

# SERVOSTAR<sup>®</sup> S- and CD-Series Position Control

This document describes the fundamentals of the SERVOSTAR<sup>®</sup> S or SERVOSTAR<sup>®</sup> CD positioning features. The SERVOSTAR offers a dedicated mode of operation (OPMODE 8) for simple positioning applications. This mode of operation provides two possible approaches to commanding position: serial or analog (PCMDMODE). Serial commands are transmitted either directly from a host computer through the serial port, or triggered through the Configurable I/O that work in conjunction with pre-configured profiles stored in variable memory. A trapezoidal (or S-curve) profile generator calculates a motion command to perform homing sequences, indexing routines, and incremental and absolute movements. Motion results are then communicated back to you through either a configurable output or through the serial port to the host (see Note 2 on page 18). The other approach, analog commands, are applied to the analog input. They are then scaled, filtered, and geared before being passed to the position control loop. Although many of the positioning attributes are similar, these two approaches are addressed separately.

The PIDFF control structure of the position loop offers a dynamic integrator (GPISATIN, GPISATOUT). You can add this term to the part of the profile where it is needed most, while minimizing its effect during the portion where overshoot and settling problems typically occur. Additionally, there are two acceleration feed-forward terms (GPAFR, GPAFR2) and a velocity feed-forward term (GPVFR).



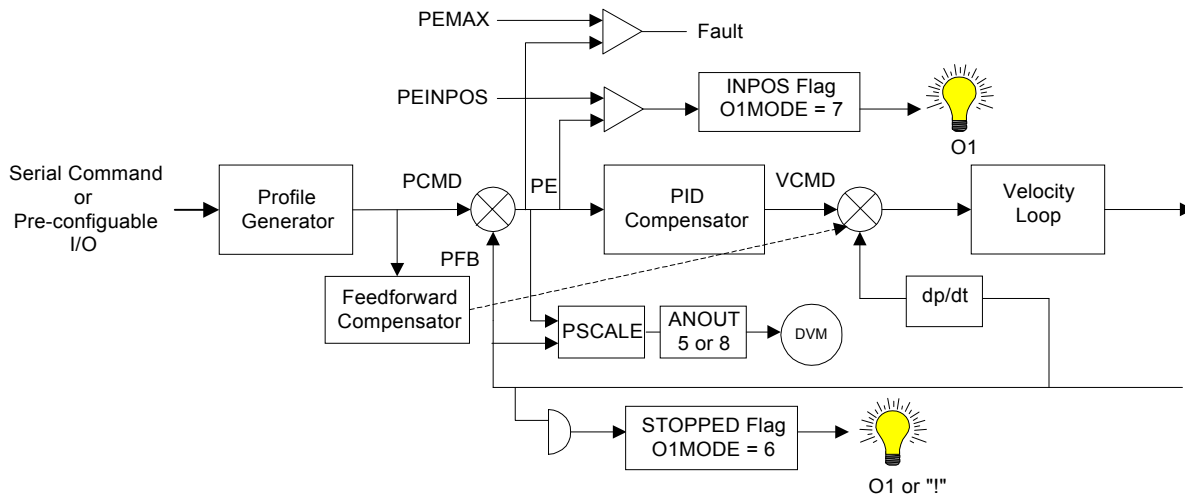
***Refer to the SERVOSTAR<sup>®</sup> S and SERVOSTAR<sup>®</sup> CD VarCom Reference Manual for a thorough explanation of the Variables and Commands.***

# Serial Positioning

The SERVOSTAR receives commands through either the serial port (MH, MI, MA) or pre-configured variables (MAPOS, MASPEED, MIDIST, MISPEED, HOMESPD) in interaction with the Configurable I/O (INxMODE). These commands become position and speed inputs to the profile generator (see Figure 1). Not entering new parameters for these variables causes the SERVOSTAR to use its current values. To create ramp control, use the acceleration (ACC) and deceleration (DEC) parameters.

A motion command is received by the profile generator, which in turn calculates the motion trajectory profile of the motor. The output of the profile generator becomes the motor's commanded position (PCMD). The Position Loop controller receives the command (PCMD), subtracts it with the actual motor position (PFB), and forwards the result as a position error (PE) signal. This position error is fed through a PID compensator and presented as the velocity command (VCMD) to the Velocity Loop controller. The position loop samples at a rate of 2 kHz.

Once movement is complete, the O1 output can be set to flag you that motion has STOPPED (O1MODE = 6) or that the motor shaft is within a tolerable range of PEINPOS (O1MODE=7) (see Note 2 on page 18 and In-Position Monitor on page 16).



**Figure 1: Serial Position Loop Diagram**

## Configurable I/O

Connector C3 has three inputs, one analog output, and one digital output that interact with the SERVOSTAR's variable/command set to enhance the communication capabilities of the drive. In particular to the position features, these I/O provide triggering action that initiate motion profiles pre-configured in the drive's memory. The following diagram highlights these I/O, as it pertains to position control, using the INx, INxMODE, ANOUT, O1MODE, and O1 variables. This diagram is referred to through the remaining discussions of this section. INx variables indicate the state (on/off) of the hardware switches tied to the three configurable input pins: 9, 10, and 11. INxMODE variables determine what the three Configurable Inputs are used to indicate. The Configurable Analog Output ANOUT can be setup to give an analog representation of either the position following error (PE) or the position feedback (PFB). The Configurable Digital Output (O1) is a state indicator (on/off) and is used to communicate that a particular action (determined by O1MODE), has been performed.

