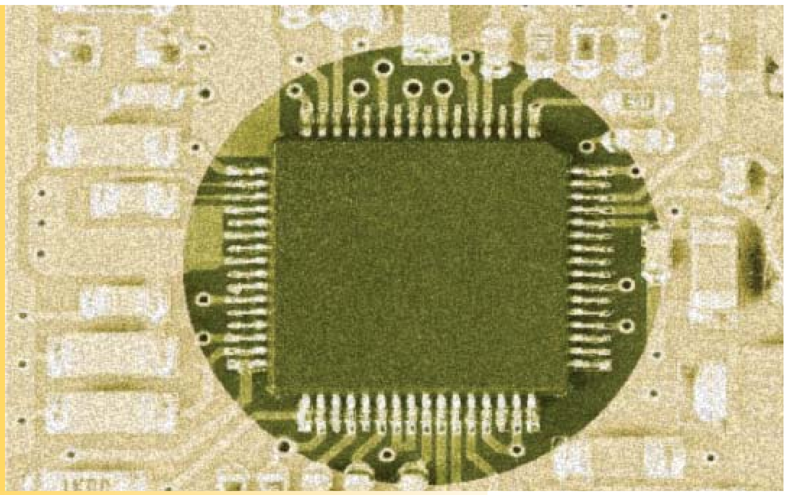
USER'S MANUAL

ServoTrack™ IC

Tomorrow's Technology for Today's Application™



Bridging the gap between servo, brushless DC and stepper motor performance

KOCO MOTION

...Intelligence in motion

PUBLICATIONS HISTORY

REVISION	DATE	CHANGE
1.0	06/20/2012	Initial release

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CHAPTER 1: Introduction

1.1 About this Document

This document contains all the specifications, connectivity information, setup and configuration instructions and software details to fully utilize your ServoTrack™ device.

This document should be read in its entirety before attempting to connect or use your ServoTrack device.

Additional copies may be downloaded in electronic (PDF) format from our web site at: http://www.kocomotionus.com.

1.2 Description

ServoTrack allows existing systems that utilize standard stepper motor technology to convert their stepper motor system into an advanced, high performance brushless system delivering ultimate performance. ServoTrack works by eliminating the loss of synchronization that can occur in stepper motors due to transient or sustained overload, extreme acceleration or deceleration or excessive slew speeds. ServoTrack™ technology allows the user to utilize the full torque of the motor, eliminating the need for derating and often allowing the use of smaller motors.

ServoTrack combines the benefit of servo, stepper and brushless DC motor technologies while eliminating many of the unwanted attributes. There is no tuning or complex setup required with ServoTrack, enabling quick startup times and easy machine changeover while maintaining the benefits of smooth precise motion, stiffness at standstill, and high starting torque. All this is accomplished while maintaining the low cost of a stepper system.

1.3 Operating Modes

ServoTrack brings unique capabilities and versatility to your stepper system through various modes of operation, as described below.

1.3.1 Clock Mode

By monitoring the relationship of the motor rotor and stator, ServoTrack reconfigures the incoming step clock and direction signals, so there is no loss of synchronization.

1.3.2 Torque Mode

Torque mode can be used to regulate and maintain a set torque level. Torque mode opens up many new applications requiring constant torque such as:

- Web tensioning
- Capping
- Clamping
- Feeders

These types of applications can now be accomplished with a much lower cost stepper motor system.

1.3.3 Velocity Mode

Velocity mode can be used to provide a constant speed output without the need for an additional controller, saving space and cost without sacrificing capability. When used in applications such as conveyor systems, ServoTrack eliminates the stalling that can occur due to quick and extreme changes in loads.

1.3.4 Variable Current Mode

Both clock and velocity modes have the ability to use variable current mode, which when mated to your drive, allows only the required current necessary to perform the task, greatly increasing system efficiency while reducing the excess heat inherent in traditional stepper systems.

1.4 System Block Diagram

The following diagram illustrates the basic ServoTrack system.

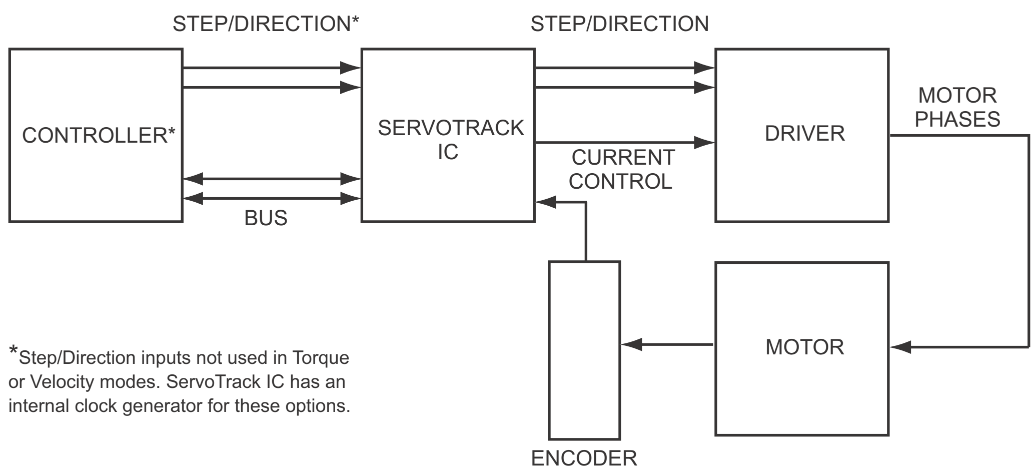


Figure 1-1. ServoTrack System Block Diagram

CHAPTER 2: Understanding ServoTrack

NOTE:	ServoTrack will not compensate for a poor design. ServoTrack will not make a motor more powerful. ServoTrack will maximize the capability of the system and make it more robust.

2.1 Lead/Lag Limits

One of four (4) limits, or control bounds, can be selected. They are 1.1, 1.3, 1.5, or 1.7 full motor steps.

Bounds of 1.1 will produce greater torque though maximum speed will be reduced. Bounds of 1.7 will allow greater speed though transient response is decreased.

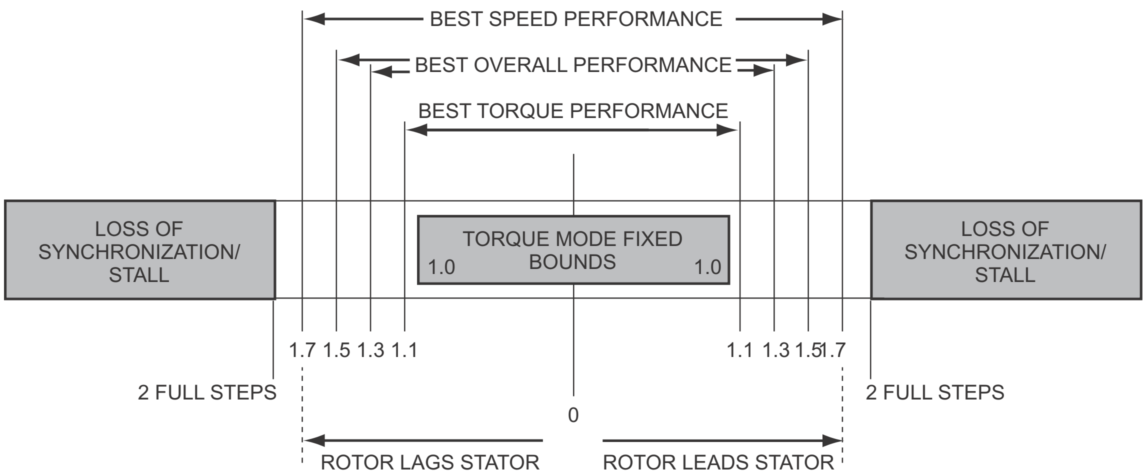


Figure 2-1. Control Bounds Operation

Best overall performance is achieved with bounds of 1.3 or 1.5 full motor steps.

NOTE:	For torque mode, the bounds are preset to 1.0 full steps.

2.2 Microstep and Encoder Resolutions

Fifteen (15) microstep resolutions and nine (9) encoder resolutions from 100 to 1024 lines are supported in any combination. Higher encoder resolutions generally provide “smoother” operation.

2.3 Calibration

The ServoTrack logic requires a calibration to understand the initial relationship between the rotor and stator before ServoTrack operation begins. A calibration is performed on power up to bring the rotor into physical alignment with the stator.

During calibration the motor and position lag / lead logic is cleared and any incoming steps are ignored.

Calibration occurs automatically upon various conditions, such as power on reset, when enabling the ServoTrack functionality, or when MSEL is changed.

NOTE: For best results maximum current should be used for calibration.

NOTE: Regarding changing MSEL or enabling ServoTrack when in motion: the resulting calibration will stop motion abruptly.
Any rotor movement during the timed period will reload the timer, therefore the calibration time specified is the minimum time. A calibration may be initiated at any time via software command.

NOTE: Calibration should not be performed if the motor is against a hard mechanical stop. The motor should be moved to a position where the shaft is free to rotate when the phases are energized.

2.4 Operating Current

Operating current defines the peak motor current in the motor phases. There are two (2) operating current modes: variable and fixed.

NOTE: Use of variable current mode and other current control features require that your drive be equipped with a current reference input. Drivers whose run and reduction current is set by switches or jumpers cannot utilize these features.

Variable mode adjusts the operating current from 2% up to 100% of a defined maximum based on the motor lag / lead from 0 to 1 full step. For example, when lag / lead equals 0.5-full step, operating current would be 51 % of maximum; when lag / lead equals 1-full step, operating current would be 100% of maximum. The operating current is increased immediately when lag / lead increases but is decreased using a filtering algorithm.

Variable mode is useful to reduce heat when the torque requirement is generally modest or varying but comes with a downside of a slight increase in torque ripple. Variable mode provides a smoother response to an external torque applied on the rotor. Variable mode, when enabled, becomes the 1st defense against loss of synchronization.

By only applying the necessary current needed to move the load, variable mode can greatly reduce motor heating and increase system efficiency.

Fixed mode consists of run current when steps are active and hold current when no steps have occurred for a defined period of time. This mode works well for extreme acceleration and / or short moves with a downside of potentially more heat.

The user can freely switch between variable and fixed current modes. When using the torque function the variable and fixed current modes do not apply.

2.5 Locked Rotor

A locked rotor is defined as no rotor movement while at the maximum allowed lag for a specified period of time. When lag equals the bounds a timer starts to count down. Upon reaching zero a locked rotor will be indicated by the assertion of a status flag. The timer reloads on any encoder movement. The timer timeout period is user selectable from 2ms to 65.5 seconds.

In torque mode the locked rotor flag can be used to indicate the rotor has been stopped at the specified torque for a preset amount of time.

2.6 Position

For reference, position lag is when the motor lags behind the commanded step position. Position lead is when the motor leads the commanded step position.

