENGINEERING	959	0.01km/h/rpm
P360	Full-scale value for max. water temperature	ENGINEERING	960	200°C
P361	Full-scale value for min. water temperature	ENGINEERING	961	-50°C
P362	Full-scale value for battery current	ENGINEERING	962	400A

P350 Traction Machine Enable

P350	Range	0 ÷ 1	0: No 1: Yes
	Default	0	0: No
	Level	ENGINEERING	
	Address	950	
	Function	This parameter enables the traction mode: it shall be activated after tuning the motor. CAUTION: to activate the traction mode, also set up the parameters in the C14x-Control Method menu accordingly.	

P351 Flux Weakening Enable from Traction Machine

P351	Range	0 ÷ 1	0: No 1: Yes
	Default	0	0: No
	Level	ENGINEERING	
	Address	951	
	Function	This parameter enables the flux weakening from the traction machine.	

P352 Reversal of Positive Running Direction

P352	Range	0 ÷ 1	0: No 1: Yes
	Default	0	0: No
	Level	ADVANCED	
	Address	952	
	Function	This parameter allows to reverse the positive running direction. Set P352 to 1: Yes if the positive running direction of the vehicle does not match with the forward run of the system.	

P353 Linear Decrease Speed for Braking Torque

P353	Range	0 ÷ 5000	0 ÷ 5000 rpm
	Default	400	400 rpm
	Level	ADVANCED	
	Address	953	
	Function	This parameter sets the speed for the linear decrease of the braking torque (Figure 4).	

P354 Null Braking Torque Speed

P354	Range	0 ÷ 5000	0 ÷ 5000 rpm
	Default	100	100 rpm
	Level	ADVANCED	
	Address	954	
	Function	This parameter sets the speed for a null the braking torque (Figure 4).	

P355 Limit Torque while Decelerating

P355	Range	0 ÷ 200	0 ÷ 200 %
	Default	10	10 %
	Level	ADVANCED	
	Address	955	
	Function	Limit torque while decelerating, which is applied when the accelerator contact is released. This is a percentage of the motor rated torque. If exceeded, the max. torque limit is limited to P355.	

P356 Limit torque while braking

P356	Range	0 ÷ 300	0 ÷ 300 %
	Default	20	20 %
	Level	ADVANCED	
	Address	956	
	Function	Limit torque while braking, which is applied when the brake contact is pressed after releasing the accelerator contact. This is a percentage of the motor rated torque. If exceeded, the max. torque limit is limited to P356.	

P357 Forward Gear Speed Setpoint

P357	Range	0 ÷ 8000	0 ÷ 8000 rpm
	Default	6000	6000 rpm
	Level	ADVANCED	
	Address	957	
	Function	Setpoint for the forward gear speed reference. This is the max. speed of the motor for the forward gear.	

P358 Reverse Gear Speed Setpoint

P358	Range	0 ÷ 8000	0 ÷ 8000 rpm
	Default	2000	2000 rpm
	Level	ADVANCED	
	Address	958	
	Function	Setpoint for the reverse gear speed reference. This is the max. speed of the motor for the reverse gear.	

P359 Wheel Ratio

P359	Range	-1000 ÷ 1000	-0.001 ÷ 0.001
	Default	10	0.010 km/h/rpm
	Level	ENGINEERING	
	Address	959	
	Function	Conversion factor between the motor speed and the vehicle speed.	

P360 Full-scale Value for Max. Water Temperature

P360	Range	0 ÷ 300	0 ÷ 300 °C
	Default	200	200 °C
	Level	ENGINEERING	
	Address	960	
	Function	Upper full-scale value for the temperature of the motor cooling water.	

P361 Full-scale Value for Min. Water Temperature

P361	Range	-100 ÷ 300	-100 ÷ 300 °C
	Default	-50	50 °C
	Level	ENGINEERING	
	Address	961	
	Function	Lower full-scale value for the temperature of the motor cooling water.	

P362 Full-scale Value for Battery Current

P362	Range	0 ÷ 500	0 ÷ 500 A
	Default	400	400 A
	Level	ENGINEERING	
	Address	962	
	Function	Full-scale value for the battery current.	

3.8. Battery Application Menu

3.8.1. DESCRIPTION

This menu contains the programming parameters for "smart" ZEBRA batteries. More details about Zebra batteries are given in the relevant User Manual.

