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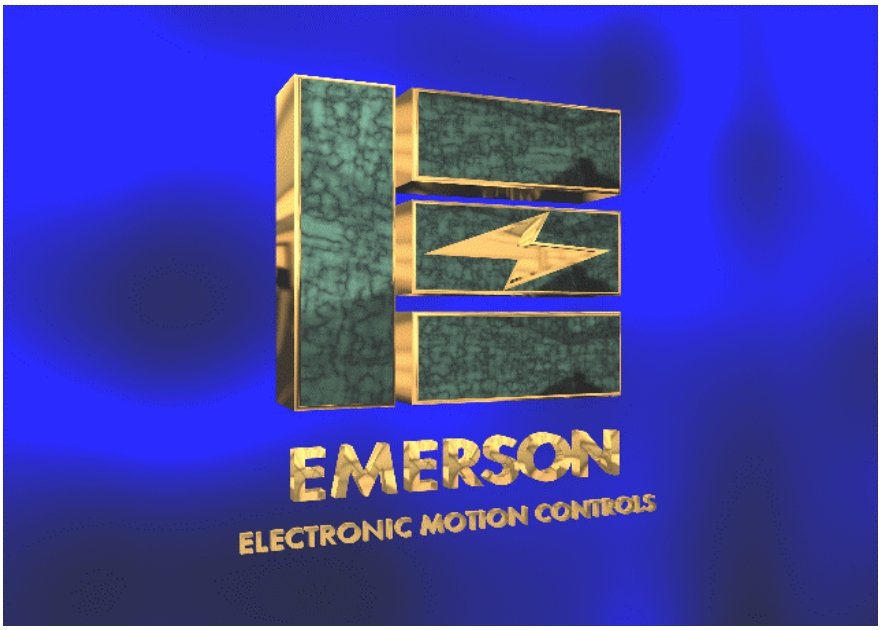
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PCM-16 Phase Synchronization Controller Operators Manual



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P/N 400286-00 Rev: A2

Date: Dec. 15 1995

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Overview Of The PCM-16

This manual provides information for setup and programming of the PCM-16 module. It is important that you become familiar with the basic setup and operation of PCX software in the FX Drives Setup And Programming Operators manual (P/N 400282-00). The PCX section of that manual provides the background information needed to setup and configure the amplifier using PCX (Ver. 6.0 and above) software.

Because of the additional memory on the PCM-16, the number of standard indexes available is increased from 32 to 64. The number of programs steps available is 512 steps.

To simplify and expand the flexibility of machines and processes, the PCM-16 can synchronize the motion of the FX Drive it's mounted on to a master axis. Master axis reference signals can come from either an upstream FX drive or from a synchronization encoder.

Features provided by the PCM-16 Phase Synchronization Controller include:

- Allows an independent follower axis to match cycles of a master axis.
- Allows you to create non-linear functions such as cam type profiles.
- Stores up to 16 different cycle profiles with 12 segments per cycle in non-volatile memory.
- Cycle PGO's (Programmable Outputs) which turn on and off up to eight predefined output lines based on the position of the master axis.
- Cycle Dropout Input function which allows the PCM-16 to drop out of a cycle, perform some task, then return to phase when the input signal is removed.
- 78 user assignable I/O functions.
- Stores parameters in non-volatile memory so the PCM-16 can be moved to another FX Drive (of the same size) without losing data.

The firmware revision on a PCM-16 module necessary for all of the programming features in this manual is A6 or higher. You can find the revision number of your module by looking at the serial number sticker located on the side of the module. The revision number is found in the "REV" field.

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Basic Operation

The PCM-16 Phase Synchronization Controller allows an Emerson FX drive to monitor the motion of another axis (defined as the master axis).

The objective of the PCM-16 Phase Synchronization Controller is to cause the **Follower axis** to produce one cycle of motion for every cycle of motion produced by the **Master axis**.

In the figure below, the FX drive controls the Follower Axis which delivers a product to the Master Axis monitored by a sync encoder.

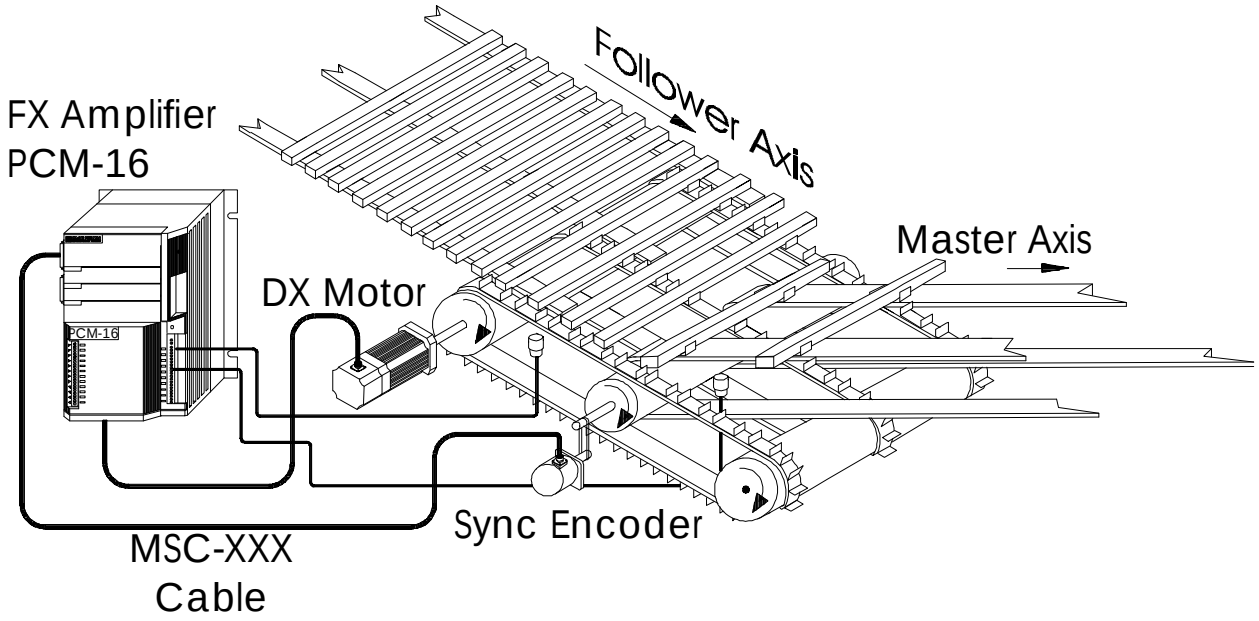


Figure 1 Basic Operation (Master/Follower)

In order to maintain proper phase synchronization between the two axis, the Drive monitors the start points (zero degree points) of both the master and the follower axes. The follower axis (PCM-16) will adjust its speed slightly as required to stay in phase with the master axis. If both the follower and the master axis are in phase no speed correction is made.

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System Setup

There are a number of ways to establish the phase relationship between the master axis and the follower axis. In the figure below sensors detect the passing lugs on each conveyor and establish the zero points for each respective axis.

Sensors are unnecessary on the follower axis in applications where there is **no slippage** between the motor and the conveyor or work piece. The follower zero point is established after initial power-up by executing a home cycle or by applying a signal to the "Zero Follower Cycle Input" when the conveyor (or load) is in its proper zero position.

The master axis sensor can be eliminated in applications where the number of external encoder steps in the "Master Cycle Length" is a whole integer. There must also be 100% accuracy and repeatability in the master cycle. The zero point is established immediately after power up by placing the master in its proper zero position and then applying a signal to the "Zero Master Cycle Input".

In applications where no sensors are used there must be no accumulated error in the ratios of the follower axis (DX motor) or master axis (encoder).

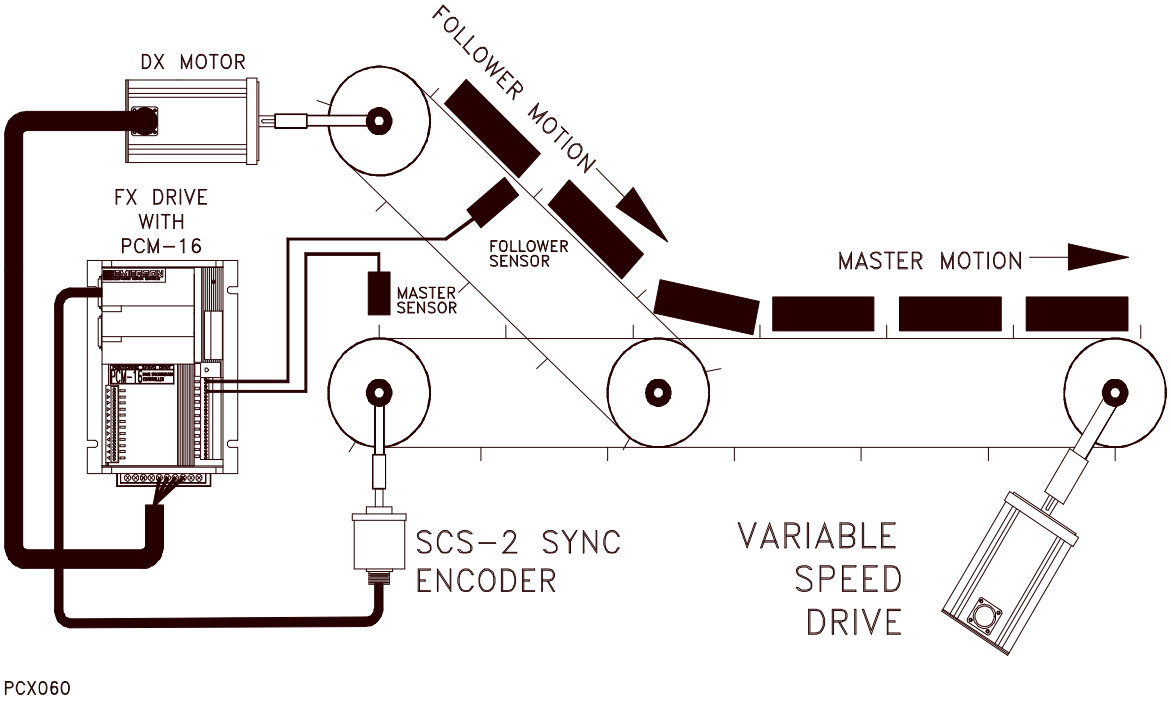


Figure 2

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Configuring Your FX Drive

The first step in setting up your FX drive with a PCM-16 is to configure the drive. This is done in the **Drive Configuration** screen. There are 5 menu selections in this screen. The parameters in the Drive Parameters and Limits screens are described in the FX Drives Operators manual (P/N 400282-00).

The first selection, **Drive Parameters**, sets and scales the user units.

The next selection, **Master Axis**, is where you determine how the master axis is defined and the necessary parameters for your system to run follower cycles or in sync mode.

The next selection, **Limits**, is where set the maximum and minimum operating parameters.

The last step in configuring your drive is to assign the I/O functions to the proper I/O connectors on either the FX amplifier or the PCM-16.

After you have configured your drive the next step is to define the motion parameters. This is done in the **Define Motion** screen. The first three menu selections, **Jog**, **Home** and **Index**, are explained in FX Drives Setup And Programming Operators manual (P/N 400282-00).

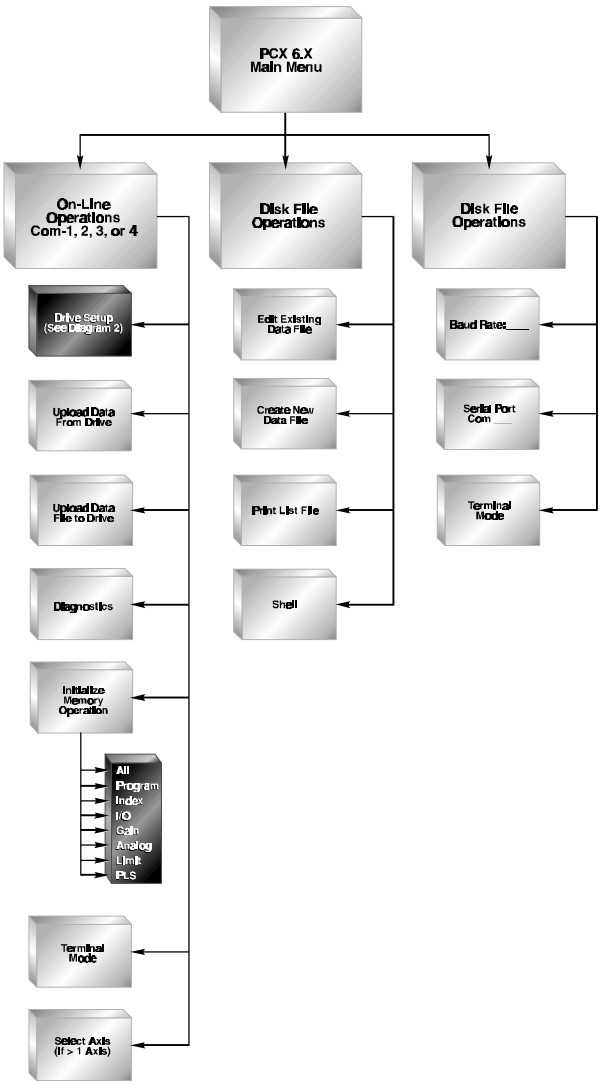
The next four selections, **Master Cycles**, **Follower Cycles**, **Cycles Profiles** and **PGO's (Programmable Outputs)** define the relationship between the master and follower.

The last step is to create a program (or programs) that use the "Y" function with other programming functions as logical steps within a program.