A count is kept of the difference (error) between the commanded step position and the actual stator position. The host controller can read step position error and take appropriate action when and how desired. Note that the position is step accurate which typically provides higher resolution than an encoder. For example, a 512 line encoder provides a resolution of 2048 while a 1.8 degree motor micro-stepping at 256 has a resolution of 51200. It is important to note that the rotor position can vary by the amount of programmed lead/lag bounds from the stator position. The count is cleared when ServoTrack is disabled or when a calibration occurs. The count also may be manually cleared via software command.

A host controller can set a position lag and lead limit. When either limit is reached or exceeded a status flag will assert. This may be useful as possible indications of excessive binding, maintenance such as lubrication required, or other mechanical system issues.

2.7 Position Maintenance

Automatic position maintenance can be enabled, which will insert steps as required when conditions allow, in the appropriate direction, to bring the position difference between the commanded number of steps and actual steps taken to zero, and the rotor being within the specified bounds.

The speed of position maintenance (the make up frequency) can be performed at one (1) of two (2) speeds. Insertion can be at a specified speed or can be set at the maximum speed the load will allow. There is no acceleration or deceleration applied to position make up, therefore make up could be abrupt if set at a high speed.

Position maintenance will only occur when the motor lag / lead is within 1.1 full motor steps independent of the set bounds. This provides maximum torque.

Depending on various conditions, make up steps may be interleaved with incoming steps and/or made after a move has completed. Where in time position maintenance occurs is dependent on motor lag/lead, step input frequency, and selected make up speed.

Example: Position lag occurred due to overly aggressive acceleration. Make up steps could be interleaved during the slew portion of the move if the make up frequency is higher than the slew frequency. Or make up could occur during the deceleration portion of the move if make up frequency is higher than initial frequency. Make up could also occur at end of profile if the make up frequency is lower than commanded frequency. Make up can also occur during multiple segments of a move profile.

For a very aggressive move profile that is also dependent on time, it is possible there will be no opportunity to make up missing steps during the time allowed for the move. Therefore the move will not complete in the allotted time as make up steps will occur at the end of the move.

Position lag for bidirectional moves with no opportunity for make up may produce an intermediate position offset. For example, moving right from A to B caused a 3 step lag, then immediately moving left from B to A. The ending position could initially be 3 steps to the left of A. The ending position would be corrected. However the intermediate position would have been off by 3 steps.

The position error is maintained in a 32 bit signed counter. This equates to 41,943 revolutions with a microstep resolution of 256 microsteps per step. If the maximum count is reached the counter will stop and an error is generated. The counter will not roll over.

2.8 Maximum System Speed

There is a process delay timer within the ServoTrack logic to set the maximum system speed. This is the speed at which step clocks are internally generated. The maximum speed is set via a step width parameter. For example a step width of 200 ns sets the maximum system speed to 2.5 MHz. The absolute maximum speed is limited to 5 MHz by the step clock generator.

There are potential issues to setting the system speed too slow. For example, if the system speed is limited to 1.5 MHz and the incoming slew speed is 2 MHz, the system will only produce steps at the maximum 1.5 MHz rate. This is a fairly benign issue as all incoming steps are still accounted for, so the position error is correct and make up would proceed normally. A more serious issue, though unlikely, is the case of motor lead due to extreme deceleration in a high inertia system. In this case the stator may not be able to keep up with the rotor causing loss of synchronization.

NOTE: In torque mode, maximum system speed can be used to limit the speed of an unloaded system.

2.9 Interrupt Output

An output is provided to indicate selected condition(s) have occurred or are occurring. A number of conditions may be combined (a logical OR) to assert the output. For example when position lag, position lead, and locked rotor are selected, any combination will assert the output.

When multiple conditions are selected, the specific cause can be determined by reading status register and/or error code.

Using the output with an indicator lamp can be very helpful when evaluating a motion profile. A good example is to select the ServoTrack active condition to light the indicator. ServoTrack active asserts when ServoTrack is intervening. Therefore if the acceleration portion of the profile is too aggressive, or the slew is too fast, or the deceleration is too aggressive the indicator will light.

The Make Up active condition is also useful for evaluation. It will show when steps are inserted during the motion profile. The user could adjust the make up frequency for the desired result. For example, if time is not critical but speed during the profile is, the user could adjust the parameters so steps are added at end of move rather then being inserted during the move.

Make Up could also be used to indicate to a host controller that move has not been completed and will continue even though the host has completed generation of the required steps.

2.10 Velocity Control Function

When setting ServoTrack to function in velocity mode, the Start/Stop input is used to initiate or end movement at a pre-programmed velocity, which is internally generated and routed to the Step Clock Output. A large array of programmable functions such as acceleration/deceleration, and max frequency, as well as many others are available.

2.11 Torque Function

When setting ServoTrack to function in torque mode, the Start/Stop input is used to initiate or end a torque whose magnitude has been pre-programmed into the unit. When the Start input is asserted in torque mode an offset between the rotor and stator of 1 full step will try to be maintained to create a torque on the rotor. If the load applied to the rotor is less then the torque required to maintain a 1 full step offset the rotor will begin to rotate in an attempt to generate the required offset. The speed of rotation will vary dependent on load. Rotational speed will increase until such time as a 1 full step phase shift between the rotor and stator is achieved.

NOTE: If the rotational speed becomes greater then the speed at which the motor can produce the necessary torque, as shown in the speed torque curve, the torque available will be less then required.
The maximum speed may be limited electronically by setting the maximum system speed. However, this may prevent reaching the set torque if the stator cannot move fast enough to maintain 1 full step of offset.
Step clock pulses may be input when in torque mode ONLY when the start/stop input is in the STOP position. This facilitates moving the motor after a desired torque level or time is achieved.

NOTE: Care should be taken so that position make up is disabled when in torque mode to prevent unwanted moves when the start/stop input is in the stop position.

NOTE: The actual torque expected by the motor is a function of motor holding torque and driver set current.

2.12 Bypass

When ServoTrack is disabled, an incoming step is routed directly to the Step Clock Output. The motor and position lag / lead calculation logic is disabled and the values are cleared. This can be useful in comparing the performance of a standard system without ServoTrack.

The user can freely move between ServoTrack and bypass. Note that an automatic calibration will be performed when ServoTrack is enabled.

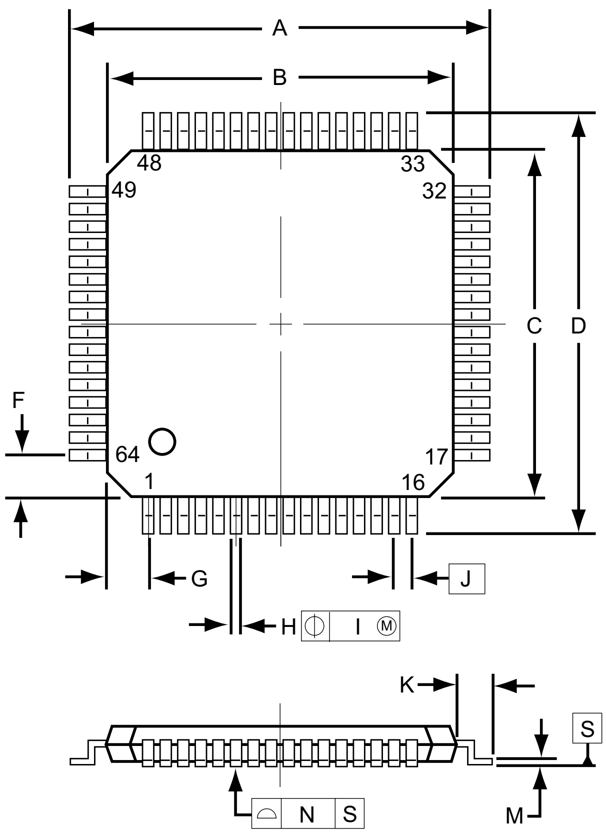
2.13 Configuration Test

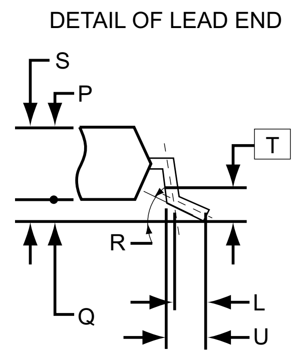
In order to correctly calculate lag / lead the resolution of the installed encoder must be correctly specified and the encoder direction must match the commanded motor direction. For example, if the motor direction is positive (dir = 1) the encoder must turn such that channel A leads channel B (dir = 1), and if a 500 line encoder is installed a 500 line encoder must be specified.

NOTE: It is strongly recommended that a configuration test be performed on a newly set up system. A miss-wired or improperly specified encoder will cause erratic operation.

CHAPTER 3: Specifications

3.1 64-Pin Plastic TQFP (Fine Pitch) (10x10)





ITEM	MILLIMETERS
A	12.0 ± 0.2
B	10.0 ± 0.2
C	10.0 ± 0.2
D	12.0 ± 0.2
F	1.25
G	1.25
H	0.22 ± 0.05
I	0.08
J	0.5 (T.P.)
K	1.0 ± 0.2
L	0.5
M	$0.17\ ^{+0.03}_{-0.07}$
N	0.08
P	1.0
Q	0.1 ±0.5
R	$3°\ ^{+4°}_{-3°}$
S	1.10 ± 0.10
T	0.25
U	0.6 ± 0.15

NOTE:
Each lead centerline is located within 0.08 mm of its true position (T.P.) at maximum material condition.