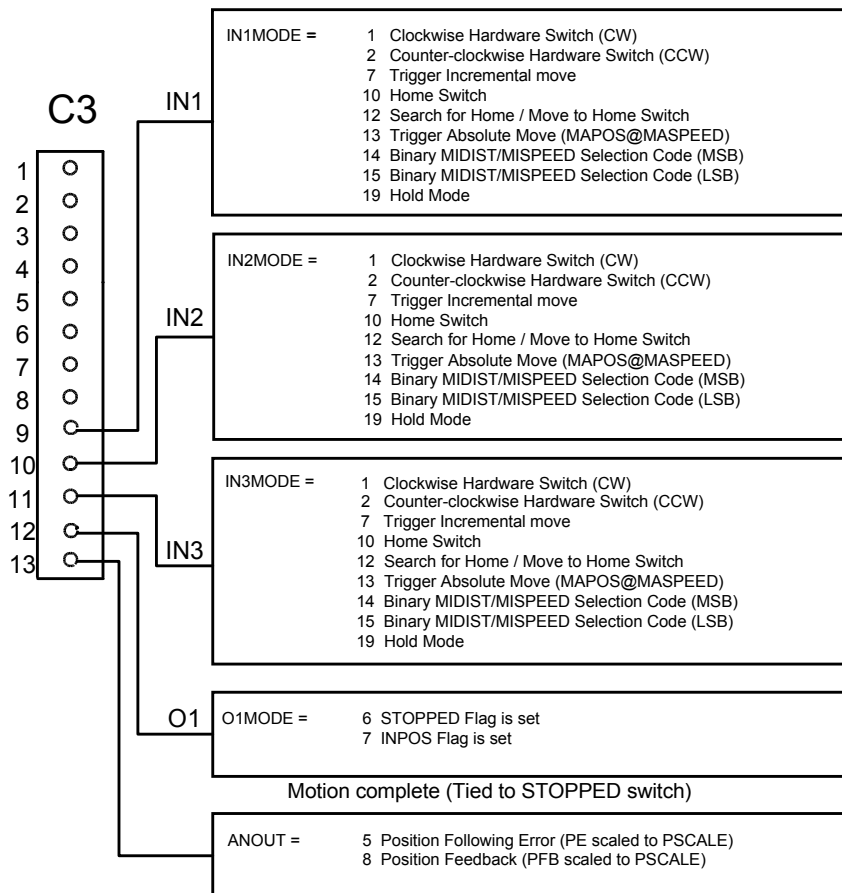


Figure 2: Configurable I/O for Positioning

## Absolute Motion

The SERVOSTAR has the capability of executing absolute motion profiles. This type of motion is always referenced to an absolute reference point. This reference point, defined internally to the drive, is where PFB = 0 (PFB is the actual absolute motor position in cumulative counts).

The following addresses the two ways to command absolute moves:

### SERIAL COMMAND (MA)

The MA command (Syntax: **MA** <position> <velocity> <in pos ack>) sent serially from a host computer executes motion with respect to the absolute position point (in counts) PFB = 0. Movement can be in either direction, depending on the present value of PFB in relation to the commanded position value. The “in pos ack” is an optional flag that returns an “!” symbol to the host if the actual and calculated generator movements are complete and within the predefined boundaries. This feature is useful because it notifies you that the next command can be sent (see Note 2 on page 18).

Example: If PFB = 11235 and a command is given, MA 5000 300 1, the motor shaft moves back to PFB = 5000 @ 300RPM and sends an “!” acknowledgment to the host (see Note 1 on page 18).

### PRE-CONFIGURED PROFILE WITH CONFIGURABLE I/O

You can pre-configure an absolute motion profile by entering the values desired into the speed and position variables, MASPEED and MAPOS. Shaft direction is determined by the value stored in MAPOS in relation to the present value of PFB. To create ramp control, use the acceleration (ACC) and deceleration (DEC) parameters.

If you set any of the three input variables (IN1MODE, IN2MODE, IN3MODE) equal to 13 (see Figure 2) and toggle its corresponding hardware input (indicated by IN1, IN2, IN3), the drive executes the motion profile stored in MASPEED and MAPOS (see Note 1 on page 18).

## Incremental Motion (Indexing)

The SERVOSTAR also has the capability of executing incremental motion profiles. This type of motion is always in reference to the current position of the load (and motor shaft) and is useful in indexing applications, such as cut-to-length feeders and rotary tables. This reference point (defined internally to the drive) is at the current value of PFB. The following addresses the two ways to command incremental moves.