3.8.2. LIST OF PARAMETERS P363-P374

PARAMETER DESCRIPTION

Table 7: List of parameters P363 to P374

Parameter	FUNCTION	Access Level	MODBUS Address	Default Values
P363	Zebra battery installed	ENGINEERING	963	0:No
P364	Battery dynamic control	ENGINEERING	964	0:No
P365	Torque reduction enable for current limits	ENGINEERING	965	0:No
P366	Power reduction with one battery	ENGINEERING	966	40%
P367	Torque reduction with one battery	ENGINEERING	967	50%
P368	Rated value for max. charge current	ENGINEERING	968	200A
P369	Rated value for max. discharge current	ENGINEERING	969	224A
P370	Torque reduction voltage	ENGINEERING	970	400V
P371	Null torque voltage	ENGINEERING	971	380V
P372	Warning threshold for battery endurance	ADVANCED	972	20%
P373	Battery charge full-scale value	ENGINEERING	973	76Ah
P374	CAN communication timeout	ENGINEERING	974	10s
P375	Battery failure handling	ADVANCED	975	0:Alarm

P363 Zebra Battery Installed

P363	Range	0 ÷ 1	0: No 1: Yes
	Default	0	0: No
	Level	ENGINEERING	
	Address	963	
	Function	This parameter indicates that Zebra batteries are installed.	

P364 Battery Dynamic Control

P364	Range	0 ÷ 1	0: No 1: Yes
	Default	0	0: No
	Level	ENGINEERING	
	Address	964	
	Function	This parameter is used for the dynamic control of the torque limit while braking. If it is enabled, the max. current for the battery charge is limited from the information sent by the MBS.	

P365 Torque Reduction Enable for Current Limits

P365	Range	0 ÷ 1	0: No 1: Yes
	Default	0	0: No
	Level	ENGINEERING	
	Address	965	
	Function	This parameter enables the torque reduction for discharge current limits. If it is set to 1: Yes, torque is reduced to the min. value % between torque limitation due to current limits and torque limitation due to voltage limits (P370-P371). Voltage limits can be disabled (torque limitation can then depend on current limits only; see parameters P370-P371).	

P366 Power Reduction with One Battery

P366	Range	0 ÷ 100	0 ÷ 100 %
	Default	40	40%
	Level	ENGINEERING	
	Address	966	
	Function	If only one battery is operating (the MBS sends the following signal: *sys_reducedNumberOfBattery*), the system reduces the maximum power that the motor can absorb from the batteries. The power that can be absorbed is reduced of this value percent, which is computed based on the motor rated power.	

P367 Torque Reduction with One Battery

P367	Range	0 ÷ 100	0 ÷ 100 %
	Default	50	50%
	Level	ENGINEERING	
	Address	967	
	Function	If only one battery is operating, the system reduces the maximum torque that the motor can produce. The produced torque is then reduced of this value percent, which is computed based on the max. torque of the motor.	

P368 Rated Value for Max. Charge Current

P368	Range	0 ÷ 800	0 ÷ 800 A
	Default	200	200 A
	Level	ENGINEERING	
	Address	968	
	Function	Reference value of the max. charge current that batteries can absorb when the equipment is braking. This parameter is used for computing battery dynamic control while braking.	

P369 Rated Value for Max. Charge Current

P369	Range	0 ÷ 800	0 ÷ 800 A
	Default	224	224 A
	Level	ENGINEERING	
	Address	969	
	Function	Reference value of the max. discharge current that batteries can produce in the traction stage. This parameter is used for computing battery dynamic control in the traction stage.	

P370 Torque Reduction Voltage

P370	Range	0 ÷ 500	0 ÷ 500 V
	Default	400	400 V
	Level	ENGINEERING	
	Address	970	
	Function	When the voltage threshold set in this parameter is attained, the traction torque begins to be reduced in a linear way due to limitation depending on bus voltage reduction. If parameter P365 is set to Yes, the torque reduction is determined by the min. value obtained from the computing of the current limit (P365) and the voltage limit. Limitation for voltage limit can be disabled by setting a lower value than the value set in parameter P371.	

P371 Null Torque Voltage

P371	Range	0 ÷ 500	0 ÷ 500 V
	Default	380	380 V
	Level	ENGINEERING	
	Address	971	
	Function	Voltage neutralizing the traction torque due to limitation depending on bus voltage reduction.	