Figure 3-1. 64-Pin Plastic TQFP (Fine Pitch) (Part #: DEST1)

3.2 Signal Summary

Table 3-1: Signal Summary

Pin #	Signal Name	Signal Function	Output Drive
1	GND	Ground	-
2	VDD	Power	-
3	AD7	Address/Data bit 7	12 mA
4	AD6	Address/Data bit 6	12 mA
5	AD5	Address/Data bit 5	12 mA
6	GND	Ground	-
7	AD4	Address/Data bit 4	12 mA
8	AD3	Address/Data bit 3	12 mA
9	GND	Ground	-
10	VDD	Power	-
11	AD2	Address/Data bit 2	12 mA
12	AD1	Address/Data bit 1	12 mA
13	AD0	Address/Data bit 0	12 mA
14	GND	Ground	-
15	ALE	ALE input	-
16	CEN	Active low Chip Enable input	-
17	WEN	Active low Write Enable input	-
18	OEN	Active low Output Enable input	-
19-21	VDD	Power	-
22	GND	Ground	-
23	TDO	Reserved - No Connection	-
24	VDD	Power	-
25	GND	Ground	-
26	SYS_CLK	20 Mhz System Clock Input	-
27	GND	Ground	-

Table 3-1: Signal Summary (Continued)

Pin #	Signal Name	Signal Function	Output Drive
28	RESETN	Asynchronous active low reset	-
29	GND	Ground	-
30	INTR_OUT	Interrupt Output	12 mA
31	PWM_CUR	Pulsewidth Modulated Motor Phase Current Reference Output	12 mA
32	VDD	Power	-
33	GND	Ground	-
34	RED	RED LED output	24 mA
35	YELLOW	YELLOW LED output - Correction Active	24 mA
36	GND	Ground	-
37	GREEN	GREEN LED output - Power On & System OK	24 mA
38	GND	Ground	-
39	OE	Output Enable (OE) output	12 mA
40*	STEP_OUT	Step Clock Output	24 mA
41	GND	Ground	24 mA
42	VDD	Power	-
43*	DIR_OUT	Direction Output	-
44	LK_RTR	Locked Rotor Output	12 mA
45	GND	Ground	-
46	ATN_OUT	Attention Output	12 mA
47	GND	Ground	-
48	VDD	Power	-
49	GND	Ground	-
50*	DIR_IN	Direction Input	-
51*	STEP_IN	Step Clock Input	-
52	ST_EN	Stop/Go/Bypass Input	-
53	VDD	Power	-
54	GND	Ground	-
55	ENC_B	Encoder B Input	-
56	ENC_A	Encoder A Input	-
57	GND	Ground	-
58	VDD	Power	-
59-60	GND	Ground	-

Table 3-1: Signal Summary (Continued)

Pin #	Signal Name	Signal Function	Output Drive
61	SOUT	Reserved - No Connection	-
62	GND	Ground	-
63	VDD	Power	-
64	GND	Ground	-

* Includes Clock Up / Clock Down and Quadrature Output Modes

3.3 Signal Descriptions

- **AD0 - AD7** (address/data bits 0 - 7): address and data signals that are used when interfacing to a microcontroller. Both address and data are shared on the same signals. The address is latched first by exerting the ALE (Address Latch Enable) signal, followed by the data.
- **ALE** (Address Latch Enable): active high input pulse used for latching the address during a register access.
- **CEN** (Chip Enable): active low input used to enable access to the internal registers.
- **WEN** (Write Enable): active low input used to write data to the internal registers.
- **OEN** (Output Enable Input): active low input used to read data from the internal registers.
- **SYS_CLK** (System Clock): 20 MHz System Clock.
- **RESETN** (Reset): asynchronous active low input used to reset the device. A minimum of 300 ns is required after the oscillator is operating.

NOTE: All internal registers are set to zero after a reset and must be configured before operating the device.

- **INTR_OUT** (Interrupt Output): signals that a flag, or combination of flags, selected by the user has been set. This output can be configured to be active high or active low.
- **PWM_CUR** (Motor Phase Current Reference Output): a pulsewidth modulated output that is used to control the phase current in the motor when in Variable Current Mode or when using current reduction when Fixed Current Mode is selected.
- **RED** (Red LED Output): can be configured by the user to flash an LED when the system detects an error has occurred.
- **YELLOW** (Yellow LED Output): can be connected to an LED to indicate that corrective action is being introduced by the ServoTrack IC.
- **GREEN** (Green LED Output): can be connected to an LED to indicate that power is on and the system is functioning properly.
- **OE** (Output Enable Output): goes high when writing to the registers in the ServoTrack IC is completed after a reset or power-up. One use for this output is to disable or tri-state outputs that need to be stable while on power-up.
- **STEP_OUT** (Step Clock Output): It is used in conjunction with DIR_OUT to incrementally move the motor position clockwise or counter-clockwise. The two signals can also be programmed to provide Clock Up / Clock Down and Quadrature Output modes.
- **DIR_OUT** (Direction Output): used to indicate the required direction of the motor. It is used in conjunction with STEP_OUT. The two signals can also be programmed to provide Clock Up / Clock Down and Quadrature Output modes.

  The level of this signal, when used in Step Clock / Direction mode, can be inverted in the I/O configuration register (address 09).

- **LK_RTR** (Locked Rotor Output): indicates when the pre-programmed time has expired after no movement of the rotor is detected, which occurs when a difference between the number of input step clocks and output step clocks exists.
- **ATN_OUT** (Attention Output): used to signal that a flag or combination of flags, selected by the user, has been set.
- **DIR_IN** (Direction Input): used by the System Controller to indicate the desired direction of motor rotation. When used in conjunction with STEP_IN, the ServoTrack IC can be programmed to accept Clock Up / Clock Down or Quadrature inputs.

  The active level of this input can be inverted by programming the I/O configuration register (address 09).
- **STEP_IN** (Step Clock Input): used to increment the motor position. It is used in conjunction with DIR_IN to move the motor clockwise or counter-clockwise. The two signals can also be programmed to provide Clock Up / Clock Down and Quadrature Output inputs.

  The active level of this input can be inverted by programming the I/O configuration register (address 09).
- **AS_EN** (Stop/Go/Bypass Input): used in Velocity and Torque modes. Starts or stops the internal Step Clock signal generator. In Step Clock and Direction mode, it is used to enable the ServoTrack IC correction circuitry or disable it and pass the Step Clock and Direction input signals to the Step Clock and Direction output pins unaltered.
- **ENC_B** (Encoder B Input): connects to the B output of the incremental encoder.
- **ENC_A** (Encoder A Input): connects to the A output of the incremental encoder.

3.4 Absolute Maximum Rating Values

Table 3-2: Absolute Maximum Rating Values

Item		Symbol	Conditions	Ratings	Units
Power Supply voltage		V_{DD}	-	-0.5 to +4.6	V
Input voltage		V_I	$V_I < V_{DD} + 3.0$ V	-0.5 to +6.6	V
Output voltage		V_O	$V_O < V_{DD} + 3.0$ V	-0.5 to +6.6	V
Output current	I_{OL} = 12.0 mA	I_O	-	40	mA
	I_{OL} = 24.0 mA	I_O	-	75	mA
Operating ambient temperature		T_A	-	-40 to +85	ºC
Storage temperature		T_{stg}	-	-65 to +150	ºC

NOTE: Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

NOTE: 5V or 3.3V must be applied to the I/O pins only after applying the power supply voltage.

3.5 Recommended Operating Range

Table 3-3: Recommended Operating Range

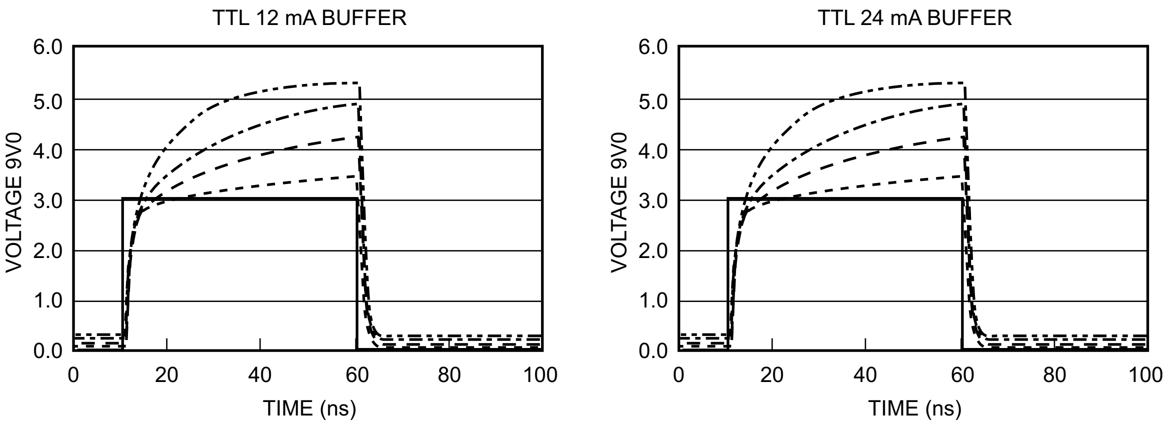
Item	Symbol	Conditions	MIN.	TYP.	MAX.	Units
Power Supply voltage	V_{DD}	-	3.0	3.3	3.6	V
High-level Input voltage	V_{IH}	5V tolerant input	2.0	-	5.5	V
Low-level Input voltage	V_{IL}	5V tolerant input	0	-	0.8	V
Input rise time	t_{ri}	-	0	-	200	ns
Input fall time	t_{fi}	-	0	-	200	ns
Operating ambient temperature	T_A	-	-40	-	+85	ºC

3.6 DC Characteristics

Table 3-4: DC Characteristics

Item	Symbol	Conditions	MIN.	TYP.	MAX.	Units
Static current consumption	I_{DDS}	$V_I = V_{DD}$ or GND	-	2.0	300	μA
Active current consumption (Note 1)	I_{DDA}	-	-	-	48	mA
OFF-state output current (Note 2)	I_{OZ}	$V_O = V_{DD}$ or GND	-	-	±10	μA
Output influx current (Note 3)	I_R	V_O = 3.0 V	-	-	0.1	μA
Output short-circuit current (Note 4)	I_{OS}	V_O = GND	-	-	-250	mA
Input leakage current	I_I	$V_I = V_{DD}$ or GND	-	-	±1.0	μA
Low-level output current, 12.0 mA type	I_{OL}	V_{OL} = 0.4 V	12.00	-	-	mA
Low-level output current, 24.0 mA type	I_{OL}	V_{OL} = 0.4 V	24.00	-	-	mA
High-level output current, 12.0 mA type	I_{OH}	V_{OH} = 2.4 V	-3.00	-	-	mA
High-level output current, 24.0 mA type	I_{OH}	V_{OH} = 2.4 V	-6.00	-	-	mA
Low-level output voltage	V_{OL}	I_{OL} = 0 mA	-	-	0.1	V
High-level output voltage	V_{OH}	I_{OH} = 0 mA	V_{DD} - 0.2	-	-	V

Notes
1. Outputs floating.
2. For 5 V tolerant three-state output buffers and I/O buffers, the OFF state current of the output increases slightly in order to bias the 5 V protection circuit.
3. If the 5 V tolerant output buffers are pulled up at a voltage higher than the supply voltage, a sink current flows from the output pins to the internal circuitry.
4. The output short-circuit time is 1 second or less per pin.



REMARKS 1.

————————	INPUT WAVEFORM
·–··–··–··–	R_{PU} = 0.5 kΩ
–·–·–·–·–	R_{PU} = 1.0 kΩ
– – – – –	R_{PU} = 2.0 kΩ
- - - - - - -	R_{PU} = 5.0 kΩ

2. MEASUREMENT CONDITIONS

V_{DD} = 3.0 V, T_J = 125°C

V_{PU} = 5.5 V

Figure 3-2. 5 V Tolerant Output Waveform

CHAPTER 4: Microcontroller Interface

The ServoTrack IC contains a standard microcontroller parallel bus interface that is used for loading parameters, reading and writing data, and reading status information. Address and data share the same 8 bit parallel port.