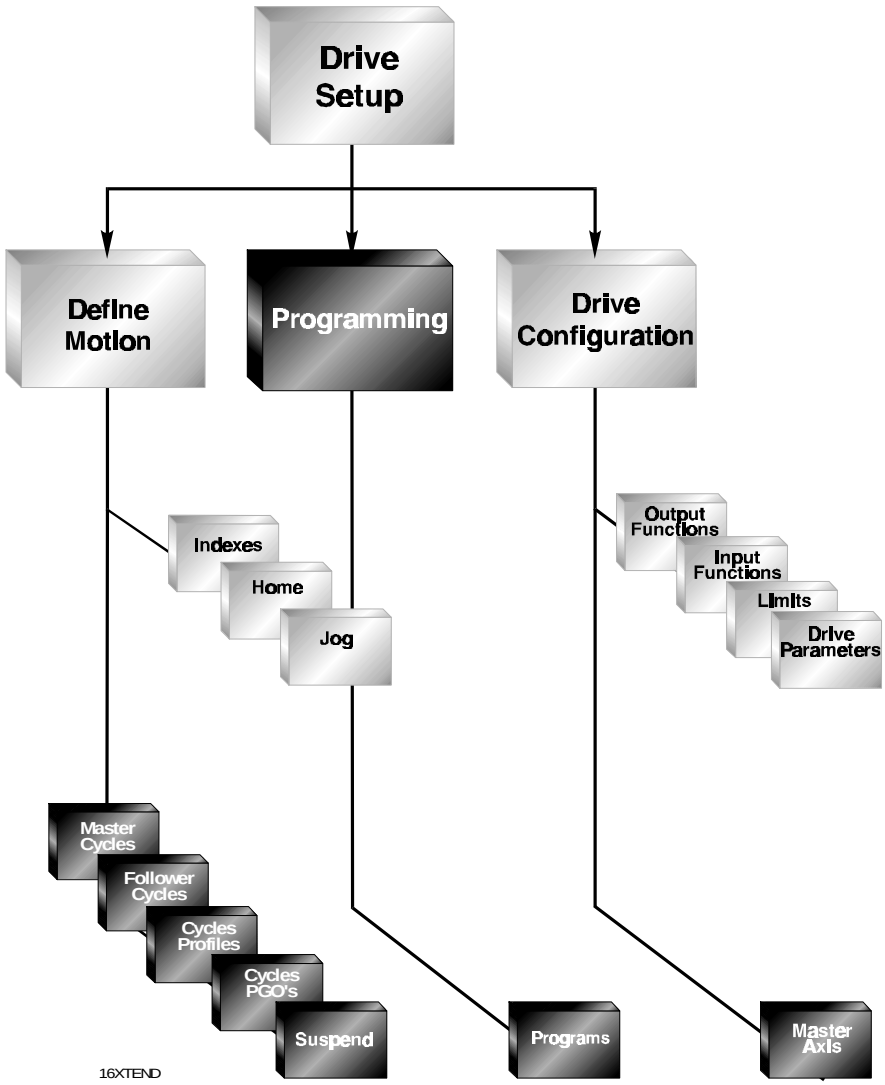
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Navigating PCX Software

Adding a PCM-16 Phase Synchronization Controller to an FX drive gives you several additional features in PCX. The hierarchy menu diagrams below show the additional features in the shaded blocks.



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PCM-16 Application Module

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Master Axis Setup

This screen is where you identify the **Signal Source** of the master axis. In addition to running Cycle Profiles the PCM-16 also has the ability to run synchronized indexes, however, in this screen only the **Signal Source**, **Signal Polarity**, **Signal Interpretation** and **Signal For Sync Output From** parameters are used by the PCM-16 when running Cycle Profiles. The Master Axis screen is found by selecting Drive Setup, Drive Configuration then Master Axis.

An external master axis becomes the time base for motion control of the follower axis (your FX Drive equipped with a PCM-16). The basis of operation is determined by the relationship of the external master axis encoder or drive to the follower axis motor.

The master axis is typically an Emerson SCS-2 encoder which produces 4000 steps per revolution or it can be a customer supplied encoder of any line density yielding the appropriate steps per revolution.

The base number system used for the FX Drive is binary and 12 bits. The smallest resolution is one part in 4096. Since this number may be difficult to work with because of units, the drive electronics allow for a conversion to any number from 200 to 25,000, with the default being 4000.

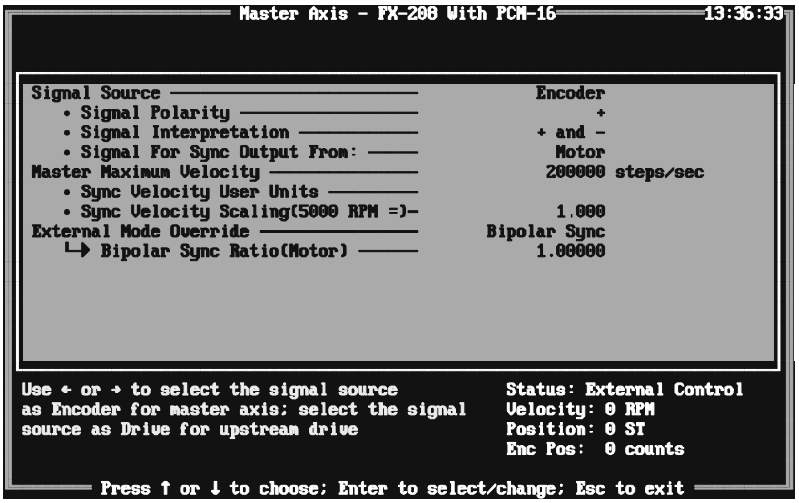


Figure 3 Master Axis Screen

Signal Source

Use the arrow keys to toggle between Encoder and Drive. Select the origin of the signals that will be used for master axis positional information.

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When a follower axis is receiving its synchronization source from an FX drive lead axis, the count source becomes the binary 4096 counts per revolution.

Signal Polarity

Defines the direction of the synchronization encoder that corresponds to a positive master position change. Clockwise is indicated with a (+); counterclockwise is indicated with a (-). CW and CCW motion of the Master Axis is defined while facing the encoder shaft.

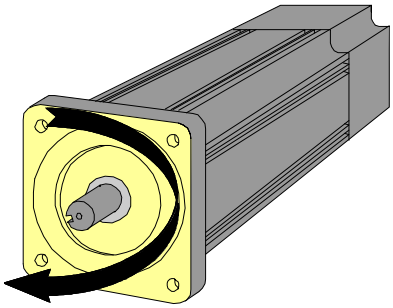


Figure 4 CW Motion

Signal Interpretation

The Signal Interpretation feature allows you to define how the follower reacts to clockwise and counterclockwise motion of the synchronization encoder. Use the arrow keys to toggle between the choices.

Mode #1 (+ and -): When the master axis moves either CW or CCW, the follower axis will move in its commanded direction. If the master axis changes direction the follower axis will continue in the original commanded direction. The follower axis will not reverse direction.

Mode #2 (+): The follower will only react to synchronization pulses when the master axis runs in the CW direction. CCW master axis pulses are ignored.

Mode #3 (-): The follower will only react to synchronization pulses when the master axis runs in the CCW direction. CW master axis pulses are ignored.

Mode #4 (COMP +): The follower will only react to synchronization pulses when the master axis runs in the CW direction. The drive counts the pulses received in the CCW direction and ignores that exact number of CW pulses before follower motion in the CW direction occurs.

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This feature compensates for master axis motion in the opposite (CCW) direction. For example, the master stops, then inadvertently backs up due to conveyer slack, vibration, etc.

Mode #5 (COMP -): The follower axis will only react to synchronization pulses when the master axis runs in the CCW direction. The drive counts the pulses received in the CW direction and ignores that exact number of CCW pulses before follower motion in the CCW direction occurs. This feature compensates for master axis motion in the opposite (CW) direction.

Signal For Sync Output From:

Use the arrow keys to toggle between the choices. If you select Motor, your FX Drive will output a sync signal to the next FX Drive based on the performance of its own motor. If you select Upstream Drive, your FX Drive will output a signal that comes from the motor of the preceding amplifier. Use the arrow keys to toggle between the choices.

Encoder pulses are passed to all amplifiers in the synchronization chain. However, the next FX Drive and PCM-16 will only operate with this pulse train if you set that drive up with the Signal Source parameter set to Drive. Your answer to this question has no effect on the integrity of the encoder signal.

Master Maximum Velocity

The Master Maximum Velocity, Sync Velocity User Units, and External Mode Override parameters are not used by the PCM-16 when running Cycle Profiles.

However, they would be used you were running synchronized indexes.

The master maximum velocity is the maximum frequency that the master axis signal source is expected to produce when running at its' full speed. To calculate the master maximum velocity, use the following formula:

$$Master\ MaxVelocity = \frac{(MV)(MS)}{60\,Sec \diagup Min}$$

MV = Master Axis Maximum Velocity (RPM's)
MS = Master Steps/Rev

If encoder is master: MS = (Encoder Line Density)*(4)

If drive is master: MS = 4096

For example: The master axis is a 1000 line encoder and rotates at a maximum speed of 3000 rpm, and, when quadratured, produces 4000 steps per revolution. Then:

$$\frac{(3000\,RPM)(4000\,Steps \diagup \mathrm{Re}\,v)}{60\,Seconds} = 200{,}000\,Steps\,Per\,Second$$

Maximum frequency into PCM module cannot exceed 210 Khz or steps/second.

This value is the master encoder velocity at which synchronized time base and real time base are equal. This parameter is used to calculate actual follower velocity while running in synchronized time base.

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Sync Velocity User Units

This parameter sets the units to be associated with all sync velocities. User units can be any three letter combination, such as IPS (inches per second), RPM (revolutions per minute), FPM (feet per minute), etc.

Sync Velocity Scaling (*Max RPM* =)

This parameter sets the sync velocity entry that will produce maximum velocity of the drive when the master axis signal source is at maximum velocity. When an index is running in sync time base, the velocity is specified in sync velocity user units.

The default value is 1.000. A setting of 0.500 in a synchronized index velocity means the drive will accel to half of maximum velocity.

External Mode Override

External mode override works in conjunction with input function #38 to override the current mode of operation. When input function #38 is assigned and active, the drive will exit its' current operating mode and default to the mode selected with this parameter. There are three modes of operation, **analog velocity**, **analog torque** and **BI-polar sync**.

Analog Velocity/Torque

When set to analog velocity or torque mode, the drive will respond to a conventional ±10VDC signal. In either of the two analog modes a ±10VDC signal is equated to either (CW) or (CCW) maximum programmed velocity or maximum full peak torque rating.

If you enable analog torque mode and apply a voltage between 0 and ±10VDC to the command connector the FX drive will attempt to produce torque equal to:

$$Max\,Torque\left(\frac{Applied\,Voltage}{\pm 10\,VDC}\right)=Actual\,Torque$$



If there is no physical resistance to the torque at the motor shaft, the motor will very quickly accelerate to maximum speed.

Bi-polar Sync Ratio (motor)

The Bi-polar Sync Ratio is the relationship of the Follower Axis to the Master axis for bi-polar sync mode only. If the bi-polar sync ratio is set to 2, for every revolution of the Master Axis, there will be 2 revolutions of the Follower Axis. Thus, the bi-polar sync ratio would be 2:1.

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The data sent to the FX Drive is actually the number of encoder counts per each motor revolution. The number of encoder counts is calculated as follows:

$$\text{Number Of Encoder Counts} = \frac{4000 \text{ Motor Counts} / \text{Rev}}{\text{Bi} - \text{Polar Sync Ratio}}$$

The limit of this formula is that number of encoder counts must be a whole number since there is no way to subdivide an encoder count. The PCM-16/FX firmware will not accept a bi-polar sync ratio that yields an encoder count ending in a fraction. The firmware will change your entry to the nearest ratio (within 5 decimal places) that yields an integer number of encoder counts.

The example above would accept a bi-polar sync ratio of 2 and send the number of encoder counts = 2000. If you entered 1.50000, the firmware will change your entry to 1.50037 and send encoder counts per revolution = 2666.

$$\frac{4000}{1.5} = 2666.666$$

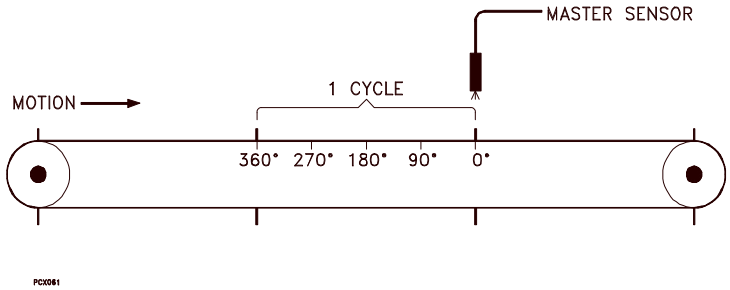
$$\frac{4000}{1.50037} = 2666.00$$

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Master Cycles

When defining a cycle using the PCX master cycles screen, a distance in user units will be entered for the **Master Cycle Length** parameter. Once this cycle is defined the PCM-16 will equate that length to 360°.

The Master Cycles screen is found by selecting Drive Setup - Define Motion, then Master Cycles. Each of the parameters in the Master Cycles screen is explained below.



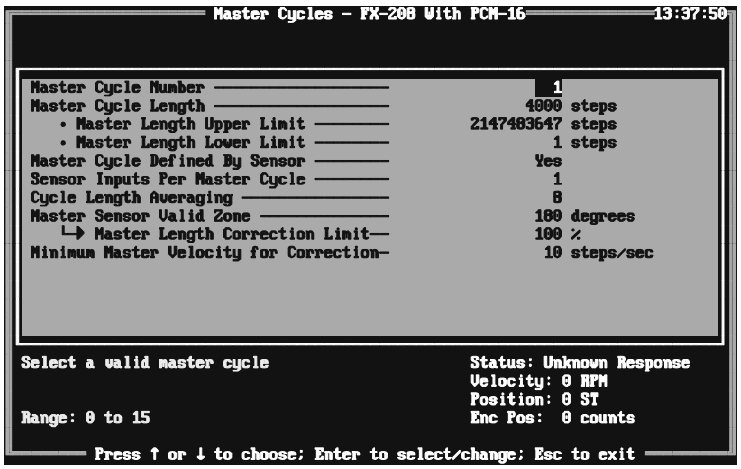


Figure 5 Master Cycle Screen

Master Cycle Number

This parameter sets the master cycle to be setup. You can define up to 16 different master cycles. Any master cycle can be used with any follower cycle.

Master Cycle Length

This parameter defines the length of the master cycle in encoder or drive steps. This is the distance that a master positioning drive, SCS-2 encoder or customer supplied encoder moves during each master cycle.

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Master length upper limit

This parameter sets the longest master cycle length that will be allowed. This limit is imposed on length changes made using serial commands or via sensors.

Master length lower limit

This parameter sets the shortest master cycle length that will be allowed. This limit is imposed on length changes using serial commands or via sensors. This may be used to prevent the drive from inadvertently "learning" a short length due to erroneous sensor inputs.

