SERVO**STAR**® S- and CD-Series Pulse Following Control

This Product Note describes the pulse following capability of the SERVO**STAR**® system. In this type of position control (OPMODE = 4), the drive is synchronized to a master input command signal in the form of a pulse train. Applications such as synchronizing one motor shaft to another (traditionally called Master/Slaving) are ideal for this type of feature. Another type is a stepper application where a typical stepper motor cannot give the torque, speed, and acceleration performance provided in a servo system. A stepper controller can provide a master pulse train signal that becomes the command for the SERVO**STAR**® system.

The drive is configured to read this input signal as an encoder follower, an up/down counter, or a pulse/direction counter. The pulse train is geared to the incremental movement of the motor shaft through the drive's Electronic Gearing feature. This feature allows for almost any integer ratio of movement to exist between the pulse train frequency and the output shaft movement.

In this mode of operation, the drive's homing capabilities are also available. The Homing process is triggered through the Configurable Inputs. Refer to the *SERVO**STAR**® Position Control* Product Note for a detailed discussion on this topic.

Basic Theory of Operation

The drive accepts an input pulse train where the rising edge of each pulse increments (or decrements depending on the direction) the external position counter (PEXT) of the drive one position count *(See Figure 1)*. This counter value is passed through a gearing block (Electronic Gearing feature) and becomes the position command for the motor. This position command is compared against the actual motor position (PFB) to create a position error (PE). The drive corrects the position error by incrementing the motor to the commanded position.

Gearing sets up a relationship between the number of input pulses (PEXT counts) and the position increments of the motor shaft (or actual motor position, PFB). The rate at which position increments of the motor shaft (motor speed) occur is determined by the gearing relationship and the line frequency of the pulse train. The direction of rotation is determined by the type of signal selected (GEARMODE) and the setting of the drive's direction variable (DIR).

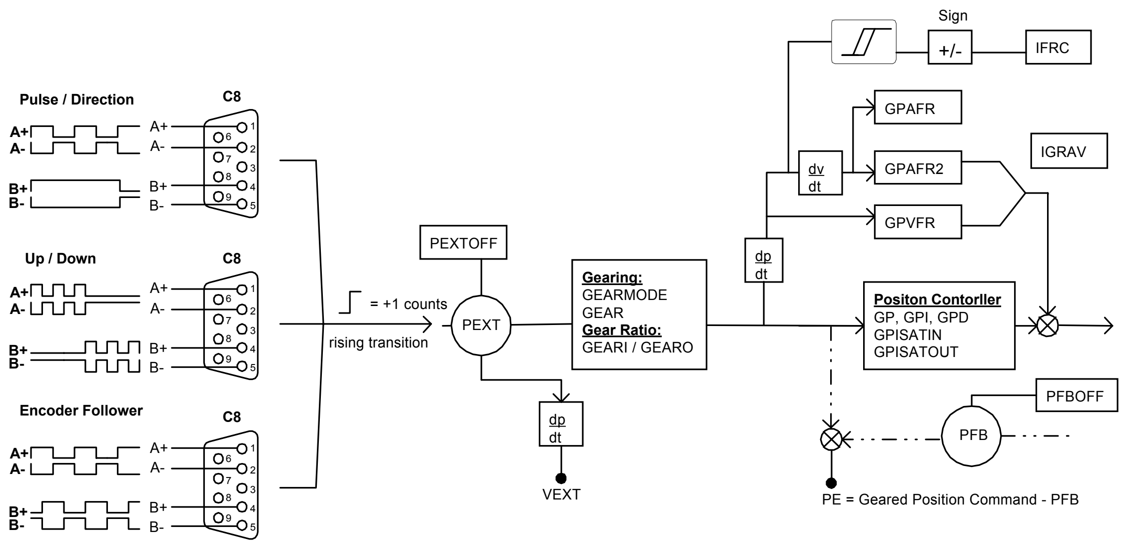

Figure 1: Pulse Control Operation

Signal Types and Connections

The pulse train signal is applied through either the RS485 Remote Encoder input (C8 connector – up to 3MHz) or the opto-isolated Configurable Inputs (C3 connector - given the appropriate INxMODE settings).

Various master input command signals can be applied to the drive. All configurations count the rising edge of each pulse (Encoder Follower also counts the falling edge). It is assumed that the drive's direction variable is at its default setting (DIR=1, clockwise positive rotation).