The signals associated with reading and writing data are:

- **ALE** (address latch enable): used to latch the address prior to reading/writing the data.
- **CEN** (chip enable): used to select the ServoTrack IC.
- **AD[7..0]** (address/data bus): contains the 8 bit address and data.
- **WEN** (write enable): used to strobe the data into the ServoTrack IC.
- **OEN** (output enable): used to read the data from the ServoTrack IC into the microcontroller.

4.1 Microcontroller Bus Timing

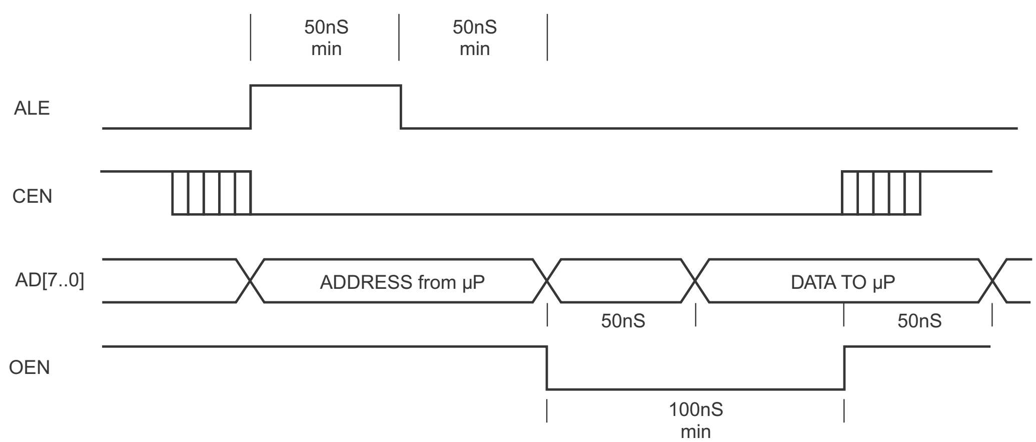


Figure 4-1. Read Cycle

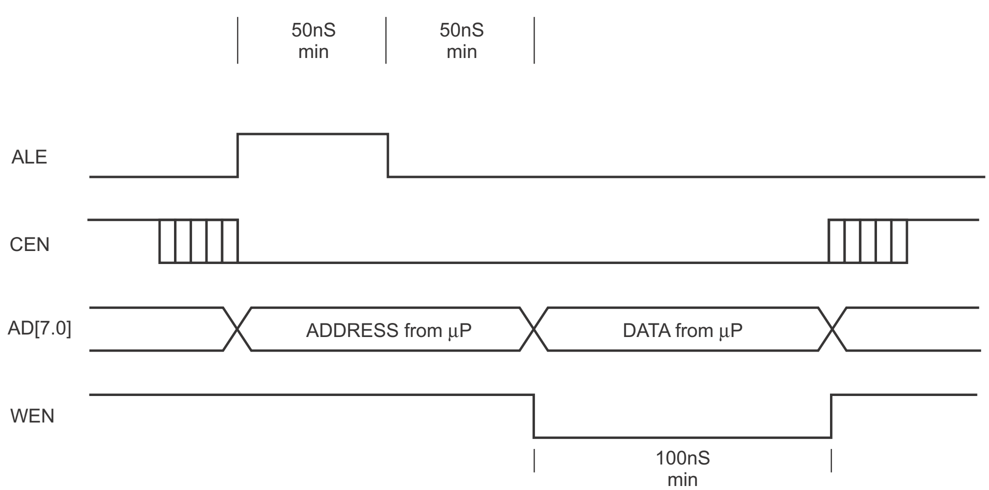


Figure 4-2. Write Cycle

CHAPTER 5: Hardware Interfaces

5.1 Variable Current Reference

The ServoTrack IC contains a pulsewidth modulated motor phase current reference output used to control the motor phase currents when Variable Current Mode is selected.

The following circuit can be used to generate a varying voltage reference proportional to the pulsewidth modulated output for use in controlling the motor phase currents:

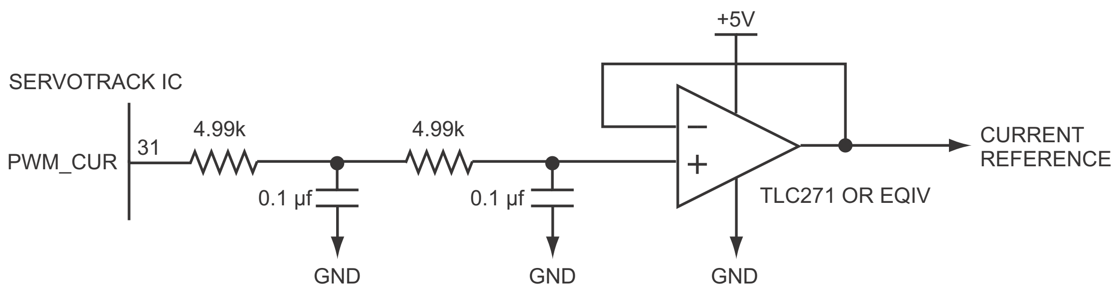


Figure 5-1. Variable Current Reference Circuit

5.2 Differential Encoder Interface

In many industrial environments, it may be beneficial to use a differential encoder to reduce the effects of noise generated by the equipment. The following circuit can be used to interface a typical 5 Vdc differential encoder with the ServoTrack IC:

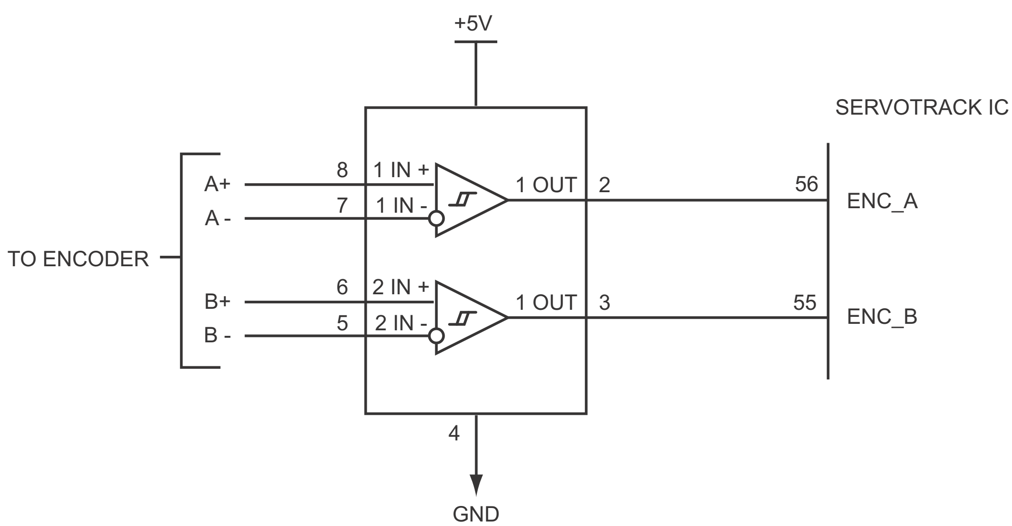


Figure 5-2. Differential Encoder Circuit

CHAPTER 6: Command Details

This section covers in detail the ServoTrack commands and associated register addresses.

6.1 General Information

6.1.1 Register Types

The following describes the types and behavior of the ServoTrack registers:

Function	Type	Description
Write	Static	Used to write a value to a register. Performing a read will return the last value written to the register.
Write	Dynamic	Used to assign a value to a register. Performing a read will return a value that has been modified by events.
Write	Self Clearing	Used to generate strobes. Reads are undefined.
Read	Dynamic	Performing a read returns a value that has been modified externally. Writes have no effect.
Read	Write to Clear	Used to read the logic state of a flag. A write will clear the flag.

NOTE: All register values are programmed in hex. Values shown in the following command details have been converted to decimal.

6.1.2 Default Values after Reset / Power-up

NOTE: After a reset or on power up, all registers are set to zero and must be initialized.

NOTE: The ServoTrack IC will not operate until all configuration registers have been initialized.

6.2 Current Control Registers

6.2.1 Run Current

Register Name		Run Current
Address		00 (1 Byte)
Function		Anti-stall disabled run current, anti-stall run current (fixed), anti-stall maximum current (variable).
Range		0 - 255
Type		Write, Static
Description		Sets the maximum run current for anti-stall (disabled and enabled) fixed and variable current modes to a per cent. The counts are scaled where 255 = 100% current and 0 = 0% current.
Usage	**Read**	@00 Returns previous setting
	Write	@00 = 128 (set maximum run current to 128 counts, or approx. 50%)

6.2.2 Reduction Current

Register Name		Reduction Current
Address		01 (1 Byte)
Function		Anti-stall disabled reduction current, anti-stall hold current (fixed).
Range		0 - 255
Type		Write, Static
Description		Sets the reduction current to a percent. The counts are scaled such that 255 counts = 100% current.
Usage	**Read**	@01 Returns previous setting
	Write	@01 = 64 (Set the reduction current to 64 counts or 25%)
Notes		Not used with anti-stall variable current mode.

6.2.3 Fixed Hold Current Delay Time

Register Name		Fixed Hold Current Delay Time
Address		02 (2 Bytes)
Function		Delay time (milliseconds) to shift to Hold current.
Range		0, 2 - 65535
Type		Write, Static
Description		Specifies the delay time (milliseconds) before shifting to the reduction current setting. Used with anti-stall (off) mode and anti-stall (fixed) mode. The range is 2 ms to 65535 ms, with an accuracy of +0/-1 ms. With a setting of zero (0), the current will not reduce.
Usage	**Read**	@02 Returns previous setting
	Write	@02 = 1000 (Set fixed hold current delay time to 1000 ms) Auto writes into registers when most significant byte is written.