## SERIAL COMMAND (MI)

The MI command (Syntax: **MI** <position> <velocity> <in pos ack>) sent serially from a host computer executes motion in reference to the current position point (in counts) of PFB. Movement can be in either direction, depending on the sign of the position value. <in pos ack> is an optional flag that returns an “!” symbol to the host if the actual and calculated generator movements are complete and within the predefined boundaries (see Note 2 on page 18).

Example: If PFB = 11235 and a command is given, MI 5000 300 1, the motor shaft moves forward to PFB = 16235 @ 300RPM (see Note 1 on page 18).

## PRE-CONFIGURED PROFILES WITH CONFIGURABLE I/O

You can pre-configure up to four incremental motion profiles by entering the values desired into the speed and position variables, MISPEEDx and MIDISTx (where x = 0, 1, 2, 3). Profile selection is accomplished by toggling two of the Configurable Inputs with a binary equivalent address that corresponds to the desired profile. Shaft direction is determined by the value stored in MIDISTx. To create ramp control, use the acceleration (ACC) and deceleration (DEC) parameters.

You can set the three input variables (any combination can be used) as follows (see Figure 2):

Binary Count		Switch	Profile Executed
C3, pin 9 (IN1) (IN1MODE = 14)	C3, pin 10 (IN2) (IN2MODE = 15)	C3, pin 11 (IN3) (IN3MODE = 7)	
OFF	OFF	Toggle ↑ ON	MIDIST0, MISPEED0
OFF	ON	Toggle ↑ ON	MIDIST1, MISPEED1
ON	OFF	Toggle ↑ ON	MIDIST2, MISPEED2
ON	ON	Toggle ↑ ON	MIDIST3, MISPEED3

See Note 1 on page 18

## Homing

The SERVOSTAR has the capability of executing absolute motion profiles. This type of motion is always in reference to an absolute reference point. This reference point (defined internally to the drive) is where  $PFB = 0$  ( $PFB$  is the actual absolute motor position in cumulative counts). Absolute motion is typically used in Homing requests where the load must return to a known physical position. There are two ways to command Homing in the SERVOSTAR.

### HOMING METHODOLOGY

In order to most efficiently use the Configurable I/O, the SERVOSTAR uses a Homing State Machine. This machine is structured so that the first “Command to Home” after logic power is applied, initiates a “Search for Home.” The type of search performed is determined by HOMETYPE. The speed and direction of the search is determined by the value stored in HOMESPD.

**HOMETYPE 0, 1, 2:** Once a Home point is established,  $PFB$  is automatically normalized (set equal to zero). Any subsequent “Command to Home” is executed as an absolute position command that traverses at the speed value stored in MISPEED0 until  $PFB$  is equal to zero.



***If the mechanical home location (or switch) is relocated, power must be cycled and a new “Search for Home” must be performed.***



***If MISPEED0 = 0 when a “Command to Home” is requested, no movement occurs and a momentary (500mS) “b” is illuminated in the Status Display.***

**HOMETYPE 3, 4, 5, 6, 7:** A “Search for Home” is executed every time a “Command to Home” is given, regardless of whether the command is initial or subsequent.  $PFB$  is automatically normalized (set equal to zero).

The SERVOSTAR allows you to select from various “Search for Home” procedures through the HOMETYPE variable. The options are:

#### **HOMETYPE = 0**

This Homing procedure, via an MH or INx trigger command, reads the state of the Home limit switch (N.O.). If it is open, motion begins at a speed and direction established by the value of HOMESPD (see Note 4 on page 18). Once closure occurs, the motor continues motion until it reaches the next mechanical marker (resolver zero or encoder index) where it decelerates to 0 speed. If the motor overshoots this position during deceleration, it reverses direction and returns to this marker position.  $PFB$  is normalized ( $PFB = 0$ ).

If the switch is closed when receiving the “Search for Home” command, the motor traverses at the rate of HOMESPD in the opposite direction until the switch is opened. It then proceeds as described above (see Note 3 on page 18).

### **HOMETYPE = 1**

This Homing procedure, via an MH or INx trigger command, reads the state of the Home limit switch (N.O.). If it is open, motion begins at a speed and direction established by the value of HOMESPD (see Note 4 on page 18). Once closure occurs, the SERVOSTAR captures this position and decelerates the motor to 0 speed. If the motor overshoots this position during deceleration, it reverses direction and returns to the captured position. PFB is normalized (PFB=0).

If the switch is closed when receiving the “Search for Home” command, the motor traverses at the rate of HOMESPD in the opposite direction until the switch is opened. It then proceeds as described above (see Note 3 on page 18).

### **HOMETYPE = 2**

This Homing procedure, via an MH or INx trigger command, goes to the first mechanical marker (resolver zero or encoder index) in the speed and direction established by the value of HOMESPD (see Note 4 on page 18). If the motor overshoots this position during deceleration, it reverses direction and returns to this marker position. PFB is normalized (PFB=0). This type of Homing is used in rotary table applications.

### **HOMETYPE = 3**

This Homing procedure, via an MH or INx trigger command, defines the current position as Home by normalizing PFB. No motor movement occurs. Every “Command to Home” is a “Search for Home” that captures the current position.

