PCM-22

Rotary Knife Controller

This document has been prepared to conform to the current release version of the PCM-22 Rotary Knife Controller. Because of our extensive developments and our desire to further improve and enhance the product, inconsistencies may exist between the product and documentation in some instances. Call your customer support representative if you encounter an inconsistency.

Customer Services

EMERSON Motion Control offers a wide range of services to support our customers' needs. Listed below are some of these services.

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Service Support Check List

To ensure the most timely and efficient support possible, please have the following items ready *before* calling for Service Support.

1. The model and serial number(s) of your FX Amplifier(s) and manual(s).

2. The model and serial number(s) of your PCM(s).

3. The result (using Terminal Mode) of *ID?; 0ID?* (zero *ID*?) if axis ID's are used.

4. The result (using Terminal Mode) of *ID1?; 0ID1?* (zero *ID1*?) if axis ID's are used.

5. A description of the symptom(s) or issue(s) observed including any fault status codes displayed on the LED Diagnostic Display.

6. Copies of the **current uploaded** program(s) that are in each of your PCM(s).

7. The gear ratio, model number and type of reducer(s) used.

8. This manual.

Table Of Contents

Introduction

This manual provides setup and programming information for the PCM-22 Rotary Knife Controller Application Module.

It is important that you become familiar with the *230V FX Drives Setup and Programming Operator's Manual* (P/N 400282-00), *460V FX Drives Setup and Programming Operator's Manual* (P/N 400310-00) or *525 Programmable Motion Controller Installation and Operation Manual* (P/N 400276-01) as appropriate.

This manual should be read completely before installing the PCM-22. It provides the background information needed to setup and configure the PCM-22/FX amplifier combination using PCX 7.x software.

Description

The PCM-22 Rotary Knife Controller is an application module that attaches to any EMERSON Motion Control FX positioning servo drive. The PCM-22 enables a FX drive to automatically calculate and create motion profiles using sensor information and/or user-defined parameters.

The PCM-22 is designed to maintain a phased relationship between the motor axis (referred to as the Follower axis) and the motion of an independent axis (referred to as the Master axis).
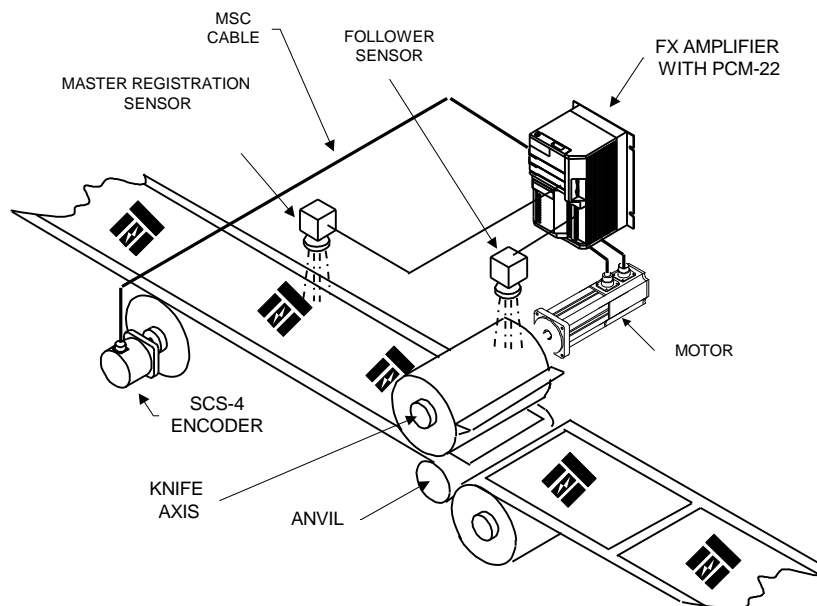
Figure 1 Typical Application - Rotary Cut-Off.

The PCM-22 accepts application data relating to the mechanical dimensions of the system entered using PCX Software. These parameters along with sensor and synchronization information allow the PCM-22 to calculate the motion profile necessary to meet the user specified positioning requirements of the application.

Many parameters relating to the PCM-22 application can be changed using hardware inputs, PCX software or serial commands. Using these new parameters, the PCM-22 will calculate the new motion automatically, without stopping, to maintain continuous machine operation.

If an axis uses a registration sensor, the PCM-22 can automatically adjust parameters based on sensor information about that axis. It will, within user-defined limits, automatically compensate for length changes and detected mechanical inaccuracies.

For example:

If the distance between registration sensor inputs on the Follower axis indicate that the length is 8.25 inches and not 8.30 inches as entered using PCX. The PCM-22 will automatically make adjustments to compensate for the difference in length.

These capabilities allow the PCM-22 to produce one or more cycles of motion for every individual cycle of motion produced by the Master axis. The PCM-22 will position the Follower axis to a corresponding position and velocity relative to the Master axis while it is executing a cycle.

This type of motion profile is commonly used in cutting, sealing, printing and perforating applications.

Features

The features of the PCM-22 Rotary Knife Controller include:

- Set up with easy-to-use PCX software.
- Works with all FX series drive products and 525 PMC products.
- Allows an FX drive to accurately position and match speed based on data received from a Master axis.
- Drive setup parameters are stored in the PCM-22 module. This allows the PCM-22 to be transferred to another FX drive of the same size without losing any setup parameters.
- Calculates cycle profiles based on user-defined parameters automatically.
- All parameters are in user-defined units.
- Most parameters can be changed automatically, without stopping.
- Two internal counters for each cycle: product cycle counter and product batch counter.
- 100 programs (with a maximum of 512 steps total for all programs).
- 16 Master axis and 16 Follower axis motion profile definitions.
- 98 user-assignable I/O functions.
- 64 indexes.
- 2 homes.
- Expands I/O line capacity of FX drive with an additional eight optically isolated input lines and four optically isolated output lines.
- Interactive cycle diagnostic capabilities.
- Always uses linear ramps for Homes, Indexes, Jogs and Follower cycles for increased accuracy.

Note: **Not all of the features available with the PCM-22 will be used in every application.**

For example:

There are 15 programming functions available with the PCM-22 however, a typical rotary knife program will use only a few of them.

Terminology

Master Cycle Length

The *Master Cycle Length* (also called the *Master Length*) is the particular distance, in user units, that the Master axis (encoder or upstream drive) moves during each Master cycle. It is the distance between two *Master Cycle* zero positions. See Figures 2 and 3.

If the *Master Cycle Defined By Sensor* is "Yes"; when the *Zero Master Cycle* sensor detects a target on the Master axis, that is the Master zero position. The distance between two *Zero Master Cycle* positions is the *Master Cycle Length.*

If the *Master Cycle Defined By Sensor* is "No"; when the first *Zero Master Cycle* input is received, that is the initial Master zero position. This will be the only *Zero Master Cycle* input required for all Master cycles following. When the Master axis has moved the user entered *Master Cycle Length,* it has moved the distance between two Master zero positions.
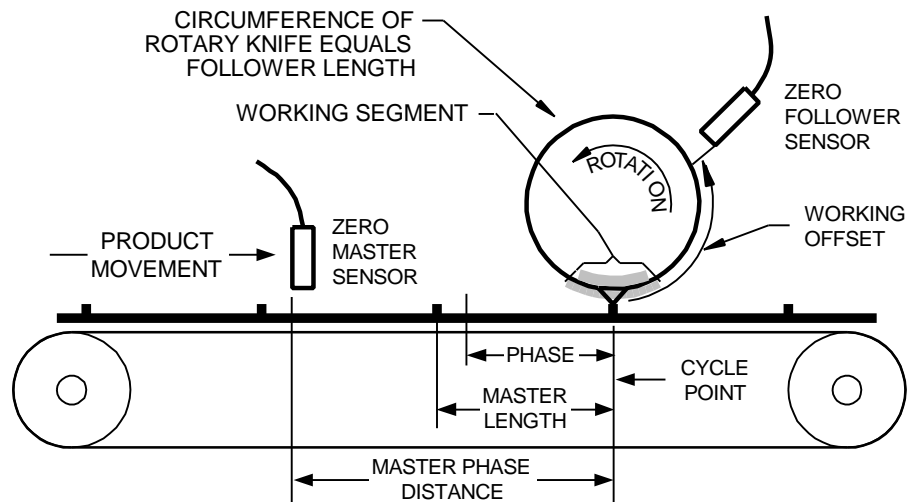
Figure 2 Typical Rotary Knife System Component Locations

Follower Cycle Length

The *Follower Cycle Length* (also called the *Follower Length*) is the distance, in user units, that the Follower axis (PCM-22/FX drive) moves during each Follower cycle. It is the distance between two Follower cycle zero positions. See Figures 2 and 3.

If the *Follower Cycle Defined By Sensor* is "Yes"; when the *Zero Follower Cycle* sensor detects a target on the Follower axis, that is the Follower zero position. The distance between two *Zero Follower Cycle* positions is the *Follower Cycle Length.*

Figure 3 Relationship Between the Master Cycle Length and the Follower Cycle Length

If the *Follower Cycle Defined By Sensor* is "No"; when the Follower cycle starts, it is at the Follower zero position. When the Follower axis has moved the user entered *Follower Cycle Length,* it has moved the distance between two Follower zero positions. See *Homes and the Follower Zero Position.*

Working Segment

This is called *Working Segment Width* on the *Follower Cycles* screen. It is the constant velocity portion of the cycle, usually when the Follower is in contact with the product. The Follower moves at the *Working Ratio* velocity relative to the Master velocity during this distance. See Figures 4, 5, and *Cycle Inter-Relationships*, *Maximum Product Velocity* and *Variable Segment.*

Note: **The Master Length also has a Working Segment. It is not directly user adjustable, it is computed from the *Follower Cycles Working Segment* divided by the *Working Ratio*. See Figure 6.**

Cycle Point

The *Cycle Point* is at the center of the *Working Segment.* It is the beginning and the end of every cycle. See *Operational Timing.*

Working Offset

The *Working Offset* is the distance from the *Cycle Point* to the Follower zero position, in the direction of Follower rotation. The Follower zero position is the same position as the *Zero Follower Sensor* if used. See Figures 4, 5, *Cycle Inter-Relationships*, *Homes and the Follower Zero Position.*

CYCLE POINT

FOLLOWER
ZERO POSITION

WORKING OFFSET

WORKING
SEGMENT

VARIABLE SEGMENT

FOLLOWER
LENGTH

*ONE
CYCLE*
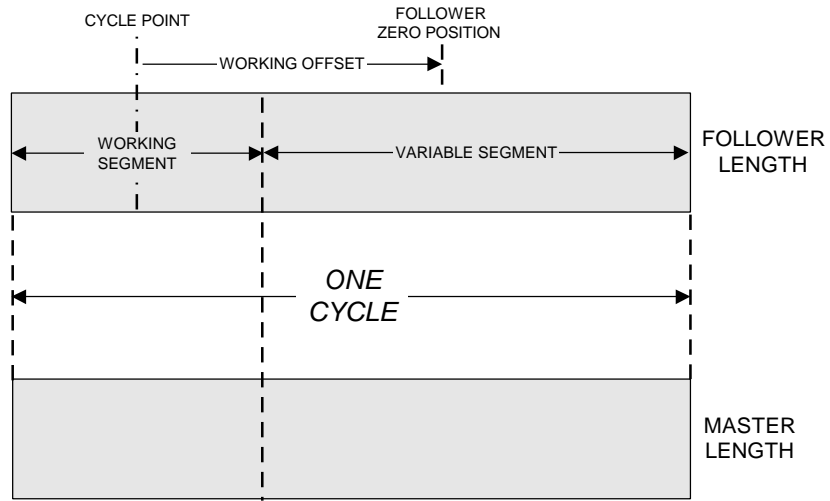
MASTER
LENGTH

ONE TO ONE RELATIONSHIP (IGNORING SCALE) BETWEEN
MASTER LENGTH AND FOLLOWER LENGTH.

Figure 4 Follower Terminology Relationships

G B A

DIRECTION
OF
FOLLOWER
ROTATION

D

E

C

F

A: FOLLOWER CYCLE LENGTH
B: FOLLOWER ZERO POSITION
C: WORKING SEGMENT
D: VARIABLE SEGMENT
E: WORKING OFFSET
F: CYCLE POINT
    (CENTER OF WORKING SEGMENT)
G: CYCLE DROPOUT POSITION
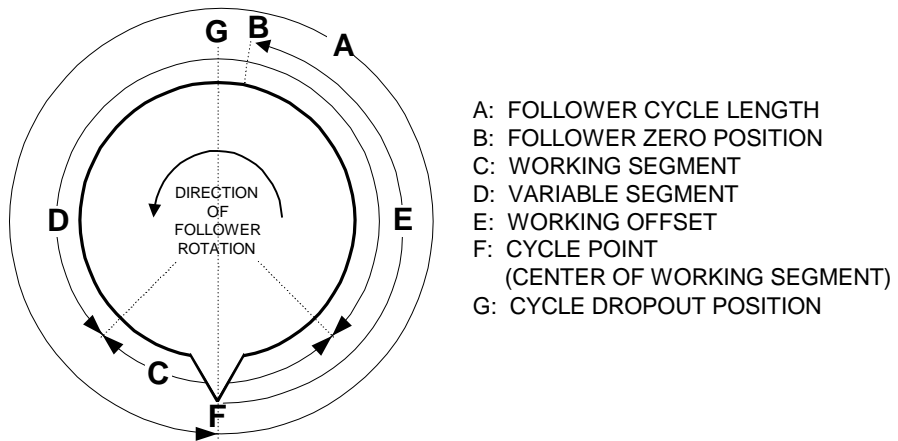
Figure 5 Circular View of Follower Terminology Relationships

Variable Segment

This is a computed parameter. It is the Follower Cycle Length minus the Working Segment. This is where all cycle adjustments occur. See Figures 4, 5, 6 and Cycle Inter-Relationships.

WARNING!

When designing a PCM-22 system, the peak acceleration and the peak velocity required during the *Variable Segment* must be calculated at the maximum process speed with the shortest Master Length spacing. This is necessary to determine the required motor size.

See *Maximum Product Velocity*.

Cycle Drop Out Position

The *Cycle Drop Out Position* is the position exactly opposite the *Cycle Point.* While *Cycle Drop Out* input function is active, the Follower will complete its current cycle and decelerate to this position and hold there. See Figure 5, the *Cycle Drop Out* input function, *Cycle Inter-Relationships, Homes and the Follower Zero Position.*

Working Ratio

The *Working Ratio* defines the relationship between the Follower velocity and the Master velocity during the *Working Segment.*

For example:

If the Follower is to move the same speed as the Master during the *Working Segment,* then the *Working Ratio* would be 1.00000. This is common in many applications.

If the Follower is to move 5 percent faster than the Master velocity during the *Working Segment,* then the *Working Ratio* would be 1.05000. The range is from 0 to 9.99999.
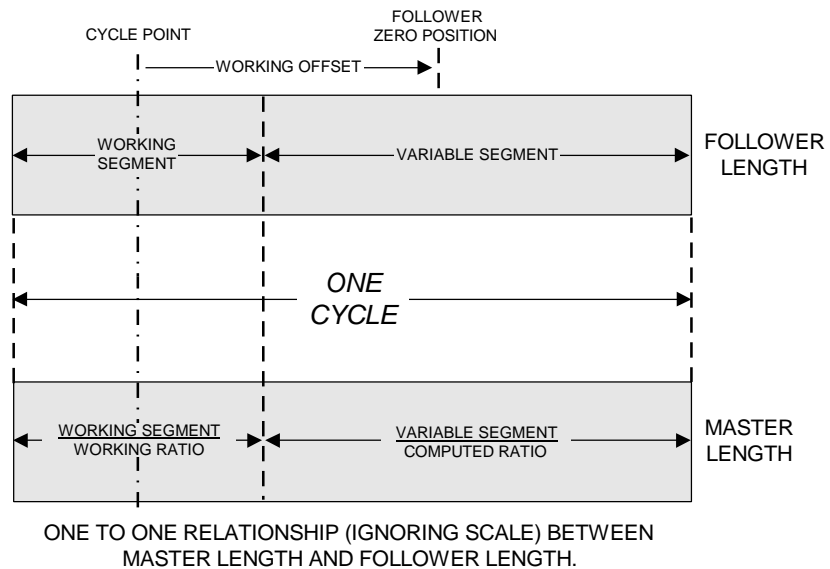
Figure 6 Follower Component Relationships to the Master Cycle Length

Phase

A repeating pattern is called a cycle. When two repeating patterns are synchronized there is an inherent position relationship between the two patterns called *phase*. See Figure 7.

This means that:

There is a one-to-one positional profile relationship between the two lengths (ignoring scale) and every point within the two lengths.
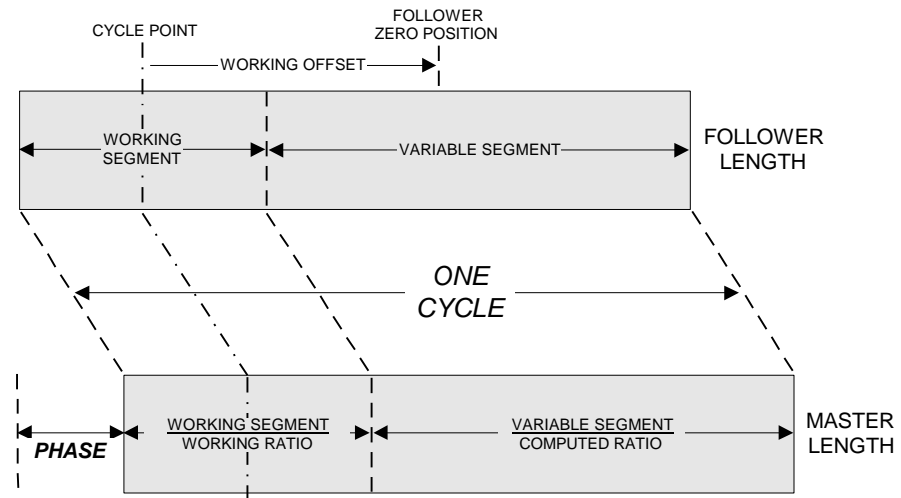
Figure 7 Phase Relationship Between Master and Follower Cycle Lengths

The PCM-22 maintains the phase relationship by automatically making adjustments based on sensor inputs and applying user-defined parameters. Figures 3, 4 and 6 show a phase relationship of zero.

Average Length

The PCM-22 uses continuous averaging when an axis is defined by sensor. Continuous averaging provides increased stability by incorporating every length into the average, starting from the initial Follower Cycle Length or Initial Master Length. Average lengths are generated from the following equation for the Master and the Follower axes:

$$\text{Average Length} = \frac{\left(\text{Current} * (\text{Averaging - 1})\right) + \text{New}}{\text{Averaging}}$$

Current is equal to the current average length.

New is equal to the new measured length.

Averaging is entered by the user from 1-8.

For example:

If eight is entered here the new average *Follower Length* calculated by the PCM would be:

$$\text{Average Length} = \frac{\left(\text{Current} * 7\right) + \text{New}}{\text{Averaging}}$$

It takes at least three times the averaging number of cycles on an axis to "learn" a change in length (e.g. if the averaging is set to eight, the PCM will need to sense at least 24 cycles to completely adjust for the new length). See *Follower Length Correction Limit* and *Master Length Correction Limit.*

Therefore, the lower the average the faster length errors are corrected. However, too low a value adversely affect the drive's ability to quickly correct for phase errors by causing overcompensation and instability. See *Maximizing Profile Performance* and *Theory of Operation*.

The *Average Master Cycle Length* and the *Average Follower Cycle Length* are the learned lengths which are used only when defined by registration sensor.

Theory of Operation

The operation of the PCM-22 is explained in the following sections.

This manual should be read completely before installing the PCM-22.

General Running

The Master axis position is monitored by the PCM-22 using synchronization signals. These signals, which come from an incremental encoder driven by the Master axis or an upstream FX drive, provide the positioning data to the PCM-22.

In order to maintain the proper phase relationship between the two axes, the PCM-22 monitors the *Zero Master Cycle* and *Zero Follower Cycle* sensors of both the Master and the Follower axes.

If the Follower axis does not use a sensor then the PCM-22 will use the *Follower Cycle Length* parameter entered and only correct for *Following Error*. *Following Error* is the difference between the motor's commanded position and it' actual position. No automatic length or phase adjustments will be made for the Follower axis.

If the Master axis does not use a sensor, no corrections to the Follower axis' motion profile will be made for product differences or encoder slippage.

If the Follower axis is not in phase synchronization with the Master axis, the PCM-22 computes a correction which is applied in the next Follower cycle. The Follower axis will speed up or slow down depending on what is required for the length or phase correction. If both the Follower and the Master axes are in phase synchronization, no correction is made.

The portion of the motion profile called the *Variable Segment* is where all user changes or profile adjustments occur for each individual *Master Length*. The remainder of the motion profile is called the *Working Segment*. The *Working Ratio* will always be maintained during the *Working Segment*.

Any changes made before the *Cycle Point* will take place during the next cycle. If parameters are entered that cannot be accommodated while in cycle, the *Cycle Limit Reached* (output function 41), if assigned, will be activated until the cycle can be executed as defined. See *Operational Timing*.