6.2.4 Torque Current

Register Name		Torque Current
Address		04 (1 Byte)
Function		Torque mode current setting.
Range		0 - 255
Type		Write, Static
Description		Specifies the maximum current for torque mode operation. The relationship between current and torque output is approximately linear, therefore 75% current will equal approximately 75% of holding torque output to the load. The counts are scaled such that 255 counts = 100% torque current.
Usage	**Read**	@04 Returns previous setting.
	Write	@04 = 128 (Set torque current to 128 counts or 50%)

6.2.5 Calibration Current

Register Name		Calibration Current
Address		05 (1 Byte)
Function		Calibration current in percent.
Range		0 - 255
Type		Write, Static
Description		Specifies the current used for calibrating the rotor-stator relationship. The counts are scaled such that 255 counts = 100% calibration current. Calibration current is typically set to 100%.
Usage	**Read**	@05 Returns previous setting.
	Write	@05 = 255 (Set calibration current to 100%)

6.3 I/O Configuration Registers

6.3.1 I/O Inversions and Corrections

Register Name		I/O configuration
Address		09 (1 Byte)
Function		Inverts clock I/O and corrects for incorrect encoder and motor direction.
Range		See Figure 6-1. Register values will read and write as the hex value of the set bits.
Type		Write, Static
Description		Figure 6-1 shows the bit positions for this command. By setting three bits to 1, the step and direction inputs may be inverted, the direction output inverted. Using the correct encoder and motor direction bits can correct for issues such as motor phases and encoder channels being swapped in error in wiring. The bit for Select Motion Source is used to select either the Step Clock input (0) or the internal oscillator (1).
Usage	**Read**	@09 Returns previous setting.
	Write	@09 = 16 (correct encoder direction)

MSb LSb

Invert Direction In	Invert Step In	Invert Direction Out	Correct Encoder Direction	Correct Motor Direction	Select Motion Source	—	—

Figure 6-1. I/O Inversions and Corrections Bit Positions

6.3.2 Step Output Pulse Width

Register Name		Step Pulse Width
Address		0A (1 Byte)
Function		Sets the pulse width of the Step Clock output in ns/μs
Range		0 - 255 (100 ns to 12.85 μs)
Type		Write, Static
Description		This register is used to control the pulse width of the output clock to the driver. When 0, the pulse width is 100 ns (5 MHz). The frequency may be stepped down in 50 ns increments to 12.85 μs (38.8 kHz).
Usage	**Read**	@0A Returns previous setting.
	Write	@0A = 255 (set output clock width to 12.85 μs)

6.3.3 Step/Direction and Encoder Input Filtering

<table>
<tr><td colspan="2">Register Name</td><td>Input Filtering</td></tr>
<tr><td colspan="2">Address</td><td>0B (1 Byte)</td></tr>
<tr><td colspan="2">Function</td><td>Sets the filtering for the step and direction inputs and the encoder inputs.</td></tr>
<tr><td colspan="2">Range</td><td>50ns to 12.9 µs (10 MHz to 38.8 kHz)</td></tr>
<tr><td colspan="2">Type</td><td>Write, Static</td></tr>
<tr><td colspan="2">Description</td><td>
<table>
<tr><td colspan="2">Input Filter Step and Direction</td><td colspan="2">Input Filter Encoder</td></tr>
<tr><td>0</td><td>50ns/10MHz</td><td>0</td><td>50ns/10MHz</td></tr>
<tr><td>1</td><td>150ns/3.3MHz</td><td>1</td><td>150ns/3.3MHz</td></tr>
<tr><td>2</td><td>200ns/2.5MHz</td><td>2</td><td>200ns/2.5MHz</td></tr>
<tr><td>3</td><td>300ns/1.67MHz</td><td>3</td><td>300ns/1.67MHz</td></tr>
<tr><td>4</td><td>500ns/1.0MHz</td><td>4</td><td>500ns/1.0MHz</td></tr>
<tr><td>5</td><td>900ns/555kHz</td><td>5</td><td>900ns/555kHz</td></tr>
<tr><td>6</td><td>1.7µs/294.1kHz</td><td>6</td><td>1.7µs/294.1kHz</td></tr>
<tr><td>7</td><td>3.3µs/151kHz</td><td>7</td><td>3.3µs/151kHz</td></tr>
<tr><td>8</td><td>6.5µs/76.9kHz</td><td>8</td><td>6.5µs/76.9kHz</td></tr>
<tr><td>9</td><td>12.9µs/38.8kHz</td><td>9</td><td>12.9µs/38.8kHz</td></tr>
</table>
</td></tr>
<tr><td rowspan="2">Usage</td><td>Read</td><td>@0B Returns previous setting.</td></tr>
<tr><td>Write</td><td>@0B = 33 (set step/direction and encoder filtering to 300 ns)</td></tr>
</table>

MSb	LSb
Filter Step/Direction Inputs 0 - 9h 10 MHz - 38.8 kHz	Filter Encoder Inputs 0 - 9h 10 MHz - 38.8 kHz

Figure 6-2. I/O Filtering

6.3.4 Attention Output

Register Name		Attention output
Address		0C (1 Byte)
Function		Register settings determine which conditions will cause the activation of the attention output.
Range		See Figure 6-3. Register will read and write as the hex value of the set bits.
Type		Write, Static
Description		This register controls which conditions activate the attention output. These conditions are: 1. Lag limit reached 2. Lead limit reached 3. Calibration active 4. Locked rotor 5. Position maintenance active 6. ServoTrack active Register will read and write as the binary coded decimal.
Usage	**Read**	@0C Returns previous setting.
	Write	@0C = 48 (Attention out active when lag and lead limit is reached)

MSb LSb

—	—	Lag Limit Reached	Lead Limit Reached	Calibration Active	Locked Rotor	Position Maintenance Active	ServoTrack Active

Figure 6-3. Attention Output Control Bit Positions

6.3.5 Error LED

Register Name		Error LED
Address		0E (1 Byte)
Function		Flashes error LED output.
Range		—
Type		Write, Static
Description		By setting the LSb of this register, the Error LED output will flash.
Usage	**Read**	@0E Returns previous setting.
	Write	@0E = 01 (Flash Error LED)

MSb LSb

—	—	—	—	—	—	—	Flash Error LED

Figure 6-4. Flash Error LED Bit Position

6.4 Velocity Configuration Registers

6.4.1 Initial Velocity

Register Name		Initial Velocity
Address		10 (4 Bytes)
Function		Sets the initial (startup) velocity of the axis.
Range		0 – 8388608 (0 – 5 x 10^6 steps/second@ 0.596 step/second resolution)
Type		Write, Static
Description		Initial or startup velocity for all motion commands. The factory default value is 0 clock pulses (steps) per second. The initial velocity for a stepper should be set to avoid the low speed resonance frequency and must be set lower than the pull in torque of the motor. It must also be set to a value lower than the terminal velocity. Example: to set startup velocity to 1000 steps/second 1000 / 0.596 = 1678.
Usage	**Read**	@10 Returns previous setting.
	Write	@10 = 1678 (set startup velocity to 1000 steps/sec)

6.4.2 Terminal Velocity

Register Name		Terminal Velocity
Address		14 (4 Bytes)
Function		Sets the terminal (maximum) velocity of the axis.
Range		0 – 8388608 (0 – 5 x 10^6 steps/second@ 0.596 step/second resolution)
Type		Write, Static
Description		0x14 specifies the maximum velocity in steps/counts per second that the axis will reach during a move command. Must be greater than initial velocity. Example: to set terminal velocity to 51200 steps/sec, 51200 / 0.596 = 85906.
Usage	**Read**	@14 Returns Previous Setting
	Write	@14 = 85906 (set terminal velocity to 51200 steps/sec)

6.4.3 Deceleration

Register Name		Deceleration
Address		18 (4 Bytes)
Function		Set axis deceleration.
Range		0 – 16777215 (90.9 to 1.5 x 10^9 steps/sec^2) by 90.95 increments.
Type		Write, Static
Description		This register sets the deceleration of the device in steps per second^2. If set to 76800 steps per second^2 the motor would decelerate at a rate of 76800 steps per second, every second. If the device was running at a maximum velocity of 768000 microsteps per second it would take 10 seconds to decelerate if terminal velocity=0. Example: to set deceleration to 768000 steps/second^2, 768000 / 90.95 = 8444.
Usage	**Read**	@18 Returns Previous Setting
	Write	@18 = 8444 (set decel to 768000 steps/second^2)

6.4.4 Acceleration

Register Name		Acceleration
Address		1C (4 Bytes)
Function		Set axis acceleration.
Range		0 – 16777215 (90.9 to 1.5 x 10^9 steps/sec^2) by 90.95 increments.
Type		Write, Static
Description		This register sets the acceleration of the device in steps per $second^2$. If set to 76800 steps per $second^2$ the motor would accelerate at a rate of 76800 steps per second, every second. Example: to set accel to 768000 steps/$second^2$, 768000 / 90.95 = 8444.
Usage	**Read**	@1C Returns Previous Setting
	Write	@1C = 8444 (set decel to 768000 steps/sec^2)

6.4.5 Current Velocity

Register Name		Read Current Velocity
Address		20 (4 Bytes)
Function		Register holds the current velocity of the motor.
Range		0 – 8388608
Type		Read, Dynamic
Description		The current velocity of the axis is stored with a resolution of 0.596 steps/ second It is calculated as <reg value> x 0.596 = <velocity in steps/sec>
Usage	**Read**	@20 = Currrent motor velocity
	Write	—

6.4.6 Velocity Strobes

Register Name		Velocity Strobes
Address		24 (1 Byte)
Function		Used to strobe in velocity settings or read the current velocity.
Range		See Figure 6-5. Register values will read and write as the hex value of the set bits.
Type		Write, Self Clearing
Description		By setting bits within the register parameter, information is written into the internal registers of the ServoTrack IC. The register is also used to capture the current velocity of the motor.
Default		—
Usage	**Read**	—
	Write	@24 =20 (write terminal (high) velocity into the velocity register)

MSb LSb

Write Strobe Acceleration	Write Strobe Deceleration	Write Strobe Terminal (High) Velocity	Write Strobe Initial (Low) (Velocity	—	—	—	Read Strobe Current Velocity

Figure 6-5. Velocity Strobe Bit Positions

6.4.7 Motor Settling Delay Time

Register Name		Motor Settling Delay
Address		25 (2 Bytes)
Function		The motor settling delay time allows the motor time to settle into position between moves.
Range		0 to 65000 ms
Type		Write, Static
Description		Specifies the motor settling delay time in milliseconds. This register allows the motor to settle following a move. This is the time between moves if consecutive motions are executed.
Usage	**Read**	@25 Returns Previous Setting
	Write	@25=5000 (set motor settling delay time to 5000 ms). Auto writes into registers when most significant byte is written.