Routing Through Configurable Inputs (C3)

Because the C3 connector inputs are opto-isolated, the applied pulse train frequency is limited (2.5kHz). For most applications, this is unusable. Users desiring to apply the signal through this connector should refer to the INx, INxMODE, and GEARMODE variables for proper configuration.

Pulse/Direction Counter

Referring to Figure 1, the pulse signal applied to the A channel increments (or decrements depending on the direction) the external position counter (PEXT). The line frequency and the gearing relationship determine the speed and amount of the shaft movement.

The direction of shaft rotation is determined by the state of the B channel. If the signal is low, the motor turns clockwise (CW). If high, the motor turns counterclockwise (CCW). Setting DIR = 0 or the sign value stored in GEARI changes this direction relationship in the opposite fashion.

Up/Down Counter

When the pulse signal is applied to the A channel, the external position counter (PEXT) increments and rotates the motor in a CW direction. The frequency and the gearing relationship determine the speed and amount of the shaft movement.

The pulse signal applied to the B channel decrements the external position counter (PEXT) and rotates the motor in a CCW direction. The line frequency and the gearing relationship determine the speed and amount of the shaft movement.

Setting DIR = 0 or the sign value stored in GEARI changes this directional relationship in the opposite fashion.

Encoder Follower

This pulse train is an A/B channel signal. Because the drive reads rising and falling edges, the external position counter increments up to four times the rate of the other two methods - given the same input line frequency. Therefore, the frequency (4x, where x = line frequency) and the gearing relationship determine the speed and amount of the shaft movement.

The direction of shaft rotation is determined by the relationship between the A/B signal. If A leads B, the motor turns CW. If B leads A, the motor turns CCW. Setting DIR = 0 or the sign value stored in GEARI changes this directional relationship in the opposite fashion.

Electronic Gearing

Gearing gives you the ability to establish any integer relationship between the external position counter (PEXT) and an incremental shaft movement. The feature is enabled through the GEAR switch variable (GEAR = 1).

Mode of Operation

The mode of operation is selected through the GEARMODE switch variable. The value stored in this variable determines which input signal type the drive reads and which connector (C3 or C8) receives the input.

Gear Ratio

The relationship between the amount of incoming pulses and the motor shaft movement is established by the gear ratio (GEARI/GEARO). GEARO is the output gear and GEARI is the input.

Disabling Gearing

There are two ways to disable the Electronic Gearing feature and thus motor movement. The first is to set GEAR = 0 through serial port communications via a host terminal. The second gives you the ability to disable via a hardware switch through one of the Configurable Inputs *(See Figure 2)*. By setting INxMODE = 3 (where x is the input of choice), you can toggle the input active (on) to disable gearing. However, PEXT continues to increment as long as the input pulse signal is applied – but without motor movement.

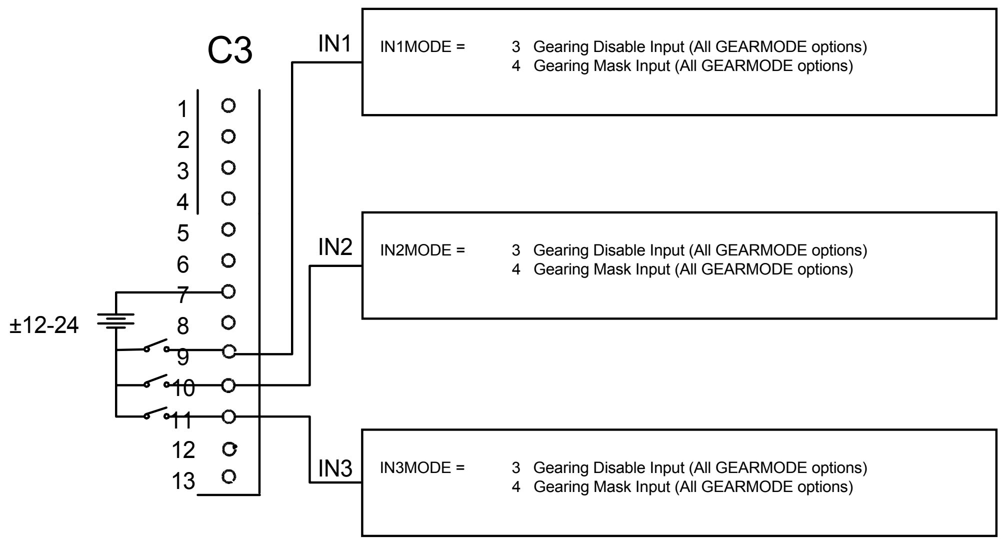

Figure 2 Disabling/Masking Input Configuration

The Configurable Input (INx) does not need to be connected to enable – only to disable and mask (See Figure 2).