Product (master) positions are continuously tracked whether a Follower cycle is executing or not. At power-up the PCM-22 is executing the *Master Cycle zero (0)* definition. See the *MF* serial command.

The PCM-22 handles the Master position information differently depending on whether a product registration (master) sensor is used or not. Each of the two ways of handling the Master position information have different applications but operate similarly in the respect that Mater position information is continuously tracked whether a *Follower Cycle* is executing or not.

Master Cycle Defined By Sensor Mode

When a *Zero Master Cycle* sensor input occurs, the distance traveled from the last product position will be checked to see if it is between the *Master Length Upper Limit* and the *Master Length Lower Limit*. This measured distance is factored into the *Average Master Length* starting from the user entered *Master Cycle Length*. Any necessary corrections will be made to the *next* Follower axis motion profile. See *Average Length, Master Cycles* screen and *Operational Timing*.
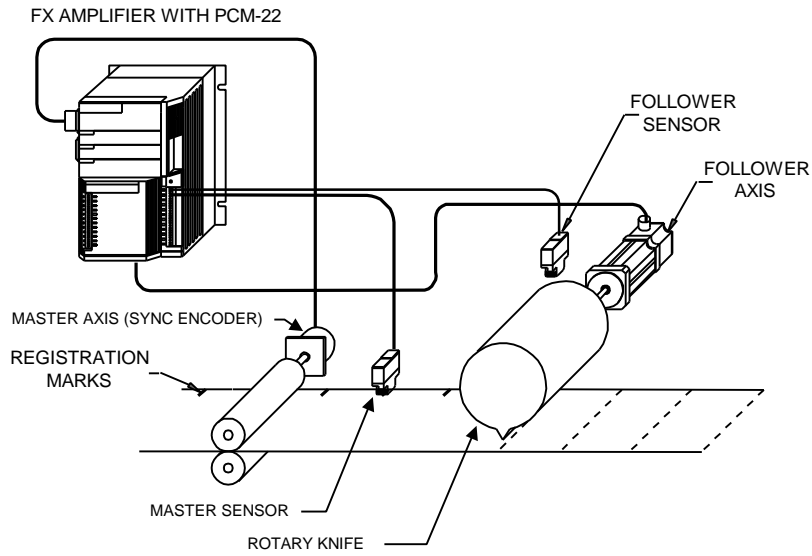
Figure 8   PCM-22 Rotary Knife System Example

Master Cycle Not Defined By Sensor Mode

If the Master is *Not Defined By Sensor*, the user entered *Master Cycle Length* will be used by the PCM-22. No corrections to the Follower axis' motion profile will be made for product or encoder slippage in this mode.

Resetting the Master Cycle Processing

Resetting the Master Cycle Processing on the PCM-22 involves reloading the user-defined *Master Cycle* parameters. This overwrites all learned and user-defined Master information currently in use. When the Master processing is reset, the *Master Cycle Defined* output function is deactivated until the Master Cycle is redefined. *Resetting the Master Cycle Processing* usually happens automatically but may be induced. See *Automatically Resetting the Master Processing* and *Manually Resetting the Master Processing.*

Note: **Resetting the Master Cycle Processing will only occur when a Follower Cycle is not executing and the Follower axis is not moving.**

How the Master Cycle is Defined

After *Resetting the Master Cycle Processing* the Master cycle is undefined and must be redefined before a Follower cycle may begin.

Master Cycle Defined By Sensor Mode

When the first *Zero Master Cycle* sensor input is received, the product is at the initial Master zero position. When the second *Zero Master Cycle* sensor input is received, the *Master Cycle Length* will be defined and the *Master Cycle Defined* output function will activate.

Master Cycle Not Defined By Sensor Mode

When the first *Zero Master Cycle* input is received, the product is at the initial Master zero position. The *Master Cycle Length* will be defined at this point and the *Master Cycle Defined* output function will activate. This will be the only *Zero Master Cycle* sensor input required for all master cycles following.

Note: **For situations where there is no need for any master axis alignment, you can wire the Follower Cycle Defined output to the Zero Master Cycle input to define the Master Cycle position automatically.**

Automatically Resetting the Master Processing

- If the PCM-22 has been powered-up but has not yet executed a Follower cycle, it is executing the *Master Cycle* 0 data definition. The first time after power-up the *Y Execute Follower Cycle* program step is executed in a PCX program, the Master processing will be reset. See the *MF* serial command.

- When the *Y Execute Follower Cycle* program step is executed in a PCX program and the *Master Cycle* definition specified in the *Follower Cycle* screen, is not the same as the currently executing *Master Cycle* definition then the Master processing will be reset. See the *CI2* serial command.

- Setting the *Force Reset Master Processing* bit using the *FF* serial command will automatically cause a Reset of the Master processing every time a *Y Execute Follower Cycle* program step is executed in a PCX program. See *Starting A Follower Cycle.*

Manually Resetting the Master Processing

Manually *Resetting the Master Cycle Processing* is particularly useful for troubleshooting product handling (slippage or registration) issues.

The PCM-22 provides two ways for resetting the Master processing manually by:

- Writing the *MF* serial command.

- *Reset Master* input function 115.

These methods allow the user to reset the Master processing as the application requires. The result is the same as selecting a different *Master Cycle* definition for the same Follower cycle on demand.

Starting A Follower Cycle

An initial *Home* or *Index* is required to move the Follower axis to the Follower zero position *before* the *Y Execute Follower Cycle* statement is executed. This will determine, using the *Working Offset,* the position of the *Cycle Point* on the product. When the *Y Execute Follower Cycle* statement is executed, the *Follower Cycle Defined* output function will activate and if the Master cycle is defined, the Follower cycle will start.

When the PCM-22 axis starts moving from the Follower zero position, *Home* position or the *Cycle Drop Out Position,* a linear acceleration is used to get to the correct velocity at the beginning of the *Working Segment.* The PCM-22 checks the first product's (*Cycle Point*) position to see if it can reach the correct velocity (*Working Ratio* * Master velocity) in the distance it would travel from the Follower zero position to the beginning of the first product's *Working Segment.* If this is not possible (i.e., the start-up distance is longer than the first product position), the PCM-22 will check the second product position. If it can not make the second product position, it will check the third and so on, until the PCM-22 finds a product position that will allow the Follower axis to reach the product's *Working Ratio* velocity at the beginning of its *Working Segment.* The Follower axis is not moving while it is determining which product position to try for. See Figure 9 and *Master Phase Distance.*
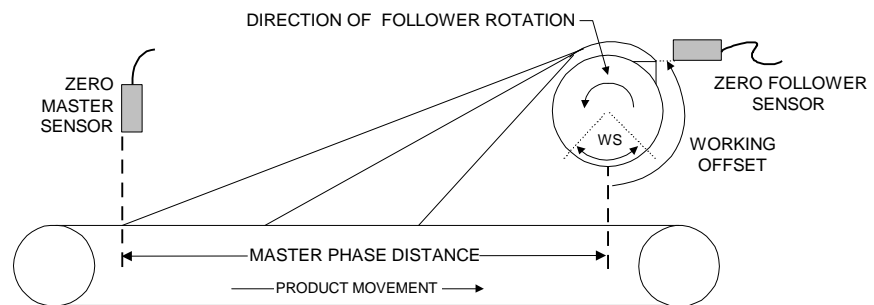
Figure 9 PCM-22 Starting Cycle Ramp

When the Follower has passed the first *Cycle Point* after the Master has moved the *Master Phase Distance,* the *In Phase* output function will activate.

In *Master Cycle Defined By Sensor* mode, it is possible for the start-up distance to be greater than the *Master Phase Distance.* If this is the case it will generate product positions to target *before the sensor* using the *Average Master Length.* Please note that the entered *Master Cycle Length* is only equal to the *Average Master Length* just after the Master processing is reset.
The Follower will start executing the computed starting ramp distance to the targeted product position. Any products that pass the *Cycle Point* before the Follower has completed the initial acceleration will be ignored. See Figure 10, *Average Length,* and *Resetting the Master Processing.*
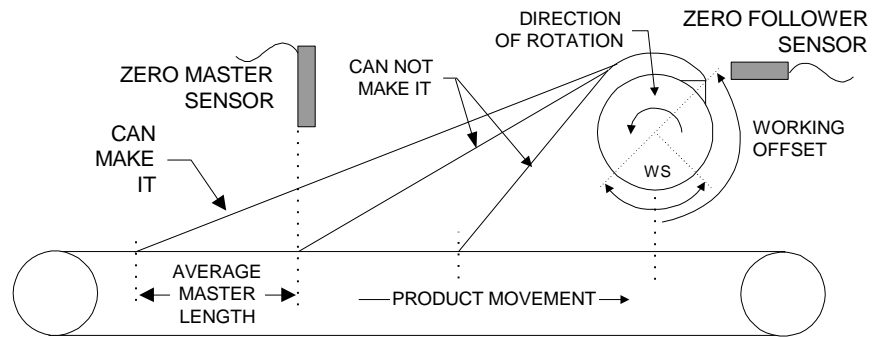
Figure 10   When the Follower Start-up Ramp Exceeds the Master Sensor Distance

Homes and the Follower Zero Position

In order to obtain the highest accuracy, certain types of homes are recommended for use with the PCM-22: *Resolver Offset* and *Feed On/Off.* Make sure the "On" move is in the direction of travel and the "Off" move is much slower in the opposite direction. The goal of this is to have the Follower's starting position be the same as the Follower zero position when the cycle is running. A reducer's backlash is minimal compared to an inaccurate initial reference position during the first several cycles.

Ensuring a correct starting position goes far in eliminating length and phase variations when the Follower is executing its first several cycles and learning its length the fastest.

It is not recommended, but it is possible, once the home is completed, to move to a different location which will be the Follower zero position. It is from this point that the Follower cycle will start. If this is not the actual Follower zero position and the Follower cycle is defined by sensor, the PCM-22 will perceive this as an error and correct for it.

Indexes and the Follower Zero Position

An index may be used instead of a home to move the Follower axis to the Follower zero reference position. It behaves the same as a home but there are more options for positioning the Follower axis before actually starting the cycle.

For example:

- A *Registration* index.

- A *Feed to Sensor* index.

- A home followed by an *Incremental* index.

The index must not be compounded and must finish before the Follower cycle begins.

Ensuring a correct starting position goes far in eliminating length and phase variations when the Follower is executing its first several cycles and learning its length the fastest.

Cycle Inter-Relationships

Every cycle has certain relationships pertaining to the *Working Segment.* These relationships must be maintained for the PCM-22 to execute the motion profile required by the Follower axis for each product on the Master axis. Please refer to the *Terminology* section for clarification of terms.

The following relationships are considered the rules for cycle operation.

1) The *Working Segment* must be less than the *Follower Cycle Length.*

2) The *Working Segment* divided by the *Working Ratio* must be less than *Master Length Lower Limit.*

3) The *Working Segment* must be less than the *Upper Working Segment Limit.*

4) The *Working Segment* must be greater than the *Lower Working Segment Limit.*

5) The *Working Segment* must not overlap the *Follower Zero Position.*

   A) The *Working Offset* must be less than the *Follower Cycle Length* minus one half of the *Working Segment.*

   B) The *Working Offset* must be greater than one half of the *Working   Segment.*

   This means that the follower sensor must not be inside the *Working Segment.*

The above *Cycle Inter-Relationship* cross-checks are performed against the following cycle parameters every time a cycle is started and every time one of these parameters is changed while the Follower is in cycle:

- Working Segment.
- Working Offset.
- Follower Cycle Length.
- Master Length Lower Limit.

If the profile is determined invalid due to one of these cross-checks when the cycle is started, the cycle will exit and *Cycle Error* (output function 66) will be activated. The *Follower Cycle* will not start and the *CQ* serial command will have flags set indicating where the problem is.

If the profile is determined invalid due to one of these cross-checks while the cycle is running due to a user change, the requested change will be ignored. The *CQ* serial command will have flags set indicating where the problem is and *Cycle Limit* (output function 41) will be activated.

If the *Working Segment* flag is set within the *CQ* serial command response then additional flags will be set indicating where the conflict is: *Working Offset, Follower Cycle Length* or *Master Cycle Length.*

Operational Timing

For every cycle, there is a one-to-one positional profile relationship (ignoring scale) between the Master cycle and the Follower cycle.

The PCM-22 may adjust the motion profile because of:

- User requested changes using I/O or serial commands.

- Learned length and/or phase variation changes if an axis is defined by sensor.
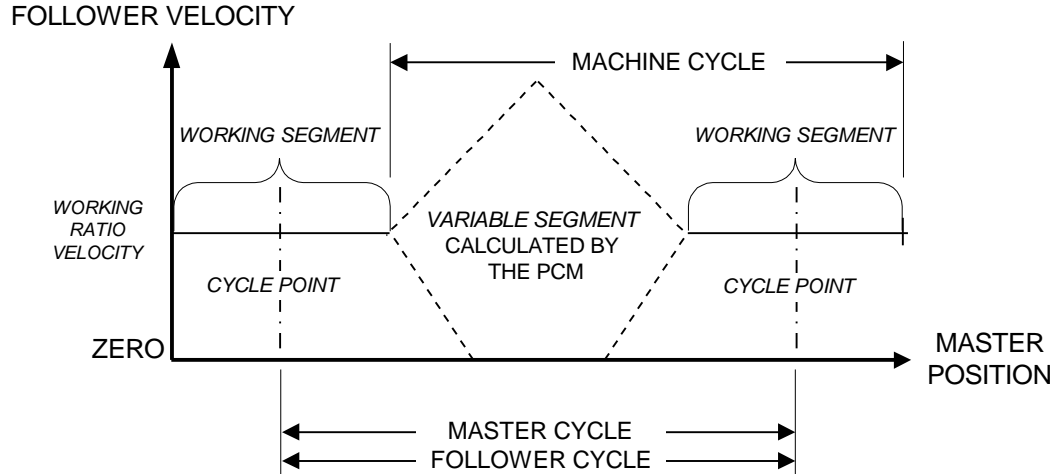
Figure 11   PCM-22 Motion Profile

In both cases, all motion profile changes (user requested changes, learned length and/or phase variations) occurring before the *Cycle Point* will be applied when the PCM-22 calculates the next *Working Segment* location.

When the Follower reaches the end of the current *Working Segment*, the new motion profile is used to move to the next *Working Segment*. See Figure 11. This new motion profile is the typical machine cycle which starts when the Follower axis leaves the *Working Segment* and gets clear of the product (e.g. the rotary knife comes out of the product).

Maximum Master Velocity

For every set of Master and Follower cycle parameters, the user must limit the maximum velocity of the Master so that the maximum velocity of the Follower is not exceeded. This is critical for product lengths shorter than the Follower Cycle Length.

$$\text{Maximum Master Velocity} = \frac{\text{MAV}}{(\text{FVS} / \text{MVS}) * 2 - \text{WR}}$$

Where:

MAV = Maximum Allowable Velocity of the Follower from the Limits screen.

WR = Working Ratio.

FVS = Follower Variable Segment = Follower Cycle Length - Working Segment.

MVS = Master Variable Segment = Master Cycle Length - (Working Segment / Working Ratio).

Note: **The above equation reflects ideal conditions and the user must reduce the calculated Maximum Master Velocity due to the effects of inertia, friction, encoder slippage, sensor, mechanical issues to allow enough velocity headroom for any motion corrections. Usually, this velocity reduction needs to be approximately 20 percent.**
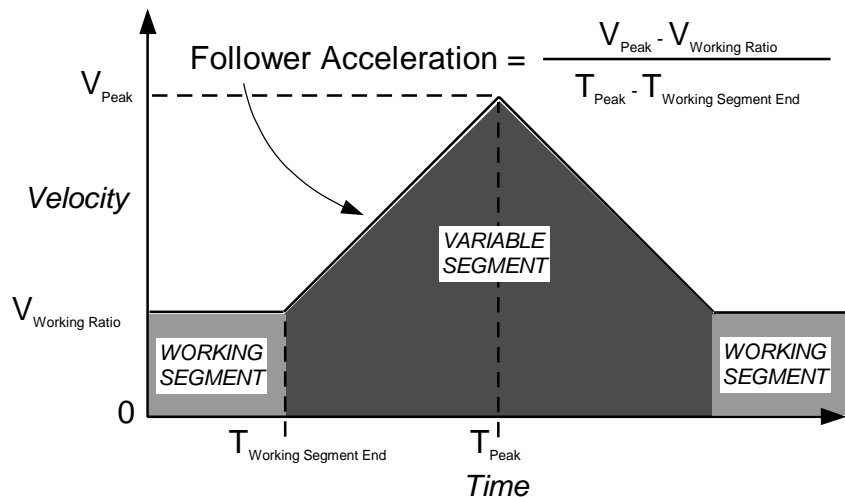
Figure 12   Variable Segment Acceleration

At the Maximum Master Velocity, V_{Peak} = MAV.

WARNING!
When sizing a system, keep in mind the velocity and acceleration of the Follower during the variable segment for the shortest product length because the Follower acceleration and deceleration rates are not controlled by PCX Limits.

Sensors

In a typical rotary knife system, the rotary knife will be designated as the Follower axis and the product or material conveyor as the Master axis. A sensor on the knife (or Follower axis) is strongly recommended since the exact position of the blade typically changes due to mechanical imperfections.

The Zero Master Cycle and Zero Follower Cycle, input functions 45 and 46 respectively, must be assigned to separate FX drive high speed inputs 1 and 2.

Selection

The PCM-22 reacts to learned sensor information by adjusting the motion of the Follower to match the Master axis. If the sensor information is inaccurate or not consistent, it will be reflected in the accuracy of the Follower positioning.

The general guidelines when selecting a sensor are related to machine issues such as the type of material being detected and the rate of input occurrences.

The sensor type is dependent on what the sensor detects, called the *target.* The surface area of the target should be as large as the sensing face of the sensor to minimize hysteresis effects as defined by the sensor type. This determines how consistently the sensor can be activated by the target.

For a target larger than the sensor moving at a constant velocity, the sensor should be selected be selected so the following equation is true:

$$\text{Response Time} \leq \frac{\text{Width of target}}{\text{Velocity of target}}$$

As the target becomes smaller approaching the size of the sensors' detection field, at a constant velocity, the sensor should be selected be selected so the following equation is true:

$$\text{Response Time} \leq \frac{\text{Width of target } - \text{ Detection field size}}{\text{Velocity of target}}$$

The response time of a sensor is defined as the elapsed time from when the target is detected until the signal appears on the sensor output. The response time of the sensor will have a direct impact on the system performance and accuracy. The response time of the sensor is part of the switching frequency of the sensor.

The switching frequency is the minimum time from when a sensor is triggered until it can be triggered again. Which is the time between successive sensor triggers. Both of these parameters should be fast enough for the application.

WARNING!
If the sensor switching frequency or response time is too slow for the application, poor system performance will result and can cause the Follower axis' position to appear to shift phase as the system speed is increased (i.e. the *Cycle Point* is in the wrong position).

For example:

The target is moving at 48 inches/second and is 0.1 inches wide. The detection field of the sensor is 0.062 inches wide. The response time of the sensor would need to be faster than 1264 Hz.

Sensors selected, should have a directed detection field such as a D.C. shielded inductive proximity sensor or a focused contrast/registration photo sensor.

Note: **Electrostatic Discharge (ESD) sensors, such as spark gap sensors, should never be used with FX products because the intense electrical noise they generate can affect the electronics in the FX amplifier.**

Refer to manufacturer's information concerning sensor selection, application and installation.

Sensors: When, Where and Why

Master Sensor

A Master sensor should be used for any of the following situations:

- When the products are randomly spaced and an average product length is desired.

- When we need to stay in phase with registration marks or products outside of a Follower cycle.

The Master sensor, ideally, should be positioned between one and two *Average Master Lengths* away from the *Cycle Point* to minimize the effects of product slippage and to allow the PCM-22 to correct for any phase variation on *that* product. See *Operational Timing.*

Follower Sensor

A Follower sensor must be used if the *Follower Cycle Length* is not an exact number of motor steps (i.e., no fractions of steps). If the *Follower Length* is not an exact number of steps, the Follower can drift out of position due to rounding. The precision of the data entered in the PCX software is the most common cause of drifting.

The recommended solution is to use a Follower sensor to let the PCM-22 determine the real *Follower Length* and allow it to compensate for any discrepancies.

Stable sensor characteristics are especially important for the Follower axis because the Follower sensor is in the *Variable Segment* which is always accelerating or decelerating.

The Follower sensor should be positioned so that it does not interfere with machine operation and so that the acceleration/deceleration is minimal. See *Maintaining Phase Issues*. Ideally, the sensor should be placed so it would be activated at *areas of the Variable Segment where the change in velocity is low (i.e., the beginning or middle of the Variable Segment).*

Note: **Typically, if the Master cycle is defined by sensor then the Follower should also be defined by sensor for the greatest accuracy.**

For example:

The Follower axis is moving at a specific acceleration and its sensor has a response time (R.T.) of 1000 Hz (0.001 seconds). The acceleration and response time effects on sensor accuracy are shown in the following table.