6.4.8 Velocity Flags

Register Name		Velocity Flags
Address		27 (1 Byte)
Function		Status of velocity functions.
Range		See Figure 6-6. Register values will read and write as the hex value of the set bits.
Type		Read, Write to Clear
Description		This register contains the status of the flags set by the ServoTrack IC for completion of motor settling delay, deceleration, and acceleration.
Usage	**Read**	@27 =04 (Deceleration complete)
	Write	@27=00 (clear flags)

MSb LSb

—	—	—	—	Motor Settling Delay Complete	Deceleration Complete	Acceleration Complete	—

Figure 6-6. Velocity Status Flags Bit Positions

6.4.9 Velocity Flags Mask

Register Name		Velocity Flags Mask
Address		28 (1 Byte)
Function		Enable velocity status bits for interrupt generation.
Range		See Figure 6-7. Register values will read and write as the hex value of the set bits.
Type		Write, Static
Description		By setting the corresponding mask bit, an interrupt will be generated upon completion of the event.
Usage	**Read**	@28 Returns Previous Setting
	Write	@28=02 (Enable interrupt generation upon completion of acceleration)

MSb LSb

—	—	—	—	Motor Settling Delay Complete Mask Bit	Deceleration Complete Mask Bit	Acceleration Complete Mask Bit	—

Figure 6-7. Velocity Status Flags Interrupt Mask Bit Positions

6.4.10 Velocity and Torque Control

Register Name		Velocity and Torque Mode Action
Address		29 (1 Byte)
Function		Controls the direction, initiation and cessation of a motion for velocity and torque mode operation.
Range		See Figure 6-8. Register values will read and write as the hex value of the set bits.
Type		Write, Dynamic
Description		This register controls the motion and direction of motion for torque and velocity mode operation. Register will read and write as the binary coded decimal.
Usage	**Read**	@29 Returns a value that is modified by events
	Write	@29=128 (abort motion)

MSb LSb

Abort Motion	—	Initiate Motion	Direction of Motion	Current Motion	—	—	Suspend

Figure 6-8. Velocity and Torque Mode Control Bit Positions

6.5 ServoTrack Configuration Registers

6.5.1 Set Microstep Resolution

Register Name		Microstep Resolution Select
Address		30 (1 Byte)
Function		Sets the ServoTrack to match the step resolution of the driver.
Range		See Figure 6-9. Register values will read and write as the hex value of the set bits.
Type		Read/Write, Static
Description		This register stores the step resolution of your driver. This MUST match the microstep setting of the driver for proper step factor.
Usage	**Read**	@30 Returns Previous Setting
	Write	@30 =3 (Set resolution to 3200 steps/rev)

Binary Resolution Parameters

µsteps/step		16	32	64	128	256
@30=		3	4	5	6	7
1.8° motor	steps/rev.	3200	6400	12800	25600	51200

Decimal Resolution Parameters

µsteps/step		10	25	50	100	125	200	250
@30=		9	10	11	18	12	20	13
1.8° motor	steps/rev.	2000	5000	10000	20000	25000	40000	50000

Special Resolution Parameters

µsteps/step	108	127	180
@30=	21	19	17
1.8° motor	21600 (1 arc/minute/step)	25400 (0.001 mm/step)	36000 (0.01°/step)

MSb							LSb
—	—	—	Microstep Select Bit 4	Microstep Select Bit 3	Microstep Select Bit 2	Microstep Select Bit 1	Microstep Select Bit 0

Figure 6-9. Microstep Resolution Selection Register Bit Positions

6.5.2 ServoTrack Settings

Register Name		ServoTrack Settings	
Address		31 (1 Byte)	
Function		Hold settings.	
Range		See Figure 6-10. Register will read and write as the binary coded decimal.	
Type		Read/Write, Static	
Description		Encoder Resolution 3...1	Sets the ServoTrack encoder resolution to match the resolution of the installed encoder. Required for proper step factor. Default=512 lines (0x6) See Table 6-1 on page 38.
		Motor Resolution	1 – 0.9, 0 – 1.8
		Motor Lead/Lag Bounds 1...0	00=1.1, 01=1.3, 10=1.5, 11=1.7 full steps
		ServoTrack Enable	1 – Enable, 0 – Disable
Usage	**Read**	@31 Returns Previous Setting	
	Write	@31 =231 (ServoTrack enabled, bounds=1.7, 1.8 degree motor, 1000 line encoder)	

MSb							LSb
ServoTrack Enable	Motor Lead/Lag Bounds 1	Motor Lead/Lag Bounds 2	Motor Resolution	Encoder Resolution 3	Encoder Resolution 2	Encoder Resolution 1	Encoder Resolution 0

Figure 6-10. ServoTrack Settings

Table 6-1: Encoder Resolutions

Encoder Line Count	ER 3	ER 2	ER 1	ER 0
100	0	0	0	0
200	0	0	0	1
250	0	0	1	0
256	0	0	1	1
400	0	1	0	0
500	0	1	0	1
512	0	1	1	0
1000	0	1	1	1
1024	1	0	0	0

6.5.3 Position Lead/Lag Error

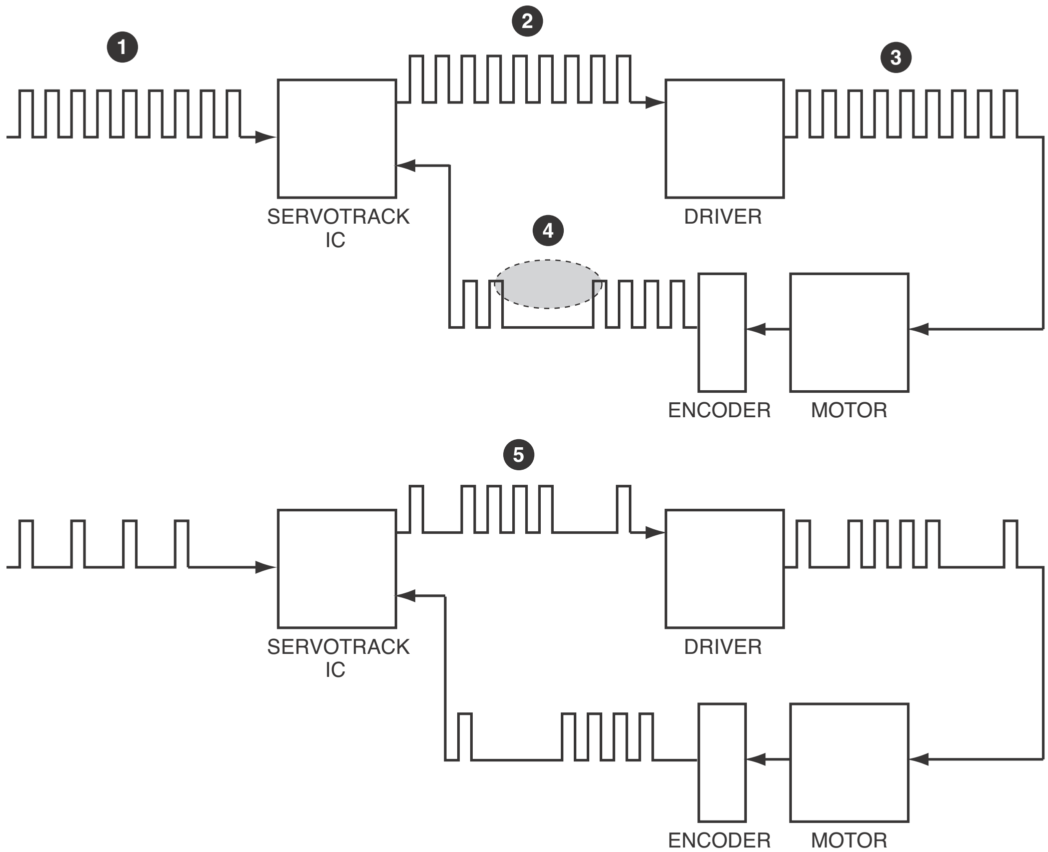
Register Name		Position Lead/Lag Error
Address		32 (4 Bytes)
Function		Holds the position lead lag error.
Range		0 - 2147483647, -2147483647 - 0 (+/- 2.1 x 10^9) counts.
Type		Read, Dynamic
Description		Signed 32 bit register represents position of stator relative to commanded position. A positive value represents lag behind the commanded position.
Usage	**Read**	@32 Returns position Lead/Lag error (must be manually strobed)
	Write	-

6.5.4 Set Lag Limit

Register Name		Lag Limit
Address		36 (4 Bytes)
Function		Sets the rotor lag limit.
Range		0 - 2147483647 (2.1 x 10^9) counts.
Type		Write, Static
Description		32 bit register sets the position lag limit (position of stator behind commanded position).
Usage	**Read**	@36 Returns previous setting
	Write	@36=204800 (Set position lag limit to 4 motor revolutions or 204800 steps at 256 microsteps/rev). Auto writes into registers when most significant byte is written.

6.5.5 Set Lead Limit

Register Name		Lead Limit
Address		3A (4 Bytes)
Function		Sets the rotor lead limit.
Range		0 - 2147483647 (2.1 x 10^9) counts.
Type		Write, Static
Description		32 bit register sets the position lead limit (position of stator ahead of commanded position).
Usage	**Read**	@3A Returns previous setting
	Write	@3A=204800 (Set position lead limit to 4 motor revolutions or 204800 steps at 256 microsteps/rev). Auto writes into registers when most significant byte is written.



1. Clock pulses commanded by controller
2. Clock pulses passed to driver clock input
3. Driver outputs commanded position to motor
4. Encoder loops back motor position, with steps lost to transient loading
5. Lost steps re-inserted when frequency allows. If steps cannot be inserted during move, steps will be re-inserted at the end of the move profile

Figure 6-11. Make-up Steps

6.5.6 Set Make-Up Frequency

<table>
<tr><td colspan="2">Register Name</td><td>Make-up Frequency</td></tr>
<tr><td colspan="2">Address</td><td>3E (2 Bytes)</td></tr>
<tr><td colspan="2">Function</td><td>Sets the frequency (period) for position maintenance if maximum system speed is not used.</td></tr>
<tr><td colspan="2">Range</td><td>0 - 65535</td></tr>
<tr><td colspan="2">Type</td><td>Write, Static</td></tr>
<tr><td colspan="2">Description</td><td>This represents how fast position maintenance (step make up) will occur. To calculate the period from the desired frequency: Period=(1/Frequency in GHz)/50 ns</td></tr>
<tr><td rowspan="2">Usage</td><td>Read</td><td>@3E Returns previous setting</td></tr>
<tr><td>Write</td><td>@3E=2,000 (Set make-up frequency to 10,000 steps/sec). Auto writes into registers when most significant byte is written.</td></tr>
</table>

6.5.7 Miscellaneous ServoTrack Flags

Register Name		ServoTrack Flags	
Address		40 (1 Byte)	
Function		Controls various ServoTrack functions.	
Range		See Figure 6-12. Register values will read and write as the hex value of the set bits.	
Type		Mixed	
Description		Bit 7	Strobes the register to read states (Write, Self Clear)
		Bit 6	Make up active? 0=No, 1=Yes (Read only)
		Bit 5	Current Mode: 0=Fixed, 1=Variable (Read/Write)
		Bit 4	Torque mode: ON/OFF: 0=OFF, 1=ON (Read/Write)
		Bit 3	Start Torque Mode: 0=No, 1=Yes (Read/Write)
		Bit 2	Clear Position Error: 0=No, 1=Yes (Read/Write, Self Clear)
		Bit 1	Cease Make-up steps: 0=No, 1=Yes (Read/Write)
		Bit 0	Use Make-up Freq? 0=No, 1=Yes (Read/Write)
Usage	**Read**	@40 Returns status and previous set values	
	Write	@40=32 (Set current mode to variable).	