Note the following FX drive and encoder parameters:

- 1 revolution of an SCS-2 encoder = 4000 steps.
- 1 revolution of an SCS-3 encoder = 10000 steps.
- 1 revolution of an FX amplifier = 4096 steps.
- 1 revolution of a customer supplied encoder is 4 x the encoder line count.

Master Axis Cycle Defined by Sensor

*If **No** is entered here, the last four master cycle parameters will not apply.*

This parameter sets how the master axis zero position (or start position) is defined. If **Yes** is entered, the zero degree position of the master axis is defined by the zero master cycle sensor input line. If **No** is entered, the zero degree position of the master axis will be defined each time the number of steps entered in the master cycle length parameter is counted by the master axis encoder.

Sensor Inputs Per Master Cycle

This parameter specifies the number of master sensor inputs per one master cycle. 360° of the Master cycle may equal one sensor input or it may require the passing of 4 lugs (sensor inputs) to establish one cycle or 360° of the master.

Cycle Length Averaging

The amplifier will average the distance measured between successive master cycle sensor input signals over the number of cycles (1 through 8) you enter here.

For example, if you enter 8 for this parameter the drive will average the last eight cycle length measurements to establish the current cycle length. The current cycle length is then used to make any required phase angle adjustment on the next cycle. This will be a running average.

This feature is employed to stabilize the measured cycle length when major variations in master cycle length occur.

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Master Sensor Valid Zone

The master sensor valid zone is the area surrounding the defined zero degree position in which a **Zero Master Cycle Sensor** input signal will be considered valid.

For example, if you enter ±10° here, any input signal which appears on the Zero Master Cycle Sensor input before -10° or after +10° will be ignored.

This is useful in applications where registration marks are printed in the same feed path as other printing (such as advertising, logos, instructions, etc.).

Master Length Correction limit

This parameter limits the amount of correction made when master length error is detected. For example, if set to 50%, the drive will use 50% of the error length to correct the master length. This type of correction may occur any time there is length error including times when the master is not active (moving).

In most systems length errors are corrected for slowly while phase errors are corrected for quickly. In systems where large phase errors occur with little or no length error, this parameter may be reduced to improve phase error handling. In most cases this parameter may be set to 100%, which is the default value.

Minimum Master Velocity For Correction

This parameter is used to prevent the follower axis form making error corrections which may cause unwanted movement of the follower. The correction will be disabled when the master velocity is below the value you enter here. Sensor inputs are also ignored when the master velocity drops below this value.

The error information will be retained and corrections will continue when the master velocity is above the value you enter here.

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Follower Cycle Setup

The next step is to define the **Follower Cycle**. The amplifier can retain up to 16 (0-15) Follower Cycles. The Follower Cycles screen is accessed by selecting Drive Setup - Define Motion, then Follower Cycles. Each of the parameters in the Follower Cycles screen is explained below.

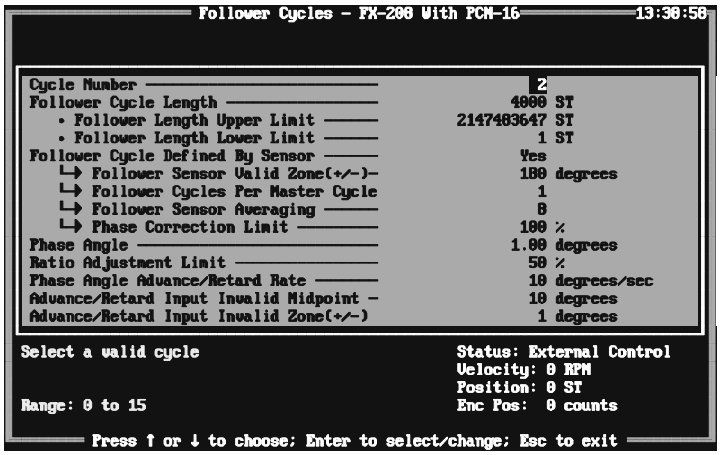


Figure 6 Follower Cycle Screen

Cycle Number

Up to 16 (numbered 0 through 15) different Follower Cycles can be defined. Each Follower Cycle requires a Master Cycle and a Cycle Profile to be attached. The same Master Cycle and Cycle Profile can be used for all 16 Follower Cycles.

Follower Cycle Length

The follower cycle length is the distance in user units that the follower axis motor moves in order to complete one cycle of motion. This distance is programmed in user units of the FX drive, i.e., inch, millimeters, etc. User units are entered in the Drive Parameters screen. See the FX Drives Operators manual (P/N 400282-00) for configuring user units.

Follower Length Upper Limit

This parameter sets the value of the longest follower cycle length that will be allowed. This limit is imposed on length changes made using serial commands or via sensors.

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Follower Length Lower Limit

This value sets the value of the shortest follower cycle length that will be allowed. This limit is imposed on length changes made using serial commands or via sensors. This may be used to prevent the drive from inadvertently "learning" a short length due to erroneous sensor inputs.

Follower Cycle Defined by Sensor

If you enter **Yes**, the zero degree position of the follower axis is established when a "Zero Follower Cycle" (input function #46) input signal is received on one of the input lines on the FX drive or PCM-16.

If you enter **No**, the zero degree position of the follower axis is defined by observing the follower cycle length. Therefore, the follower cycle will automatically begin a new cycle each time the follower motor reaches the distance you entered for the follower cycle length.

Follower Sensor Valid Zone

This parameter defines a window (in degrees) either plus or minus of the defined zero degree position that a Zero Follower Cycle input signal will be considered valid. For example, if you enter ±10° here, any input signal which appears on the Zero Follower Cycle Sensor input which appears before -10° or after +10° will be ignored.

This is useful in applications where registration marks are printed in the same feed path as other printing (such as advertising, logos, instructions, etc.). The amplifier will ignore all inputs except those which appear within the follower sensor valid zone.

Follower Cycles Per Master Cycle

This parameter allows you to have multiple follower cycles per master cycle. This is useful if only one master registration mark is available for multiple products.

Follower Sensor Averaging

This parameter is used when cycle to cycle variations in the Follower Cycle length occur. The FX drive will average the distance measured between successive Follower Cycle Sensor input signals over a set number of cycles.

For example, if you enter 8 here (8 is the default value), the FX drive will average the last eight cycle length measurements to establish the current follower zero degree position. The averaged position is then used to make any required Phase Angle adjustments (see description of Phase Angle below). This running average will be continually updated.

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Phase Correction Limit

When a follower sensor is received and error is found to exist between the master and follower sensors, the absolute error value is scaled by the value you enter here. This error value is then used to determine a velocity profile to follow during the new cycle in order to correct the error.

Phase Angle

The phase angle is the amount (in degrees) that the follower axis zero degree point is offset from the master axis zero degree point, measured in degrees. This parameter can be set from 0° to 360° and should not be altered while the amplifier is running this specific follower cycle.

Changes made while running should be made using Phase Advance/Retard input functions. If the follower screen in PCX is exited and then re-entered, the display will reflect any changes made using the input lines.



Large changes to the phase angle of the follower cycle currently running will cause the amplifier to jump or fault.

Example: If a phase angle setting of 70° is entered, the follower axis will be at its 0° position when the position of the master axis is measured at its 70° position. The follower axis will maintain a 70° offset relative to the master axis throughout each cycle.

Any error in the sensed phase angle will result in a slight compensatory speed (or ratio) adjustment of the follower axis at the beginning of the next cycle.

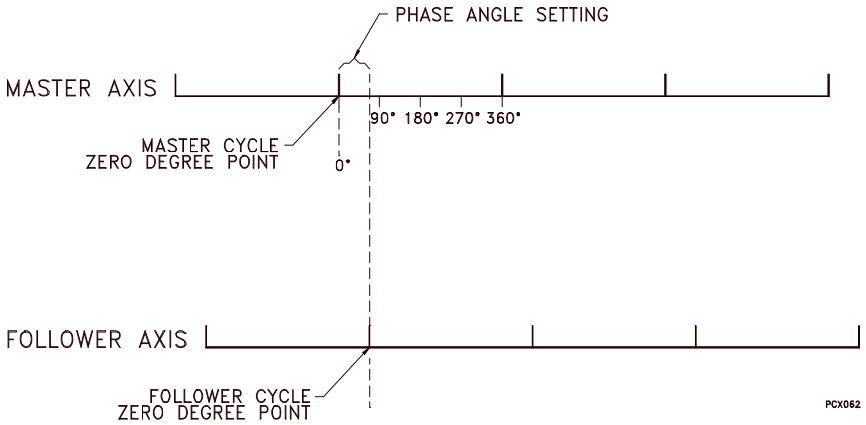


Figure 7 Phase Angle Setting

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Ratio Adjustment Limit

This parameter assigns a percentage of the current velocity ratio to be the maximum amount of change which can occur to the velocity ratio during a correction for sensor error. This correction is made only when a follower sensor is recorded and master to follower error exists.

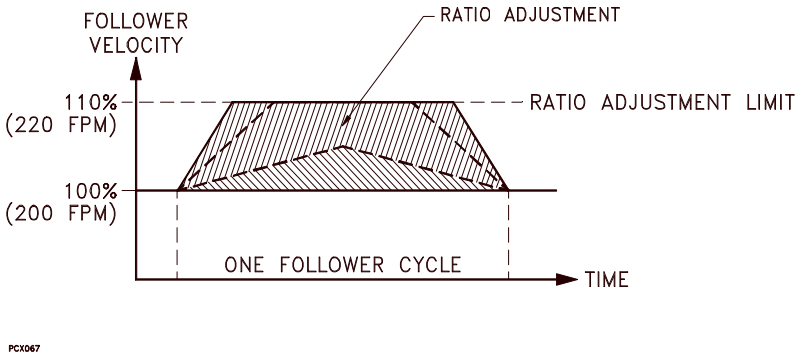
Example: If the ratio adjustment limit = 10%.

The master velocity = 100 FPM

And the base ratio = 2:1

Then the follower velocity = 200 FPM

The adjustment velocity would be no more then 220 FPM (see the figure below).



Phase Angle Advance/Retard Rate

A signal on the input line where either the Phase Angle Advance or Phase Angle Retard input functions are assigned will cause the phase angle to change. This parameter establishes the rate at which this change is made in Phase Angle degrees per second.

Advance/Retard Input Invalid Midpoint

This parameter defines the midpoint of the Advance/Retard Input Invalid Zone. See Advance/Retard Input Invalid Zone (+/-) below.

This typically is used in flying shear applications when a knife is in contact with the product to eliminate any undesirable positional/speed changes during cutting.

Advance/Retard Input Invalid Zone (+/-)

This parameter defines an invalid zone either side of the Advance/Retard Input Invalid Midpoint. While the follower cycle is in this invalid zone, no advance/retard inputs will be accepted and no Master or Follower length corrections will be made.

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Follower Acceleration

This parameter specifies the rate at which the FX drive will accelerate from zero speed to maximum velocity when a velocity increase is needed. This parameter, measured in seconds, is scaled against a change from 0 to the maximum velocity of the FX drive (follower axis).

For example, to correct for a phase angle error or the removal of a Cycle Dropout input requires an increase of follower velocity over the programmed base ratio (i.e., follower axis gets behind). The follower axis will use this acceleration rate when accelerating to become in phase with the master.

Follower Deceleration

This parameter specifies the rate at which the FX drive will decelerate from maximum velocity to zero when a velocity decrease is needed. This parameter, measured in seconds, is scaled against a change from maximum velocity of the FX drive (follower axis) to zero.

For example, to correct for a phase angle error or when the FX drive receives a Cycle Dropout input may require a decrease of follower velocity over the programmed base ratio (i.e., follower axis gets ahead). The follower axis will use this deceleration rate when decelerating to be in phase with the master.

Phase Angle Error Limit (+)

This parameter designates a maximum positive deviation from the Phase Angle. You can assign the Phase Angle Error Limit output (output function # 23) as an indicator. Exceeding this limit will **not** stop the follower axis, although you may employ this output with external logic to generate an appropriate command.

Phase Angle Error Limit (-)

This parameter is identical to Phase Angle Limit (+) except that it sets a maximum negative deviation from the Phase Angle.

Cycle Dropout Stop Position

This parameter is the position (in degrees) at which the follower axis will stop any time a Cycle Dropout signal is accepted. To use this feature you must assign input function #49, Cycle Dropout.

Master Cycle Number

Designates which Master Cycle this Follower Cycle will use.

Cycle Profile Number

Designates which Cycle Profile this Follower Cycle will use as it follows the designated Master Cycle.

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Phase Correction Deadband

If the angular error of the follower to master sensor is less than this number, no Phase Correction is made.

Follower Length Correction Limit

This parameter limits the amount of correction made when follower length error is detected. For example, if set to 50%, the FX drive will use 50% of the error length to correct the follower length. This type of correction may occur any time there is length error including times when the follower is not active (moving).

In most systems length errors are corrected for slowly while phase errors are corrected for quickly. In systems where large phase errors occur with little or no length error this parameter may be reduced to improve phase error handling.

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Cycle Profiles

The Cycle Profiles option allows you to designate angle-to-angle relationships for 64 different points within the cycle. To simplify this operation the Cycle Profile screen assumes a Phase Angle of zero. However, the phase angle that has been programmed in the follower cycle screen will be valid.

There are 16 cycle profiles available (0 to 15) and any profile can be used in any follower cycle.

In some applications the follower cycle can remain essentially linear with the master cycle profile and will constantly maintain a 1:1 ratio. In other applications such as rotary knife cut-offs, labelers, printers, etc., the follower cycles' motion profile may have to be non-linear during specific parts of a cycle even though the over-all cycle ratio would still be 1:1.