Working Segment Velocity (W.S.V.)	Follower Acceleration (F.A.) *See Figure 12*	Time Factor (T.F.) $= \dfrac{W.S.V.}{F.A.}$	Sensor Accuracy $= \dfrac{W.S.V.}{R.T.} * (T.F. + 1)$
10 in/sec	0 in/sec²	0 sec	0.010 in
10 in/sec	10 in/sec²	1 sec	0.020 in
10 in/sec	20 in/sec²	2 sec	0.030 in

Installation Guidelines

Attaching the PCM-22 Module

PCM modules attach to the front of any FX amplifier with two locking arms. All electrical connections (except I/O) are made using the 48 pin connector.

All PCM modules are equipped with eight input lines and four output lines, doubling the I/O capability of the standard FX drive. All inputs and outputs are optically isolated for +10.5 to +30 VDC operation. Each input and output line has two screw terminals associated with it to provide for either current sinking or current sourcing operation.

The first eight pairs of terminals (numbered 13 - 20) are inputs and the last four pairs of terminals (numbered 21 - 24) are outputs. The outputs are capable of sinking or sourcing 200 mA. You must limit the output current to 200 mA per output or less.

I/O Wiring

Input Wiring

Inputs require an external voltage source for operation. This voltage source must be in the range of 10.5 to 30 VDC. The negative (-) lead of the external power supply must be connected to the enclosure or safety ground. See Figure 13.

Output Wiring

Outputs are similar to inputs in that they can be connected to either sinking or sourcing type loads. Outputs require an external isolated supply voltage, usually the same supply as the inputs. Each output can sink or source 0.2 amps DC. The negative (-) lead of the external power supply must be connected to enclosure or safety ground. See Figure 13.
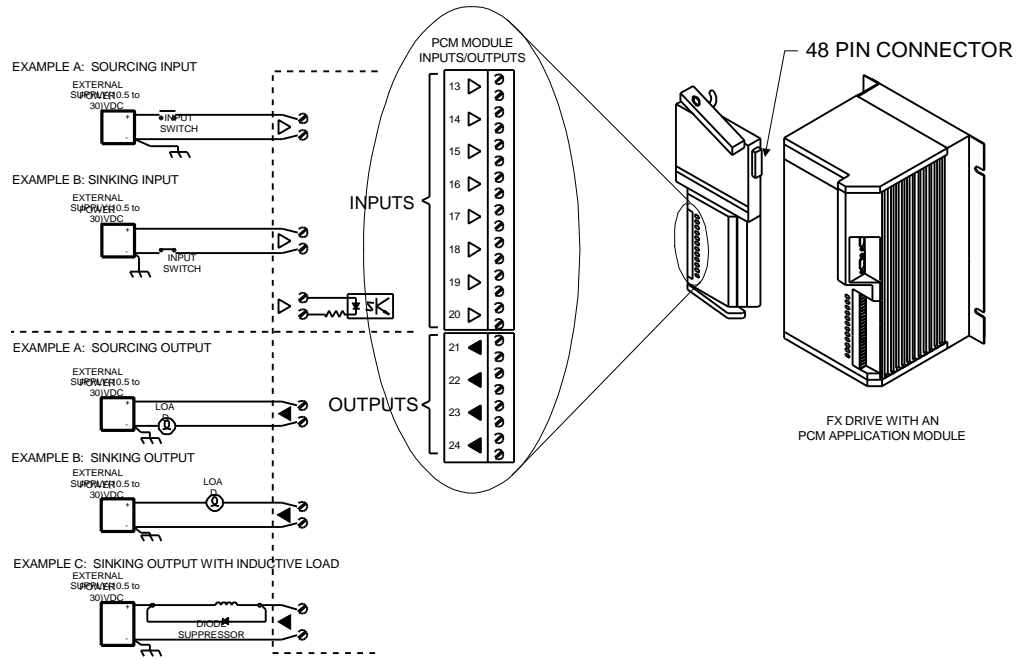
Figure 13   Installing the PCM Module

WARNING!
Do not install or remove the PCM module when there is power applied to the FX drive or 525 PMC because damage will occur to one or both.

PCM-22 Software Setup

This manual should be read completely before installing the PCM-22. It provides the background information needed to setup and configure the PCM-22/FX amplifier combination using PCX 7.x software.

Programming the PCM-22

The first step in programming your FX drive with a PCM-22 is to configure the drive using the 5 (7 for 525 PMC) menu options in the Drive Configuration screen. The Drive Parameters, Limits, Inputs and Outputs screens are explained in the Software Setup and Operation section of the *230V FX Drives Setup and Programming Operator's Manual, 460V FX Drives Setup and Programming Operator's Manual* or *525 Programmable Motion Controller Installation and Operation* manual as appropriate.

The Master Axis screen is where you identify the signal source of the Master axis and set up synchronization parameters.

The next step is to define the motion parameters in the Define Motion screen. The first three menu selections; Jog, Homes and Indexes, are explained in the Software Setup and Operation section of the 230V/460V *FX Drives Setup and Programming Operator's Manual* or *525 Programmable Motion Controller Installation and Operation* manual as appropriate. The next two selections, *Master Cycles* and *Follower Cycles*, define the relationship between the Master and Follower axes.

The last step is to create a program (or programs) that use the *Y Execute Follower Cycle* command with other programming functions as logical steps within a program.

The shaded boxes in the PCX menu hierarchy charts, in Figures 14 and 15, show the menus in the that are added or changed in PCX 7 software when a PCM-22 module is employed with an FX drive or 525 PMC.
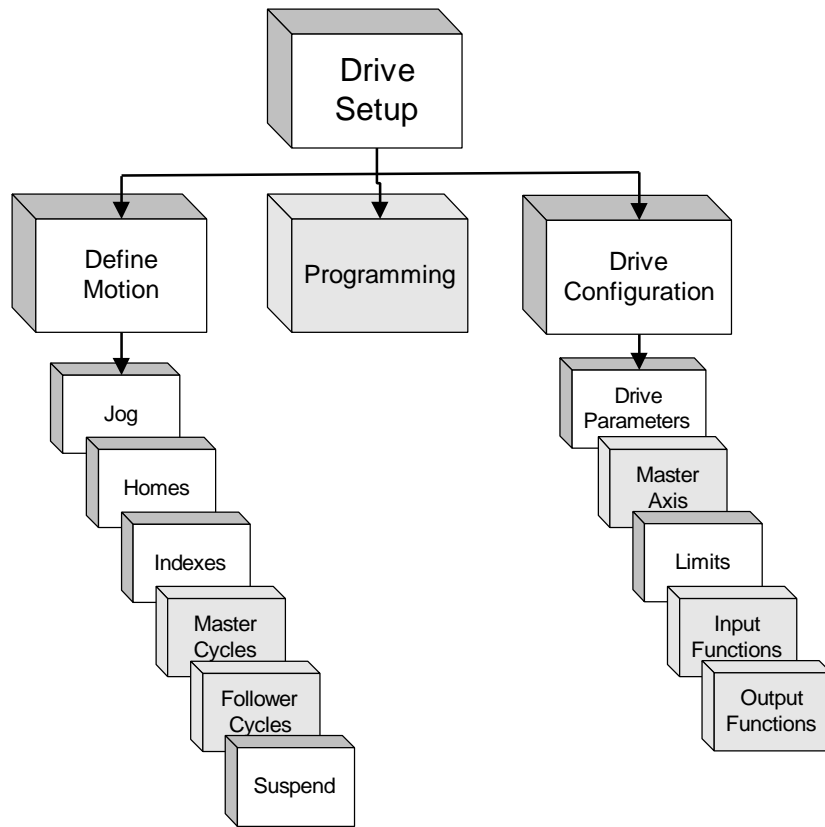
Figure 14   PCX Hierarchy Diagram #1
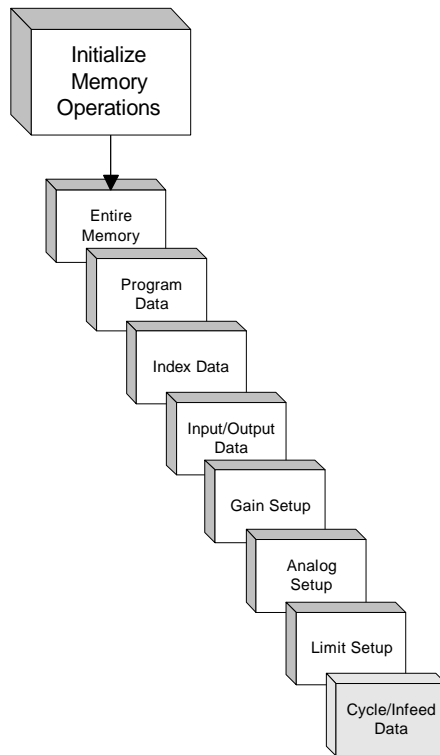
Figure 15   PCX Hierarchy Diagram #2

The PCX features necessary to run a Cycle Profile are listed below in the order in which they should be addressed. Each feature listed must be set up before you use them in a Cycle Profile application.

Individual setup information for each feature is covered on the following pages and in the *230V/460V FX Drives Setup and Programming Operator's Manual* or *525 Programmable Motion Controller Installation and Operation* manual as appropriate.

1. **Drive Parameters:**
   The first step in setting up the PCM-22 is to define the parameters in the Drive Parameters screen. A description of the parameters in this screen can be found in the Software Setup and Operation section of the *230V/460V FX Drives Setup and Programming Operator's Manual* or *525 Programmable Motion Controller Installation and Operation* manual as appropriate. The Drive Parameters screen can be found by selecting *Drive Setup*, *Drive Configuration* then *Drive Parameters* from the PCX menu.

2. **Master Axis (Signal Source):**
   Specify the signal source of the Master axis. In this screen, only the following parameters are used by the PCM-22 when running Cycle Profiles:

   > *Signal Source*
   > *Encoder Count Per Revolution*
   > *User Distance Per Revolution*
   > *Signal Polarity*
   > *Signal Interpretation*
   > *Sync Output Signal from*

   In addition to running Cycle Profiles, the PCM-22 also has the ability to run synchronized Indexes and Homes. This is what the remaining parameters on this screen are used for. The Master Axis screen is found by selecting *Drive Setup*, *Drive Configuration* then *Master Axis* from the PCX menu.

3. **Master Cycle:**
   Define the parameters of the Master Cycle screen. The Master Cycles screen is found by selecting *Drive Setup*, *Define Motion* then *Master Cycles* from the PCX menu.

4. **Follower Cycle:**
   Define the parameters of the Follower Cycle screen. The *Follower Cycles* screen is found by selecting *Drive Setup*, *Define Motion* then *Follower Cycles* from the PCX menu.

5. **Input and Output lines:**
   Assign the input and output functions to the I/O lines on the FX amplifier and the PCM-22 module. There are several input and output functions used specifically for Cycle Profiles. The Input and Output Function screens can be found by selecting *Drive Setup, Drive Configuration* then either *Input Functions* or *Output Functions* from the PCX menu. For a list of basic I/O functions see Input and Output functions in your FX drive or 525 PMC manual. See *Typical Input Assignments* and *Recommended Output Assignments.*

6. **Homes and Indexes:**
   Determine the type of Home or Index reference move and other motion operations as needed. See *Homes and the Follower Zero Position* and *Homes and the Follower Zero Position.*. The Homes and Indexes screens are found by selecting *Drive Setup* then *Define Motion* from the PCX menu.

7. **Cycle Profile Programs:**
   Create a program using the "*Y Execute Cycle Profile*" programming function. The program typically contains motion statements before and after the *Y Execute Follower Cycle* statement.

Master Axis

Description

With synchronized moves, an external Master axis becomes the time base for the motion of the Follower axis (your FX drive equipped with a PCM-22). Operation is determined by the relationship of the Master axis signal source (encoder or upstream drive) to the Follower axis motor.

The Master axis is typically an EMERSON SCS series encoder, upstream drive, EMERSON Master Frequency Generator or a customer supplied encoder of any line density yielding the appropriate steps per revolution.

In this screen, only the following parameters are used by the PCM-22 when running cycle profiles:

> *Signal Source*
> *Encoder Count Per Revolution*
> *User Distance Per Revolution*
> *Signal Polarity*
> *Signal Interpretation*
> *Sync Output Signal from*

In addition to running Cycle Profiles, the PCM-22 also has the ability to run synchronized Homes, Indexes and Jogs. The remaining parameters on this screen are listed below and used for these synchronized operations.

> *Master Maximum Velocity*
>
> *Sync Velocity User Units*
>
> *Sync Velocity Scaling*
>
> *External Mode Override.*

Encoder selection should be based-on the accuracy desired for the application.

For example:
If your encoder delivers 12,000 counts per revolution and the distance per revolution is 12.000 inches, then the distance per count is 0.001 inches.

For highest system performance and accuracy, the number of resolver steps per *Follower Cycle Length* should ideally be no more than two times the number of synchronization steps for the shortest *Master Cycle Length.*

For example:
If the *Follower Cycle Length* is 20,480 resolver steps long, then the shortest a *Master Cycle Length* should be is 10,240 synchronization steps.

Note: If a high mismatch between Follower and Master steps exist, it will cause poor system performance and may cause machine damage.

WARNING!

WARNING!
The maximum Master axis frequency into the PCM-22 module must not exceed 210 kHz (210,000 steps/second).

Master Axis Setup

To set up a relationship between the Master axis and the Follower axis, select the *Master Axis* option from the Drive Configuration screen.

Signal Source

Select the origin of the synchronization (also referred to as "sync") signal (*Drive* or *Encoder*) used for Master axis positional information. When *Drive* is selected, the Follower axis (PCM-22) is receiving its synchronization source from a FX/DX upstream drive, the *Counts Per Revolution* becomes 4096 counts per revolution.

If you select *Drive* for your signal source, the *Encoder Counts Per Revolution* parameter will not appear (shown below).

```
╔══════════════════ Master Axis – 2:FX–340 With PCM–22 ═══════════════10:56:01╗
║                                                                              ║
║                                                                              ║
║   ┌────────────────────────────────────────────────────────────────────┐    ║
║   │ Signal Source ─────────────────────────          Drive              │    ║
║   │    ↳ User Distance Per Revolution ──             4.096 IN           │    ║
║   │    ↳ Signal Polarity ────────────────            –                  │    ║
║   │    ↳ Signal Interpretation ───────────           (comp)+            │    ║
║   │    ↳ Maximum Velocity ─────────────────          200000 steps/sec   │    ║
║   │    ↳ Sync Velocity User Units ────────                              │    ║
║   │    ↳ Sync Velocity Scaling(3000 RPM=)            1.000              │    ║
║   │ Sync Output Signal from ───────────────          Motor              │    ║
║   │ External Mode Override ────────────────          Bipolar Sync       │    ║
║   │    ↳ Bipolar Sync Ratio(Motor) ───────           1.02400           │    ║
║   │                                                                     │    ║
║   └────────────────────────────────────────────────────────────────────┘    ║
║   Use ← or → to select external encoder          Status: External Control   ║
║   counting mode for all external time and        Velocity: 0 RPM            ║
║   distance modes                                 Position: –0.001 IN        ║
║                                                  Enc Pos:  0.000 IN          ║
║      ══════ Press ↑ or ↓ to choose; Enter to select/change; Esc to exit ══  ║
╚══════════════════════════════════════════════════════════════════════════════╝
```

Figure 16   Master Axis Screen for an Upstream Drive

If your Master axis is an *Encoder*, there will be up to seven parameters that you need to set up that pertain to the signal source (see *Master Axis* screen below).

```
╔══════════════════ Master Axis – 2:FX–340 With PCM–22 ═══════════════10:54:09╗
║                                                                              ║
║                                                                              ║
║   ┌────────────────────────────────────────────────────────────────────┐    ║
║   │ Signal Source ─────────────────────────          Encoder            │    ║
║   │    ↳ Encoder Counts Per Revolution──             12000 steps        │    ║
║   │    ↳ User Distance Per Revolution ──             12.000 IN          │    ║
║   │    ↳ Signal Polarity ────────────────            +                  │    ║
║   │    ↳ Signal Interpretation ───────────           (comp)+            │    ║
║   │    ↳ Maximum Velocity ─────────────────          200000 steps/sec   │    ║
║   │    ↳ Sync Velocity User Units ────────                              │    ║
║   │    ↳ Sync Velocity Scaling(3000 RPM=)            1.000              │    ║
║   │ Sync Output Signal from ───────────────          Motor              │    ║
║   │ External Mode Override ────────────────          Bipolar Sync       │    ║
║   │    ↳ Bipolar Sync Ratio(Motor) ───────           1.00000           │    ║
║   │                                                                     │    ║
║   └────────────────────────────────────────────────────────────────────┘    ║
║   Use ← or → to select external encoder          Status: External Control   ║
║   counting mode for all external time and        Velocity: 0 RPM            ║
║   distance modes                                 Position: –0.001 IN        ║
║                                                  Enc Pos:  0.000 IN          ║
║      ══════ Press ↑ or ↓ to choose; Enter to select/change; Esc to exit ══  ║
╚══════════════════════════════════════════════════════════════════════════════╝
```

Figure 17   Master Axis Screen for an Encoder

Encoder Counts Per Revolution

This parameter is not available if the *Signal Source* is set to *Drive.*

The *Encoder Counts Per Revolution* parameter sets the number of encoder steps per revolution of the synchronization encoder. The default value is 4000 steps per revolution. The minimum value is 1 and maximum value is 65,535.

User Distance Per Revolution

The default value for this parameter is 4000 "user units" per revolution of the sync source. See definition of user units in the PCX section of the *230V* and *460V FX Drives Setup and Programming Operator's Manual* or *525 Programmable Motion Controller Installation and Operation* manual as appropriate. The minimum value is 1 and maximum value is 65,535.

Signal Polarity

This feature defines the direction of the synchronization source that corresponds to a positive Master axis 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.

WARNING!
The Signal Source must count upwards for cycle operation. If the count is going the wrong way, change the signal polarity in PCX to correct this.

Figure 18   CW Encoder Rotation.

Signal Interpretation

The signal interpretation feature allows you to define how the Follower reacts to clockwise and counterclockwise motion of the synchronization source.

WARNING!
The *COMP+* mode must be used when running *Follower Cycles* on the PCM-22.

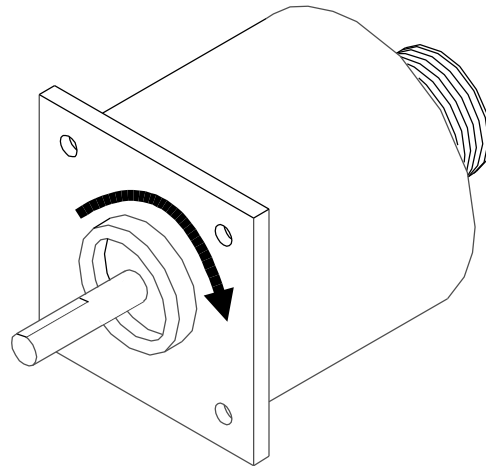The following signal interpretation modes apply to all the synchronization modes of operation.

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.

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, 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.

Maximum Velocity

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:

$$Master\,Max\,Velocity = \frac{(MV)(MS)}{60\,Sec\,/\,Min}$$

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:

$$\frac{(3000\,RPM)(4000\,Steps/Rev)}{60\,Sec\,/\,Min} = 200,000\,Steps\,Per\,Second$$

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.

> ## WARNING!
>
> **The maximum frequency into the PCM-22 module must not exceed 210 kHz (210,000 steps/second).**

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 Equals)

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. For example, when an *Index* is running in sync time base, the velocity is specified in user units.

The default value is 1.000. In this case a setting of 0.500 in an *Index* velocity when in synchronized time means the drive will accel to half of maximum velocity.

Sync Output Signal from

If you select *Motor*, your FX drive will output the sync signal to the next FX drive based on the motion of its own motor. If you select *Upstream Drive*, your FX drive will output the signal that comes from the preceding PCM/Drive. The *Signal Source* of the next FX drive and PCM-22 in the synchronization chain must be set to *Drive* in order to operate with this signal.

Encoder pulses are passed to all amplifiers in the synchronization signal chain. How you answer this question has no effect on the integrity of the encoder signal.

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. This is operable outside of a program only.

There are three modes of operation: *Analog Velocity*, *Analog Torque* and *Bipolar Sync*.

Analog Velocity/Torque

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

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

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

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

Bipolar Sync

When set to Bipolar Sync, this parameter allows for direct movement of the FX drive motor ratioed to the sync encoder. This mode moves the motor shaft in direct response to encoder or drive signals. This means immediate velocity without ramping in your FX drive. If the Master axis accelerates very quickly, your FX drive (Follower axis) will try to follow just as quickly. Too fast an acceleration by the Master axis could result in "F" (Following Error) faults for the Follower axis.

Bipolar Sync Ratio(Motor)

This parameter is the relationship of the *Follower axis* position to the *Master axis* position.

For example:

If you set it to three, for every revolution of the Master axis there will be three revolutions of the Follower axis. Thus, the bipolar sync ratio would be 3:1.