MSb LSb

Read Strobe (wr, self clear)	Make-up Active (rd, dynamic)	Current Mode (wr, static)	Anti-stall or Torque Mode (wr, static)	Start Torque Operation (wr, static)	Clear Position Error (wr, self clear)	Stop Make-up (wr, static)	Set Make-up Frequency (wr, static)

Figure 6-12. Miscellaneous ServoTrack Flags

6.5.8 Calibration Time

Register Name		Calibration Time
Address		41 (2 Bytes)
Function		Sets the countdown timer for calibration.
Range		2 - 65535 ms
Type		Write, Static
Description		Sets the time for calibration to occur in ms.
Usage	**Read**	@41 Returns previous setting
	Write	@41=500 (Set timed calibration for 500 ms). Auto writes into registers when most significant byte is written.

6.5.9 Locked Rotor Timeout

Register Name		Locked Rotor Timeout
Address		43 (2 Bytes)
Function		Sets the countdown timer for locked rotor condition.
Range		0, 2 - 65535 ms
Type		Write, Static
Description		When there is no rotor movement this register holds the time in milliseconds between no rotor movement; locked rotor will be indicated. If set to 0, the timer is disabled.
Usage	**Read**	@43 Returns previous setting
	Write	@43=3000 (Set locked rotor timeout to 3000 ms). Auto writes into registers when most significant byte is written.

6.5.10 ServoTrack Status Flags

Register Name	ServoTrack Status Flags	
Address	45 (1 Byte)	
Function	Reads state of various ServoTrack status flags.	
Range	See Figure 6-13. Register values will read and write as the hex value of the set bits	
Type	Read, Dynamic	
Description	Bit 7	Indicates that calibration is complete.
	Bit 6	Indicates that the encoder line count is correct.
	Bit 5	Indicates that the encoder direction is correct.
	Bit 4	In anti-stall mode this flag will assert whenever the ServoTrack is actively preventing loss of synchronization. In torque mode this flag will assert whenever the torque is achieved. (rotor/stator relationship within ±1 full step.)
	Bit 3	Flag asserts when the Locked rotor timer has expired.
	Bit 2	Indicates that the position error counter has reached its maximum value.
	Bit 1	Lag limit reached or exceeded.
	Bit 0	Lead limit reached or exceeded.
Usage	**Read**	@45 Returns ServoTrack status information
	Write	—

MSb LSb

Calibration Complete	Encoder Line Count Check Bit	Encoder Direction Check Bit	ServoTrack Active	Locked Rotor Time-out Reached	Max Position Error Reached	Lag Limit Reached	Lead Limit Reached

Figure 6-13. ServoTrack Status Flags

6.5.11 ServoTrack Interrupt Flags

Register Name		ServoTrack Interrupt Flags
Address		46 (1 Byte)
Function		Reads status of interrupt flags.
Range		See Figure 6-14. Register values will read and write as the hex value of the set bits.
Type		Read, Write to Clear
Description		The register contains the state of the status flags that, when enabled, will exert an interrupt signal. See " ServoTrack Status Flags" on page 44.
Usage	**Read**	@46 Returns status of interrupt flags.
	Write	@46 Clears Flags

MSb LSb

Calibration Complete	—	—	ServoTrack Active	Locked Rotor Time-out Reached	Max Position Error Reached	Lag Limit Reached	Lead Limit Reached

Figure 6-14. ServoTrack Interrupt Flags

6.5.12 ServoTrack Interrupt Mask

Register Name		ServoTrack Interrupt Mask
Address		47 (1 Byte)
Function		Mask interrupt status flags.
Range		See Figure 6-15. Register values will read and write as the hex value of the set bits.
Type		Write, Static
Description		The register is used to enable/disable the associated status flags from generating an interrupt when the flag becomes set. 1=Enabled, 0=Interrupt Disabled. See " ServoTrack Status Flags" on page 44 for flag description.
Usage	**Read**	@47 Returns previous setting.
	Write	@47 =05 (assets interrupt when either max position error is reached or lead limit is reached)

MSb LSb

Calibration Complete Mask Bit	—	—	ServoTrack Active Mask Bit	Locked Rotor Time-out Mask Bit	Max Position Error Reached Mask Bit	Lag Limit Reached Mask Bit	Lead Limit Reached Mask Bit

Figure 6-15. ServoTrack Interrupt Mask

6.5.13 ServoTrack State Flags

Register Name		ServoTrack State Flags	
Address		48 (1 Byte)	
Function		Reads status of various ServoTrack state flags.	
Range		See Figure 6-16. Register values will read and write as the hex value of the set bits.	
Type		Read, Dynamic	
Description		Bit 7	Stop/Go/Bypass input state
		Bit 6	Encoder A state
		Bit 5	Encoder B state
		Bit 4	Asserted when the velocity generator is idle
		Bit 3	—
		Bit 2	Asserted when in current reduction. This flag is only valid in fixed current mode.
		Bit 1	—
		Bit 0	—
Usage	**Read**	@48 Returns value of ServoTrack state flags.	
	Write	—	

MSb LSb

Stop/Go Bypass Input State	Encoder A State	Encoder B State	Velocity Generator Idle	—	In Current Reduction	—	—

Figure 6-16. ServoTrack State Flags

6.5.14 Interrupt Level Control

Register Name		Interrupt Level
Address		49 (1 Byte)
Function		Sets the Level of Interrupt to assert.
Range		Register values will read and write as the hex value of the set bits.
Type		Write, Static
Description		Bit 7 of this register sets the level of the interrupt output when asserted. 0 =Interrupt asserted low 1 =Interrupt asserted high All other bits are not applicable.
Usage	**Read**	@49 Returns previous setting.
	Write	@49 =128 (interrupt out goes high when interrupt is asserted).

6.5.15 Start Calibration and Type Select

Register Name	Start Calibration	
Address	4A (1 Byte)	
Function	Manual starts the calibration using the selected calibration type.	
Range	See Figure 6-17. Register values will read and write as the hex value of the set bits.	
Type	Mixed	
Description	Bit 7	Start calibration - Write, Self Clear
	Bit 2-6	—
	Bit 0-1	0 =Fixed calibration time 1 =Calibration with current ramp 2 =Minimal offset, fixed time 3 =Minimal offset with current ramp
Usage — **Read**	@4A Returns previously set type.	
Usage — **Write**	@4A =81 (Hex) (start calibration with current ramp)	

MSb LSb

Start Calibration	—	—	—	—	—	Calibration Type Bit 1	Calibration Type Bit 0

Figure 6-17. Start Calibration Bit Positions

NOTE: The selected type occurs automatically when all the appropriate registers are valid. If ServoTrack is disabled, then re-enabled, a calibration will automatically occur. During calibration, all step clocks are ignored, the position error counter is cleared, and the rotor/stator offset accumulator is cleared.

6.5.16 Hardware Version and Reset

Register Name		Hardware Version
Address		7F (1 Byte)
Function		To read the hardware version of the ServoTrack IC and to generate a reset.
Range		—
Type		Mixed
Description		Reading this register returns the hardware version of the ServoTrack IC. Writing an AA (Hex) to this register forces a hardware reset of the Servo-Track IC and will set all registers to zero.
Usage	**Read**	@7F Returns hardware version.
	Write	@7F =AA (Hex) (resets the ServoTrack IC)

6.5.17 Command Summary

GROUP	REGISTER NAME	WR/RD STROBE	NOTE	ADDR	OFFSET HEX	OFFSET DEC	# OF BYTES	REGISTER TYPE	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
CURRENT	RUN CURRENT			00	0	0	1	WR, STATIC	Sets anti-stall off run current, anti-stall (fixed) run current, anti-stall (variable) maximum current							
	REDUCTION CURRENT			01	1	1	1	WR, STATIC	Sets anti-stall off reduction current, anti-stall (fixed) reduction current 0 - FFH							
	CURRENT REDUCTION DELAY	AUTO WR WHEN MSB WRITTEN		02	2 - 3	2 - 3	2	WR, STATIC	Sets anti-stall off reduction delay, anti-stall (fixed) reduction delay 0, 2 - FFFFH 2 mS to 65535 mS (±0/-1), 1 mS resolution, 0 = never reduce							
	TORQUE CURRENT			04	4	4	1	WR, STATIC	Sets torque current 0 - FFH							
	CALIBRATION CURRENT			05	5	5	1	WR, STATIC	Sets calibraton current 0 - FFH							
IO	I/O CON-FIGURATION			09	9	9	1	WR, STATIC	INV_DIR_IN	INV_STP_IN	INV_DIRO	EW_FIX	MW_FIX	VG_PINN 0 = DRIVE 1 = OSC	SEL_CLK	SEL_CKL0
	STEP PULSE WIDTH			0A	A	10	1	WR, STATIC	Sets step output pulse width 0 - FFH 100 nS to 12.85 uS, 50 nS resolution							
	INPUT FILTERING			0B	B	11	1	WR, STATIC	Step and direction digital input filter 0 - 9H 10 MHz - 38.8 KHz							
	ATTENTION			0C	C	12	1	WR, STATIC			LG_LMT	LD_LMT	CAL_ACTV	LK_RTR	MU_ACTV	AS_ACTV
	ERROR LED			0E	E	14	1	WR, STATIC								FLASH

GROUP	REGISTER NAME	WR/RD STROBE	NOTE	ADDR	OFFSET HEX	OFFSET DEC	# OF BYTES	REGISTER TYPE	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
VELOCITY	INITIAL VELOCITY	MANUAL (VLOW_STB)		10	10 - 13	16 - 19	4	WR, STATIC	Set initial (low) velocity 0 - 800000H 0 to 5 x 10^6 steps/sec, 0.596 step/sec resolution							
	TERMINAL VELOCITY	MANUAL (VHI_STB) WR		14	14 - 17	20 - 23	4	WR, STATIC	Set terminal (high) velocity 0 - 800000H 0 to 5 x 10^6 steps/sec, 0.596 step/sec resolution							
	DECEL-ERATION	MANUAL (DEC_STB)		18	18 - 1B	24 - 27	4	WR, STATIC	Sets deceleration 0 - FFFFFFH 90.9 to 1.5 x 10^9 steps/sec ^{2}							
	ACCEL-ERATION	MANUAL (ACC_STB)		1C	1C - 1F	28 - 31	4	WR, STATIC	Sets acceleration 0 - FFFFFFH 90.9 to 1.5 x 10^9 steps/sec ^{2}							
	CURRENT VELOCITY	MANUAL (CURVEL) RD		20	20 - 23	32 - 35	4	RD, DYNAMIC	Read current velocity 0 - 800000H							
	VELOCITY STROBES			24	24	36	1	WR, SELF CLEAR	WRITE STROBE ACC_STB	WRITE STROBE DEC_STB	WRITE STROBE VHI_STB	WRITE STROBE VLOW_STB				READ STROBE CURVEL
	MOTOR SET-TLING DELAY	AUTO WR WHEN MSB WRITTEN		25	25 - 26	37 - 38	2	WR, STATIC	Sets motor settling delay time 0 - FFFFH 0 mS TO 65535 mS, 1 mS resolution							
	VELOCITY FLAGS			27	27	39	1	RD, WR TO CLEAR					MSDT_DN	DEC_DONE	ACC_DONE	
	VELOCITY FLAGS MASK			28	28	40	1	WR, STATIC					MSDT_DN	DEC_DONE	ACC_DONE	
	VELOCITY & TORQUE CONTROL		WR LAST IN GROUP, 1ST TIME ONLY (REG VALID)	29	29	41	1	WR, DYNAMIC	ABORT_MTN		RUNMTN	DIRMTN	DIR_CV			SUSPEND