P372 Warning Threshold for Battery Endurance

P372	Range	0 ÷ 100	0 ÷ 100 %
	Default	20	20 %
	Level	ADVANCED	
	Address	972	
	Function	This parameter sets the threshold for battery endurance. The BATTERY_EMERGENCY warning is displayed (measure M116 in the Traction Measures Menu).	

P373 Battery Charge Full-scale Value

P373	Range	0 ÷ 200	0 ÷ 200 Ah
	Default	76	76 Ah
	Level	ENGINEERING	
	Address	973	
	Function	Battery rated capacity.	

P374 CAN Communication Timeout

P374	Range	0 ÷ 10000	0 ÷ 1000.0 s
	Default	100	10.0 s
	Level	ENGINEERING	
	Address	974	
	Function	Timeout in CAN communication between the batteries and the inverter. If communication is suspended, the CAN_KO BATTERY warning (measure M116 in the Traction Measures Menu) is displayed. For safety reasons, regeneration current is decreased by 50% of the rated value. In the traction stage, the last acquired values are considered. If communication stops for more than *timeout* seconds, alarm A106 CAN Communication KO trips.	

P375 Battery Failure Handling

P375	Range	0 ÷ 1	0: Set Alarm 1: Set Warning
	Default	0	0: Set Alarm
	Level	ADVANCED	
	Address	975	
	Function	This parameter handles battery failures (switch off delay, switch off) either as warnings or as alarms.	

3.8.3. ADVICE FOR ZEBRA BATTERY MAINTENANCE

Zebra batteries must be recharged frequently and completely. They're almost discharged when their charge current drops below –0.5 A and their SOC is 100%.

NOTE **Frequently recharge Zebra batteries!**

3.8.4. HOW TO CHARGE BATTERIES

Do the following to charge the vehicle batteries:

- Deactivate Sinus Penta drive.
- Remove the COMMAND ACTIVATION key.
- Change the operating mode from DISCHARGE to CHARGE.

3.8.5. BATTERY DISCHARGE

Do the following to charge the vehicle batteries:

- Remove the COMMAND ACTIVATION key; the PARK MODE activates.
- Change the operating mode from CHARGE to DISCHARGE.
- Fit the COMMAND ACTIVATION key to enter the discharge mode. Before fitting the key, remove voltage from the vehicle (discharge mode) and wait at least 10 seconds.

0

1

2

3

3.8.6. CAN-BATTERY COMMUNICATION

A BMI (*Battery Management with Interface*) is supplied with ZEBRA batteries. The BMI allows communication concerning the battery diagnostics, while the ZEBRAmonitor software allows to monitor the battery status (see the relevant installation manual).
Connect the CAN cable via USB and launch the ZEBRAmonitor software; if active, batteries are automatically detected and the system configures as follows:

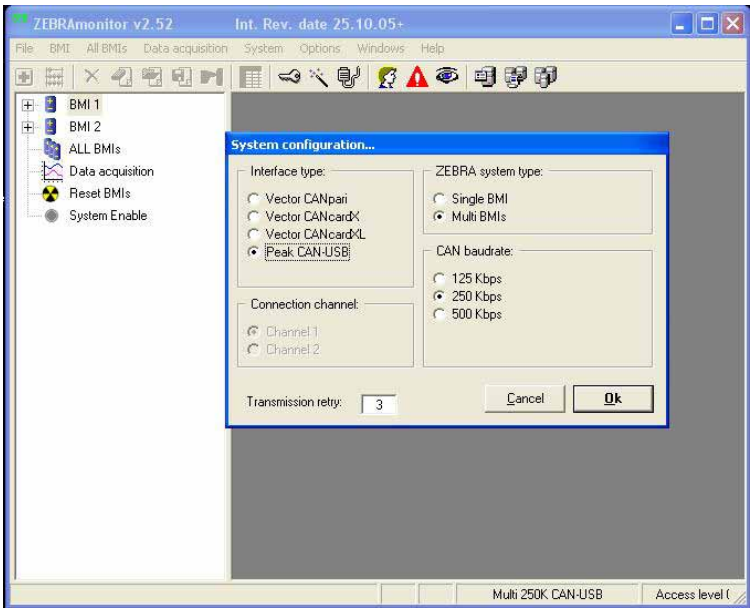

Figure 5: ZebraMonitor configuration

Data concerning Zebra batteries can be acquired and stored to memory.