Masking

The drive provides a masking switch *(See Figure 2*) to allow you to stop motor movement and prevent PEXT from incrementing, even though the input pulse signal is still applied. By setting INxMODE = 4 (where x is the input of choice), you can toggle the input active (on) to mask PEXT from the input pulse signal.

Following Accuracy

Under normal operating conditions, the drive (as a slave unit) follows the command signal without accumulating any count error. However, under certain conditions, counts can be lost and inaccuracies introduced into the system's operation. Some of these conditions are:

- GEAR disabling (as mentioned above)
- Masking (as mentioned above)
- ACTIVE = 0 (drive is disabled)
- A fault occurs during operation
- The drive enters a HOLD state
- Drive is not in OPMODE 4 (Pulse/Direction mode)
- If PROFMODE = 1, profiling is enabled and the acceleration and deceleration ramps are limited. If the ramps are limited below the accel/decel ramps of the master, counts are lost. As a default, PROFMODE = 0 and provides no limits on the ramps.

Homing

Homing is also available in this mode of operation. A command (or search) to home is initiated either through the configurable inputs (INxMODE) or via a serial command (MH). Homing can be performed even while pulse motion is taking place. Once the inputs are correctly configured and the drive receives a trigger to home, motion stops and the homing process begins. An "8" appears in the status display (operation is still in the pulse control mode) as an indicator that homing is in process and returns to "4" upon completion. Refer to the *SERVO**STAR**® S- and CD-Series Position Control* Product Note for a detailed explanation of homing capabilities and setup.

Examples

To calculate a gear ratio that must be present to meet a desired relationship between the input pulse signal and the motor shaft movement, the counts per mechanical revolution of the motor shaft must be known. SERVO**STAR** systems provide the following resolutions:

Resolver-Based Systems (SRxxxxx): 65536 counts/rev

Encoder-Based Systems (SExxxxx or SBxxxxx): 4 x MENCRES lines/rev (or lines/pitch for linear motors)

Pulse / Direction

A stepper controller is programmed to provide 1024 line pulses as an input command to a resolver-based SERVO**STAR** system in order to make the motor rotate one revolution. Calculate the gear ratio needed to accomplish this relationship (GEARMODE = 4).

Relationship = 1 = (GEARI / GEARO) x (PEXT / SERVO**STAR** System Resolution)

1 = (GEARI / GEARO) x (1024 / 65636)

This ratio must be factored down because the number 65636 exceeds the upper limit of the GEARO variable.

1 = (GEARI / GEARO) x (1 / 64)

Therefore: GEARI = 64, GEARO = 1

Encoder Follower

An application has two SERVO**STAR** systems. You want to synchronize one system off the other through the Encoder Equivalent Output. The slave motor must move two CCW revolutions for every CW revolution of the master. The following provides the system information:

Given

Master: SR03xxx with an Encoder Equivalent Output setting of 1024 lines/revolution
Slave: SE06xxx with a special motor encoder resolution of 6400 lines/revolution
Relationship 1 = (GEARI / GEARO) x (PEXT / SERVO**STAR** SE06 System Resolution)
Settings: GEAR = 1, GEARMODE = 3
Find: GEARI, GEARO

Calculations

PEXT = 4 x 1024 = 4096 counts/rev (rising and falling A/B transitions)
SERVO**STAR** System Resolution = 6400 x 4 = 25600 counts/rev

Remember, the slave must turn two revolutions for every one of the master. Therefore, for every 4096 counts of the master, the slave must turn 51200 counts (2 x 25600). Let's put this in the equation for the system resolution of the SE06.

1 = (GEARI / GEARO) x (PEXT / SERVO**STAR** SE06 System Resolution)
1 = (GEARI / GEARO) x (4096 / 51200)

This ratio must be factored down because the number 51200 exceed the upper limit of the GEARO variable.

1 = (GEARI / GEARO) x (2048 / 25600)

Therefore: GEARI = -25600, GEARO = 2048 where the minus sign turns the slave motor in the opposite direction from that of the master.