Master Cycles

A *Master Cycle Length* is defined as the distance between successive Master zero positions. The FX drive, with the PCM-22 acting as the Follower axis, will produce one or more cycles of motion for every cycle produced by an independent (Master) axis while maintaining a phase relationship. All values are in user units of the amplifier as defined in the *Drive Parameters* screen (i.e., inch, millimeters, etc.) from the PCX menu.
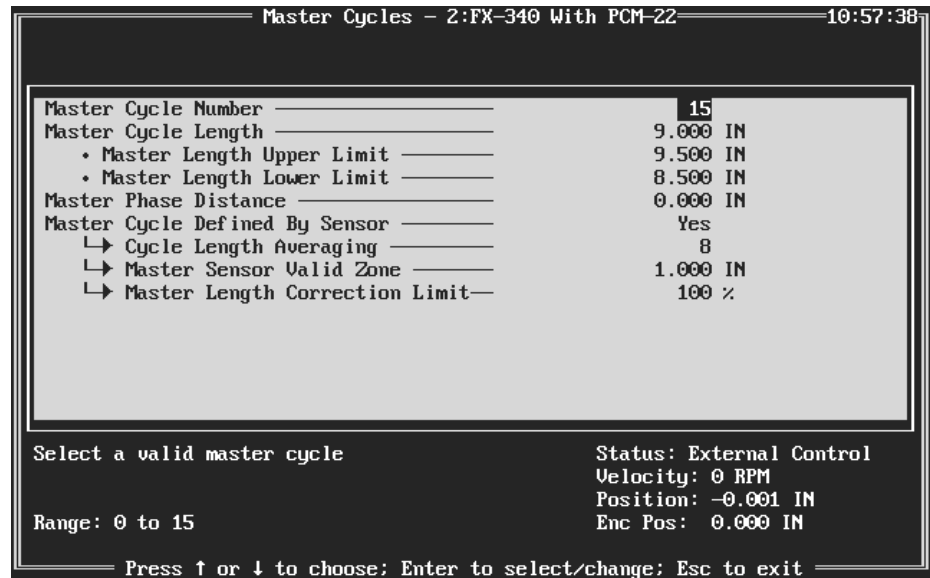
```
╔═════════════════ Master Cycles – 2:FX-340 With PCM-22 ═══════════ 10:57:38 ╗



  ┌─────────────────────────────────────────────────────────────────────┐
  │ Master Cycle Number ──────────────────────────────      15           │
  │ Master Cycle Length ──────────────────────────────    9.000 IN       │
  │    • Master Length Upper Limit ────────────           9.500 IN       │
  │    • Master Length Lower Limit ────────────           8.500 IN       │
  │ Master Phase Distance ─────────────────────           0.000 IN       │
  │ Master Cycle Defined By Sensor ─────────────            Yes          │
  │    ↳ Cycle Length Averaging ──────────────              8            │
  │    ↳ Master Sensor Valid Zone ────────────            1.000 IN       │
  │    ↳ Master Length Correction Limit──────             100 %          │



  └─────────────────────────────────────────────────────────────────────┘

  Select a valid master cycle              Status: External Control
                                           Velocity: 0 RPM
                                           Position: -0.001 IN
  Range: 0 to 15                           Enc Pos:  0.000 IN
  ══════════ Press ↑ or ↓ to choose; Enter to select/change; Esc to exit ═══
```

Figure 19   Master Cycles Screen.

The Master Cycles screen is found by selecting *Drive Setup*, *Define Motion* then *Master Cycles* from the PCX menu.

Note: The Master Cycle must be defined before a Follower Cycle may start. See *Resetting the Master Cycle Processing* for details on Master Cycle definition.

Master Cycle Number

This parameter identifies the *Master Cycle* currently being defined. Up to 16 different Master cycles can be defined (0 to 15). Any *Master Cycle* can be used with any Follower cycle.

Master Cycle Length

The *Master Cycle Length* is used when the Master processing is reset. It is the product length that is used when the Master Cycle Is Not Defined by Sensor.

When the Master Cycle Is Defined by Sensor, the *Master Cycle Length* is used until a valid Master sensor input is received and averaged. The value entered should be the *average* product length. See *Average Length*, *Resetting The Master Processing* and the *FM12* serial command.
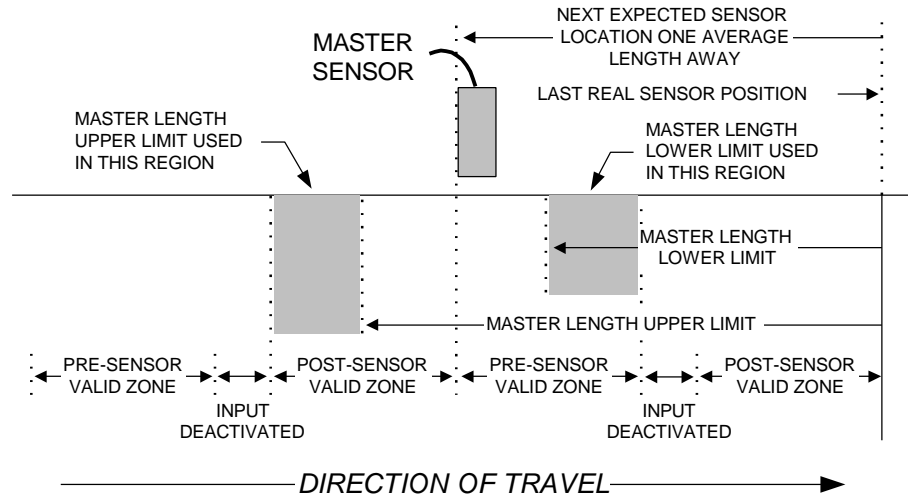
Figure 20   Master Length Upper Limit, Master Length Lower Limit and Master Sensor Valid Zone Operation

Master Length Upper Limit

The *Master Length Upper Limit* performs several functions:

1. It specifies the largest product length that is acceptable

2. When the Master cycle is not defined by sensor, it limits the upper range of I/O and serial adjustments.

3. When the Master cycle is defined by sensor, if the distance traveled since the last *Zero Master Cycle* sensor input exceeds the *Master Length Upper Limit,* the length is considered invalid and is replaced by the *Master Length Upper Limit* value which will be averaged. The *Cycle Limit Reached* (output function 41) is activated until a valid sensor input is received. See Figure 20, *Master Length Lower Limit, Master Sensor Valid Zone* and the *CQ* serial command.

The *Master Length Upper Limit* must be within the *Master Sensor Valid Zone* for proper operation.

Missing Master Sensors

When the Master Cycle is Defined by Sensor and the distance from the last *Zero Master Cycle* sensor input is greater than the 150 percent of *Average Master Length,* the PCM-22 will assume that the Master axis target was missed. If so, the sync position from the last sensor plus the *Average Master Length* will be used. The *Master Sensor Missing* (output function 25) and *Cycle Error* (output function 66) will be activated while the condition is occurring. See the *Master Sensor Missing* output function, Figure 21 and the *CQ* serial command.

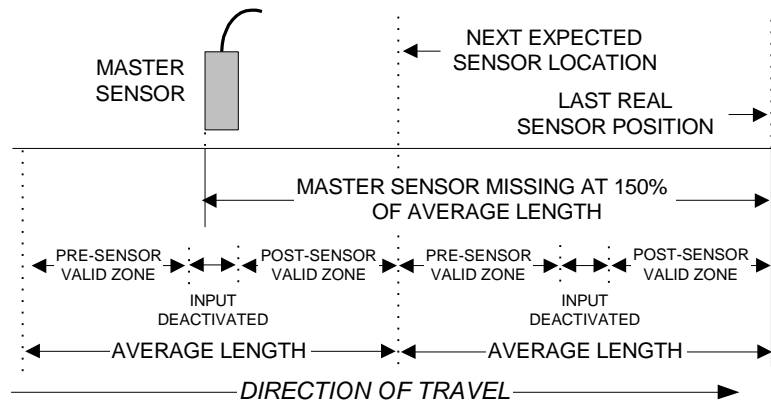| WARNING! |
| --- |
| *Master Sensor Missing* operation is independent of the *Master Sensor Valid Zone.* When this condition occurs, it is possible to get into a situation that sensor targets occur continuously outside the *Master Sensor Valid Zone* and the system will not return to the correct phase. |

Figure 21   Master Sensor Missing Operation

Master Length Lower Limit

The *Master Length Lower Limit* performs several functions:

1. It specifies the shortest product that is acceptable.

2. When the Master cycle is not defined by sensor, it limits the lower range of I/O and serial adjustments.

3. This parameter defines a length which is used to determine that an "extra" sensor has occurred. If a new sensor input measured from the previous input indicates a length less than the *Master Length Lower Limit*, the sensor input is considered invalid and is replaced by the *Master Length Lower Limit* value which will be averaged. The *Extra Master Sensor* (output function 47) and *Cycle Limit Reached* (output function 41) is activated until a valid sensor input is received. See Figure 20, *Master Sensor Valid Zone* and the *CQ* serial command.

4. It limits the largest *Working Segment* allowed to maintain the *Cycle Inter-Relationships*.

WARNING!

The Master Length Lower Limit must be large enough for the PCM-22 Follower axis to be able to perform the next cycle. The PCM-22 needs to be able to reach the velocity required to handle this short product length. See *Operational Timing* and *Maximum Master Velocity*.

The *Master Length Lower Limit* must be within the *Master Sensor Valid Zone* for proper operation.

See *Cycle Inter-Relationships*, *Operational Timing* and *Maximum Master Velocity*.

Note: The Master Length Lower Limit is checked against the Working Segment only when:

- **The Follower cycle is starting.**

- **The Working Segment is adjusted while the Follower cycle is running.**

Master Phase Distance

The *Master Phase Distance* is the distance that determines how far the Master zero position lags behind the Master *Cycle Point.* If the *Master Phase Distance* is longer than the *Average Master Length*, the *Average Master Length* distance will be subtracted from the *Master Phase Distance* until the remaining distance is between zero and the *Average Master Length.* This remaining distance is used as the phase relationship between the Master and Follower axes. The minimum *Master Phase Distance* is zero. See *Terminology* and *FM12* serial command.

Master Phase Distance Adjustment

If the desired *Cycle Point* is at a position other than the registration mark, the *Master Phase Distance* parameter is used to move the *Cycle Point* . Increase the *Master Sensor Distance* to move the *Cycle Point* before the start of the product; decrease the *Master Sensor Distance* to move the *Cycle Point* after the product registration mark.

The *Master Phase Distance* may be adjusted serially or by using *Sensor Dist. Increment* and *Sensor Dist. Decrement (*input functions 72 and 73 respectively) while in cycle.

Master Cycle Defined By Sensor

This parameter determines if the product position is defined by a sensor input "Yes", or if not defined by a sensor "No".

Master Cycle Defined By Sensor - "No"

If "No" is entered, the *Master Cycle Length* entered using PCX will be executed. The *Zero Master Cycle* input must be activated once to define the Master zero position. Once the Master zero position has been set the master axis length is determined by encoder counts only.

Master Cycle Defined By Sensor - "Yes"

If "Yes" is entered, the Master cycle will be defined by a sensor on the *Zero Master Cycle* input line. The sensor will then be used to determine the beginning of each Master cycle. The synchronization source will provide positional information of the *Master Cycle Length* along with the sensor input to compensate for length and phase variations. See *Average Length* and *Maximizing Profile Performance.*

Note: **Typically if the Master cycle is defined by sensor then the Follower should also be defined by sensor for the greatest accuracy.**

Cycle Length Averaging

This parameter determines how much the new measured length affects the current operational Master Length. The lower the average, the faster length errors are corrected for. The higher the *Cycle Length Averaging* value, the more it will filter out sensor and machine anomalies.

Setting this value lower will adversely affect the drives ability to quickly correct for phase errors. If it is too low, it will cause the system to over compensate and "hunt" or wander around the Cycle Point. If the averaging is set too high, it will cause the Follower motion to be sluggish in response to changes in the Master axis.

The Master Sensor Averaging should never be less than two except for diagnostic reasons. The range is from 1 to 8. See *Average Length*, the *FM12* serial command and *Maximizing Profile Performance*.

Master Sensor Valid Zone

This parameter defines a window (+ or -) around the expected Master zero position. It is only within the *Master Sensor Valid Zone* range that a *Zero Master Cycle* sensor input signal is considered valid.

This is useful in applications where registration marks are printed in the same path as other printing (such as advertising, logos, instructions, etc.). The amplifier will ignore all inputs except those which appear within the *Master Sensor Valid Zone*. See Figures 20, 21 and the *CQ* serial command.

The *Master Sensor Valid Zone* must encompass both the *Master Length Upper Limit* and the *Master Length Lower Limit* positions for proper operation.

For example:

If the user enters ±10 mm here, any input signal which   occurs > 10 mm before or after the expected *Zero Master Cycle* sensor input will be ignored.

Master Length Correction Limit

The *Master Length Correction Limit* is used to reduce the amount of *Master Length Variation* corrected during each Master cycle.

When an input is received from the *Zero Master Cycle* sensor input and a difference is found to exist between the *Current Average Master Length* and the length determined by the new sensor input, the PCM-22 corrects for a percentage of that difference in the next Master cycle.

Length Variation = (New Average Length - Current Average Length) * Length Correction Limit

This parameter does not filter the length changes due to sensor inputs. It only limits the rate at which length errors are corrected for, similar to a gain. When operating at high line speeds, rapid corrections for length errors may be undesirable especially with high inertial loads. This parameter would be used to slow the rate of correction of the length errors and allow smoother operation. Small amounts of variation are normal. The effects of adjusting this parameter are more noticeable at higher speeds. The range is from 0 to 100 percent. See *Average Length,* the *FM9* serial command and *Maximizing Profile Performance.*

For example:

If you entered 90 percent here, and the variation was 0.010 inch between consecutive Master cycles, the PCM would correct 90 percent (or 0.009 inches) of the variation to correct the *Master Length* in the next Master cycle.

Follower Cycles

A *Follower Cycle Length* is the distance between successive Follower zero positions. The PCM-22 allows the drive to position and maintain a phase relationship of its motor to an independent axis. The FX drive, with the PCM-22 acting as the Follower axis, will produce one or more cycles of motion for every cycle produced by the Master axis.
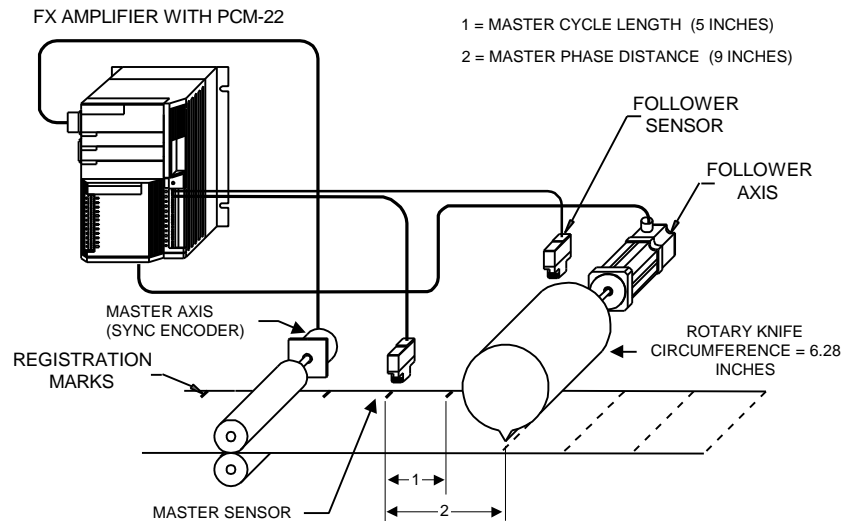

Figure 22   System Example

The system example above shows a flat product (such as paper or plastic) that moves through a set of pinch rollers which feeds back Master axis positional information to the PCM-22 using an encoder. The Master (registration) sensor allows the PCM-22 to reference the registration marks on the product in relation to the *Cycle Point.* Similarly the Follower sensor provides reference information for the Follower axis using a registration mark on the rotary knife and the motor provides feedback information of the Follower axis' position. In this example, the *Cycle Point* will be directly on the registration mark and there would be one Follower cycle completed for every Master cycle.

Note: Typically, the Zero Follower Cycle sensor would also be used as a Home Sensor (0 or 1) for the Follower axis. These input functions (15 or 40 and 45) would be assigned to the same FX input line (1 or 2).
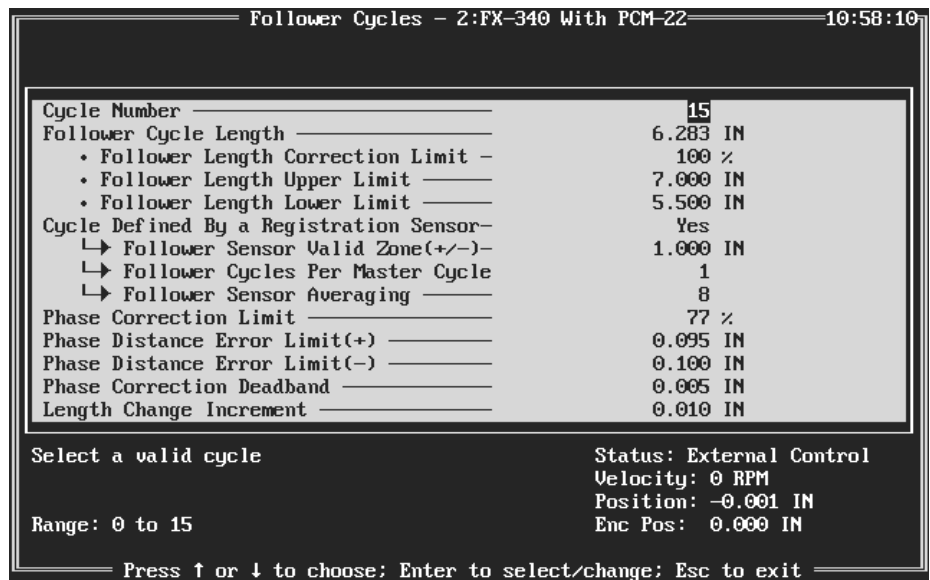
```
╒════════════════ Follower Cycles - 2:FX-340 With PCM-22═══════════10:58:10╕
│                                                                          │
│ ┌──────────────────────────────────────────────────────────────────────┐│
│ │ Cycle Number ─────────────────────────────────     15                 ││
│ │ Follower Cycle Length ────────────────────────    6.283 IN            ││
│ │   • Follower Length Correction Limit ─            100 %               ││
│ │   • Follower Length Upper Limit ───────────       7.000 IN            ││
│ │   • Follower Length Lower Limit ───────────       5.500 IN            ││
│ │ Cycle Defined By a Registration Sensor─            Yes                ││
│ │   ↳ Follower Sensor Valid Zone(+/-)─              1.000 IN            ││
│ │   ↳ Follower Cycles Per Master Cycle               1                 ││
│ │   ↳ Follower Sensor Averaging ───────              8                 ││
│ │ Phase Correction Limit ───────────────────        77 %               ││
│ │ Phase Distance Error Limit(+) ────────────        0.095 IN           ││
│ │ Phase Distance Error Limit(-) ────────────        0.100 IN           ││
│ │ Phase Correction Deadband ────────────────        0.005 IN           ││
│ │ Length Change Increment ──────────────────        0.010 IN           ││
│ └──────────────────────────────────────────────────────────────────────┘│
│ Select a valid cycle                      Status: External Control       │
│                                           Velocity: 0 RPM                 │
│                                           Position: -0.001 IN             │
│ Range: 0 to 15                            Enc Pos:  0.000 IN              │
│                                                                          │
╞══════════ Press ↑ or ↓ to choose; Enter to select/change; Esc to exit ═══╡
```

Figure 23   Follower Cycles Screen up to Length Change Increment

The Follower Cycles screen is found by selecting *Drive Setup, Define Motion* then *Follower Cycles* from the PCX menu. In this screen additional parameters appear when you reach the bottom of the screen using the down arrow, page down or Enter keys.

All values are in the user units of the amplifier (i.e., inch, millimeters, etc.) unless noted differently.

Cycle Number

This parameter identifies the *Follower Cycle* currently being defined. Up to 16 different Follower cycles can be defined (0 to 15).

Follower Cycle Length

The *Follower Cycle Length* (also called the *Follower Length*) is the distance in user units that the Follower axis moves in order to complete one cycle of motion.

Follower Length Correction Limit

This parameter only applies if the Follower cycle is defined by sensor.

The *Follower Length Correction Limit* is used to reduce the amount of Follower Length Variation corrected during each Follower cycle.

When an input is received from the *Zero Follower Cycle* sensor input and a difference is found to exist between the current average Follower length and the length determined by the new sensor input, the PCM-22 corrects for a percentage of that difference in the next Follower cycle.