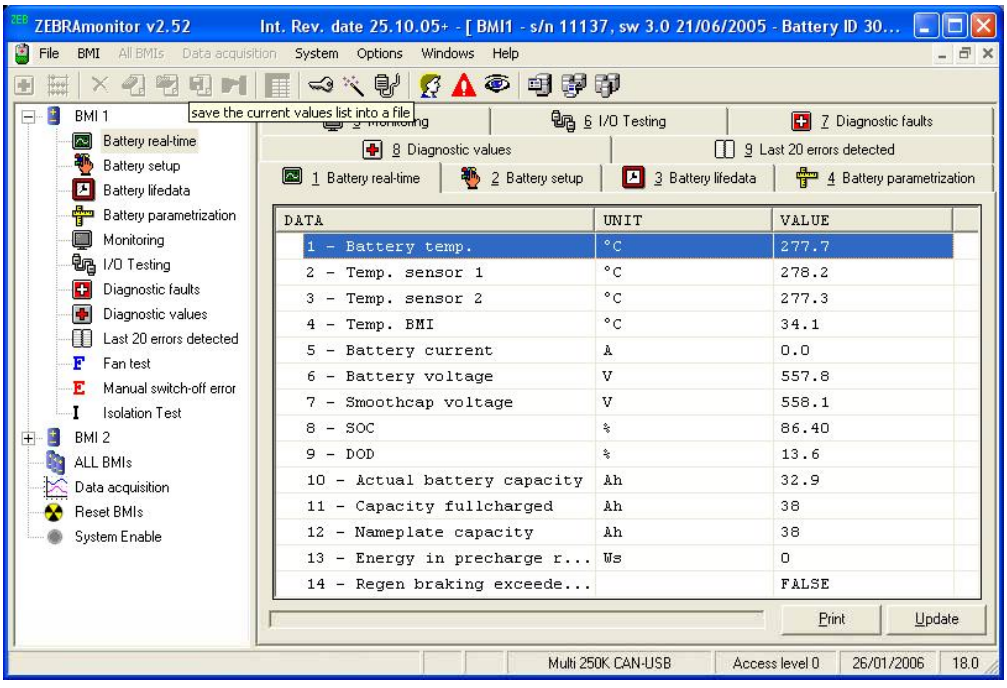

Figure 6: ZebraMonitor screen

The following menus are available:

- **Battery Real-time menu**
- **Battery Setup menu**
- **Battery Lifedata menu**
- **Battery Parameterization menu**
  Parameter 60 MainsCurrentMaxAvalaible: if the mains is limited, power for each battery can be limited accordingly.
  Parameter 4 in menu 2: if current is limited below 16A and is supplied via AC header, input current is limited.
- **Monitoring menu**
  The following measures are particularly important:
  11) DC supply available (PIN 10)
  12) Emergency voltage (PIN 9)
  13) External Ub voltage (PIN10)
  14) Ub voltage (PIN 11)