### **HOMETYPE = 4**

This Homing procedure, via a command from either an enabling of the Remote Enable switch (assuming ACTIVE=1 after toggling the switch), an MH through the serial port, or an INx trigger, goes to the first mechanical marker (resolver zero or encoder index) in the speed and direction established by the value of HOMESPD (see Note 4 on page 18). If the motor overshoots this position during deceleration, it reverses direction and returns to this marker position. PFB is normalized (PFB=0). This differs from HOMETYPE=2 in that every “Command to Home” is a “Search for Home” and can be triggered through the Remote Enable.

### **HOMETYPE = 5**

This Homing procedure, via an MH or INx trigger command, goes to the first mechanical marker (resolver zero or encoder index) in the speed and direction established by the value of HOMESPD (see Note 4 on page 18). If the motor overshoots this position during deceleration, it reverses direction and returns to this marker position. PFB is normalized (PFB=0). This differs from HOMETYPE=2 in that every “Command to Home” is a “Search for Home”.

### **HOMETYPE = 6**

This Homing procedure, via an MH or INx trigger command, reads the state of the Home limit switch (N.O.). If it is open, motion begins at a speed and direction established by the value of HOMESPD (see Note 4 on page 18). Once closure occurs, the motor continues motion until it reaches the next mechanical marker (resolver zero or encoder index) where it decelerates to 0 speed. If the motor overshoots this position during deceleration, it reverses direction and returns to this marker position. PFB is normalized (PFB=0).

If the switch is closed when receiving the “Search for Home” command, the motor traverses at the rate of HOMESPD in the opposite direction until the switch is opened. It then proceeds as described above (see Note 3 on page 18).

### **HOMETYPE = 7**

This Homing procedure, via an MH or INx trigger command, reads the state of the Home limit switch (N.O.). If it is open, motion begins at a speed and direction established by the value of HOMESPD (see Note 4 on page 18). Once closure occurs, the SERVOSTAR captures this position and decelerates the motor to 0 speed. If the motor overshoots this position during deceleration, it reverses direction and returns to the captured position. PFB is normalized (PFB=0).

If the switch is closed when receiving the “Search for Home” command, the motor traverses at the rate of HOMESPD in the opposite direction until the switch is opened. It then proceeds as described above (see Note 3 on page 18).

The SERVOSTAR provides a monitoring variable, HOMESTATE, that defines the status of the homing function. Indicated status values include: whether the Home limit switch is closed or open, whether the command to move is a “Search for Home” or a “Command to Home”, Homing complete, and Homing execution interrupted (see the *SERVOSTAR<sup>®</sup> S and SERVOSTAR<sup>®</sup> CD VarCom Reference Manual* for details on these variables).

## **SERIAL COMMAND (MH)**

The first MH command (Syntax: **MH** <*in pos ack*>) sent serially after applying logic power, begins a “Search for Home” procedure defined by HOMETYPE and HOMESPD (see Note 4 on page 18). A subsequent MH command (given HOMETYPE = 0, 1, or 2) is interpreted as a “Command to Home” where the motor traverses toward PFB = 0. The “in pos ack” is an optional flag that returns an “!” symbol to the host once movement is complete (see Note 2 on page 18).



## PRE-CONFIGURED PROFILE WITH CONFIGURABLE I/O

You pre-configure a “Command to Home” by entering a speed and direction value into the HOMESPD variable, while toggling the execution through the Configurable Inputs. To create ramp control, use the acceleration (ACC) and deceleration (DEC) parameters (see Note 2 on configurable output on page 18).

If you set two of the three input variables (IN1MODE, IN2MODE, IN3MODE) equal to 10 and 12 (see Figure 2), toggling the “Search for Home” or “Move to Home” switch executes the motion profile configured in HOMESPD. You can set the three input variables (any combination can be used) as:

C3, pin 9 (IN1) (IN1MODE = 10)	C3, pin 10 (IN2) (IN2MODE = 12)	Home Sequence	Profile Executed (HOMETYPE = 0-7)
Closed	Initial Toggle ↑ ON	“Search for Home”	Determined by HOMETYPE and HOMESPD
Open	Initial Toggle ↑ ON	“Search for Home”	Determined by HOMETYPE and HOMESPD
C3, pin 9 (IN1) (IN1MODE = 10)	C3, pin 10 (IN2) (IN2MODE = 12)	Home Sequence	Profile Executed (HOMETYPE = 0-2)
Closed	Subsequent Toggle ↑ ON	“Command to Home”	Remains at PFB $\cong$ 0
Open	Subsequent Toggle ↑ ON	“Command to Home”	Move @ MISPEED0 till PFB = 0

## Feature Combinations

The SERVOSTAR is designed to carry out several positioning feature combinations. It can be set up for the Homing feature and still be pre-configured to command either an incremental or an absolute move. Consider the following variations:

EXAMPLE 1:

Absolute Move	Homing: HOMETYPE, HOMESPD	
C3, pin 9 (IN1) (IN1MODE = 13)	C3, pin 10 (IN2) (IN2MODE = 10)	C3, pin 11 (IN3) (IN3MODE = 12)

EXAMPLE 2:

Homing: HOMETYPE, HOMESPD		Increment Move
C3, pin 9 (IN1) (IN1MODE = 12)	C3, pin 10 (IN2) (IN2MODE = 10)	C3, pin 11 (IN3) (IN3MODE = 7)

EXAMPLE 3:

Homing HOMETYPE = 2 HOMESPD	Absolute Move	Increment Move
C3, pin 9 (IN1) (IN1MODE = 12)	C3, pin 10 (IN2) (IN2MODE = 13)	C3, pin 11 (IN3) (IN3MODE = 7)

## Combination Examples

EXAMPLE 1:

Homing: HOMETYPE, HOMESPD		Increment Move	Action
C3, pin 9 (IN1) (IN1MODE = 12)	C3, pin 10 (IN2) (IN2MODE = 10)	C3, pin 11 (IN3) (IN3MODE = 7)	
Initial Toggle ↑ ON	Switch State: Open		"Search for Home"
	Toggle ↑ Closed		Movement occurs until Homing process complete - Set PFB = 0
		Toggle ↑ ON	Determined by MISPEED0, MIDIST0
Subsequent Toggle ↑ ON			"Command to Home" Move to PFB = 0

EXAMPLE 2

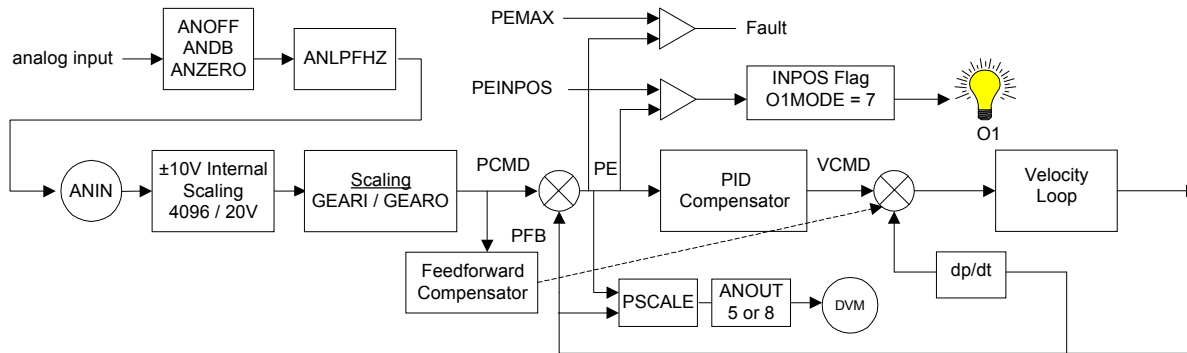
Homing: HOMETYPE = 2, HOMESPD	Absolute Move	Increment Move	Action
C3, pin 9 (IN1) (IN1MODE = 12)	C3, pin 10 (IN2) (IN2MODE = 13)	C3, pin 11 (IN3) (IN3MODE = 7)	
Initial Toggle ↑ ON			"Search for Home" Move until first mechanical marker - Set PFB = 0
	Toggle ↑ ON		Determined by MASPEED, MAPOS
		Toggle ↑ ON	Determined by MISPEED0, MIDIST0
Subsequent Toggle ↑ ON			"Command to Home" Move to PFB = 0

# Analog Position

The analog input to the SERVOSTAR is differential, meaning that the signals received at the two inputs are subtracted from each other to create a “difference”. This difference is then used to command the rest of the system. This type of input has a high degree of noise immunity and, in many cases, allows for ground isolation between systems. This analog input also has a digital low-pass filter (ANLPHZ) to prevent high-frequency noise from entering the system.

The input voltage from the differential receiver is applied to a precise 14-bit Analog-to-Digital (A/D) conversion system. The A/D conversion system is read by the microprocessor every 500µS for the position loop. Encoder-based units come with the additional benefit of a Dual Gain (ANDG) input. When enabled, the system uses two 14-bit A/D inputs to read the user-supplied analog signal. One input is a direct reading of the ±10V signal, while the other incorporates a 2x gain term. When the input voltage is less than 4V, the 2x channel is used to determine the user’s input voltage, extending the resolution to a 15-bit equivalent. Above 4V, the system uses the straight 14-bit conversion. Special software algorithms are used to minimize crossover distortion and add 0.25V of hysteresis.

Analog systems often require scaling and offset bias. As shown in Figure 3, the SERVOSTAR adds an analog offset (ANOFF) variable to this reading, performs an analog deadband (ANDB) adjustment, and scales it internally from volts (±10V) to position command counts (4096). The analog input (ANIN) variable represents the analog reading in counts with a range of ±22500mV (counts equating to mV).



**Figure 3: Analog Position Loop Diagram**

After the command is scaled, it is passed through the SERVOSTAR's Gearing feature (see Note 5 on page 18). From the factory, this feature is enabled and the GEARI/GEARO ratio is set to one. Changing the ratio between GEARI and GEARO provides an added scaling option. Once the position command (PCMD) is developed, control is similar to that of the serial mode.

## Command Scaling

In the analog position mode, the **SERVOSTAR** facilitates various approaches to scaling the analog input command to actual motor shaft movement. Refer to the *SERVOSTAR<sup>®</sup> S and SERVOSTAR<sup>®</sup> CD VarCom Reference Manual* for detailed information about the variables and commands described in this document.