Length Variation = (New Average Length - Current Average Length) * Length Correction Limit

This parameter does not filter the length changes due to sensor inputs. It only limits the rate at which length errors are corrected for, similar to a gain. When operating at high line speeds rapid corrections for length errors may be undesirable especially with high inertial loads. This parameter would be used to slow the rate of correction of the length

errors and allow smoother operation. Small amounts of variation are normal. The effects of adjusting this parameter are more noticeable at higher speeds. The range is from 0 to 100 percent. See *Average Length,* the *FM10* serial command and *Maximizing Profile Performance.*

For example:
If you entered 90 percent here, and the variation was 0.010 inch between consecutive Follower cycles, the PCM would correct 90 percent (or 0.009 inches) of the variation to correct the *Follower Length* in the next Follower cycle.
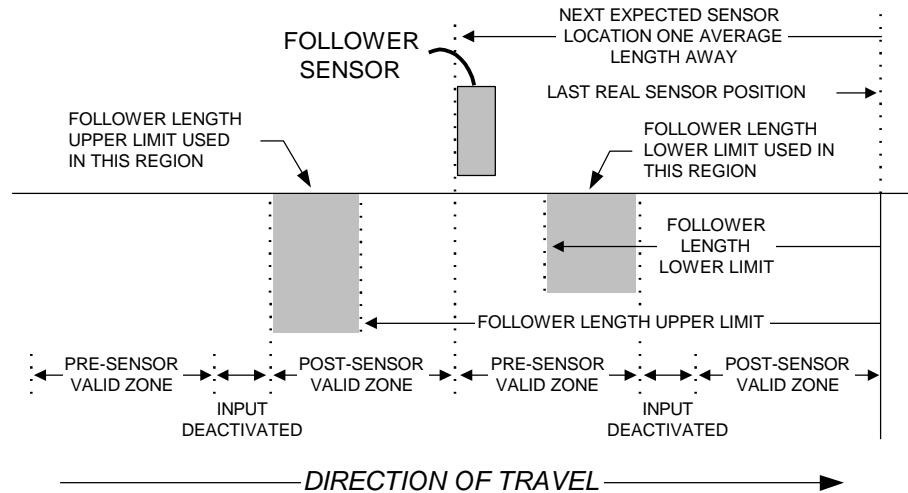
Figure 24   Follower Length Upper Limit, Follower Length Lower Limit and Follower Sensor Valid Zone Operation

Follower Length Upper Limit

The *Follower Length Upper Limit* performs several functions:

1. It specifies the largest product length that is acceptable.

2. When the Follower cycle is not Defined By a Registration Sensor, it limits the upper range of I/O and serial adjustments.

3. When the Follower cycle is Defined By a Registration Sensor, if the distance traveled since the last *Zero Follower Cycle* sensor input exceeds the *Follower Length Upper Limit,* the length is considered invalid and is replaced by the *Follower Length Upper Limit* value which will be averaged. The *Cycle Limit Reached* (output function 41) is activated until a valid sensor input is received. See Figure 24, *Follower Length Lower Limit, Follower Sensor Valid Zone* and the *CQ* serial command.

Note: The Follower Length Upper Limit must be within the Follower Sensor Valid Zone for proper operation.

Missing Follower Sensors

When the Follower Cycle is Defined By a Registration Sensor and the distance from the last *Zero Follower Cycle* sensor input is greater than the 150 percent of *Average Follower Length,* the PCM-22 will assume that the Follower axis target was missed. If so, the sync position from the last sensor plus the *Average Follower Length* will be used. The *Follower Sensor Missing* (output function 26) and *Cycle Error* (output function 66)

will be activated while the condition is occurring. See the *Follower Sensor Missing* output function, Figure 25 and the *CQ* serial command.

WARNING!

Follower Sensor Missing **operation is independent of the** *Follower Sensor Valid Zone***. When this condition occurs, it is possible to get into a situation that sensor targets occur continuously outside the** *Follower Sensor Valid Zone* **and the system will not return to the correct phase.**
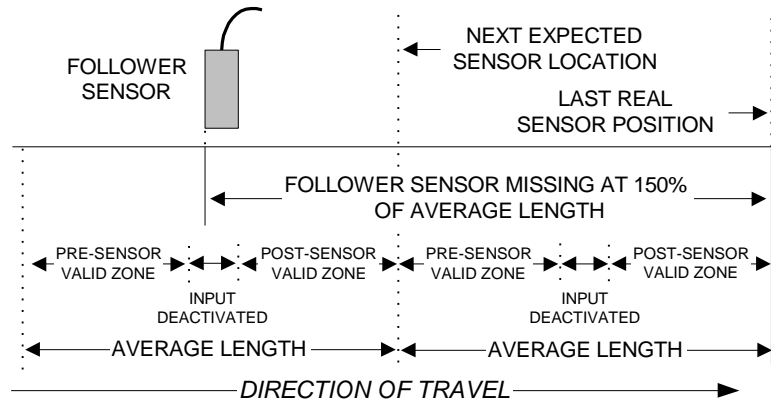

Figure 25   Follower Sensor Missing Operation

Follower Length Lower Limit

The *Follower Length Lower Limit* performs several functions:

1. It specifies the smallest product length that is acceptable.

2. When the Follower cycle is not Defined By a Registration Sensor, it limits the lower range of I/O and serial adjustments.

3. When the Follower cycle is Defined By a Registration Sensor, if the distance traveled since the last *Zero Follower Cycle* sensor input is less than the *Follower Length Lower Limit,* the length is considered invalid and is replaced by the *Follower Length Lower Limit* value which will be averaged. The *Cycle Limit Reached* (output function 41) is activated until a valid sensor input is received. See Figure 24, *Follower Length Upper Limit, Follower Sensor Valid Zone* and the *CQ* serial command.

Note: The Follower Length Lower Limit must be within the Follower Sensor Valid Zone for proper operation.

If a *Zero Follower Cycle* input occurs early within the *Follower Sensor Valid Zone,* and the distance traveled since the last sensor is less than 50 percent of the *Average Follower Length,* the sensor input is considered invalid and is ignored. See Figure 24, *Average Length* and the *CQ* serial command.

Cycle Defined By a Registration Sensor

This parameter determines if the *Follower Length* and position are defined by *Zero Follower Cycle* sensor inputs "Yes", or if not Defined By a Registration sensor "No".

Cycle Defined By a Registration Sensor - No

If "No" is selected, the Follower zero position reference must be set once before starting the cycle by executing an *Index* or *Home* move.

Cycle Defined By a Registration Sensor - Yes

If "Yes" is selected, the Follower zero position will constantly be updated by an external sensor using the *Zero Follower Cycle* input function 46. The following parameter fields will be used to control how the Follower cycle motion is adjusted by the sensor information.

Note: **The Follower must be at the *Zero Follower Cycle* input position before starting the cycle by executing an *Index* or *Home* move.**

Follower Sensor Valid Zone (+/-)

This parameter defines a window (+ or -) around the expected Follower zero position. It is only within the *Follower Sensor Valid Zone* range that a *Zero Follower Cycle* sensor input signal is considered valid.

This is useful in applications where the follower sensor may detect something other than the target on the Follower axis such as another portion of the machine. The amplifier will ignore all inputs except those which appear within the *Follower Sensor Valid Zone*. See Figure 24 and the *CQ* serial command.

Note: **The Follower Sensor Valid Zone must encompass both the Follower Length Upper Limit and the Follower Length Lower Limit positions for proper operation.**

For example:
If the user enters ±10 mm here, any input signal which occurs > 10 mm before or after the expected *Zero Follower Cycle* sensor input will be ignored.

Follower Cycles Per Master Cycle

This parameter sets the number of Follower cycles which occur between two successive Master zero positions. The *Follower Cycle Length* entered should be the average distance between Follower sensor inputs. The average *Master Cycle Length* is divided by this value for the running *Master Cycle Length*. The *Working Segment* and *Working Offset* use the *Average Follower Cycle Length*.

This value may be changed only outside of a cycle. The range is from 1 to 127. See *Cycle Inter-Relationships, FM12, FM13, FN1* serial command*s* and *Terminology.*

Follower Sensor Averaging

This parameter determines how much the new measured length affects the current operational *Follower Length.* The lower the average, the faster length errors are corrected for. It will also filter out sensor and machine anomalies.

Setting this value lower will adversely affect the drives ability to quickly correct for phase errors. If it is too low, it will cause the system to over compensate and "hunt" or wander around the *Cycle Point.* If the averaging is set too high, it will cause the Follower motion to be sluggish in response to changes in the Follower axis.

The *Follower Sensor Averaging* should never be less than two except for diagnostic reasons. The range is from 1 to 8. See *Average Length,* the *FM13* serial command and *Maximizing Profile Performance.*

Phase Correction Limit

This parameter only applies if the *Master Cycle* and / or *Follower Cycle* is Defined By a Registration Sensor.

When an input is received from either the *Zero Master Cycle* or *Zero Follower Cycle* sensor and a difference is found to exist between the corresponding *Average Length* and the length determined by the new *Zero Master Cycle* or *Zero Follower Cycle* sensor input (i.e., the measured length). The PCM-22 uses a percentage of that difference to correct for the phase variation in the next corresponding Master or Follower cycle.

The *Phase Correction Limit* is used to limit the rate at which phase variations are corrected for in the next cycle and allow for smoother operation. It is similar to a gain and is used to slow the rate of correction for Follower phase variations and allow smoother operation. Small amounts of Follower phase variation are normal.

Phase Variation = (Measured Length - Average Length) * Phase Correction Limit

The effects of adjusting this parameter are more noticeable at higher speeds. When operating at high line speeds, rapid corrections for phase variation are usually undesirable especially with high inertial loads.

The range is from 0 to 100 percent. See *Maximizing Profile Performance.*

Phase Distance Error Limit (+)

This parameter designates a maximum positive phase variation from the *Cycle Point.* The total phase variation is the sum of Master phase variation and Follower phase variation. When the total phase variation is above this value, the Phase Distance Error Limit output function 44 will activate and it's complement, the *In Phase* output function 24, will deactivate. Exceeding this limit will not stop the Follower axis, however, you may employ this output with outside logic to generate an appropriate action. See *Maximizing Profile Performance,* the *FM7* and *FM8* serial command*s.*

Phase Distance Error Limit (-)

This parameter is identical to phase distance error limit (+), except that it detects a negative deviation from the *Master Phase Distance* or *Working Offset.* See *Maximizing Profile Performance,* the *FM7* and *FM8* serial command*s.*

Phase Correction Deadband

This is a +/- value. If the phase variation is outside this range, it will be corrected for. The phase variation will be ignored if it is within this range.

This is important because even small corrections can affect consistency at higher speeds. See *Phase Correction Limits, Maximum Master Velocity*, and *Maximizing Profile Performance.*
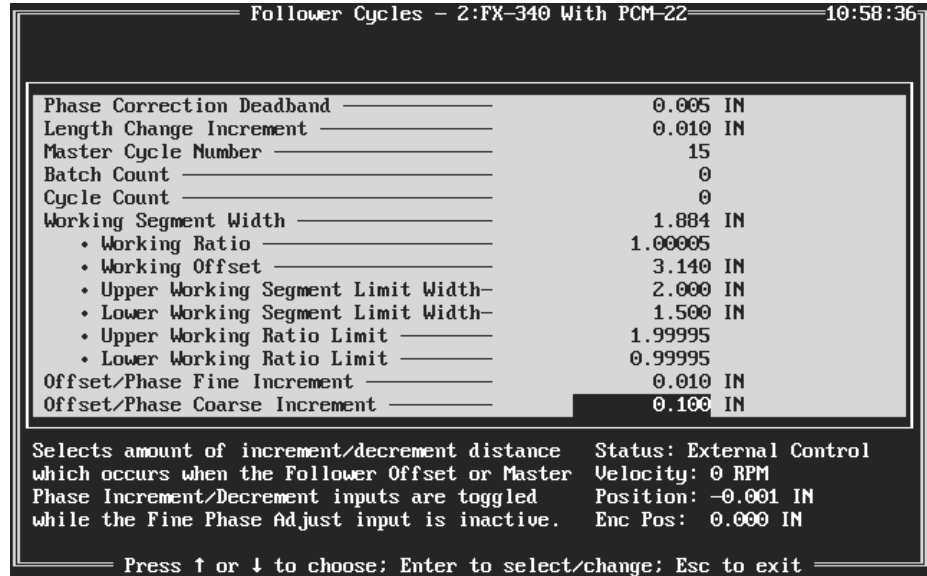


```
══════════════ Follower Cycles - 2:FX-340 With PCM-22 ══════════ 10:58:36



  Phase Correction Deadband ─────────────         0.005 IN
  Length Change Increment ───────────────         0.010 IN
  Master Cycle Number ───────────────                 15
  Batch Count ───────────────────────                  0
  Cycle Count ───────────────────────                  0
  Working Segment Width ─────────────────         1.884 IN
    • Working Ratio ─────────────────────       1.00005
    • Working Offset ────────────────────         3.140 IN
    • Upper Working Segment Limit Width─           2.000 IN
    • Lower Working Segment Limit Width─           1.500 IN
    • Upper Working Ratio Limit ─────────       1.99995
    • Lower Working Ratio Limit ─────────       0.99995
  Offset/Phase Fine Increment ───────────         0.010 IN
  Offset/Phase Coarse Increment ─────────         0.100 IN

  Selects amount of increment/decrement distance    Status: External Control
  which occurs when the Follower Offset or Master    Velocity: 0 RPM
  Phase Increment/Decrement inputs are toggled       Position: -0.001 IN
  while the Fine Phase Adjust input is inactive.     Enc Pos:  0.000 IN
═══════════ Press ↑ or ↓ to choose; Enter to select/change; Esc to exit ═══════
```

Figure 26   Remaining Follower Cycles Screen Parameters

Length Change Increment

This parameter selects the amount of distance incremented or decremented when the *Follower Length Increment* or *Follower Length Decrement,* input functions 66 and 67 respectively, are toggled. The *Length Change Increment* is also the value used when *Working Segment Increase* or *Working Segment Decrease,* input functions 70 and 71 respectively, are toggled.

This parameter is only valid when the Follower cycle is not defined by a registration sensor.

Master Cycle Number

Designates which *Master Cycle* this *Follower Cycle* will be associated with. Each *Follower Cycle* requires a *Master Cycle* to be selected. Any *Master Cycle* may be used with any *Follower Cycle*. The same *Master Cycle* can be used for all 16 *Follower Cycles*. See *Resetting the Master Processing.*

Batch Count

This parameter is used in conjunction with the *Batch Count Reached* output function 43. The *Batch Count Reached* output becomes active when the programmed *Batch Count* is reached.

The batch count is incremented automatically when the cycle counter reaches the programmed cycle count.

When the batch counter reaches the programmed batch count, the *Batch Count Reached* output is activated and the batch counter is cleared. The output will be de-activated automatically on the next *Cycle Count.* The batch counter may also be cleared by the *Reset Batch Counter* input function 75. The range is 0 to 2,147,483,648.

Cycle Count

This parameter is used in conjunction with the *Cycle Count Reached* output function 42. See *Batch Count.*

The cycle counter is incremented each time a cycle is completed unless the *Cycle Counter Hold* input function 76 is active. When the cycle counter reaches the programmed cycle count, the batch counter is incremented and the cycle counter is cleared. The *Cycle Count Reached* output is cleared when the next cycle is completed. The cycle counter and *Cycle Count Reached* output may also be cleared by the *Reset Cycle Counter* input function 74. The range is 0 to 2,147,483,648. See the *FF and KC4* serial command*s.*

Working Segment Width

This is also called the *Working Segment.* This parameter is the distance that the Follower moves at the *Working Ratio.* The position of this segment is centered around the *Cycle Point* which is determined by the *Working Offset.* See Figure 27.
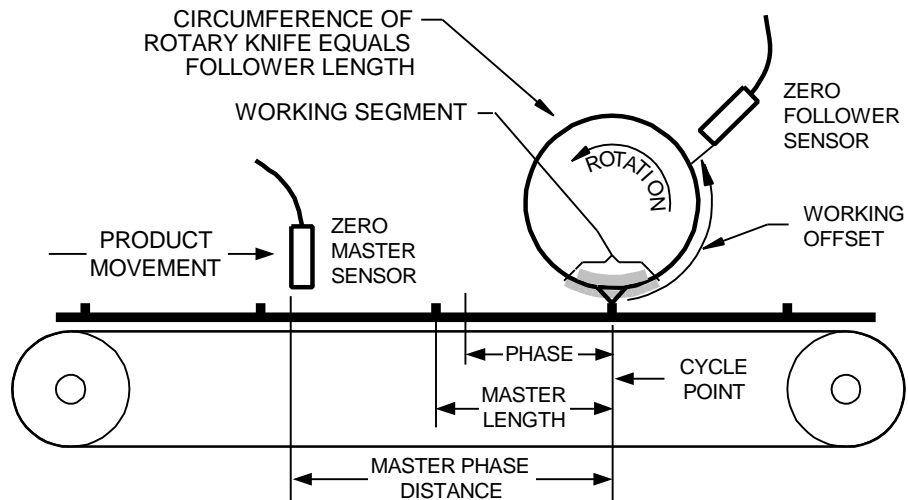
Figure 27   Typical Rotary Knife System Component Locations

A good starting point is to set the *Working Segment* at 30 percent of the shorter of the Master length or Follower length.

It should be kept between 15 percent and 65 percent of the shorter of the Master or Follower length.

For example:

The Master length is 10 inches and the Follower length is 5 inches. The Follower axis is in contact with the material for 0.5 inches. This may be too short of a *Working Segment* for many systems to perform a good operation on the material. A better choice to start at would be 30 percent of the Follower length, which is 1.5 inches, for a *Working Segment.*

The largest *Working Segment* value allowed is:

$$\text{Working Segment} \geq \frac{\text{Master Length Lower Limit}}{\text{Working Ratio}}$$

See Figures 4, 5 and *Cycle Inter-Relationships.*

Note: **The Working Segment may need to be reduced, the product speed reduced or the Working Ratio may need to be increased if there is a significant inertial load mismatch on the motor.**

Working Ratio

This parameter is the Follower velocity to Master velocity ratio during the *Working Segment.* The range is 0 to 9.99999.

For example:

If the Follower axis is to move the same speed as the material while it is in the *Working Segment* and in contact with the material, then the *Working Ratio* would be 1.00000. This is common in many applications.

If the Follower axis is to move 1.5 percent faster than the material during the *Working Segment* to increase the efficiency of the cut, then the *Working Ratio* would be 1.01500.

See *Cycle Inter-Relationships* and Figures 6 and 27.

Working Offset

This parameter sets the distance from the *Cycle Point* to the Follower zero position. When the Follower cycle is started, the Follower is assumed to be at the Follower zero position.

If the Follower zero position falls within the programmed *Working Segment*, the cycle will not execute.

See *Starting a Follower Cycle, Homes and the Follower Zero Position, Cycle Inter-Relationships* and Figures 6 and 27.

Upper Working Segment Limit Width

This parameter determines the maximum length of the *Working Segment.*

Lower Working Segment Limit Width

This parameter determines the minimum length of the *Working Segment.*

Upper Working Ratio Limit

This parameter determines the maximum *Working Ratio.*

Lower Working Ratio Limit

This parameter determines the minimum *Working Ratio.*

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Offset/Phase Fine Increment

This parameter is the amount of adjustment which occurs in the next cycle when the *Working Offset Increment* / *Working Offset Decrement* or *Master Phase Increment* / *Master Phase Decrement*, input functions 68, 69, 72 and 73 respectively, are toggled while the *Phase Fine Inc Select* input function 77 is active.

Offset/Phase Coarse Increment

This parameter is the amount of adjustment which occurs in the next cycle when the *Working Offset Increment* / *Working Offset Decrement* or *Master Phase Increment* / *Master Phase Decrement*, input functions 68, 69, 72 and 73 respectively, are toggled while the *Phase Fine Inc Select* input function 77 is not active.

Input Functions

On the Input Functions screen, the left-hand column (Input Assignments) of numbers corresponds directly to the input lines on the drive. The next column (Function) lists all of the input functions available and shows which input line each function is assigned to on the drive. Any functions assigned to Line Zero are inactive. In cases where two or more functions are assigned to the same input line, those functions will appear on the same line in the left column.

Most of the input functions are discussed in the 230V FX Drives Setup and Programming Operator's Manual (P/N 400282-00), 460V FX Drives Setup and Programming Operator's Manual (P/N 400310-00) or 525 Programmable Motion Controller Installation and Operation Manual (P/N 400276-01) as appropriate. The input functions which are specific to the PCM-22 are discussed in this section.

Figure 28   Input Functions Screen

To assign an input function, use the up/down arrows to move the cursor to the desired input function, type in the desired line number and then press Enter. The left hand window will then show the function beside the selected input line. If you wish to access a function that is off the screen, press the up/down arrow key or page down until the cursor is on the desired function. The screen will scroll as needed.

When an input line is activated, the corresponding input line on the PCX screen will be highlighted. This may be useful when setting up or testing the drive inputs.

Inputs require an external voltage source for operation. This voltage source must be in the range of 10.5 to 30 VDC.

Description of Input Functions

45	Zero Master Cycle

This edge triggered input function is used to establish the executing Master cycle's zero position. If the *Master Cycle* is Defined By Sensor, it allows the PCM-22 to sense and refine the *Master Cycle Length* and phase position. See *Master Length Upper Limit, Master Length Lower Limit* and *Master Sensor Valid Zone.*

Note: **1) This input must be assigned to one of the high speed input lines (1 or 2) and not the same input line as the *Zero Follower Cycle*.**

2) Do not assign filtering to this function.

46	Zero Follower Cycle

This edge triggered input function is used only if the Follower cycle is Defined By Registration Sensor. It establishes the executing Follower cycles' zero position. It also allows the PCM-22 to sense and refine the *Follower Cycle Length* and phase position. See *Follower Length Upper Limit, Follower Length Lower Limit* and *Follower Sensor Valid Zone.*

Note: **1) This input must be assigned to one of the high speed input lines (1 or 2) and not the same input line as the *Zero Master Cycle*.**

2) Do not assign filtering to this function.