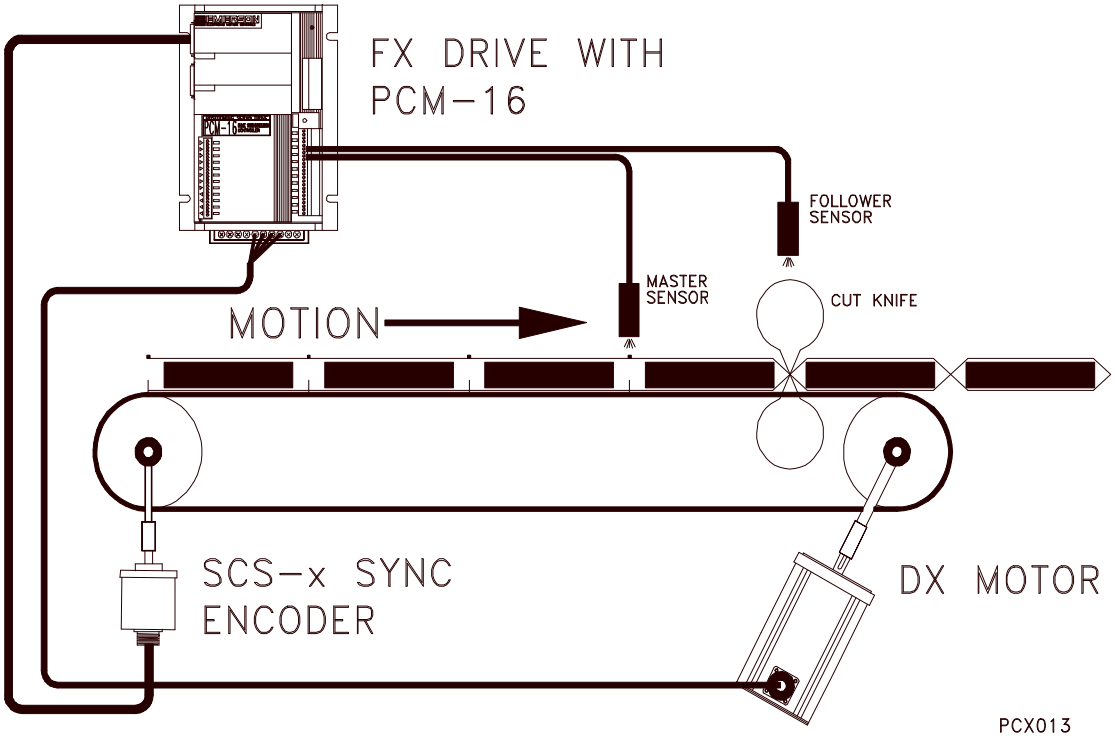


Figure 8 Cycle Profiles Example

WARNING

When in PCX, large changes to the Phase Angle of the follower cycle currently running will cause the amplifier to jump or fault.

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Below is a graph depicting the instantaneous ratio as a function of the master cycle in a typical rotary knife application. Note that the area of A+C = B. The data entered in the Cycle Profile screen shown in Figure 10 corresponds with the graph in Figure 9. For each master cycle completed the follower axis must also complete one cycle. The average ratio of each cycle is 1:1 (one follower cycle completed = one master cycle completed).

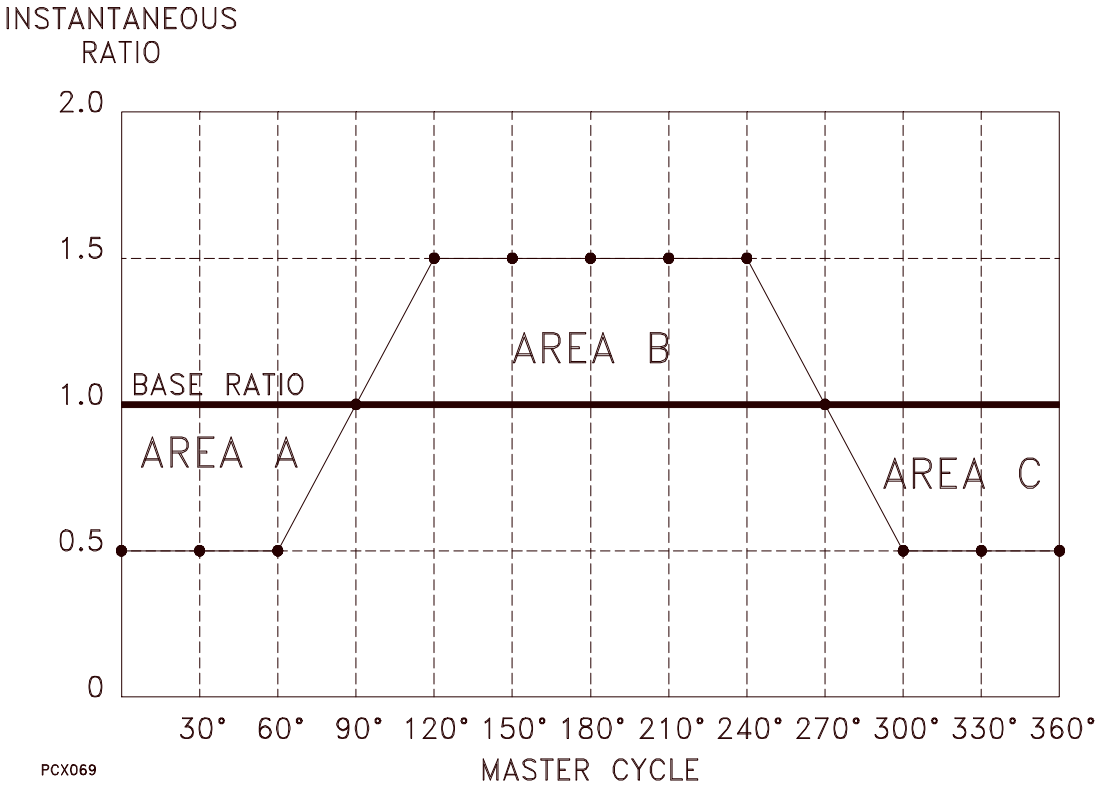


Figure 9 Cycle Profile Graph

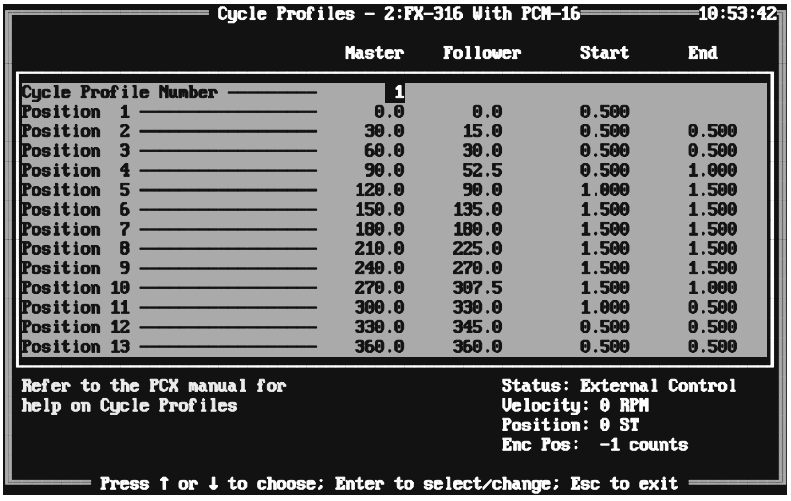


Figure 10 Cycle Profiles Setup Screen

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Execution of non-linear profiles causes the phase angle to deviate from the programmed value during the execution of a cycle creating a pattern which is applied to the load. This profile is repeated accurately each cycle within the ability of the selected amplifier to accelerate and decelerate the load.

Shown below is a graph depicting the position-to-position relationship corresponding to the data entered in the Cycle Profiles screen shown in Figure 10.

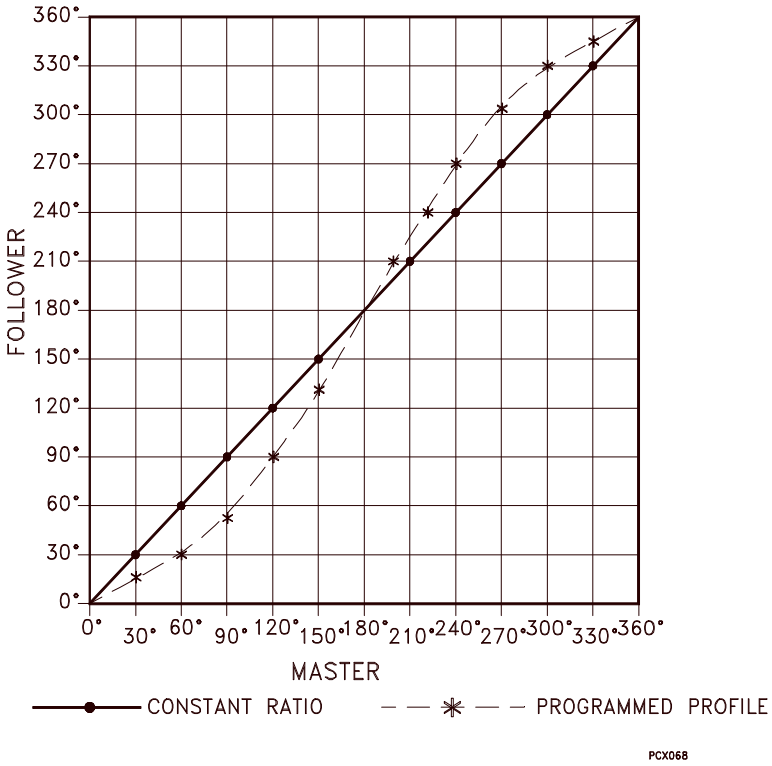


Figure 11 Position-to-Position Cycle Profile Graph

To ensure that the phase angle is maintained at the completion of each cycle the ratio values integrated over the cycle must equal the base ratio. For example, if the ratio is higher than the base ratio during the first part of the cycle, then the ratio must be less by an equal amount during the remaining portion of the cycle.

The starting and ending ratio must be the same or very close to the same. If it's not, the machine will exhibit a bump/jump in the follower's motion. It is not imperative that the starting and ending ratio be exact, however they should be very close. +/- 0.020 works Ok in most applications.

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How To Create A Cycle Profile

Listed below are some suggestions for creating cycle profiles.

- When creating a cycle profile, think in terms of user units for cycle profiles and velocities (Inches, centimeters etc..).
- For follower ratios use user units and think in terms of:

$$\frac{\text{follower distance travelled}}{\text{master distance travelled}} = \left(\frac{\text{follower velocity}}{\text{master velocity}} \right)$$

- Keep in mind that the follower axis must complete its cycle at the same instant that the master axis completes its cycle. The follower axis must travel 1 follower cycle length for every master axis cycle length.
- Convert to PCM-16 units as the last step before entering the positions into the cycle profiles screen.

The suggestions above should make it easier to calculate cycle profiles. Start by drawing a plot of the follower velocity (ratio) Vs. master position as shown below.

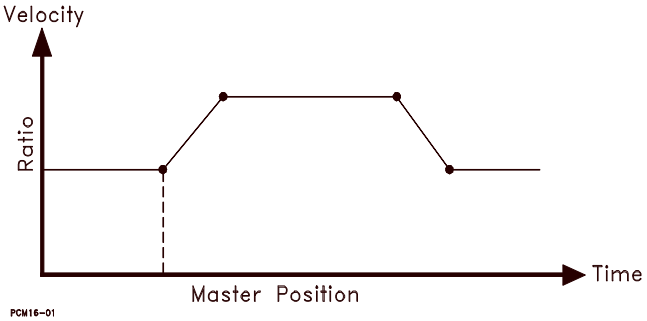


Figure 12 Follower Velocity Vs. Master Position

The horizontal axis (master position) is related to time (assuming that the master is running at a relatively constant speed). And since the vertical axis is in units of $\frac{\text{follower position}}{\text{master position}}$, the master position has taken the place of time in the velocity profile above. Therefore, we are thinking in terms of $^{\text{inches}}/_{\text{inch}}$ rather than $^{\text{inches}}/_{\text{second}}$ for our velocity term. This is important because we calculate our profile velocities and positions using the basic physics equations (shown below) for motion.

$$FD = \left(\frac{R_0 + R_1}{2} \right) \left(MP_1 - MP_0 \right)$$

The area under the velocity curve (if the horizontal axis is the master distance) is equal to the distance traveled by the follower axis.

Where FD = follower distance, R = the follower to master ratio and MP = master position.

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Uniform Acceleration Formulas		
to find	given these	use this formula
t	a,v_0,v	$t = \frac{v - v_0}{a}$
t	a,v_0,s	$t = \frac{\sqrt{2as + v_0^2} - v_0}{a}$
t	v_0,v,s	$t = \frac{2s}{v_0 + v}$
a	t,v_0,v	$a = \frac{v - v_0}{t}$
a	t,v_0,s	$a = \frac{2s - 2v_0 t}{t^2}$
a	v_0,v,s	$a = \frac{v^2 - v_0^2}{2s}$
v_0	t,a,v	$v_0 = v - at$
v_0	t,a,s	$v_0 = \frac{s}{t} - \frac{1}{2}at$
v_0	a,v,s	$v_0 = \sqrt{v^2 - 2as}$
v	t,a,v_0	$v = v_0 + at$
v	a,v_0,s	$v = \sqrt{v_0^2 + 2as}$
s	t,a,v_0	$s = v_0 t + \frac{1}{2}at^2$
s	a,v_0,v	$s = \frac{v^2 - v_0^2}{2a}$
s	t,v_0,v	$s = \frac{1}{2}t(v_0 + v)$

Where s = position a = acceleration
v = velocity t = time

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Master Cycle PGO's

The Programmable Outputs may be programmed to be updated at specific positions within the master cycle. For each master cycle, up to 8 positions may be specified. For each position the output pattern must be specified along with the option to use a finite on-time and/or a mask which ensures that previously set outputs will not be affected.

The outputs are only updated when the master moves in the positive direction. If the master is moved backwards no updates are made until the master is moved forward and the position within the cycle where the last forward motion stopped is reached.

However, if the master is moved backwards past the beginning of the current cycle, the first PGO updated upon resuming forward motion is the first PGO in the cycle.

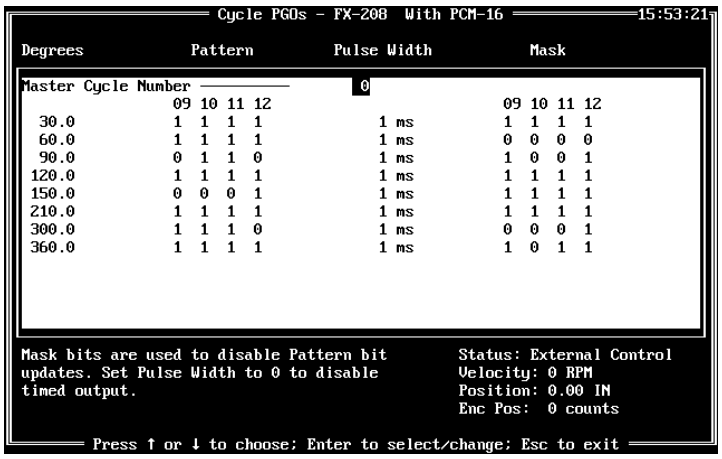


Figure 13 Master Cycles PGO's

Position

The position for each PGO update is entered in degrees, and always relates to the Master position. Enter the positions throughout the cycle sequentially. It is required that the positions are ordered in the table when they are entered such that the positions increase from top to bottom of the table.