GROUP	REGISTER NAME	WR/RD STROBE	NOTE	ADDR	OFFSET HEX	OFFSET DEC	# OF BYTES	REGISTER TYPE	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
SERVO TRACK	MICROSTEP RESOLUTION			30	30	48	1	WR, STATIC				MSEL4	MSEL3	MSEL2	MSEL1	MSEL0
	SERVOTRACK SETTINGS			31	31	49	1	WR, STATIC	AS_EN	BNDS1	BNDS0	MTRRES	ENCRES3	ENCRES2	ENCRES1	ENCRES0
	POSITION ERROR	MANUAL RD		32	32 - 35	50 - 53	4	RD, DYNAMIC	Reads position lead / lag (position of stator relative to commanded position) Signed, 0 - 7FFFFFFFH, FFFFFFFFH - 80000000H +/- 2.1 X 10^9counts							
	LAG LIMIT	AUTO WR WHEN MSB WRITTEN		36	36 - 39	54 - 57	4	WR, STATIC	Sets position lag limit (position of stator behind commanded) 0 - 7FFFFFFFH 2.1 X 10^9counts							
	LEAD LIMIT	AUTO WR WHEN MSB WRITTEN		3A	3A - 3D	58 - 61	4	WR, STATIC	Sets step make-up frequency (period) 0 - FFFFH							
	MAKE-UP FREQUENCY	AUTO WR WHEN MSB WRITTEN		3E	3E - 3F	62 - 63	2	WR, STATIC	Sets position lag limit (position of stator behind commanded) 0 - 7FFFFFFFH 2.1 X 10 counts							
	SERVOTRACK FLAGS			40	40	64	1	MIXED	Read strobe RD_STRB (WR, SELF CR)	MU_ACTV (RD, DYNAMIC)	OPCUR (WR, STATIC)	MODE_BIT (WR, STATIC)	START_TRQ (WR, STATIC)	CLR_ERRCNT (WR, SELF CR)	STP_MU (WR, STATIC)	USE_MUFRQ (WR, STATIC)
	CALIBRATION TIME	AUTO WR WHEN MSB WRITTEN		41	41 - 42	65 - 66	2	WR, STATIC	Sets calibration time 0 - FFFFH 2 ms to 65535 ms (+0/-1), 1 ms resolution							
	LOCKED ROTOR TIME-OUT	AUTO WR WHEN MSB WRITTEN		43	43 - 44	67 - 68	2	WR, STATIC	Sets locked rotor time-out 0 - FFFFH 2 ms to 65535 ms (+0/-1), 1 ms resolution, 0 = disable timer							
	SERVOTRACK STATUS FLAGS			45	45	69	1	RD, DYNAMIC	CAL_DONE	ENC_RSP	ENC_DIR	ASACTIVE	ASLRTM	MAX_PCNT	ASPLGLMT	ASPLDLMT

GROUP	REGISTER NAME	WR/RD STROBE	NOTE	ADDR	OFFSET HEX	OFFSET DEC	# OF BYTES	REGISTER TYPE	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
SERVO TRACK	INTERRUPT FLAGS			46	46	70	1	RD, WR TO CLEAR	ASCAL_EN			AS_ACTV	AS_LR	MAX_CNT	ASPLGLMT	ASPLDLMT
	INTERRUPT MASK			47	47	71	1	WR, STATIC	ASCAL_EN			AS_ACTV	AS_LR	MAX_CNT	ASPLGLMT	ASPLDLMT
	SERVOTRACK STATE FLAGS			48	48	72	1	RD, DYNAMIC	SGP_PIN	ENC_A	ENC_B	VG_IDLE		CURRED		
	INTERRUPT LEVEL			49	49	73	1	WR, STATIC	INV_INT							
	START CALIBRATION		WR LAST IN GROUP, 1ST TIME ONLY (REG VALID)	4A	4A	74	1	MIXED	START_CALT (WR, SELF CLR)						CAL_T1	CAL_T0
	HARDWARE VERSION		WR $AA TO INITIATE RESET	7F	7F	127	1	MIXED	Hardware version							

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Appendix A: ServoTrack Module

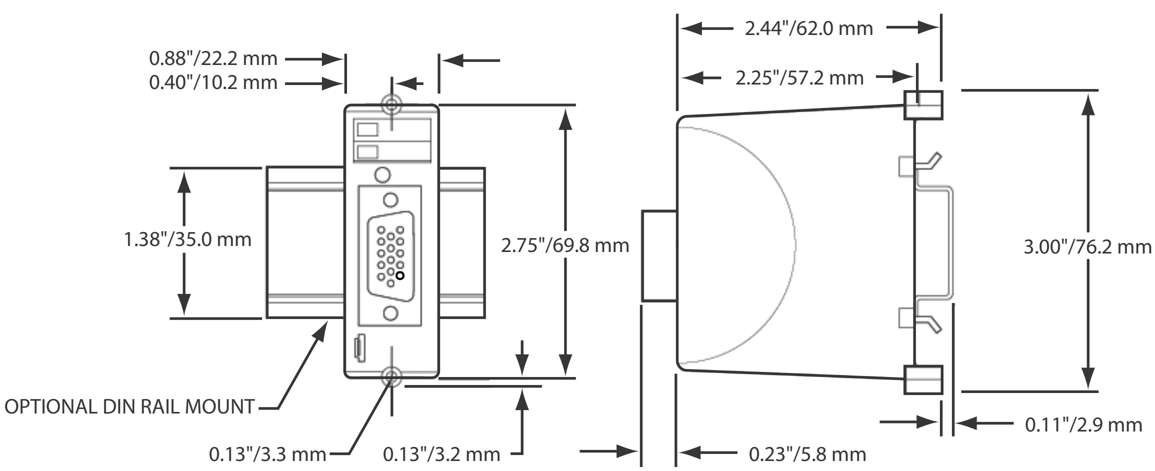
A.1 Introduction

The ServoTrack Module is ideal for rapid prototyping and proof of concept designs based around the ServoTrack IC. The module incorporates additional interface hardware, connectors, low voltage power supplies, as well as a microcontroller with a USB communication interface.

The graphical user interface makes it easy to change parameters and verify motor performance. On-board non-volatile memory stores variables and automatically loads them into the ServoTrack IC when power is cycled.

Figure A-1. ServoTrack Module (Part #: STU-01)

A.2 Mechanical Specifications



A.3 Specifications

Connections:

Power:	+5 Vdc to +26 Vdc +/-5% Current: 245 mA at 5 Vdc, 52 mA at 24Vdc Connector type - 2 Position, spring clamp terminal block
Communication:	USB Version 2.0 Connector type - Micro USB
Signal:	Encoder power (+5 Vdc - current limited to 100 mA) Encoder A+, Encoder A-, Encoder B+, Encoder B- — Encoder may be single ended or differential Encoder Ground Step Clock in, Direction in — Includes clock up/clock down and quadrature input modes Stop/go (in velocity and torque mode); Bypass (in clock and direction mode) Locked rotor - output Interrupt - output Step clock out (20 mA drive capability), Direction out (20 mA drive capability) — Includes clock up/clock down and quadrature output modes Motor Current reference (for variable current control) Motor Current reference ground Connector Type - Compact Female 15 pin D-type
Illumination:	LED: 3 color Green - Power on & everything is OK Yellow - Correction active Red - Continuous: locked rotor. Blinking: fault.
Mounting:	35 mm DIN Rail or Panel mountable

Appendix B: Breakout Board Option

B.1 Introduction

The optional breakout board, when used in conjunction with the ServoTrack Module, facilitates wiring in proof of concept designs. The breakout board may be plugged directly into the ServoTrack, or panel mounted using the included spacers.

Signals are accessed via a pluggable 15-pin clamp-type terminal connector.

Figure B-1. ServoTrack Breakout Board (Part #: BBST1)

B.2 Mechanical Specifications

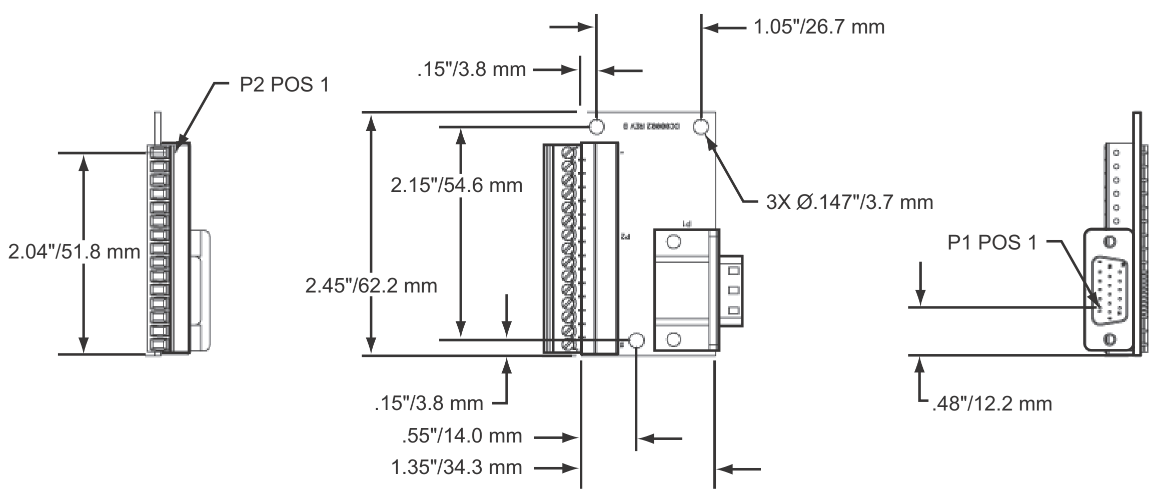


Figure B-1. ServoTrack Breakout Board Dimensions

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