49	Cycle Drop Out

When this input function is activated before the *Cycle Point*, the Follower will complete the current *Working Segment* then decelerate at a calculated rate until it's stopped at the *Cycle Drop Out Position.* If the Master axis stops before this occurs the Follower axis will also stop.

When *Cycle Drop Out* is used, the Master axis will travel approximately the following distance before the Follower is stopped:

$$\text{Average Master Length} + \left(\frac{\left(\text{Follower Cycle Length} \ / \ 2 \right)}{\text{Working Ratio}} \right)$$

If the *Cycle Drop Out* input function is deactivated *before* the Follower has reached the *Cycle Drop Out Position*, then the Follower will begin to accelerate to the next *Cycle Point,* similar to starting a cycle. See *Starting A Follower Cycle.*

If the *Cycle Drop Out* input function is active when a Follower cycle is started, the Follower axis will not move until the input is deactivated. Since the Follower cycle did not start, it is not at the *Cycle Drop Out* position, therefore the *Cycle Dropped Out* output function 71 will not activate.

64	**Master Length Increment**

This edge triggered input function increments the *Master Cycle Length* by the *Length Change Increment* value each time an input signal is received. It is checked against the *Master Length Upper Limit* and the *Cycle Inter-Relationships*. It is not functional if the Master cycle is defined by sensor. See *Cycle Inter-Relationships, Master Cycles* screen and the *PH4* serial command.

65	**Master Length Decrement**

This edge triggered input function decrements the *Master Cycle Length* by the *Length Change Increment* value each time an input signal is received. It is checked against the *Master Length Lower Limit* and the *Cycle Inter-Relationships*. It is not functional if the Master cycle is defined by sensor. See *Cycle Inter-Relationships, Master Cycles* screen and the *PH4* serial command.

66	**Follower Length Increment**

This edge triggered input function increments the *Follower Cycle Length* by the *Length Change Increment* value each time an input signal is received. It is checked against the *Follower Length Upper Limit* and the *Cycle Inter-Relationships*. It is not functional if the Follower cycle is Defined By a Registration Sensor. See *Cycle Inter-Relationships, Follower Cycles* screen and the *PH4* serial command.

67	**Follower Length Decrement**

This edge triggered input function decrements the *Follower Cycle Length* by the *Length Change Increment* value each time an input signal is received. It is checked against the *Follower Length Lower Limit* and the *Cycle Inter-Relationships*. It is not functional if the Follower cycle is Defined By a Registration Sensor. See *Cycle Inter-Relationships, Follower Cycles* screen and the *PH4* serial command.

68	**Working Offset Increment**

This edge triggered input function increments the *Working Segment Offset* value by the *Offset/Phase Coarse Increment* or *Offset/Phase Fine Increment* value as appropriate each time an input signal is received.

It is checked against the *Cycle Inter-Relationships*. See *Cycle Inter-Relationships, Follower Cycles* screen and the *PH4* serial command.

69	**Working Offset Decrement**

This edge triggered input function decrements the *Working Segment Offset* value by the *Offset/Phase Coarse Increment* or *Offset/Phase Fine Increment* value as appropriate each time an input signal is received.

It is checked against the *Cycle Inter-Relationships*. See *Cycle Inter-Relationships, Follower Cycles* screen and the *PH4* serial command.

70   Working Segment Increase

This edge triggered input function increments the *Working Segment* value by the *Length Change Increment* value each time an input signal is received. It is checked against the *Upper Working Segment Limit* and the *Cycle Inter-Relationships*. See *Cycle Inter-Relationships, Follower Cycles* screen and the *PH4* serial command.

71   Working Segment Decrease

This edge triggered input function decrements the *Working Segment* value by the *Length Change Increment* value each time an input signal is received. It is checked against the *Lower Working Segment Limit* and the *Cycle Inter-Relationships*. See *Cycle Inter-Relationships, Follower Cycles* screen and the *PH4* serial command.

72   Master Phase Increment

This edge triggered input function increments the *Master Phase Distance* value by the *Offset/Phase Coarse Increment* or *Offset/Phase Fine Increment* value as appropriate each time an input signal is received. It is only functional when in a cycle. See the *Master Cycles* screen, the *Follower Cycles* screen and *PH4* serial command.

73   Master Phase Decrement

This edge triggered input function decrements the *Master Phase Distance* by the *Offset/Phase Coarse Increment* or *Offset/Phase Fine Increment* value as appropriate each time an input signal is received. It is only functional when in a cycle. See the *Master Cycles* screen, the *Follower Cycles* screen and *PH4* serial command.

74   Reset Cycle Counter

This input is used to reset the cycle counter. It is only functional when in a cycle. See the *Follower Cycles* screen.

75   Reset Batch Counter

This input is used to reset the batch counter. It is only functional when in a cycle. See the *Follower Cycles* screen.

76   Cycle Counter Hold

This input is used to temporarily stop the cycle counter from counting. It is only functional when in a cycle. See the *Follower Cycles* screen.

77   Phase Fine Inc Select

This input is used to toggle between fine and coarse increment settings. When this input is active all adjustments made to the *Master Phase Distance* and the *Working Offset* using inputs will be made using the *Offset/Phase Fine Increment* value. When not active, the *Offset/Phase Coarse Increment* value will be used. It is only functional when a cycle a cycle is operating. See the *Master Cycles* screen, the *Follower Cycles* screen and the *PH4* serial command.

115	Reset Master

Performs the same function as the *Force Reset Master Processing* flag described in the FF command. It is intended for troubleshooting purposes.

Note: ***Resetting the Master Cycle Processing*** **will only occur when a Follower Cycle is not executing and the Follower axis is not moving.**

116	Cycle Exit

Upon activation of this input function, the Follower will complete the current cycle. When it has reached the end of the Working Segment, the cycle will exit at the Working Segment velocity (see Working Ratio) and execute the next step in the PCX program. After exiting the cycle, all program steps are allowed except *Dwell* immediately following the *Y Execute Follower Cycle statement. Dwell* requires that the Follower axis be at zero velocity. If there are additional motion statements, the Working Ratio velocity at the end of the Working Segment will serve as the initial velocity for them. This is similar to compounded Indexes but also works with Homes as well. If there are no more motion statements, the Stop/Hold Decel Time from the Limits screen will be used after the completion of the Working Segment.

This input is a latching type function. This means that the input need only be pulsed once. It is cleared when the cycle is exited.

> ### WARNING!
> **The next motion statement following the *Y Execute Follower Cycle* statement should not be an *Absolute Index* because the Follower axis might reverse direction.**

When used in conjunction with the *Cycle Drop Out* input function, the following behaviors will be observed.

Please note that a machine cycle is viewed as going from the end of one *Working Segment* to the end of the next *Working Segment*. This input function is only functional when in a cycle. See Figure 11.

- If the *Cycle Drop Out* input function is active and the *Cycle Exit* input function is activated, the Follower will complete the *Cycle Drop Out* and then exit the cycle at the *Cycle Drop Out Position.*

- If the *Cycle Exit* input function is active and the *Cycle Drop Out* input function is activated, the *Cycle Drop Out* input function is ignored and the Follower will exit the cycle at the end of the current *Working Segment.*

- If the *Cycle Exit* input function and the *Cycle Drop Out* input function are activated simultaneously, the *Cycle Drop Out* input function is ignored and the Follower will exit the cycle at the end of the current *Working Segment.*

- If the *Cycle Drop Out* input function is active, then the *Cycle Exit* input function is activated, and the *Cycle Drop Out* input function is deactivated, then the Follower will exit the cycle at the end of the current *Working Segment*. If the Follower is past the end of the current *Working Segment* and is decelerating when the *Cycle Drop Out* input function is deactivated, then the *Cycle Drop Out* input function will not complete and it will exit at the end of the next *Working Segment*.

---

118   Working Ratio Increment

This edge triggered input is used to increment the *Working Ratio* by the *Working Ratio Change Increment* value. It is only functional when in a cycle. It must be assigned using the *IF* serial command. It is uploaded and downloaded by PCX. See the *TC5* serial command.

---

119   Working Ratio Decrement

This edge triggered input is used to decrement the *Working Ratio* by the *Working Ratio Change Increment* value. It is only functional when in a cycle. It must be assigned using the *IF* serial command. It is uploaded and downloaded by PCX. See the *TC5* serial command.

Typical Input Assignments

The following input assignments handle most customer needs.

Input	Function	Notes
1	45-Zero Master Cycle	Active at all times, if the Master is defined by sensor.
2	15-Home Sensor (0)	Only active outside of a cycle or index.
	46-Zero Follower Cycle	Only active in a cycle.
3	11-Stop Motion	Active at all times.
	21-Reset Fault	Only active when faulted.
4	29-Initiate Program	Only active outside of a program.
5	1-Home (0) Initiate	Only active outside of a program.
	116-Cycle Exit	Only active in a cycle.
6	49-Cycle Drop Out	Only active in a cycle.
7	72-Master Phase Increment	Only active in a cycle.
8	73-Master Phase Decrement	Only active in a cycle.
13	115-Reset Master	Only active outside of a cycle.

Output Functions

On the Output Functions screen, the left-hand column of numbers (Function Assignments) corresponds directly to the output lines on the drive. The next column (Function) lists all of the output functions available and shows which output line each function is assigned to on the drive. Output functions assigned to line 0 are inactive.

Use the up/down arrow keys to move the cursor to the desired output function, type in the desired line number and press Enter. The output function number will now appear beside the correct line number in the left window. The drive will accept multiple output assignments on any output line.

Most of the output functions are discussed in the 230V FX Drives Setup and Programming Operator's Manual (P/N 400282-00), 460V FX Drives Setup and Programming Operator's Manual (P/N 400310-00) or 525 Programmable Motion Controller Installation and Operation Manual (P/N 400276-01) as appropriate. The output functions which are specific to the PCM-22 are discussed in this section.

```
════════════ Output Functions - 2:FX-340 With PCM-22 ═══════════11:05:52
    Function Assignments        Function              Line

  9▶: 26,66,               0-Ready ───────────────   0
 10▶: 41,47,               1-External Mode ────────  0
 11▶: 25,                  2-In Motion ────────────  0
 12▶: 6,7,8,               3-End Of Index ─────────  0
 21▶:                      4-End Of Home(0) ───────  0
 22▶: 21,                  5-End Of Index Count ───  0
 23▶: 22,                  6-Hardware Fault ───────  12
 24▶: 24,                  7-Travel Limit Fault ──   12
                           8-Position Error Fault ─  12
                           9-Home Completed ───────  0
                          10-Sensor Limit Hit ─────  0
                          11-End Of Sequence ──────  0
                          12-Programmable Outputs ─  0
                          13-End Of Program ───────  0
                          14-End Of Program Count ─  0
                          15-In Suspend ───────────  0

                                     Status: External Control
                                     Velocity: 0 RPM
                                     Position: 0 ST
 Range: 0(unused), 9 to 12, 21 to 24 Enc Pos:  593292 ST
 ═══════ Press ↑ or ↓ to choose; Enter to select/change; Esc to exit ═══
```
Figure 29   Output Functions Screen

Outputs require an external isolated supply voltage, usually the same supply as the inputs. Each output can sink or source 0.2 amps DC.

Description Of Output Functions

17   At Sync

Activates when the Follower axis is in sync with the Master axis (i.e. the acceleration portion of the Index is complete). This is not used during PCM-22 Follower Cycles, it is only used for synchronized Indexes.

For example:

In a flying 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. It must be assigned by *OF* serial command. It is uploaded and downloaded by PCX.

18	Sync Fault/Fly Cut-off

Indicates that the programmed length reached a count that should have initiated another flying cutoff but the FX drive was not in position to initiate the flying cutoff operation. This is not used during PCM-22 Follower Cycles, it is only used for synchronized Indexes.

21	Master Cycle Defined

When the *Master Cycle* is not *Defined By Sensor*, one *Zero Master Cycle* input is required for the *Master Cycle Defined* output function to activate.

When the *Master Cycle* is *Defined By Sensor*, two *Zero Master Cycle* inputs are required for the *Master Cycle Defined* output function to activate.

It is always functional.

22	Follower Cycle Defined

Activated when a Follower cycle is initiated and a reference *Home* or *Index* was completed. It is only functional in a cycle.

24	In Phase

Activates when the total phase variation is between *Phase Distance Error Limit(+)* and *Phase Distance Error Limit(-)*. It will not activate until the Follower has completed its phase correction. It is the compliment of the *Phase Distance Error Limit* output function 44. It may be active in a cycle and is always deactivated outside of a cycle. When the Follower cycle is starting, it will be inactive until the start of the first *Working Segment* is reached.

It is useful for monitoring system performance and diagnostic purposes. See Follower Cycles screen and *Maximizing Profile Performance*.

25	Master Sensor Missing

Activates if the Master distance traveled from the last *Zero Master Cycle* sensor input is greater than 1½ times (default) the average *Master Cycle Length*. The *Master Sensor Missing* output is deactivated when a valid Master sensor input is received. It is always functional.

During a missing Master sensor condition, the *Cycle Error* output function will be active and the *CQ* serial command will return 0x810.

The *Master Sensor Missing* activation distance is controlled by the *SM* serial command. It is entered in degrees from 0 to 360 with a default of 180, this is 50 percent longer than the *Average Master Cycle Length*.

See *Average Length*, *Master Sensor Valid Zone,* the *ML11* and *FM12* serial command*s*.

26	**Follower Sensor Missing**

Activates if the Follower distance traveled from the last *Zero Follower Cycle* sensor input is greater than 1½ times (default) the average *Follower Cycle Length*. The *Follower Sensor Missing* output is deactivated when a valid Follower sensor input is received. It is only functional in a cycle.

During a missing Follower sensor condition, the *Cycle Error* output function will be active and the *CQ* serial command will return 0x820.

The *Follower Sensor Missing* activation distance is controlled by the *SF* serial command. It is entered in degrees from 0 to 360 with a default of 180, this is 50 percent longer than the *Average Follower Cycle Length*.

See *Average Length*, *Follower Sensor Valid Zone*, the *FL11* and *FM13* serial commands.

41	**Cycle Limit Reached**

Activates when one of the cycle limit flags is set and deactivates when the condition is eliminated. Under certain conditions, it may stay active after the cycle has ended. See the *CQ* serial command and the *Cycle Error* output function.

42	**Cycle Count Reached**

Active when the *Cycle Count* number (set in the Follower Cycles screen) is reached. It may stay active after the cycle has ended.

This output function may be deactivated by activating the *Reset Cycle Counter* input function #74 or by changing the value of the *Cycle Count* which will clear the current *Cycle Count.* See the *FF* and *KC4* serial commands.

43	**Batch Count Reached**

Active when the *Batch Count* number (set in the Follower Cycles screen) is reached. It may stay active after the cycle has ended.

This output function may be deactivated by activating the *Reset Batch Counter* input function #75 or by changing the value of the *Batch Count* which will clear the current *Batch Count.*

44	**Phase Distance Error Limit**

Active any time the *Follower Phase Variation* exceeds the *Phase Distance Error Limits.* It is the compliment of *In Phase* described earlier. It may be activated when in a cycle and is always deactivated when outside of a cycle.

47	**Extra Master Sensor**

This output function is primarily for diagnostic purposes. It is activated when a *Zero Master Cycle* input occurs when the distance traveled by the Master axis is less than the *Master Length Lower Limit.* The output will deactivate when a valid Master Length is detected. When this condition occurs the *Cycle Limit Reached* output will also be activated. It

is always functional. See *Master Length Lower Limit* and the *CQ* serial command.

66	Cycle Error

This output function activates in situations where a serious profile error was detected and it is not possible for the PCM-22 to execute the specified profile.

1) Activates when a cycle is started without executing a *Home* or *Index* reference move first. In this case, a **F** *External Distance Error* fault will occur and the *CQ* serial command will return zero. See *Homes and the Follower Zero Position*.

2) Activates when a cycle is starting if a *Cycle Inter-Relationship* problem is detected. In this case the PCM-22 will stop the cycle without initiating motion. The *CQ* serial command will have flags set indicating where the problem is.

3) Activates when excessive Follower Phase Variation, Master Phase Variation, *Follower Length* or *Master Length* change is detected. This causes the next *Master Length*, next *Follower Length* or the next *Cycle Point* to become less than the corresponding *Master/Follower Length Lower Limit*. In order to attempt to control the situation, the average length will be used and the phase will be temporarily changed. The output will be latched active even if the situation was controlled. It is up to the user to decide how to handle this error condition when a cycle is executing. The *CQ* serial command will have flags set indicating where the problem is. Other than user changes, the primary causes of this would be too small of a *Working Segment* for the Follower velocity required, encoder slippage, mechanical failure, noisy sensors or low averaging in the Follower profile.

4) Activates when a *Missing Master Sensor* or *Missing Follower Sensor* condition is detected. The serial command *CQ* will return 0x810 or 0x820, respectively, indicating this. The output will be deactivated if the situation was corrected.

5) Activates when a cycle is stopping and an active cycle limit flag is detected. The *CQ* serial command will have flags set indicating where the problem is.

It may be active after the cycle has ended. See *Cycle Limit Reached* and *Maximum Master Velocity*.

71	Cycle Dropped Out

Activates after the *Cycle Drop Out* input was activated and the Follower axis has arrived at the *Cycle Drop Out Position*. Please note that if the Master sync source stops while the *Cycle Drop Out* input is activated, but before the dropout position is reached, *the output will not activate.* It may be active after the cycle has ended if used in conjunction with *Cycle Exit*.

Recommended Output Assignments

It has been found that the following output arrangement allows the greatest diagnostic and system control capability. The output functions should be assigned but do not all need to be wired to the panel outputs.

Output	Function	Notes
9	66-Cycle Error	Machine needs to be stopped soon and checked. There is a serious issue in progress. Check CQ serial command for reason.
	26-Follower Sensor Missing	Only active in a cycle if the Follower Cycle is defined by sensor. Possible sensor failure or Follower Sensor Valid Zone issue.
10	41-Cycle Limit Reached	There is an issue in progress, usually the last user adjustment exceeded a limit. Check CQ serial command for reason.
	47-Extra Master Sensor	If the Master Cycle is defined by sensor see Lower Master Length Limits.
11	25-Master Sensor Missing	Only active in a cycle if the Master Cycle is defined by sensor. Possible sensor failure or Master Sensor Valid Zone issue. See CQ serial command.
12	6-Hardware Fault 7-Travel Limit Fault 8-Position Error Fault	Check FS serial command for reason.
21	Unassigned	
22	21-Master Cycle Defined	Must be active before Follower Cycle can begin.
23	22-Follower Cycle Defined	Only active in a cycle. Will not activate until a reference move is performed.
24	24-In Phase	Only active in a cycle. Complement of 44-Phase Dist Error Limit.

Programming

Motion Programs are a series of Homes, Indexes and other operations 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.

Multiple programs can be created using PCX software and stored in the PCM-22, each designed for a different machine function. The PCM-22 is capable of storing up to 16 (0 to 15) Master cycle definitions, 16 (0 to 15) Follower cycle definitions, 64 (0 to 63) Indexes, 2 Homes, 100 motion programs (0 to 99), and a maximum of 512 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 5 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.

Please refer to your FX Drives manual for a complete description of the programming capabilities available.

Additional programming functions

The PCM-22 has additional programming capabilities available. Each program function has a designated single or double letter function code that is used when creating a program. This section describes the unique PCM-22 functions. Please refer to your FX Drives manual for a complete description of all other programming functions.

R	Wait For Counter

An *R* function code allows you to wait for the number of counts you enter before continuing to the next program line. 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* function code.

WARNING!

The Master processing must be reset *after* using this command *before* executing a *Y Execute Follower Cycle* function code.

S	Start Counter

An *S* function code resets and starts the internal counter for counting the external encoder pulses.

WARNING!

The Master processing must be reset *after* using this command *before* executing a *Y Execute Follower Cycle* function code.

T	Time Base

This code determines whether the *Time Base* for any programming function placed after the *Time Base* function code in a program (including *Dwells*) 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.

Note: **Follower cycles do not execute in synchronized time but are synchronized in position.**

Y	Execute Follower Cycle

When the program reaches the *Y Execute Follower Cycle* function code the designated *Follower Cycle* will begin.

No program steps after the *Y Execute Follower Cycle* function code will be executed unless the *Cycle Exit* input function 116, is activated. If a stop motion command is issued the program will end.

Example program

Typically the first step in the program moves the Follower axis to some valid start point or home.