Pattern

Enter the desired pattern by selecting a 1 or 0 for each output (1 indicates line on, 0 indicates line off). Note that each output will be updated whether it is a 1 or a 0 unless the mask prevents the update. Programmable Outputs must first be setup in the output function screen before any pattern can be specified.

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Pulse Width

This is a selectable "on_time" for each update. Any output which is set to active ("1") for the update being specified will remain active only for this pulse width. The pulse width is programmed in milliseconds. Specify 0 msec to disable the pulse width function.

If the master axis moves through this area more quickly than the pulse width time, the PGO will then change to the pattern/mask combination for the next position. Position changes will always override pulse width.

Mask

The mask may be used to "shield" any outputs which may have been previously set or cleared from the current pattern being specified. A "0" will mask the appropriate output and prevent it from being changed.

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PCM-16 Operation

Operation of the FX Drive while executing phase sync control can be broken into three parts.

1. Start up
2. Continuous operation
3. Cycle Dropout

Start Up

In the start up sequences described below it is assumed that neither the Master Cycle nor the Follower Cycle is defined. Three different sequences for establishing the zero degree point of the cycles along with a description of program operation are provided below. The startup sequence you use will depend on your application.

Startup sequence #1: Manual definition of both axes

To manually define both the master and follower axes, answer **no** to the "**Master Cycle Define by Sensor**" and "**Follower Cycle Defined by Sensor**" questions in the Master Cycles and Follower Cycles screens respectively.

After power up, manually move both axes to their desired zero positions. Then zero both axes by placing a momentary input signal on both the **Zero Master Cycle** input and the **Zero Follower Cycle** Input.

A home function may be employed in place of manual movement of the follower axis. In this case the amplifier automatically establishes a zero follower position at the completion of the home cycle (see Home functions in the FX Drives Operators manual P/N 400282-00).

Start up sequence #2: Manual Definition of Follower Automatic Definition of Master Axis

To automatically define the master axis and manually define the follower axis, apply power to the drive then manually move the follower axis into the correct zero position. Then place a momentary input signal to the Zero Follower Cycle Input.

A home function may be employed in place of manual movement of the follower axis. In this case the amplifier automatically establishes a zero follower position at the completion of the home cycle (see Home functions in the FX Drives Operators manual P/N 400282-00).

The master axis zero point is defined when motion is started and as soon as two Master Cycle Zero degree sensor Signals are received.

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Start up sequence #3: Automatic Definition of Both Axes

To automatically define both axes answer **yes** to the "**Master Cycle Define by Sensor**" and "**Follower Cycle Defined by Sensor**" questions in the Master Cycles and Follower Cycles screens respectively.

When power is applied, the master axis starts running and the master axis cycle is defined when two sensor signals have been received.

Program Operation

After you have defined the master and follower zero points, you can initiate a program whose first executable function is a home function (H), followed by an execute cycle function(Y). When the follower axis receives the program initiate signal, it will accelerate to the programmed home speed. The follower cycle is defined as soon as the first Zero Follower Cycle Sensor Input is received.

As soon as the follower cycle is defined, the follower axis will attempt to achieve the proper phase angle by accelerating at the **Max Follower Acceleration** setting until it achieves the proper phase angle.

"Y" Programming Function, Execute Cycle

When the program reaches the Cycle "Y" (Execute Cycle) step, the designated cycle will begin. Cycles do not have counts and will run until stopped or until cycle dropout is activated. Program count has no effect except that the count must be greater than 1 to enable the program to execute. No steps after the Cycle step will be executed. Typically the first step in the program moves the follower axis to some valid start point or home.

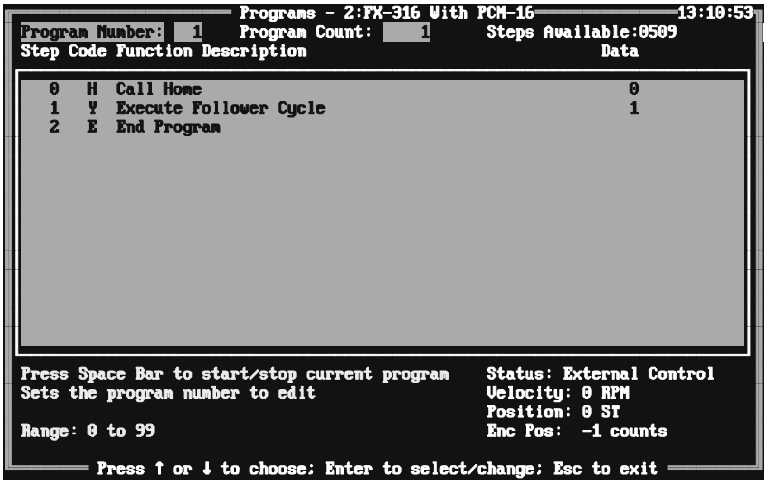


Figure 14 Program Example Using The "Y" Function

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Using A Home Function To Establish A Starting Point

The Home function is inserted prior to the Y function to establish a follower zero point. In this example the follower is not defined by a sensor (see Figure 14).

The follower moves to a Home position and waits until the Master Zero Position is established. After the Master Zero Position has been established the follower will accelerate to the base ratio velocity to be in phase with the Master Axis at a pre-calculated position (see Figure 15).

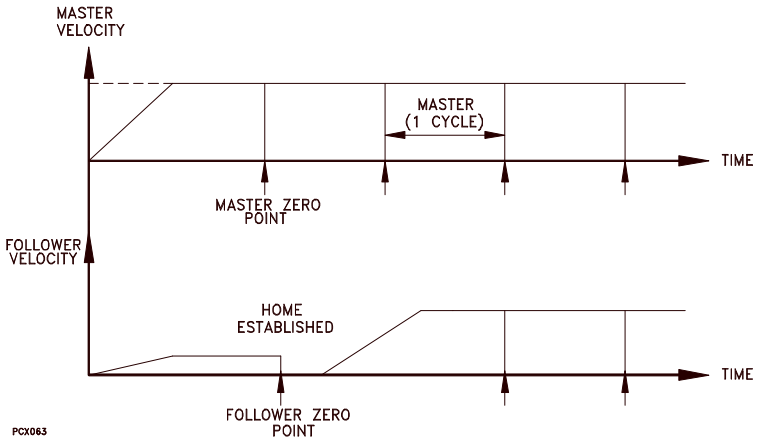


Figure 15 Example Using The Home function

Alternate Start Method

If the "Follower Cycle Length" is defined by sensor and Home function is not inserted prior to "Y" (Execute Cycle) function, the follower will immediately start tracking the master. The follower zero point will be established when the follower reaches base ratio velocity. At this point the PCM-16 calculates the *phase correction profile* to eliminate any phase error. (see Figure 16).

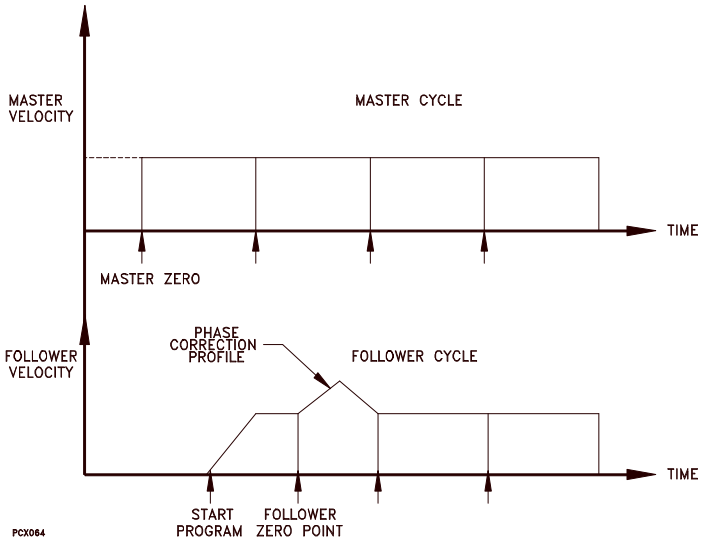


Figure 16 Example Not Using A Home Function

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The method used to achieve proper phase synchronization will depend on the mechanical characteristics of your system and the speed of the master axis. See the examples below.

Example 1: Master Axis Running Slow.

The follower axis will calculate its "zero point" in correlation to the position of the master axis, then accelerate directly into the correct phase angle position and continue running. If cycle profiling is used, the follower axis will attempt to get into phase by the time the first segment of the Cycle Profile is complete.

Example 2: Master Axis Running Fast.

Depending on load and acceleration capability, the follower axis may require several cycles of the master axis to get into proper sync. In this situation, the follower axis will accelerate immediately to the base ratio speed. The FX drive will then make adjustments to the base ratio to get into proper phase (angle) within the constraints of the "Maximum Adjustment Limit" setting.

Continuous Operation

During continuous operation the follower axis maintains the proper speed (ratio relative to the master axis) by monitoring a signal which is driven by the master axis. If the master axis speeds up or slows down, the follower axis does likewise in order to maintain the required cycle per cycle motion.

The ratio between the Follower Cycle length and the Master Cycle length is called the Base Ratio.

Base Ratio = *Follower Cycle Length (Units)* ÷ *Master Cycle Length (Steps)*

Controlling the follower axis at a velocity equal to Base Ratio should theoretically cause the system to maintain the programmed phase relationship as the master axis speeds up or slows down. However, due to slippage of the material being moved or perhaps due to variations in the printing of registration marks, etc., the zero degree point of the follower axis may start lagging behind (or in some cases get ahead of) the zero degree point of the master axis.

Error is eliminated by monitoring the start points (zero degree points) of both the master and the follower axis' cycles. The follower axis will slightly speed up or slow down within the constraints of the *Ratio Adjustment Limit* setting.

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Cycle Dropout

When the drive receives a **continuous** cycle dropout input (input function #49), the motor will decelerate to a stop at the follower deceleration rate in the **Cycle Dropout Stop position** (as programmed 0° to 360°). The motor will hold in the programmed position until the signal is removed.

When the cycle dropout signal is removed, the drive will accelerate, limited by the **Follower Maximum Acceleration** setting, until the proper phase angle is achieved.

The method used to achieve proper phase synchronization when the cycle dropout input signal is removed will depend on the mechanical characteristics of your system and the speed of the master axis. See the examples below.

Example 1: Master Axis Running Slow.

The follower axis will calculate its "zero point" in correlation to the position of the master axis, then accelerate directly into the correct phase angle position and continue running. If cycle profiling is used, the follower axis will attempt to get into phase by the time the first segment of the Cycle Profile is complete.

Example 2: Master Axis Running Fast.

Depending on load and acceleration capability, the follower axis may require several cycles of the master axis to get into proper sync. In this situation, the follower axis will accelerate immediately to the base ratio speed. The FX drive will then make adjustments to the base ratio to get into proper phase (angle) within the constraints of the "Maximum Adjustment Limit" setting (see Figure 17).

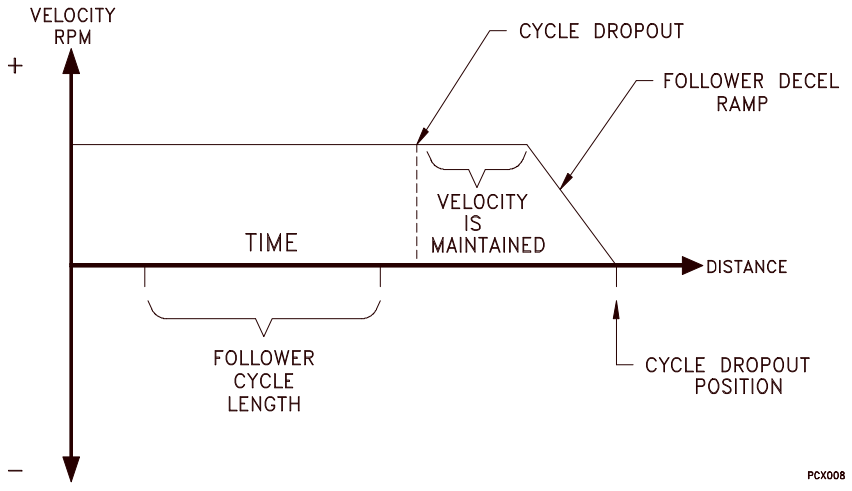


Figure 17

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In Figure 18 the profile is aborted at the same time that cycle dropout occurs and current velocity is maintained until decel ramp can be used.

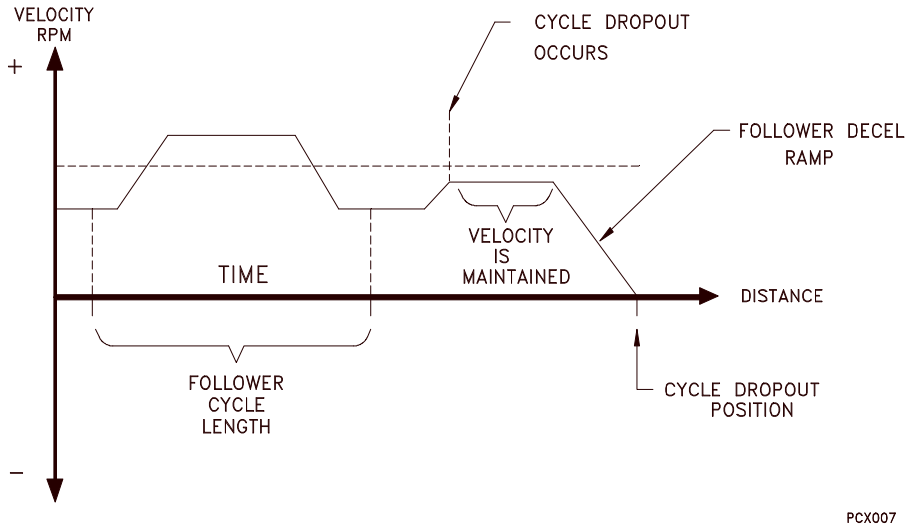


Figure 18

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Building A Program

Indexes are described in the FX Drive Operator's Manual in the PCX section (P/N 400282-00).