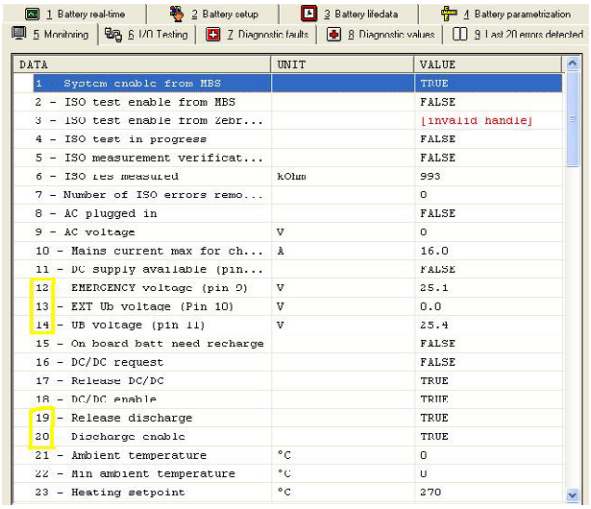

Figure 7: Monitoring menu

- **I/O Testing menu (detects the contactor status)**

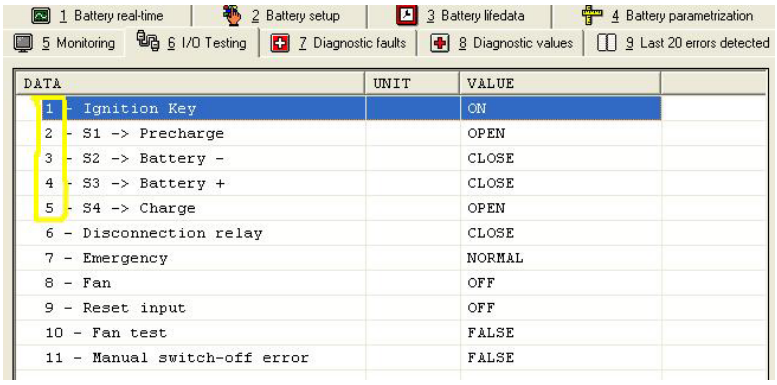

Figure 8: I/O testing menu

- **Diagnostic Fault menu**
  Some faults are automatically reset, some faults are to be reset by the user and the remaining faults are to be cancelled via computer. To cancel faults via computer, access the key icon, select Level 1 and enter *zeb001* (password). An icon with a + appears; press the + to cancel the alarm. When Level 1 is selected for certain parameters in the Battery Parameterization menu and the Battery Setup menu, those parameters are highlighted by a W and can be altered (after entering the password). Other parameters can be altered, but their alteration is to be enabled by calling the Customer service.
- **Diagnostic Values menu**
- **Last 20 Errors Detected menu**
- **Fan Test - Isolation Test menu**
  The Fan Test menu allows to test the fan operation for approx. 30s; the Isolation Test menu allows to test the isolation system. The isolation test is normally performed every 10 minutes (MBS forces MBI to perform the isolation test). Isolation failures can be internal or external to the equipment: if contactors are closed, isolation failures are external to the equipment; if contactors are open, isolation failures can be either internal or external. If internal isolation failures are detected, allow batteries to cool down; if two isolation failures are detected, a serious failure is occurring. The Manual Switch-off Error alarm allows to manually set an error to switch off one battery; to reset this alarm in menu 7, select the error and click +.
- **Icons with three computers**
  Click the first icon to create a *ZebraAcquisitionDir* file, which detects the battery status.
  Click the second icon to create the *ZebraDataBase_V20* database containing service parameters that are periodically sent out to update the battery status memory (parameters should be sent once a month).
  Click the third icon to create a *ZebraDataBase* file, allowing the user to periodically store battery data and create an archive. A second *vel* password is required.
- **ALL BMIs**
  This menu allows to simultaneously display all batteries and select the measures to be displayed.
- **Data Acquisition**
  Right-click to display a measure list to a text file.

3.9. Traction Mode Enable

After setting parameters in Sinus Penta-Traction mode, you can start the equipment in Traction mode. Do the following:

- Make sure that the water flow pump switch and the water/air exchanger switch are closed.
- Enter the DISCHARGE mode (see relevant section above).
- Turn on your computer, launch RemoteDrive, activate the connection and open the project.