The *Home* function is executed prior to the *Y Execute Follower Cycle* function code to establish a Follower zero position. See *Homes and the Follower Zero Position.*
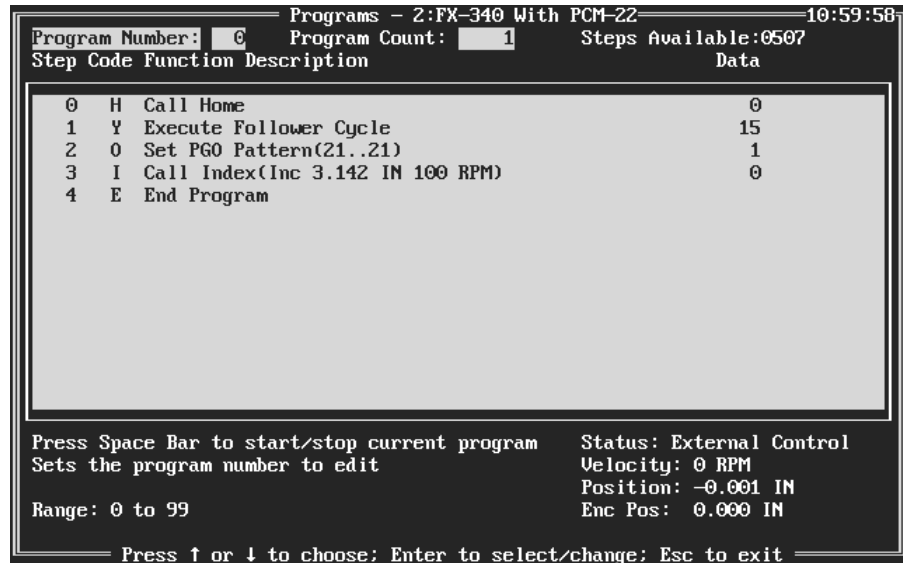
Figure 30   Program Example

The Follower first moves to the *Home 0* position and begins accelerating to be in phase with the Master Axis at the start of the first possible *Working Segment*. The Follower will continue executing the cycle until a *Stop Motion* or *Cycle Exit* is issued. If *Cycle Exit* is activated, the Follower cycle is exited at the end of the *Working Segment* at the *Working Ratio* velocity. The programmable output pattern is activated

and could be fed to the stop motion input of the material feed (master) axis. The exiting Follower axis velocity will automatically become the starting velocity of the next motion command, a real time, incremental *Index* in this example. See *Cycle Exit.*

Example Applications

Rotary Knife

MSC CABLE

FOLLOWER SENSOR

FX AMPLIFIER WITH PCM-22

MASTER REGISTRATION SENSOR

MOTOR

SCS-4 ENCODER

KNIFE AXIS

ANVIL
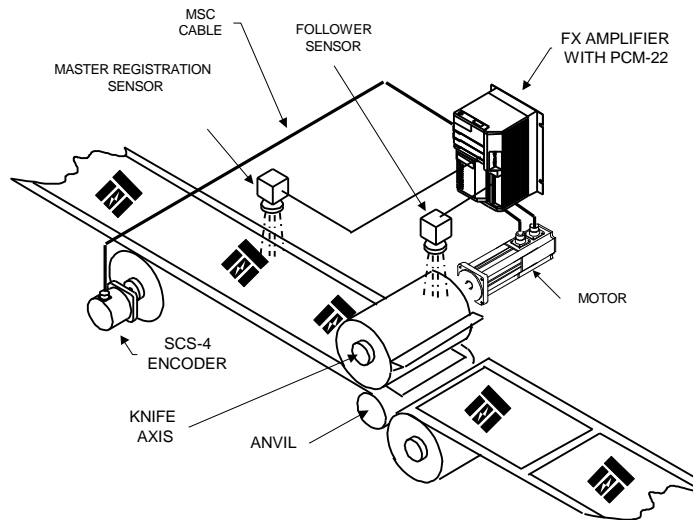
Objective

Cut off sheets of material at a specific distance from the leading edge of a printed image.

Solution

FX positioning drive with a PCM-22 Rotary Knife Controller using a sync. encoder measuring the movement of the conveyor belt, a master registration (product) sensor on the conveyor belt (Master axis) and a follower (proximity) sensor on the knife axis (Follower axis).

Operation

As the leading edge of the printed image is sensed, the distance from the last image is computed. This allows the PCM-22 to compute a correction necessary to compensate for any phase or length variation on the next cycle. When the product reaches the correct position, the PCM-22 will have positioned the leading edge of the knife assembly at the correct position and will be matching the speed of the product.

Results

High degree of flexibility and accuracy in the size of the product.

Seal and Cut Off Packages
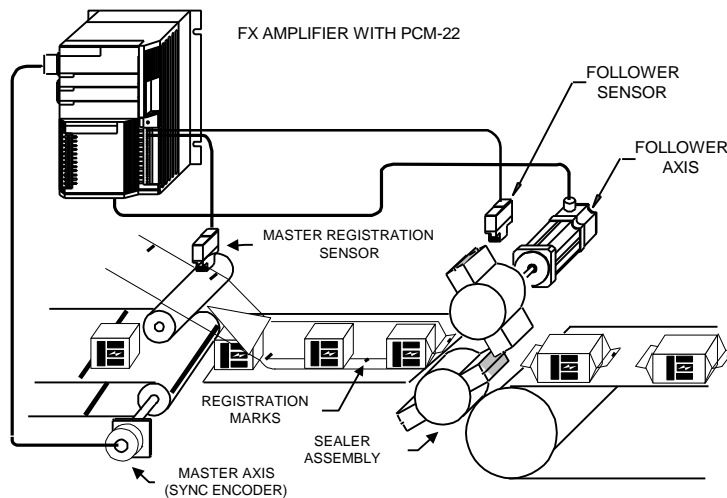
Objective

Seal and cut off packages at a specific distance from the leading edge of a registration mark on wrapping film.

Solution

FX positioning drive with a PCM-22 Rotary Knife Controller using a sync. encoder measuring the movement of the conveyor belt, a master registration (product) sensor on the conveyor belt (Master axis) and a follower (proximity) sensor on the seal/cut head (Follower axis).

Operation

As the leading edge of the registration mark is sensed, the distance from the last registration mark is computed. This allows the PCM-22 to compute a correction necessary to compensate for any phase or length variation on the next cycle. When the product reaches the correct position, the PCM-22 will have positioned the leading edge of the seal/cut assembly at the correct position and will be matching the speed of the product.

Results

High degree of flexibility and accuracy in the size of the sealed product.

Flexible Bag Maker
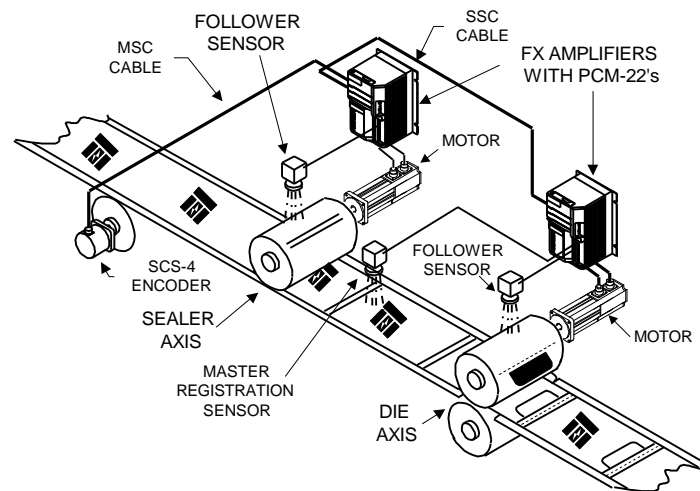
Objective

To accurately place a die cut out and perforation in relationship to a pair of seals on a continuous tube of material while easily being able to change the size of the product without physical changes to the machine. The product length can be changed easily by selecting one of up to 16 previously setup products serial commands or by Master Length increment/decrement inputs switches.

Solution

Two FX Positioning Drives with PCM-22 Rotary Knife Controllers using an encoder on the material tension roll (Master axis), a position sensor on the seal head (1st Follower axis), a product seal position sensor (Master axis) and the rolling die position sensor (2nd Follower axis).

Operation

When the desired amount of material has passed, the first PCM-22 will have positioned the seal bar at the correct position relative to the last seal. The seal functions as a registration mark for the rolling die operation. When the seal reaches the correct position for punching, the second PCM-22 will have positioned the edge of the die at the correct position relative to the seal. This is done automatically by speeding up or slowing down the sealer axis while it is not in contact with the material. The die axis tracks the seal positions and automatically by speeds up or slows down to punch at the correct position relative to the seal position. The PCM-22's will match the speed of the product while they are in contact with it.

Results

High degree of flexibility in product size and great accuracy in the length, placement of the seal and punching of the product.

Pick and Place
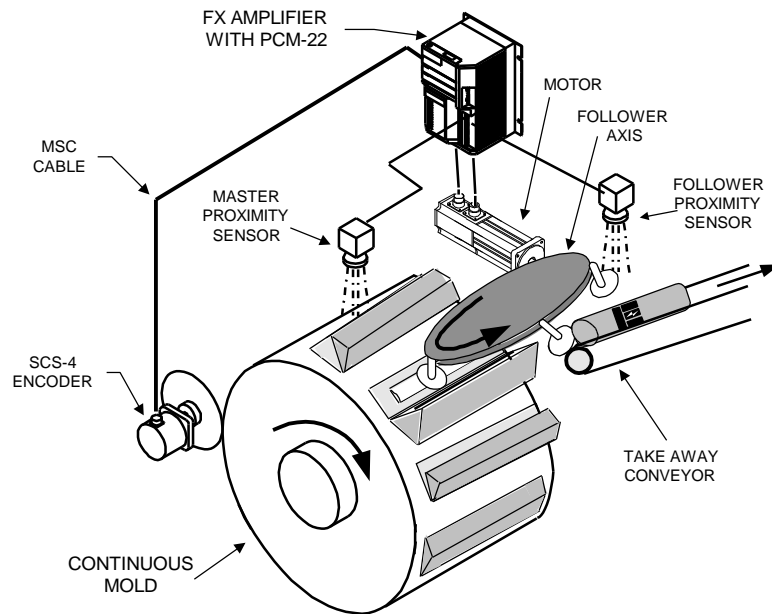
Objective

To move delicate parts from a continuous molding process while handling the sequencing requirements of the molding process. Conventional pick and place approaches were not suitable because the mold does not stop moving and the products were still soft.

Solution

A FX positioning drive with a PCM-22 Rotary Knife Controller using an SCS-4 encoder measuring the movement of the molding process, a master registration (product) sensor on the process (Master axis) and a follower proximity sensor on the vacuum pick up take away assembly (Follower axis).

Operation

The PCM-22s' Working Segment is positioned so as the mold is opening, it matches the speed of the mold. The vacuum pick up lifts the part from the mold and gets it clear before the mold closes again.

As the Working Segment occurs to pick up the product from the mold, the product that was previously picked up is deposited on to the take away conveyor at the same speed as the mold due to the mechanical linkage of the vacuum pick ups.

An additional benefit to the kind of motion profiles the PCM-22 provides, is that the smoothness of the velocity transitions may be adjusted by changing software parameters.

Results

A flexible system capable of moving parts from one process to another easily without any mechanical changeover for a large range of products sizes.

Imprinter
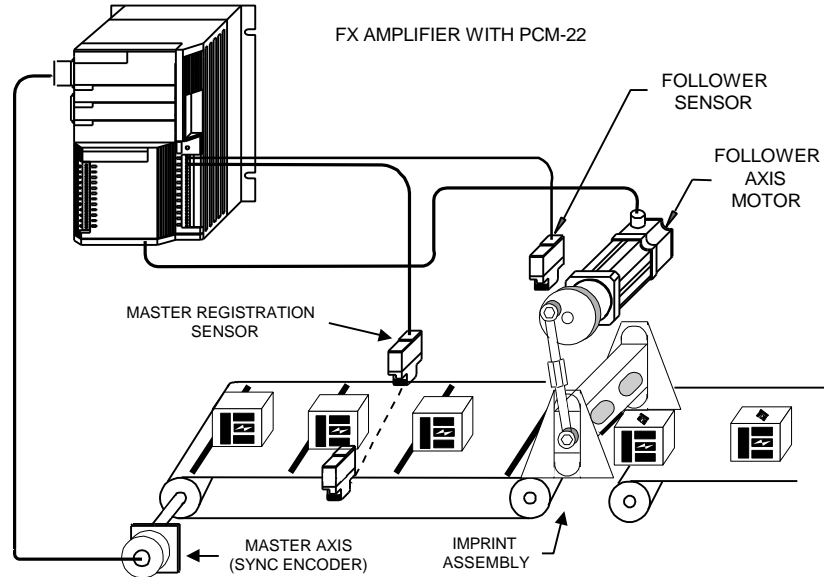
Objective

A flexible way to way to imprint products at a specific distance from the leading edge of the product which are difficult due to their size or shape.

Solution

A FX positioning drive with PCM-22 Rotary Knife Controller, a master axis synchronization encoder, a master (product) registration sensor and a proximity follower sensor for the imprint (Follower) axis.

Operation

The union of the reciprocating eccentric imprint mechanism with the PCM-22 Rotary Knife Controller allows the motion profile to be changed.
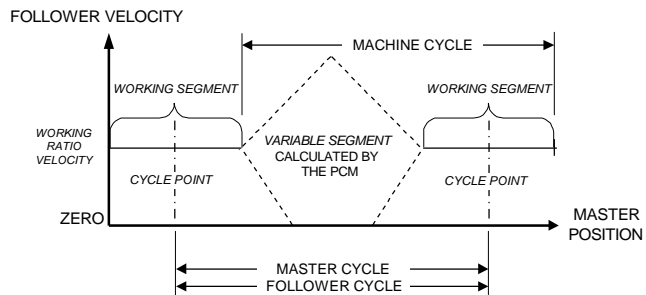
The motion may be adjusted from the standard elliptical motion to a more circular or egg shaped motion profile by changing software parameters in the PCM-22. This allows control over where the imprint occurs along with the speed and duration of the imprint while the product is moving.

Results

A flexible system capable of precise placement and control over an imprint.

Maximizing Profile Performance

This process only applies when at least one axis is defined by sensor.

To achieve maximum performance, the PCM-22 motion profile needs to be adjusted before production use.

IMPORTANT!
The performance of the PCM-22 will only be as good as the information it gets from the registration sensor(s) and synchronization source.
Before the system can be adjusted for performance, it is critical that the sensors are producing a strong, distinct signal and that the encoder is riding on the product without slipping or vibrating.

This adjustment process is done in two stages:

1. The *Average Master* and *Average Follower Length Variations* are minimized.

2. The *Master* and *Follower Phase Variations* are minimized.

The process will take the longest the first time and successive profile styles will only need minor adjustments to account for profile variation.

Following is a detailed explanation of how to perform the adjustment process. A large part of this is learning to use and interpret the information from the various drive commands that are available.

Note: **It is normal to have small amounts of variation even after profile adjustment due to machine and material issues such as gear reducer backlash, web material which stretches and other mechanical issues.**

Commands Referenced

The following commands will be referenced during the tuning process. PCM-22 Firmware, P/N: 401167-01, version A6 and higher is required to support all of these commands.

New Commands

FM7:   Master Phase Variation - user units

FM8:   Follower Phase Variation - user units

FM9:   Master Length Variation - synchronization steps

FM10: Follower Length Variation - resolver steps

Existing Commands

FL11: Average Follower length - resolver steps.

ML11: Average Master Length - synchronization steps.

PH1:   Phase Correction Limit - 0 to 100 percent.

PH2:   Follower Cycle Length Correction Limit - 0 to 100 percent.

PH3:   Master Cycle Length Correction Limit - 0 to 100 percent.

Note: **A tool called MON.EXE may be used to read and write the serial commands described in the following sections;** *Minimizing Length Variation* **and** *Minimizing Phase Variation*. **Usage instructions for MON.EXE are in the README.TXT file.**

A sample script file, PCM22.MON, for MON.EXE has been provided to be used when performing the procedures described in *Minimizing Length Variation* **and** *Minimizing Phase Variation*.

MON.EXE, PCM22.MON and README.TXT files are located on the PCX diskette. They may also may be obtained from the EMERSON Motion Control BBS or the Internet web page.

Minimizing Length Variation

1) Start with the following parameters at the default settings:

- The *Master Cycle Length Correction Limit* at 100 percent.
- The *Master Sensor Averaging* to 8 cycles.
- The *Follower Cycle Length Correction Limit* at 100 percent
- The *Follower Phase Correction Limit* at 100 percent.
- The *Follower Sensor Averaging* to 8 cycles.

If you have MON.EXE available, start it and load the PCM22.MON file. MON.EXE will do all of the querying for you during the adjustments and allow user to more effectively monitor the machines performance.

2) Start the machine and let it run at least 24 cycles so it can "learn" the mechanical variations of the *Master Length* (products) and the *Follower Length*.

3) Query *FM9* and *FM10* serial commands, the *Master Length Variation* and *Follower Length Variation* respectively. Each are updated once per cycle.

4) Choose the larger value of the two and query *ML11* for *FM9* or *FL11* for *FM10* . The *Average* (running) *Master* and *Follower Lengths* are updated once per cycle and will help determine when the lengths are stable.

5) In order to track as tightly as possible, the amount of length variation must be reduced. *Cycle Length Correction Limit* reductions should be done in 5 percent or smaller increments.

   - If FM9 is larger than FM10, reduce the *Master Cycle Length Correction Limit* (*PH3* serial command) using PCX software.

   - If FM10 is larger than FM9, reduce the *Follower Cycle Length Correction Limit* (*PH2* serial command) using PCX software.

6) Let the machine run at least three times the larger of the *Master* or *Follower Length Averaging* number of cycles so the average lengths can adjust with the new length correction limit.

7) Repeat steps 3 through 6 until the length variation is minimal for the Master and the Follower axes. After several passes you should see a trend towards stability when querying ML11 and FL11 that will verify that the lengths are becoming more regular. This will be easy to see if you are using MON.EXE.

Notes: If the length variations do not stabilize to an acceptable level or if the either *Master or Follower Length Correction Limit* is below 35 percent something is wrong mechanically with the system. It will be necessary to do the following on the appropriate axis.

   1) **If this fails to improve the Master length variation, check the following:**

   - **The *Zero Master Cycle* sensor is producing a strong, distinct signal.**

   - **The encoder is riding on the product without slipping or vibrating.**

   - **Examine the Master axis material control/tensioning system.**

   2) **If this fails to improve the Follower length variation, check the following:**

   - **The *Zero Follower Cycle* sensor is producing a strong, distinct signal.**

   - **Examine the Follower axis mechanics for looseness, sensor functionality and mounting.**

   3) **It is sometimes necessary to reduce the *Master* or *Follower Length Averaging* and increase the *Master* or *Follower Length Correction Limit* as appropriate to make the system more responsive in order to track tighter. This should be done carefully so as not to miss the point where the length variations are as small as possible. Otherwise the**

responsiveness of the system will over compensate and make the length variations worse.

Minimizing Phase Variation

Once the Master and Follower length variation are minimized, you may start adjusting the *Phase Correction Limit* (*PH1* serial command).

It is normal to have small amounts of phase variation. However, large errors should not occur during normal cycle operation. Large variations at high speed could cause undesirable acceleration rates. Lowering the *Phase Correction Limit* value will reduce the size of the phase variations on the system.

Note: The total phase variation is the sum of the detected Master phase variation (*FM7* serial command) and Follower phase variation (*FM8* serial command).

The *FM7* and *FM8* serial commands are accessed individually. They are each updated once per cycle and are in user units without decimal points. The information gained from the commands is used as a indication of general system performance and is not accurate during user-induced phase changes using I/O or serial.

If you have MON.EXE available, start it and load the PCM22.MON file. MON.EXE will do all of the querying for you during the adjustments and allow user to more effectively monitor the machines performance.

1) Query *FM7* and *FM8*. Add them to obtain the total phase variation.

2) Query *FL11* and *ML11*, the average Follower and Master Lengths respectively. The average lengths should stabilize further as the adjustment process continues.

3) For the system to track as tightly as possible, you need to reduce the *Phase Correction Limit* (*PH1* serial command), which is applied to both the Master and Follower phase variation. This adjustment should be done in 5 percent or smaller increments.

4) Repeat steps 1, 2, and 3 until the phase variation is minimal i.e. until the amount of Master and Follower phase variation is within application tolerances and stable. After several passes you should see a trend towards stability when querying ML11 and FL11 that will verify that the lengths are becoming more regular. This will be easy to see if you are using MON.EXE.

Note: If the phase variations do not stabilize to an acceptable level or if the *Phase Correction Limit* is below 40 percent something is wrong with the system. It will be necessary to do one of the following (one at a time) in order:

1) Examine the Master axis material control tensioning system, encoder mounting, sensor functionality and mounting.

2) Examine the Follower axis mechanics for looseness, sensor functionality and mounting.

3) Perform the process for *Minimizing Length Variation* again.

4) Adjust the *Working Segment* wider or narrower by 5 percent.

5) Adjust the *EG* gain by increments of 0x10, upwards first.

6) Decrease the DG gain by increments of 0x1.

The length and phase variation should be re-checked after any of the six possible adjustments above.

Once the total phase variation is reduced as much as possible, the final adjustment if desired, is the *Phase Correction Dead Band* (*PH0* serial command*). See *Follower Cycles*

Once this is accomplished, *Phase Correction Limit*, does not need to change unless there are large *Follower Length* or sensor position changes due to a machine or product change.

Note: **The value of *FM7* plus *FM8* is tested against the *Phase Distance Error Limit (+)* and *Phase Distance Error Limit (-)* to activate the In Phase output. An alternate way of minimizing phase variation is to monitor the *In Phase*, output function 24 and adjust *Phase Correction Limit* slowly while reducing the *Phase Distance Error Limit(+)* and *Phase Distance Error Limit(-)* to the performance desired. This is a better approach for high speed applications because of the inherent latency of serial commands.**

See *Issues Maintaining Phase* in *Tips and Troubleshooting*.