### ANALOG SIGNAL DEAD BAND (ANDB)

This scaling feature allows you to set a dead band range for which no analog command is generated. This is particularly useful when the analog input signal is noisy or exhibits drift that results in undesired motor shaft movement. An example of this is a given system set at idle with an applied signal to the analog input of 0 V, where an ambient room temperature change occurs of 15° creating a -500 mV drift. You could set ANDB = 600 and experience no shaft movement because this 500 mV drift does not get passed to the next block until the analog input signal reaches -600 mV. The actual deadband range where ANDB = 600 is -600 mV to +600 mV. When the input voltage is beyond the dead band, it passes the complete signal (e.g., with an input voltage of 601 mV and ANDB = 600, the signal passed is 601 mV - not 1 mV).

### ANALOG SIGNAL OFFSET (ANOFF)

The **SERVOSTAR** can only receive an analog input signal range of  $\pm 10$  V. The drive uses the value stored in the ANIN variable to command the position loop. As a default, the input relationship between the actual signal and the value of ANIN is  $\pm 10$  V =  $\pm 10000$  mV. However, there are applications that either provide a different analog input signal range or demand a different command range.

The **SERVOSTAR** provides an offset feature (ANOFF) that changes the range relationship between the analog input signal and the position loop command (ANIN). For example, if ANOFF=5000, an analog input signal range of  $\pm 10$  V equates to a position loop command range of -5000 mV to +15000 mV. Motor movement reacts to a -5 V to 15 V range on the input.

### ZEROING THE ANALOG INPUT (ANZERO)

The **SERVOSTAR** offers an automatic analog input zeroing function. Executing this command samples the analog input 64 times, calculates an average, and adjusts ANOFF accordingly to cancel out any input offset that may be present from factors such as drift and noise.

## ANALOG SIGNAL TO MOTOR SHAFT SCALING (GEARI, GEARO)

The analog position loop in the SERVOSTAR is similar in operation to the Pulse Following option (OPMODE 4), except that it receives a constant DC voltage as its input signal (verses a DC pulse train). This feature offers the flexibility of varying an analog input increment to a corresponding incremental shaft movement. The amount of incremental change is determined by a gearing relationship between the values stored in GEARI and GEARO variables.

As a default, the SERVOSTAR sets GEARI and GEARO to 1. Therefore, a one-to-one gear ratio is established. Since the command is scaled for a 4096 count resolution over a 20 V range, a 10 V command creates a movement of 2048 counts (total counts per mechanical revolution is 65536). A  $\pm 10$  V range creates a 4096 count movement. If you want to make a 10 V command equal to a full mechanical revolution of movement, a gear ratio of 32:1 (65536/2048) must be established between GEARI and GEARO.

## Homing

The SERVOSTAR offers two sets of Homing options in the Analog Position mode. Both sets are identical to those mentioned in the Homing section under Serial Positioning except that a Home position reference point is established through two quantities: analog input (ANIN) and the position feedback (PFB) verses one in serial (PFB=0).

Commands to “Search for Home” (or “Command to Home” if sequential command in HOMETYPES 0, 1, 2 or 50, 51, 52) are still issued via an MH command from a terminal, the Configurable Inputs, or an enabling transition of the Remote Enable switch (assuming ACTIVE=1 after the transition).

### HOMETYPE 0, 1, 2, 3, 4, 5, 6, 7

After the Homing sequence has occurred, PFB is normalized (PFB=0) at the current value of ANIN (ANIN is a count representation in mV of the analog input signal plus any offset, ANOFF). If the Remote Enable is toggled, the home position is lost and the Homing sequence must be reestablished. For example, if 4 V is on the analog input and an Configurable Input (INx switch) triggers a “Search for Home”, the Home position becomes PFB=0 at 4 V of analog input (ANIN=4000).

### HOMETYPE = 50, 51, 52, 53, 54, 55, 56, 57

If one of these HOMETYPES is selected, the drive defaults in the HOLD state upon enabling until a “Search for Home” is requested. After the Homing sequence has occurred, PFB is normalized (PFB=0) at the zero value of ANIN. Toggling the Remote Enable will not cause a loss of the home position. For example, if 4 V is on the analog input and a Configurable Input trigger occurs, the Home position is PFB=0 at 0 V of analog input (ANIN=0000).



***The 4 V analog input signal is seen as a 4 V command upon triggering the INx switch and motor movement will occur.***

## Additional Features

The following features apply to the overall position loop, no matter what motion type (homing, incremental, absolute) is selected for an application. These features complete the platform from which a thorough understanding of the position loop's functionality is possible.

### Following-Error Monitor

A basic realtime error checking routine monitors the following error (PE) between the commanded position (PCMD) and the motor shaft's actual position (PFB). This following-error routine enables when a value greater than zero is stored in the PEMAX variable. If the distance (in incremental counts) between the motor shaft position and the position command is greater than this stored value, the drive disables in a fault condition. For example, a **SERVOSTAR** resolver-based system is based on 65536 ( $2^{16}$ ) bits per revolution. A value stored in PEMAX of 32768 (usually a good choice cut-to-length applications) equates to  $\frac{1}{2}$  of a mechanical revolution. Should the motor shaft lag the actual command by more than  $\frac{1}{2}$  a turn, the drive enters a fault condition. Many factors effect this mechanical lag including ramping rate, load inertia, loop gains, or a locked rotor.