Motion Programs are a series of indexes that have been previously set up that you combine with other programming steps to create a motion profile. Each motion program provides a series of movements in conjunction with other machine functions. The movements are used to perform a particular machine operation.

Multiple programs can be created using PCX software and stored in the PCM-16, each designed for a different machine function. The PCM-16 is capable of storing up to 256 indexes, 100 motion programs (∅ to 99), and a maximum of 1024 program steps in the non-volatile memory.

The number of available programs and average number of steps per program are directly related to each other. The memory is set up such that if you require 100 programs (maximum), each program can have an average of 10 program steps each. If the number of programs is reduced to a minimum, you could have as many as 255 steps in a single program.

A motion program is created by entering program functions in the order in which they are to be executed. A motion program is made up of function codes, some of which are listed across the bottom of the PCX program screen. To see the complete list of available codes when you are in the program screen lower half, press the <F1> key. A pop-up screen will display all of the function codes.

As you enter steps in a program, the function codes and function data (index numbers, program numbers, dwell times, etc.) are displayed on the program screen so you can easily follow the program sequence.

You may use any index or program which you have previously created to build your program. The example motion program shown in Figure 16 could be accomplished with one program; however, two programs have been used to show the use of the Call Program (P) function. In this example, program numbers 1 and 2 are used and index numbers 1, 2, 3, 4, and 5 are used.

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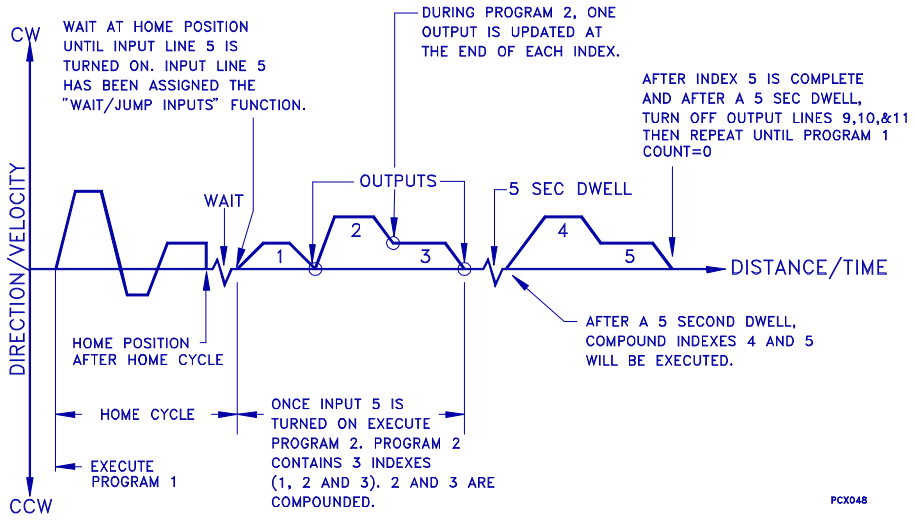


Figure 19 Motion Program Profile

show the program setup screens used to generate the motion program in . The program count determines how many times the program will be executed. In this example the program count for Program 1 is 10. This means everything within Program 1 will repeat 10 times including Program 2. If the program count is set equal to zero, the program will not execute. If the program count is set equal to 65535 or larger, the program will execute indefinitely.

The program function codes determine the actual moves to be executed. Each function will be performed in the sequence that is shown in the program screen. Once you enter the sequence, you can download the program to the FX drive by pressing the <Esc> key, or by moving the cursor up to the Program Number position using the arrow keys. The upper left corner of the screen will display a "BUSY" message during the download.

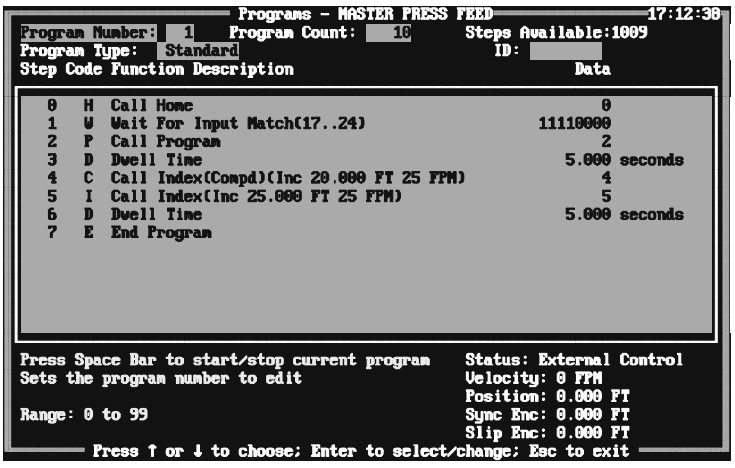


Figure 20 Program Example

In the example shown above, Program 1 is the main program and Program 2 is called as a subroutine of Program 1. This call can be seen in step 2 of Program 1.

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Time Base (Indexes And Homes)

The "Time Base" feature is available from the Index and Home screens and can be set to Real Time, Synchronized or Analog.

The Time Base feature relates to the velocity scale factor pre-determined by drive parameters. If you select Time Base Synchronized, then you program index, jog and home velocities based on the sync scale factor. The PCX program screens will show the scale factors you choose.

To run a synchronized index you must call the index from a program. The program must toggle the time base from Real Time to Synchronized prior to running the index.

Programming Functions

Each program function has a designaed single or double letter function code that is used when creating a program. This section describes the functions.

C Compound Next Index

The Compound Index feature allows you to link two indexes together without stopping motion between the indexes.

A Compound Index is an index whose final velocity is not zero, but the velocity of the next index. Because a Compound Index ends by accelerating or decelerating to a velocity, not a dead stop, that compounded index cannot be used again as a regular index. However, identical Compound Index sequences can be repeated in a program. Three Compound Index examples are shown below:

Example 1: You can use the Compound Index feature to run special Indexes which have different velocities and distances.

In this example, the drive will accelerate at the Index #1 acceleration rate until it reaches the velocity of Index #1. Then, after this distance in Index #1, the drive decelerates at the deceleration rate of Index #1 to the velocity of Index #2, without coming to a stop.

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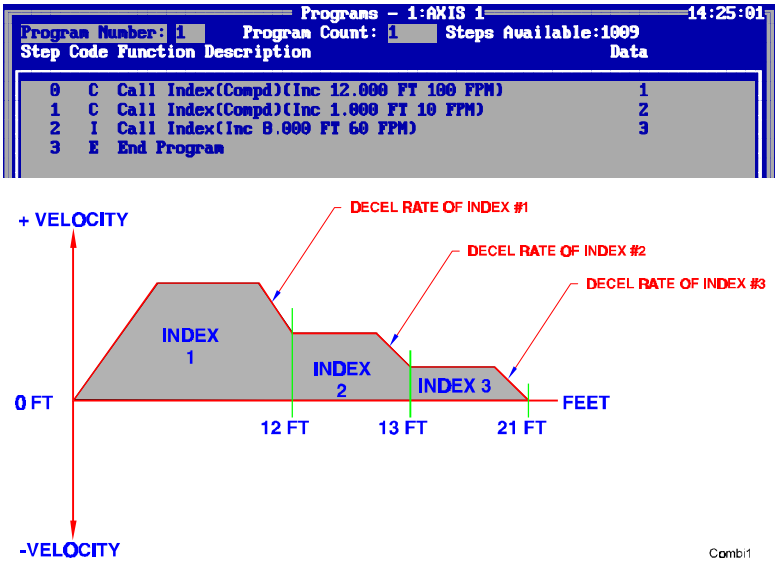
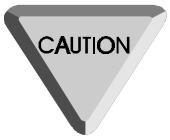


Figure 21 Compound Index Example

The drive will continue at that velocity until it approaches the programmed distance of Index 2, then decelerate at the Index #2 deceleration rate to the Index #3 programmed velocity. It will continue at that velocity until it approaches the programmed distance of Index #3, at which time it will decelerate at the Index #3 deceleration rate and stop.



When using multiple compound indexes within the same program, all compound index directions must be the same. The direction of movement is set by the first of the compound indexes and is not scanned again until the next index is initiated that is outside the compound ones.

Example 2: This example is much the same as #1, except in this compound index the drive will accelerate instead of decelerate at the end of each individual index.

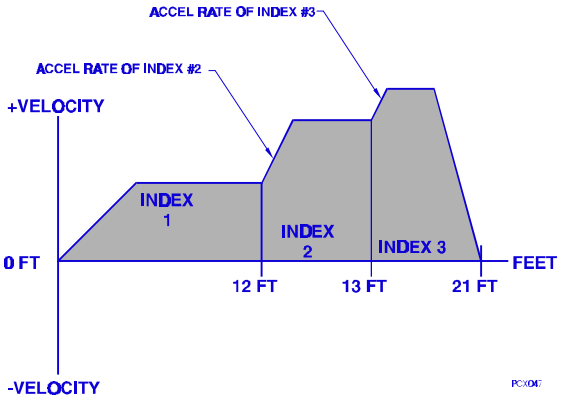


Figure 22 Example #2, Compound Index Motion Profile

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After completing Index #1, the drive will accelerate at the acceleration rate of Index #2 until it reaches the programmed velocity of Index #2. After completing Index #2 the drive will accelerate to the programmed velocity of Index #3 and move at that velocity until it approaches the programmed distance, at which time it will decelerate at the Index #3 deceleration rate and stop.

Example 3: Use the compound index feature to turn an output on, then off without stopping motion. Each index is incremental, has a count of 1, and has the same velocity.

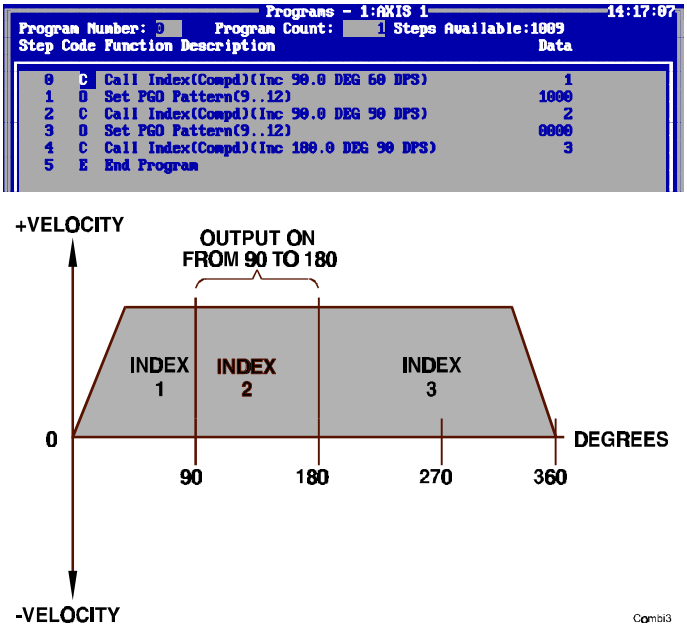


Figure 23 Compound Index Example #3

D Dwell Time

The Dwell Time function allows the program to pause for a number of seconds between program functions. Time may be directly entered or recalled from one of the 64 user registers. Minimum time is 1 ms; maximum time is 65.535 seconds.

E End Program

This function is used to designate the end of a program. It may be used more than once when using the Jump commands. The END function is also used to terminate programs prior to the last program step.

F Set Maximum Following Error

This function overrides the "Maximum Following Error" which is set up in the "Limits" screen. When the program has completed, Following Error is reset to the value programmed in the Limits screen. This function is often used with the "Q, Set Maximum Torque" function. A large value entered here prevents the drive from faulting out during a "Torque" move.

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H Call Home

The Call Home function is used to initiate a previously programmed Home Cycle. There are two Home Cycles that can be called within a program.

I Call Index

The Call Index function is used to initiate the execution of an index. When this function is used, the index number must also be given. After you enter an index number in the data field, PCX will display that index's distance and speed.

O Set Outputs

Entering "O" in a program step will display a sub-menu in the middle of the program screen.

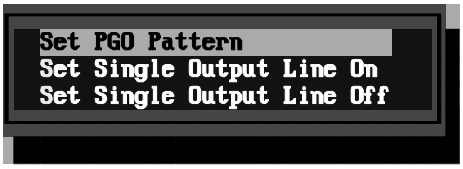


Figure 24 Programmable Output Options

Set PGO pattern.

Before this function can be used, you must first assign Output Function #12 "Programmable Outputs" to one or more internal and/or external output lines. This function allows you to change the status of any or all of the programmable outputs you assigned in the output function screen.

Once selected, the cursor will move to the data field where zeros that represent the programmable outputs are displayed. The leftmost zero represents the first programmable output line and the others follow in numerical sequence. If you enter a one, that output will be forced on.

If you enter a zero, that output will be forced off. These outputs will remain in this pattern until they are updated. If you enter an "X" for any line, that line state will not be changed.

Set single output line On

Turns any output, hardware or internal, on. Output remains in this state.

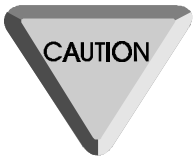
Set single output line Off

Turns any output, hardware or internal, off. Output remains in this state.

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P Call Program

The Call Program function is used to initiate a program from within a program. You can use the "P" function to call additional programs as sub-routines of your original program. This is called "Nesting". PCX allows you to nest up to 30 programs under any one Program Call function before returning to the original program.



Use care in constructing programs that create a continuous loop condition by "Nesting" programs. When nesting programs, your program must return to the "Master" program somewhere in the loop to prevent programs from becoming stacked up in memory.

For example: You initiate Program #1, which uses the "P" function to call Program #2, which uses the "P" to call Program #3, which uses the "P" function to again call Program #2. This continuous loop condition could cause the memory to get stacked up, causing the drive to drop out of the program and return to external mode or register a "∅" fault on the diagnostic display.

To avoid this condition, make all of your program calls from your original program (Program #1 in this example). Then use the Jump function (J) right after the "P" function calling Program #3 to jump back to "P" function calling Program #2. This will allow the memory (RAM) to clear and the loop to continuously run program #2 and #3 from Program #1.