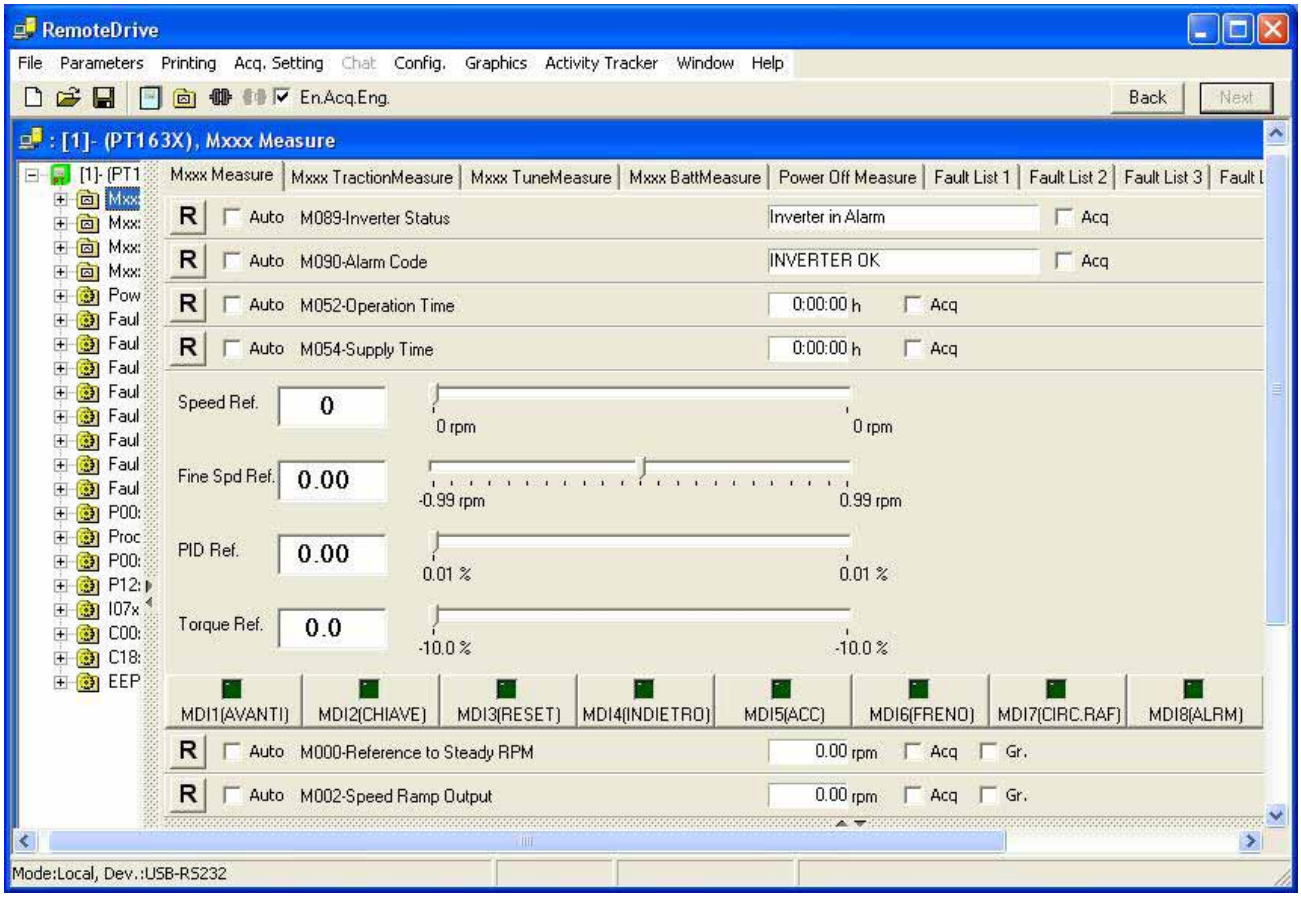

Figure 9: RemoteDrive control screen

- **To activate the ignition key**, click MDI2 (KEY) signal to set it (it turns to light green).
- Put the FORWARD or REVERSE gear.
- Activate the ACCELERATOR contact (digital signal).
- Adjust the potentiometer (ACCELERATOR).
- Remove the ACCELERATOR contact (digital signal) to decelerate.
- Remove the ACCELERATOR contact (digital signal) to brake, and activate the BRAKE contact.
- You can also send the FORWARD, REVERSE, ACCELERATOR, BRAKE signals via RemoteDrive (do not change the sequence above).
- The torque reference cannot be sent via RemoteDrive.
- If inverter alarms trip (they are detected by M090), press the RESET button or reset the alarms tripped via RemoteDrive by clicking the MDI3(RESET) button twice; this button turns to light green if clicked once, then it returns dark green if clicked twice.

NOTE If the vehicle is in gear and/or the accelerator is pressed before the ignition key is fitted, the vehicle will not start.

NOTE If both the ACCELERATOR contact (digital signal) and the BRAKE contact are active, the equipment acts as if the BRAKE was pressed.

NOTE If both selectors for FORWARD and REVERSE gear are active, the drive stops.

NOTE If the forward and/or reverse gear is set when the equipment is running, the drive does not stop.

3.10. Alarms for Sinus Penta-Traction Application

3.10.1. INTRODUCTION

This section covers the alarms for the Traction application. Different alarms are detailed in Sinus Penta's Programming Instructions Manual.

3.10.2. ALARM CODES

Table 8: List of the Traction application alarms

Alarm	Name	Description	Can be enabled by the user
A105	Zebra Battery KO	This alarm trips if the *b_discharge_enable* message is sent by the MBS, or if the MBS detects an error level higher than the Notice level (see Zebra battery user manual) when parameter P375 is set to 0:Alarm.	*Yes*
A106	CAN Communication KO	This alarm trips if communication is suspended for more than *timeout* seconds (P374).	*No*