### Position Scaling Factor

The **SERVOSTAR** provides an analog output monitor that can be configured (ANOUT) and scaled (PSCALE) to indicate position following error (PE) and the actual motor's position (PFB) in reference to a  $\pm 10$  V range (see Figures 1 and 2). For example, if PSCALE is set to 65536 bits, a PFB value of 32768 equate to a 5 V output on C3, pin 13.

### Profile Ramp Control

As a default, the drive is set with no acceleration or deceleration limits (PROFMODE = 0). However, there are applications where the need for linear ramp control is vital for minimizing system overshoot or tracking (following) error. The profile mode (PROFMODE) of operation determines the state of linear ramp control.

#### LINEAR CONTROL (PROFMODE = 1)

When this linear mode of ramp control is implemented, the value set in each variable becomes the upper limit and not a commanded acceleration. This drive provides two variables (ACC, DEC) for linear ramping with units in rpm/sec.

## S-CURVE CONTROL (PROFMODE = 2)

To implement S-curve control, the drive uses the PROFSCRV variable. When PROFSCRV=0, the motor is under the same linear ramp control as PROFMODE=1, except that it uses the ACC (not both ACC and DEC) value for both acceleration and deceleration. As the value of PROFSCRV increases, S-curve acceleration is introduced. The tradeoff of using this type of ramp control is that peak accelerations and horsepower requirements are higher than that of linear control.



***S-curve ramp control is only available in the position mode (OPMODE=8) of operation.***

## FAULT RAMP CONTROL

The SERVOSTAR provides for a special deceleration ramp (DECSTOP) that overrides normal deceleration control in cases where a system fault occurs and a faster ramp is needed. The procedure is implemented through the ACTFAULT variable and, if enabled, uses a preset speed (DISSPEED) and time (DISTIME) to ramp to a stop. Other non-fault usages of this special ramp control occur during a holding state (HOLD), a serial command to stop (S), or a trigger from a Configurable Input (INxMODE = 17).

## External Feedback Control

The drive can receive an external position feedback signal through the C8 connector. This feature (DUALFB, PEXTOFF, PEXT, VEXT, XENDIR, XENCRES) provides the ability to position from a load feedback device (e.g. remote encoder) while controlling velocity and torque from the motor feedback signal through C2. Very stiff coupling with no backlash or compliance between the motor and the external feedback device is a must for proper system performance. Poor mechanical designs will not allow for system compensation.



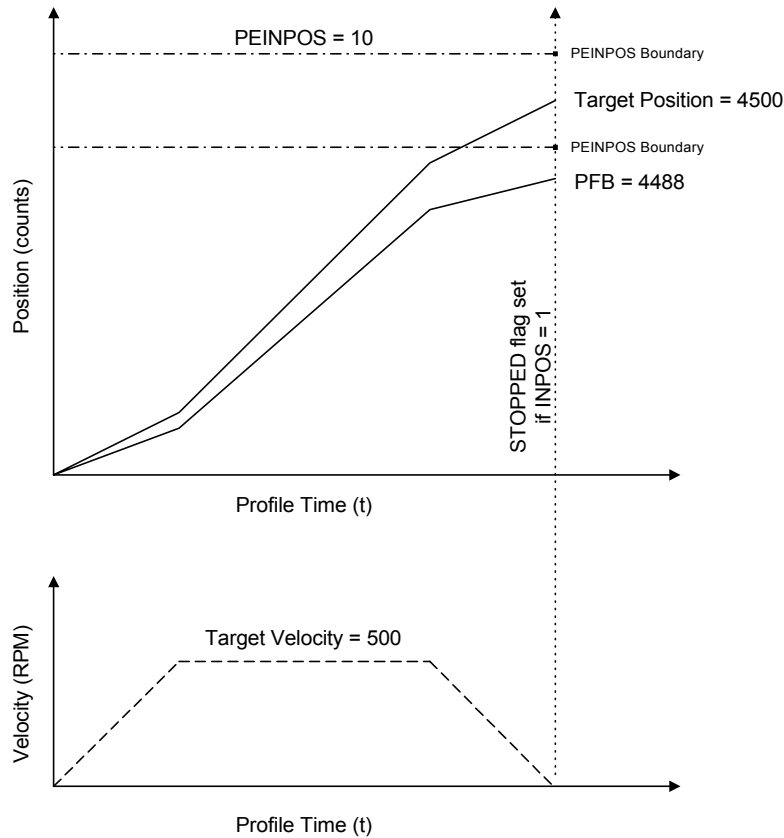
***This operation will not operate with the GEAR mode feature.***

## In-Position Monitor

This status-checking routine allows you to establish boundaries within which the final position must fall. It monitors the accuracy of the motor's actual final position (PFB) to its commanded position (PCMD). The drive compares this position error (PE) against a pre-defined position boundary (PEINPOS) and sets a flag (INPOS) with respect to the following equations:

If  $\{(Target\ position - PEINPOS) < PFB < (Target\ position + PEINPOS)\}$  Then  
 INPOS=1; out of bounds

Example: MA 4500 500 (PFB=0)



**Figure 4: In-Position Error**

In Figure 4, the actual shaft position is outside the tolerable limits set by the user and the INPOS flag is not set (INPOS = 0). Had PEINPOS = 15, the INPOS flag would have been set (INPOS = 1). In this case, the user could configure O1MODE = 6 such that O1 toggled (C3, pin 13) as the shaft pulled into position.