Q Set Maximum Torque Output

This function overrides the "Maximum Torque Output" which is set up in the "Limits" screen. When the program has completed, the original value is restored. If you use a low value for "Q" (less then 100%) you may need to set a high value for following error (F). This will avoid faulting the drive if it runs into a condition requiring more torque than it is allowed to deliver.

R Wait For Counter

An (R) code allows you to wait for the number of counts you enter before moving on to the next program step. Enter the desired number of counts in the data field. Counting is determined by the CW(+) and CCW(-) rotation of the sync encoder as viewed from the shaft end of the sync encoder. The count originates from the last Start External Counter (S) or Wait For Counter (R) code.

S Start Counter

An (S) code resets and starts the internal counter for counting the external encoder pulses. The SCS-2 with 2 (1000 line) channels produces 4000 counts/steps per revolution.

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T Time Base

This code determines whether the Time Base for any programming function placed after the Time Base code in a program (including Dwells and Homes) is Synchronized (sync encoder), Real Time (normal) or Analog. It is important to remember that if you want a limited number of program steps done in Synchronized mode, you must restore the Time Base to Real Time after those program steps.

J, W Jump/Wait

The Jump and Wait For External Input Functions include unconditional jumps to another program step, jumps if an input line pattern is matched, or a jump/wait on a single input line being made active, whether that line has been assigned as an External Input Line or not.

The statements "Jump If Input Match" and "Wait For Input Match" are satisfied if the input line pattern of active lines (hardware and/or internal) matches the specified pattern exactly. In addition, a "don't care" character, "X", is available to mask off from the pattern any input lines whose condition should be ignored at this point.

Using Jump Statements in a Program

When the "J" command is entered as a program step, PCX displays the screen shown in Figure 32. The first choice, Jump Always, means exactly that, an unconditional jump to another statement number or label.

The second choice, Jump on Input Pattern (PGI), brings up another window with these match selections:

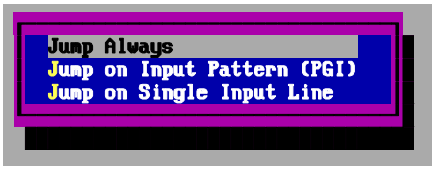


Figure 25 Jump Command Options

The first and third choices in the figure above are alike in that they are asking for an AND condition of the selected Input Lines before jumping to the destination program step. In other words, the Jump will be made if, for example, selected Lines 1 AND 3 AND 4 are ALL on or off, depending on your selection. A numeral 1 looks for that Input Line to be on or off; the letter X causes that Input Line condition to be ignored.

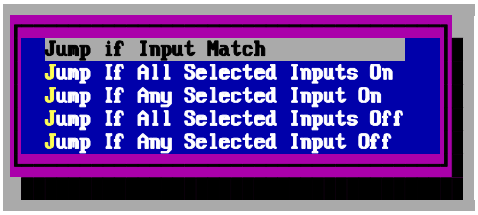


Figure 26 Jump "If" Options

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The second and fourth choices are alike in that they are asking for an OR condition of the selected Input Lines before jumping to the destination program step. That is, the Jump will be made if Line 1 OR Line 3 OR Line 4 is on or off, depending on your selection. Again, a numeral 1 looks for that Input Line to be on or off; the letter X causes that Input Line condition to be ignored.

The fifth choice, Jump if Input Match, will then ask you for an Input Line pattern to match before Jumping, with numeral 1 representing a Line ON, numeral ∅ representing a Line OFF, and X representing a Line whose condition is ignored by this statement. This choice will Jump program execution to the specified program step if and only if the exact PATTERN is matched line for line. If any of these conditions are not met, program execution proceeds to the next step in the sequence.

Another feature of both jumps and waits is the ability to monitor a single input line (hardware or internal) that is independent (or part of) of the existing jump/wait pattern (i.e. Programmable Input (PGI) Pattern). The following four jump/wait options are available.

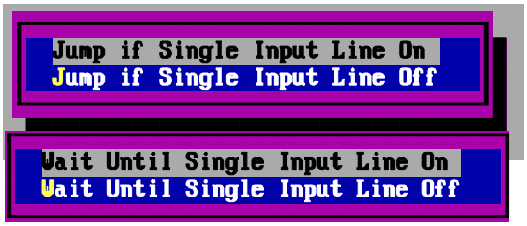


Figure 27 Jump/Wait Single Input

Wait for External Input Functions are very similar, except that program execution is halted at that spot in the program until the desired Input Line condition is met. If the condition is not met, program execution proceeds immediately to the next step.

Jump Commands

To select this option, enter "J" in the program step. Then select one of three Jump options shown in Figure 25.

The "Jump Always" command is an unconditional jump statement that causes program execution to move immediately to the specified program step. The "Jump on Input Pattern (PGI)" command causes program execution to skip to the designated program step if the specified input lines match the pattern you have selected. If the specified lines do not match that pattern the program continues to the next step in the program.

Before this command can be used in a program, Input Function #28 Wait/Jump Input" must be assigned to one or more hardware or internal input lines (see "Input Functions" section).

Once the Jump Command has been selected, the cursor will move to the center of the PCX screen. The zeroes that appear in this field correspond with the number of Input Lines selected with Input Function #28. The left-most zero corresponds to the first input line selected.

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You may now choose which lines to monitor during this step by entering a (1) in the field corresponding to the input line you wish to monitor. Any field that has a zero or an "X" will cause that input line to be ignored during execution of this step.

The "Jump on Single Input Line" command causes program execution to jump to the designated program step if the specified input line matches the condition you set in the next screen.

This line can be any input line and is not restricted to those lines assigned to Input function #28, Wait/Jump Inputs. If the specified line does not match the condition (On or Off), the program continues to the next step.

Wait For Input Commands

Before this command can be used in a program, you must assign Input Function #28 "Wait/Jump Input" to one or more hardware or internal input lines (see Input Functions, of this Manual). To use Wait For External Input when editing or writing a program, enter W as a program step. When you have entered the W, the screen will offer the choices shown below.



Figure 28 Wait For Input Command Options

When the "Wait On Single Input Line" function is selected, the system will hold program execution at this step until the designated input line meets the On or Off condition you select in the next screen. This line can be any hardware or internal input line and is not restricted to those lines assigned to Input Function #28, Wait/Jump Inputs.

When the "Wait On Input Pattern (PGI)" function is selected, the system will hold program execution at this step until the input pattern you designate in the pop up menu is satisfied. These lines are restricted to those that you have assigned as "Wait/Jump" inputs.

Once the Wait Command has been selected and a choice made from the pop-up screen, the cursor will then move to the center of the PCX screen. Zeroes will appear in this field that correspond to the number of External Lines selected in the Input Function Screen. The left-most zero will correspond to the first line selected.

You now choose which lines to monitor during this step. You make this choice by entering a "1" in the field corresponding to the line whose state you wish to monitor. Any field that has a zero or an "X" will cause that line to be ignored during execution of this step.

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Suspend/Resume Functions

The Suspend Function is used to temporally suspend the operation of a running program and is initiated with Input Function #31. The Resume Function causes the system to finish the program that was suspended. Resume is initiated with Input Function #32.

When a Suspend command is received, the FX Drive will stop motion using the Stop/Hold Decel ramp entered in the Limits screen. The motor position will then be stored in a Return To Position Index, and the interrupted program task will be stored in the memory of the drive. The drive will now accept and execute new motion commands such as Jog, Home, Index, or Program Initiate. This can continue until a Resume command is received.

Upon receiving a Resume command, the drive will continue the execution of the program which was suspended. If an index was in progress when the suspend occurred, any index distance remaining at the end of the Suspend ramp will be executed by the Resume function, regardless of the motor position at the time of Resume.

If you move the motor in any way during a Suspend function, and you want the motor position to be the same as if the Suspend had not occurred, you must run a "Return To Position Index" before you initiate a Resume function. You must have previously set up this index as an absolute index with the speed and ramps you wish to use for the Return to Suspended Position move, along with a repeat count of 1. The index you set up is the one you select when you enter "Return/Resume Index Number" in the Suspend/Resume screen.

Suspend, Resume, Return to Position, and Clear Suspend functions are activated through input functions in the I/O.

A Suspend will not be accepted while a Hold cycle is active, while a previous Suspend is active, or a decel ramp is in progress. The memory for the Suspend function will only hold one event. If you attempt a Suspend command after the drive has already been suspended and the Suspend memory not cleared, the new information will not be retained.

You can clear suspended memory by using the Abort Suspend Function (Input Function #33), or a hardware Stop command (Input Function #11).

Suspend Screen Parameters

When you select the Suspend option from the "Define Motion" screen, the Suspend data entry screen shown in Figure 40 is displayed.

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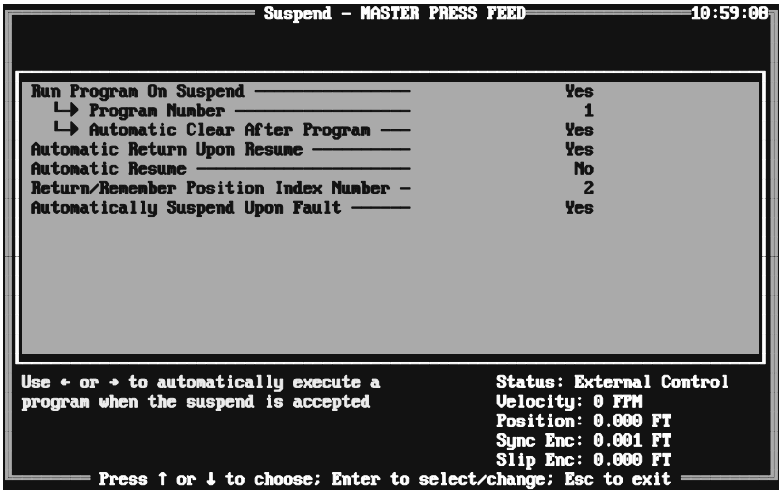


Figure 29 Suspend Setup Screen

Run Program On Suspend

This feature allows another program to be automatically initiated when a Suspend is accepted. After the FX Drive stops on Suspend, the program you specify in the program number parameter will be executed without the need for a Program Initiate.

Program Number

This parameter determines which program is to be initiated when a suspend is accepted and the "Run Program On Suspend" feature is used.

Automatically Clear After Program

This feature may be used to automatically clear a Suspend cycle. When used with the Run Program On Suspend feature, the program you selected will be executed before the Automatic Clear occurs. Once a Suspend cycle is cleared, the original program will not be resumed and the controller will be free to accept another Suspend input or motion command. When this feature is not used, a Resume input is needed to clear the Suspend cycle.

Automatically Resume

This feature will cause the drive to resume a suspended program without the need for a Resume input following the Run Program On Suspend program.

Automatically Return After Resume

This feature causes the "Return Index Number" index to be automatically initiated when a Resume input is accepted. When a Suspend input is accepted and the motor stops, the current position is stored in the index position specified by the "Return Index Number" value. To perform properly this index must be set up as an absolute index with a count of one. Then the motor will return to the

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position where the Suspend occurred, and continue with the original program.

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Return/Remember Position Index Number

This parameter determines which index is to be initiated when a Resume is accepted and the "Automatically Return After Program" feature is used. When a Suspend input is accepted, the current position will be saved to this index. All other index information should be set up by the operator. This index must be set up as an absolute index.

Automatically Suspend Upon Fault

This function allows a fault to be handled without losing the current program setup or motor position. When this function is enabled, the following conditions apply:

1. A Suspend is automatically executed following a reset of a qualified fault. After the drive has been reset, operation is identical to a normal Suspend.
2. The Suspend-Upon-Fault capability applies only to the following faults:

   1 fault - RMS current or Continuous Torque Exceeded fault

   5 fault - Motor temperature fault

   6 fault - Bridge circuit breaker is open or low AC voltage

   7 fault - Amplifier bridge temperature faultF fault - Following error fault only.
3. The Suspend Upon Fault may only occur in a situation where Suspends are allowed, i.e. Programs. Unlike other Suspend conditions however, a Suspend Upon Fault may occur during the ramp down portion of an index which occurs in a program.
4. When a fault occurs during a Suspend function, the program which was running during the Suspend is terminated. However, the Suspend remains active following a fault reset.

All suspend functions and rules apply to fault initiated suspends.The "Out Of Index" output (output #45) is used to indicate that the motor position is within the faulted index distance when a Suspend occurs as a result of a fault. This output will become active if the motor moves past the end of an index during a Suspend Upon Fault, or is moved backwards before the faulted position where the Suspend was activated.

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Input/Output Functions

The input and output functions listed below are available with a PCM-16 in addition to the input and output functions listed in the FX drives operators manual (P/N 400282-00).

Input Functions

24 Remember Position

Stores the current position of the drive in a **return** absolute index. (default = index 0). This index number may be changed in the suspend function dialog box. You must set the index you select in the Suspend/Resume screen as an Asolute Index.

25 Return To Position

Returns to the position defined by remember position input. This input uses the **return index** which must be set up as an absolute index in the Suspend screen.

26 Clear End Of Sequence

Clears the **end of sequence output**. If not assigned, the end of sequence output will automatically clear when the next motion occurs. If this input is assigned, the output can only be cleared by activating a **clear end of sequence** input.

27 Clear Programmable Output

Clears a programmable output line. Each assigned programmable output line requires a separate Clear Programmable Output line which corresponds to the PGOs (output function #12) in the same order. If four lines are selected for PGOs, this input function requires four lines to clear the PGOs.

28 Wait/Jump Inputs

Used with the **wait for input** program function to stop program execution until the input line assigned with External Input is activated, and with the Jump program command to change program flow based on line conditions. Sets the starting Input Line number for multiple Wait/Jump Input Lines. If your system requires four (4) wait for external input lines, assign any four consecutive input lines.

29 Program Initiate

Executes the selected program. Edge sensitive function. Must be taken from low level to high level to be recognized.

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30 Program Select Lines

This input function allows you to select a program with input lines and sets the starting input line number for a number of **program select lines**. For example: If your system requires four program select lines, assign any four consecutive Input Lines. If you assign the program select function to Input Line #5, then enter 4 as the number of Program Select Lines, the Program Select function would now be assigned to Input Lines #5, 6, 7 and 8. You could now select programs 0 through 15.

The default format of the program select lines is binary. That is, the first line that you assign has a value of 1, the second a value of 2, the third a value of 4, the fourth a value of 8 and so on. The program number selected is the sum of the values of the lines activated.