## Software Travel Limits

Another basic realtime error checking routine monitors the load movement (or cumulative absolute motor shaft movement) against an absolute software travel point. There are two travel points (P<sub>MAX</sub>, P<sub>MIN</sub>) provided in the SERVOSTAR, called Software Position Limits. P<sub>MIN</sub> is called a minimum limit, but usually references counter-clockwise (CCW) direction while P<sub>MAX</sub> references clockwise (CW) motion. The values stored in these variables are compared against the actual load (or incremental motor shaft) position, P<sub>FB</sub>. Should the motor ever traverse to where either of these two conditions are met, P<sub>FB</sub>>P<sub>MAX</sub> or P<sub>FB</sub><P<sub>MIN</sub>, the drive decelerates to 0 speed (with respect to the value stored in DECSTOP) and enters a HOLD state for that particular direction of movement. Then, you command motion in the opposite direction; backing off the absolute limit previously engaged. This feature enables by setting PLIM=2 (PLIM=0 disables).



***Be careful to store the correct value in PLIM. If PLIM=1 and a Software Position Limit is reached, the drive disables and the motor coasts to a stop; possibly causing physical damage to whatever becomes the hardstop for the load.***

## Hardware Travel Limits

The SERVOSTAR provides a routine for monitoring the load location (or incremental shaft position) against two hardware travel points. Limit switches commonly added to the configurable inputs (IN<sub>x</sub>, IN<sub>x</sub>MODE) provide a CW or CCW motion safety limit. This feature enables through the variable, LIMDIS. The state of the switches is monitored through the variables, CCLIM and CCWLIM. Refer to the *SERVOSTAR<sup>®</sup> S and SERVOSTAR<sup>®</sup> CD Installation Manual* for more information on this feature.

## System Resolution

SERVOSTAR resolver-based systems have a motion resolution of 65536 bits per revolution. This implies that to get the motor to move one revolution, the command distance must be 65536. Encoder-based systems use the encoder resolution after quadrature decode. For a 4096 line encoder, a desired movement of one revolution requires a commanded motion of 16,384.

# System Tuning

A summary is provided below. For detailed information, refer to the *SERVOSTAR® S- and CD-Series Velocity Tuning Algorithms*.

Upon entering OPMODE 8, the Position Loop compensation variables (GPD, GPI, GPISATIN, GPISATOUT, GPVFR, GPAFR, GPAFR2) all default to zero. The proportional gain, GP, does not. The drive ships from the factory in the Velocity Mode already compensated for a particular motor (unless the customer ordered it uncomped). When the Position Loop is selected, the Velocity Loop compensation variables retain their values. Presetting the Position Loop variables could cause a dilemma in that both loops would have an integrator term. Additionally, Kollmorgen products have traditionally included integration in the Velocity Loop.

In the interest of users who may be more familiar with traditional PID Position Loop control, Kollmorgen has now made it possible to tune the system in this manner. In this configuration, it is recommended that COMPMODE 0 be used. This allows you to minimize the integrator value in the PI Velocity Loop algorithm to an ineffective level, thus leaving only the proportional velocity gain to adjust.

Refer to the *SERVOSTAR® S- and CD-Series Velocity Tuning Algorithms* for instructions on loop tuning when desiring to tune the integrator in the Velocity Loop.

## Notes:

Note 1: The **SERVOSTAR** provides one command buffer. You can send the next command before the current profile is completed. If more than one command is sent while the current profile is in motion, the **SERVOSTAR** ignores it.

Note 2: Handshaking to the user that motion has stopped can be accomplished in three ways:

- 1) “!” flag through the serial port
- 2) reading the STOPPED variable
- 3) setting O1MODE = 6 and reading the digital output (C3: pin 12)

Note 3: Mechanical switches are often used for the Home limit switch and may have some variability to the actual position the **SERVOSTAR** detects as closure. If this variability occurs around a resolver zero setting, an error in Homing of  $\pm 1$  revolution can be expected. Good switch designs include strategies that make certain the switch is closed anywhere and anytime the motor has passed the Home limit switch.

Note 4: **Caution!** Be careful to enter the correct  $\pm$  sign when setting the direction in HOMESPD so that the motor moves toward the Home limit switch during a “Search for Home.”

Note 5: The Analog Positioning feature works similarly to the Pulse/Direction feature in OPMODE 4. The only difference is that the analog input is a constant DC voltage, while in OPMODE 4 the input is a pulse train.