Selecting program 5 in this example would require activating lines 5 (value 1) and 7 (value 4) while activating the line assigned to input function 29, Program Initiate. If no lines are activated, this is the same as selecting Program #0.

31 Suspend Program

Stops the execution of a program until the input line assigned with resume is activated. See suspend/resume on page .

32 Resume Program

Resumes the execution of a suspended program. See suspend/resume on page.

33 Abort Suspend

Clears the **in suspend output** and returns the drive from a suspend cycle to normal operation without the need to "resume" and completion of the suspended program.

34 Clear End Program

Clears the **end of program output**. If not assigned, the end of program output will automatically clear when further motion is initiated. If this input is assigned, an input is required to clear the output.

35 Clear End Program Count

Clears the **end of program count output**. If not assigned, the end of program count output will automatically clear when the next motion occurs. If this input is assigned, an input is required to clear the output.

36 Clear All Prog Outputs

When the line assigned to this function is activated, this function will clear (set to **off**) all programmable output lines. (See Input function #27 to clear individual programmable output lines.)

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38 External Mode Override

An active input allows direct and immediate movement of the FX drive motor using the Bi-polar sync setup in the master axis dialog box.

45 Zero Master Cycle

Establishes master zero degree point. The Zero Master Cycle sensor must be assigned to the **high speed** input lines 1 or 2. The Zero Master Cycle must be set at least once each time a new Master Cycle is initiated via the Follower Cycle. If the master cycle is defined to use the sensor, this input is used each time a master cycle zero point passes.

46 Zero Follower Cycle

Establishes follower zero degree point. If the Zero Follower Cycle sensor is used to sense and redefine each Follower Cycle, this input must be assigned to **high speed** input lines 1 or 2. The Follower Cycle Zero must be set at least once each time a new Follower Cycle is initiated. This can be done by toggling this input line or executing a Home function.

47 Phase Angle Advance

When this input is activated it will cause the Follower to lag further behind the Master Axis. Once the input is no longer active the Follower will remain in sync but will maintain the new phase relationship. This has the effect of advancing the Master Axis relative to the Follower.

48 Phase Angle Retard

This input is exactly like the Phase Angle Advance except it works to effectively retard the Master Axis by causing the Follower to advance.

49 Cycle Dropout

When the drive receives a continuous cycle dropout input (input #49), the motor will decelerate to a stop at the follower deceleration rate in the Cycle Dropout Stop position (as programmed 0° to 360°). The motor will hold in the programmed position until the signal is removed.

When the cycle dropout signal is removed, the drive will accelerate, limited by the **Follower Maximum Acceleration** setting, until the proper phase angle is achieved.

78 Clear Program Error

This input is used to clear the Program Error output (Output Function #46). If this function is assigned, this input is required to clear the output.

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Output Functions

12 Programmable Outputs

The output lines assigned to this function can be turned on or off with the Set PGO programming function. The maximum number of PGO lines is 16; the maximum number of Jump/Wait Input lines is 8.

Similarly, the internal output lines support programmable outputs (PGOs). The PGOs can be overlapped between the external and internal output lines. For example, if output #12 (PGOs) is assigned to external line 9, and sixteen output lines are selected, then the PGOs would be assigned to external output lines 9,10,11, and 12, along with internal output lines 1 through 12.

13 End Of Program

This output is activated after each completion of all steps (motion and non-motion) in a program. It is automatically deactivated with the next motion or when the clear end of program input is used.

14 End Of Program Count

This output is activated only after a program is executed the number of times specified by the Program Count. It is automatically deactivated with the next motion or when the Clear End Of Program Count is used.

15 In Suspend

This output is activated when the suspend program function is active.

17 At Sync

This output is activated when the follower axis is in sync with the master axis (i.e. the acceleration portion of the index is complete). For example; In a fly cut-off system, the cut-off can not be made until the follower and master are in sync. This output would signal the cut-off mechanism that the follower axis is in sync with master axis.

18 Sync Fault/Fly Cut-off

This output indicates that the programmed cut length reached a count that should have initiated another flying cutoff but the FX drive was not in position to initiate the flying cutoff.

21 Master Cycle Defined

Output turns on once the Master Cycle is defined after power up.

22 Follower Cycle Defined

Output turns on once the Follower Cycle is defined after power up.

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23 Phase Angle Error Limit

This output, will activate any time the PHASE ANGLE ERROR LIMIT parameter in the Follower Cycle screen is exceeded.

24 In Phase

Compliment of Phase Angle Error Limit output. When a home is executed and the follower cycle is initiated, the **In Phase** output will not be active until the follower has completed its phase correction. If the cycle is initiated without defining the follower zero point, the In-Phase output becomes active when a cycle is initiated, Then will only become inactive if the **Phase Angle Error Limit** is exceeded once the follower and master are defined.

25 Master Sensor Missing

This output turns on if the Master Cycle sensor input fails to appear after 1½ times the Master Cycle length

26 Follower Sensor Missing

This output turns on if the Follower Cycle sensor input fails to appear after 1½ times the follower Cycle length.

45 Out Of Index

This output is activated if the motor moves past the end of an index during a fault initiated suspend. It will also be activated if the motor has moves past the fault position.

46 Program Error

This output is activated when a math error occurs in a program, however, program execution is not interrupted. This output is cleared using the clear program error input.

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Helpful Math Information

If a complex profile is used (a profile where the follower to master ratio is other than 1:1, where the velocity of the follower changes throughout the cycle relative to the master velocity), it becomes necessary to calculate the ratio of the master axis to the follower axis at the end of each segment of the follower cycle. The following formula works well for determining the end ratio of a segment.

$$\frac{R_0 + R_1}{2} = \frac{F_1 - F_0}{M_1 - M_0}$$

$$Where \ \frac{R_0 + R_1}{2} = average\ ratio$$

$$Where \ F_1 - F_0 = \Delta \ follower\ position$$

$$And \ M_1 - M_0 = \Delta \ master\ position$$

This can also be expressed as:

$$R_1 = \frac{2 \bullet (F_1 - F_0)}{M_1 - M_0} - R_0$$

Variables:

Δ Follower Position = The change in position of the follower axis during the segment.

Δ Master Position = The change in position of the master axis during the segment.

F_1 = Follower position at the end of the segment.

F_0 = Follower position at the start of the segment.

M_1 = Master position at the end of the segment.

M_0 = Master position at the start of the segment.

R_0 = The Ratio at the beginning of the segment.

R_1 = The Ratio at the end of the segment.

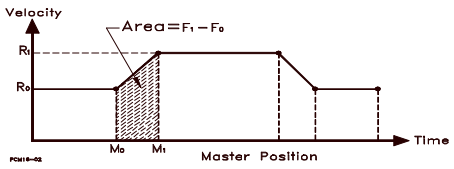


Figure 30 Cycle Profile Example

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The next few pages contain worksheets that can be used to help define and program the PCM-16 module.

Cycle Profile Worksheet #1

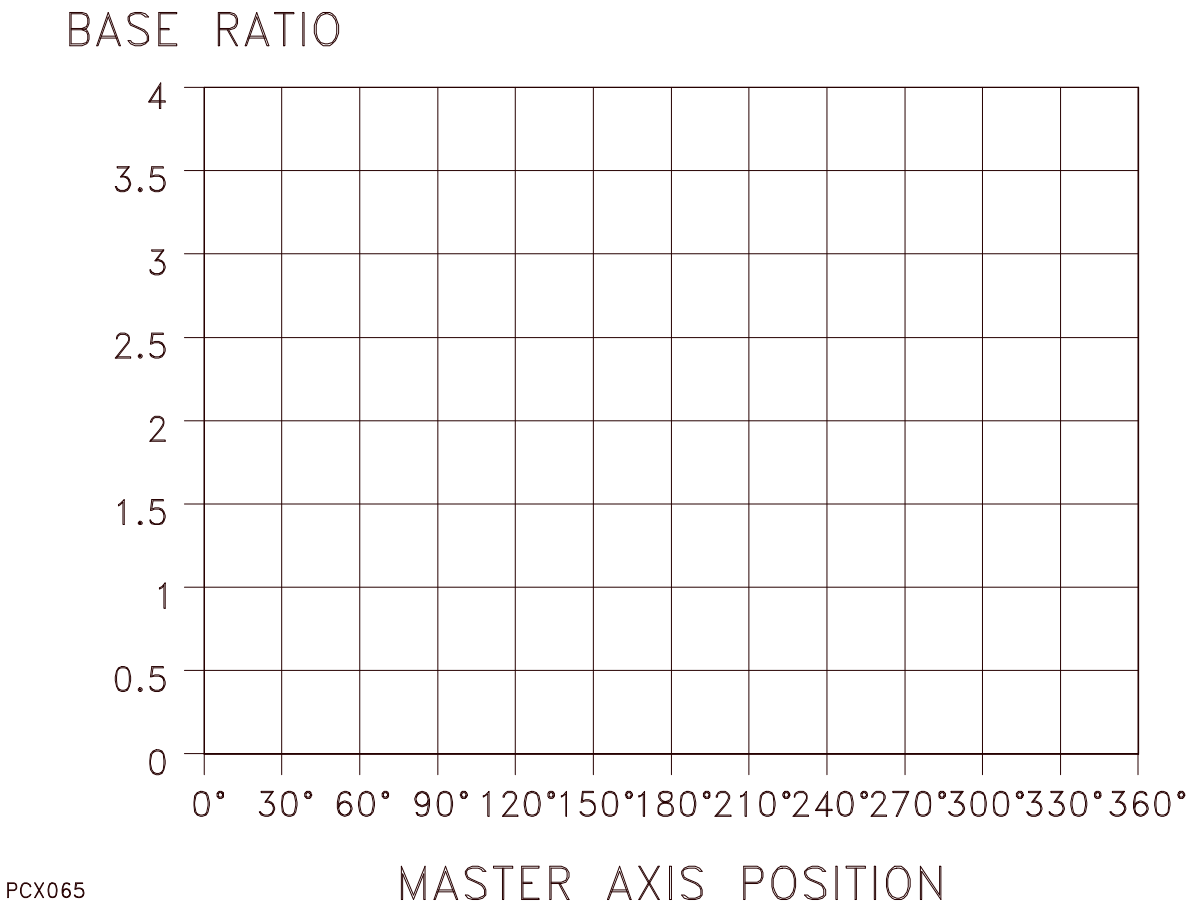
Cycle Pro	Mast	Follow	Follower M	
1	0	0		
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13	360	360		

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Cycle Profile Worksheet #2

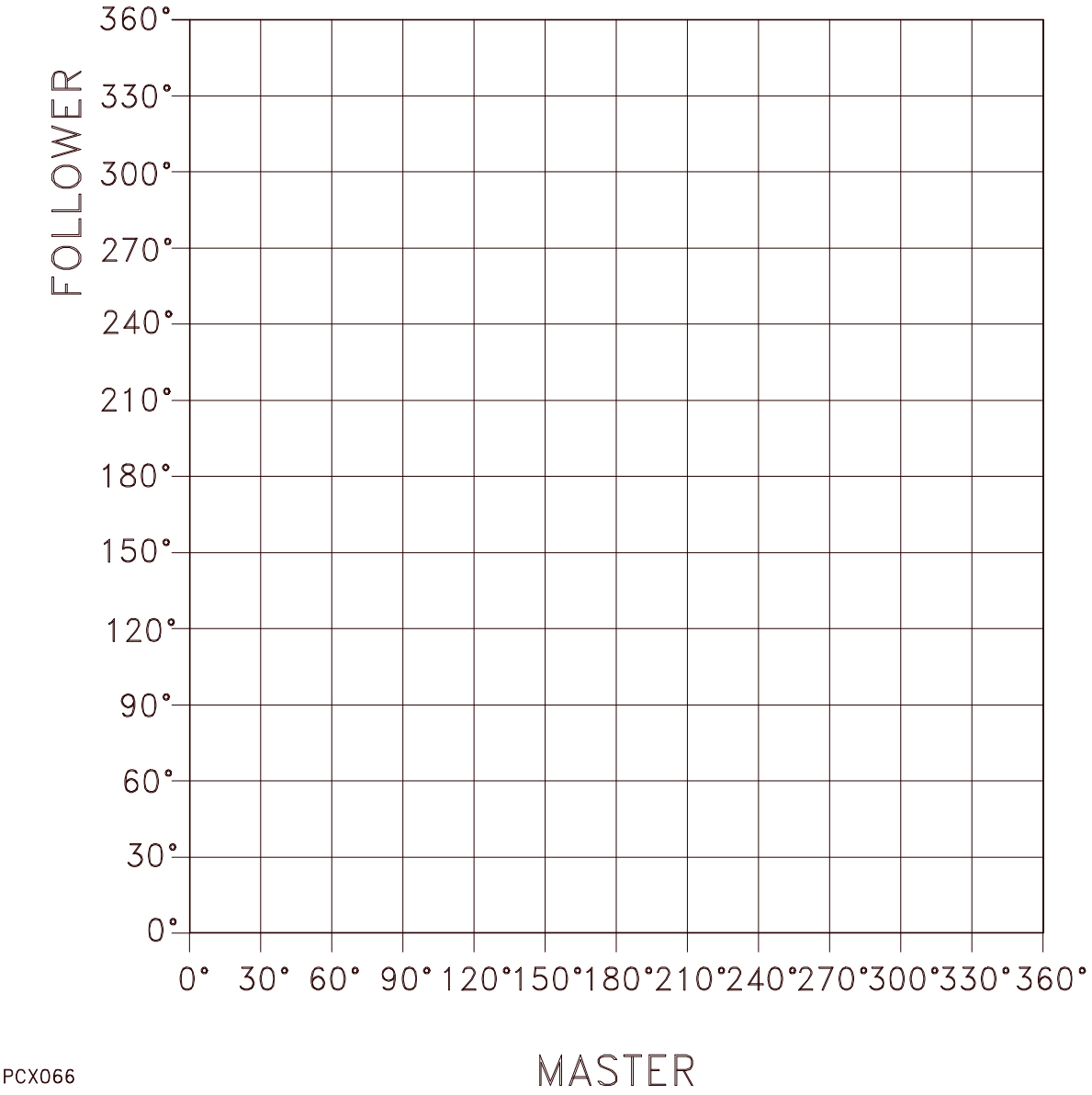
Cycle Pro	Mast	Follow	Follower M	
1	0	0		
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13	360	360		

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