Tips and Troubleshooting

General Issues

If an odd behavior is seen (e.g., the *In Phase* output is deactivated or is blinking, a *Cycle Error*/*Cycle Limit Reached* error output is active) go online and query the *CQ, FM7, FM8, FM9* and *FM10* serial command*s*. This should indicate what the issue is.

Once a user adjustment change occurs the system can take up to two cycles to complete the change depending on when the change is requested in the cycle. See *Operational Timing*.

Product Ranges and Limits

The behavior of the PCM-22 is controlled by the limits/parameters entered. They **must** match the product for correct operation. This is why it is a not a good idea to attempt a "one size fits all" approach (i.e., one set of product parameters for a wide range of product lengths).

There are three solutions to this situation:

1. The simplest approach is to setup several *Master Cycle* definitions and have each called from identical Follower cycle definitions. Each *Master Cycle* definition would cover a smaller product range. Each Follower cycle could then be called from separate programs. This may be accomplished with program select lines.

2. Setup several smaller product ranges in separate *Master Cycle* definitions and only use one Follower cycle definition. This can be accomplished by using the *FT* serial command and a T-21 Data Entry Panel.

    For example:

    CY = 1   Select Follower Cycle 1 to edit.

    FT = 15   Select Master Cycle 15 to use with Follower Cycle 1.

    The next time Follower Cycle 1 is started, the Master processing will be reset and Master Cycle 15 definition will be used. The *CI2* serial command returns the current Master cycle.

3. Using only one *Master Cycle* and one *Follower Cycle* definition, a T-21 or T-60/T-61 could be programmed to change the *Master Length Upper Limit, Master Length Lower Limit, Follower Length Upper Limit* or *Master Length Upper Limit* or *Master Length Lower Limit Length Lower Limit*

Follower Cycle Will Not Start

Symptom

When the *Y Execute Follower Cycle* function code is reached in the PCX program an *F External Distance Error* fault occurs and the *Cycle Error* output function 66 is activated.

Cause

1) The *Working Segment* is overlapping the Follower zero position. The *Working Segment Offset* or *Working Segment* needs to be adjusted. See *Cycle Inter-Relationships.*

2) A reference Home or Index motion was not performed to move the Follower axis to the Follower zero position before executing the *Y Execute Follower Cycle* PCX function code.

Symptom

When the *Y Execute Follower Cycle* function code is reached in the PCX program, the drive displays an *E* and the *Cycle Error* output function 66 is activated.

Cause

One or more of the *Cycle Inter-Relationships* is invalid. Check the *CQ* serial command for what the issue(s) are. See *Cycle Inter-Relationships.*

Symptom

The Follower is in cycle with *P* on the display but no motion is occurring.

Cause

1) Check to make sure that the drive is receiving sync. pulses from the encoder or up stream drive and that the sync. polarity and compensation are correct. See *Master Axis.*

Note: **The synchronization source must count in a positive direction for proper operation.**

2) The Master cycle is not defined. See *How the Master Cycle is Defined.*

3) The *Cycle Drop Out* input function 49 is active.

Verifying the Working Segment Position

Where the center of the *Working Segment*/*Cycle Point* is in relationship to the product can impact the quality of the operation (cutting, printing, etc.). Verifying the *Cycle Point* and the *Working Offset* may be done two ways:

1. Activate the *Cycle Drop Out* input function. Where the Follower axis stops will be exactly opposite the *Cycle Point.*

2. Enter a long, not defined by sensor Master Product at least twice as large as the Follower Length. The Follower axis will stop in the middle of the *Variable Segment.* This position will be exactly opposite the *Cycle Point.*

Issues Maintaining Phase

Phase issues may be caused by a number of different reasons:

1) Master / Product control issues.

2) Master phase variations are primarily a combination of product slippage, encoder slippage, material stretch and sensor latency. This will become worse as the system speed increases if not compensated for by the Follower and/or mechanical adjustments. This would also be seen if the Master distance per revolution does not match the distance traveled. The Master sensor position should be at least the computed minimum *Master Sensor Distance* from the center of the *Working Segment* so that the effects of material stretch are minimized.

3) Follower phase variations are primarily *Following Error* and will become worse as the system speed increases if not compensated for.

4) Follower length variations are primarily differences between the individual Follower lengths which can be controlled by adjusting the *Follower Length Correction Limit* or *Follower Sensor Averaging*. If the Follower distance per revolution does not match the gear ratio then it will first be perceived as length variation and then as phase variation once the *Follower Upper/Lower Length Limit* is reached.

5) If the Master phase variation / Follower phase variation is positive due to a late sensor from a short length or potential noise, a positive phase variation is added to the of the next *Cycle Point*. Inversely, the Master phase variation / Follower phase variation may be negative due to an early sensor and is subtracted from the Follower/Master position on the next cycle.

6) A Master axis that is running too fast for the profile. Too narrow or wide of *Master* or *Follower Length Upper/Lower Limits*.

7) Too narrow or wide of a *Follower Sensor Valid Zone.*

8) Extra or missing sensors.

See *Maximizing Profile Performance*, *Master Cycles* and *Follower Cycles* screens.

System Calibration Issues

Symptom

The measured Master Length or Follower length does not match the values returned by the PCM-22 using the *FM12* or *FM13* serial command*s* which return the average Master Length or Follower Length in user units respectively.

Causes

The *User Distance Per Motor Revolution* on the PCX Drive Parameters screen or User Distance Per Revolution on the PCX Master Axis screen needs to be adjusted in the direction of the measured length. If not done, this will cause other issues as the speed is increased and the machine is fine tuned.

For example:

A "not defined by sensor" *Product Length* measures 9.875"; FM12 and the entered *Product Length* is 9.800". The *User Distance Per Revolution* on the PCX Master Axis screen needs to be multiplied by (9.875 / 9.800) to calibrate the PCM-22 data to the mechanical data.

Synchronization Source Issues

Symptom

The Follower motion is jumpy or coarse.

Possible Causes

A) The PCM-22 is synchronized with the encoder (Master) position. Any slippage or bounce of the encoder to the product will be reflected in the position and motion of the Follower. Chain & sprocket coupling to the encoder such as should not be used.

B) The number of sync steps per Master Length is much less than the number of resolver steps per Follower length. See *Maximum Product Velocity* and *Master Axis.*

Symptom

The *Cycle Point* appears to "walk" as the speed is increased.

Possible Causes

A) The Master encoder should be as close as possible to the Follower and not be allowed to vibrate or slip relative to the product. If product slippage is occurring it, will usually appear as *Master Phase Variation.*

Note: Encoder selection should be based on the accuracy desired in the operation.

For example, If your encoder delivers 12,000 counts per revolution and the distance per revolution is 12.000 inches then the distance per count is 0.001 inches. The PCM-22 will attempt to track the Master to +/- 0.001 inches as this is the highest accuracy possible.

B) The *Follower Cycle Length* entered is wrong when the Follower cycle is not defined by sensor.

C) One or more of the following are set incorrectly: *Master Cycle Length Correction Limit, Follower Cycle Length Correction Limit* and *Phase Correction Limit*. See *Maximizing Profile Performance*.

D) Sensor response time is too slow for the application's speed. See *Sensors*.

Running Into a Length Limit

Symptoms

One or more of the following symptoms would be observed:

1. The *In Phase* output function will be blinking.

2. The *Cycle Limit Reached* output function 41 is active.

3. The *CQ* serial command returns 0x10 or 0x20.

4. The *Extra Master Sensor* output function 47 is active.

5. Follower cycles occur with no products or between products.

6. Products are being skipped (i.e., no Follower cycle occurs).

7. A constant *Master Phase Variation* (*FM7*) equal to the difference in what was measured between Master sensor inputs (*ML1-8, ML11* or *FM12*) and one of the *Master Length Limits*.

8. A constant *Follower Phase Variation* (*FM8*) equal to the difference in what was measured between Follower sensor inputs (*FL1-8, FL11* or *FM13*) and one of the *Follower Length Limits*.

9. The product length appears to oscillate long, short, long, short.

10. The Follower motion will become aggressive or erratic.

Possible Causes

If an input occurs inside the *Master Sensor Valid Zone* or *Follower Sensor Valid Zone* but is less than the *Follower Length Lower Limit*, the *Follower Length Lower Limit* is used. Similarly, if an input occurs inside the *Follower Sensor Valid Zone* but is greater than the *Follower Length Upper Limit*, the *Follower Length Upper Limit* is used. See the *Follower Cycles* screen, *Missing Sensor Issues, Extra Sensor Issues* and the *CQ* serial command.

Missing Sensor Issues

Symptoms

One or more of the following symptoms would be observed:

1. The *Master Sensor Missing* output function 25 is active.

2. The *Follower Sensor Missing* output function 26 is active.

3. The *Cycle Error* output function 66 is active. and the *CQ* serial command returns 0x810 or 0x820.

4. Several *ML1-8* values are the same and that value is the *Master Length Upper Limit* in sync. steps.

5. Several *FL1-8* values are the same and that value is the *Follower Length Upper Limit* in resolver steps.

6. Follower cycles occur with no products or between products.

7. Products are being skipped (i.e., no Follower cycle occurs).

Possible Causes

1) Check the functionality of the sensor using *IO0 (IO zero)* serial command. It returns a hexadecimal mask of the active inputs.

2) Electrical noise can be picked up on the sensor leads and cause false triggering.

Follower Axis

1) Make sure you are getting the Follower sensor input when you are supposed to by widening the *Follower Sensor Valid Zone.* This can be checked by querying serial command *IO0 (IO zero)* while monitoring the position of the Follower axis and the *Follower Sensor Missing* output function.

2) Make sure that the *Follower Length Upper Limit* is within the *Follower Sensor Valid Zone* is close to the tolerances of the application.

Master Axis

1) Make sure you are getting the Master sensor input when you are supposed to by widening the *Master Sensor Valid Zone.* This can be checked by querying serial command *IO0 (IO zero)* while monitoring the position of the Master axis and the *Master Sensor Missing* output function.

2) Make sure that the *Master Length Upper Limit* is within the *Master Sensor Valid Zone* is close to the tolerances of the application.

See the *CQ* serial command, *Follower Cycles* and *Master Cycles* screens.

Extra Sensor Issues

Symptoms

One or more of the following symptoms would be observed:

1. The *Cycle Limit Reached* output function 41 is active.

2. The *CQ* serial command returns 0x10 or 0x20.

3. The *Extra Master Sensor* output function 47 is active.

4. Follower cycles occur with no products or between products.

5. Products are being skipped (i.e., no Follower cycle occurs).

6. Several *ML1-8* values are the same value and that value is the *Master Length Lower Limit* in sync. steps.

7. Several *FL1-8* values are the same and that value is the *Follower Length Lower Limit* in resolver steps.

Possible Causes

Check the position of the sensor, the wiring, and that the sensor is functional. The *IO0 (IO zero)* serial command returns a hexadecimal mask of the active inputs.

Follower Axis

1) Make sure you are not getting extra Follower sensors when you are not supposed to by narrowing the *Follower Sensor Valid Zone*. This can be checked by querying *IO0 (IO zero)* serial command while monitoring the position of the Follower axis as appropriate.

2) Make sure that the *Follower Length Lower Limit* is within the *Follower Sensor Valid Zone* and *Follower Length Lower Limit* is close to the tolerances of the application.

Master Axis

1) Make sure you are not getting extra Master sensors when you are not supposed to by narrowing the appropriate *Master Sensor Valid Zone*. This can be checked by querying *IO0 (IO zero)* serial command while monitoring the position of the Master axis and the *Extra Master Sensor* output function.

2) Make sure that the *Master Length Lower Limit* is within the *Master Sensor Valid Zone* and *Master Length Lower Limit* is close to the tolerances of the application.

See the *CQ* serial command, *Follower Cycles* and *Master Cycles* screens.

Common Operation Issues

Symptom

Drive displays an *E* but motion can not be initiated and the motor shaft has torque in both directions.

Possible Causes

- A Home Lock is active.
- A Jog Lock is active.
- The Stop input function 11 is active.
- Input switch or wiring is faulty.
- Serial control is active (the decimal point of the LED display, on the front of the drive, is lit).

Symptoms

Drive displays a *H, J* or *P* but motor does not move and the motor shaft has no torque in either direction.

Possible Causes

- The FX drive is inhibited by *Inhibit Drive* input function 12 or by the *BR* serial command.
- The *Hold* input function 3 is active.

Symptom

Drive will not *Suspend.*

Possible Causes

- It is already suspended. The FX drive can only be suspended once.
- Serial control is active (the decimal point of the LED display on the front of the drive is lit).
- Input switch or wiring is faulty.

Appendix A

Serial Commands

The following sections explain the new and enhanced serial commands since the *FX Drives Serial Commands Manual* P/N: 400255-00 was last revised.

CI2 - Executing Master Cycle

The CI2 command returns the *Master Cycle* definition that is currently executing. The command is query only. See *FT* serial command.

CQ - Cycle Status Query

The PCM-22 will detect and prevent learned and user changes which would invalidate the *Cycle Inter-Relationships*. The cycle limit flags are set when a condition occurs. The flags indicate what the error condition is. The flag will clear when the condition is eliminated. More than one flag may be set as the flags are additive.

These eight flags will cause the Cycle Limit Reached output (function 41) to activate. The Cycle Error output (function 66) will activate if one of these conditions exist when the cycle is exited.

Ratio Limit	0x01	Not able to make ratio change at the current Master velocity. The *Working Ratio* will be changed temporarily to get through the problem; i.e., the *Master Length* or *Working Ratio* is changing too quickly to track fully.
Velocity Limit	0x02	The *Maximum Allowable Velocity* of the Follower will be exceeded in the next cycle; i.e., the Master is going too fast to track. The Master Length will be changed temporarily to get through the problem.
Working Segment Limit	0x04	User tried to adjust past the *Working Segment Limits*. It may set be in conjunction with *Master Length Limit*, *Follower Length Limit* or *Working Offset Limit* to indicate which inter-relationship the requested change violated.

CQ- Cycle Status Query Continued

User Ratio Limit	0x08	User tried to adjust past the *Working Ratio* limits.
Master Length Limit	0x10	User tried to adjust the *Master Cycle Length* past the *Master Length Limits*.
		If the *Master Cycle is Defined By a Registration Sensor:* 1) *Master Length Limit* is encountered.
		2) Set in conjunction with *Missing Sensor* when the Master sensor is missing.
Follower Length Limit	0x20	User tried to adjust past the *Follower Length Upper or Lower Limit*.
		If the *Follower Cycle is Defined By a Registration Sensor*: 1) A *Follower Length Limit* is encountered.
		2) Set in conjunction with *Missing Sensor* when the Follower sensor is missing.
Phase Distance Limit	0x40	User tried to decrease the *Master Phase Distance* below zero.
Working Offset Limit	0x80	User tried to adjust the *Working Offset* so that the working segment would be overlapping the Follower zero position.

The following four flags will cause the Cycle Error output (function 66) to activate and stay on until the cycle is stopped and restarted. They usually indicate a mechanical failure, sensor failure or invalid profile in the corresponding system.

Master Profile Error	0x100	Profile data for the next Master cycle indicates a serious problem will occur or is in progress. The average length is used to attempt to get through the problem.
Follower Profile Error	0x200	Profile data for the next Follower cycle indicates a serious problem will occur or is in progress. The average length is used to attempt to get through the problem.
Phase Change Error	0x400	Not able to make the phase change required (the variable segment is too short for Follower velocity required).
Missing Sensor	0x800	If the *Master* or *Follower Cycle is Defined By a Registration Sensor* and the corresponding sensor input is missing. *Master Length Limit* or *Follower Length Limit* bits will be set to indicate which sensor is missing. If the condition is eliminated, the *Cycle Error* output will deactivate.

Reading *CQ* Flags

Following are some typical examples of various issues, diagnostic codes and their definitions.

Starting issues

Example: CQ = 0x84

The *Working Offset* is too short or too long for the size of the *Working Segment* which is overlapping the Follower zero position.

One of two items: *Working Offset* or *Working Segment*, needs to be changed.

Adjusting the Working Segment

Example 1: CQ = 14

The user tried to adjust the *Working Segment* larger than the *Master Length Lower Limit*, which would violate the *Cycle Inter-Relationships*. See *Working Segment* and *Cycle Inter-Relationships*.

Example 2*:* CQ = 84

The user tried to adjust the *Working Segment* larger than the *Cycle Inter-Relationships* will allow.

Adjusting the Master Phase Distance

Example: CQ = 40

The *Master Phase Distance* requested is less than zero.

Sensor Issues and Length Limits

Example 1: CQ = 810

The Master Sensor is missing. See *Missing Sensors.*

Example 2: CQ = 20

If the *Follower Cycle* is *Defined By a Registration Sensor* and the learned Follower length has reached the *Follower Length Upper Limit* or *Follower Length Lower Limit.*

If the *Follower Cycle* is not *Defined By a Registration Sensor*, the user has attempted to adjust the *Follower Cycle Length* past either the *Follower Length Upper Limit* or *Follower Length Lower Limit.*

See *Running Into A Length Limit.*

FF - Follower Cycle Flags

The *Follower Cycle Flags* are a bit map in hexadecimal containing selections for the control of operational and starting modes on a cycle by cycle basis. More than one flag may be set or cleared at a time as the flags are additive. It is on a individual cycle basis. The *Follower Cycle Flags* are uploaded and downloaded by PCX.

Follower Defined By Sensor	0x01
Disable Cycle Counter Reset	0x08
Force Reset Master Processing	0x20
Disable Master Processing Reset Upon Fault	0x40

Following is an example of changing an operational flag:

CY = 5   Select the cycle five to edit.

FF?   Query the Follower flags on cycle 5 and PCX returns the
FF = 1   current flags for cycle 5:

      The Follower cycle is defined by sensor.

      The Master processing will be reset upon fault clearing.

      Force Reset Master Processing mode is disabled.

FF = 21   Adding 0x20 to the current value will enable *Force Reset Master Processing* before starting on cycle 5.

Follower Cycle Defined By Sensor 0x01

This command specifies if this Follower cycle definition is defined by sensor. It is available from PCX on the *Follower Cycles* screen.

Disable Cycle Counter Reset 0x08

This command allows the user to disable clearing the *Cycle Counter* when the Follower cycle is started. When active, the *Cycle Counter* will be reset when the Master processing is reset. The default is disabled. See *KC4* serial command.

Force Reset Master Processing 0x20

This command allows the user to empty/reset the Master processing as if a new *Master Cycle* definition was selected for the same Follower cycle. This will occur every time the cycle is run. This causes the *Master Cycle* information to be loaded, thus overwriting the "learned" information when a cycle starts.

Note: This is only supported in Master defined by sensor mode.

The default setting for the *Force Reset Master Processing* flag is disabled for all cycles.

Disable Master Processing Reset Upon Fault 0x40

This command allows the user to disable resetting the Master processing upon clearing a fault.

Note: This should be used for diagnostic purposes only.

The default setting for the *Disable Master Processing Reset Upon Fault* flag is zero for all cycles by default, because the Master and Follower relationships are lost when a fault occurs.

FM7 - Master Phase Variation In User Units

This is the amount of *Master Phase Variation* in user units between sensors. This should be used in conjunction with FM8. The sum of FM7 and FM8 is the total phase variation for that cycle. This command is used for *Maximizing Profile Performance* and diagnosis. It is only supported in Master defined by sensor mode and is query only. See *Maximizing Profile Performance.*

FM8 - Follower Phase Variation In User Units

This is the amount *Follower Phase Variation* in user units from the measured distance between sensors to the average length. This should be used in conjunction with FM7. The sum of FM7 and FM8 is the total phase variation for that cycle. This command is used for *Maximizing Profile Performance* and diagnosis. It is only supported in Master defined by sensor mode and is query only. See *Phase Correction Limit* and *Maximizing Profile Performance.*

FM9 - Master Length Variation In Sync. Counts

This is the difference from the current *Average Master Length* to the new *Average Master Length*. This command is used for *Maximizing Profile Performance* and diagnosis. It is only supported in Master defined by sensor mode and is query only. See *Master Length Correction Limit* and *Maximizing Profile Performance.*

FM10 - Follower Length Variation In Resolver Counts

This is the difference from the current *Average Follower Length* to the new *Average Follower Length*. This command is used for *Maximizing Profile Performance* and diagnosis. It is only supported in Follower defined by sensor mode and is query only. See *Follower Length Correction Limit* and *Maximizing Profile Performance.*

FM11 - Master Axis Velocity

This is the velocity of the synchronization source in steps per second. It is updated once per second. The command is query only.

FM12 - Average Master Length In User Units

The current *average* Master length in Master Defined by Sensor mode in user units.

This value should be used to verify the *Master Cycle Length* field in PCX for executing *Master Cycle* definition.

The command is query only. See *ML11.*

FM13 - Average Follower Length In User Units

This is the same value as *FL11 (*average Follower Cycle Length*)* but in user units instead of resolver steps. This value can be used to verify the *Follower Cycle Length* field when the Follower cycle is defined by sensor in PCX for executing Follower cycle definition. The command is query only.

FM14 - Computed Starting Master Distance In Master Steps

This is the computed distance that the Master must move for the Follower to execute a starting ramp or cycle drop-in to the first possible *Cycle Point.* It is useful for verifying the minimum *Master Sensor Distance* needed. The distance that the Master will actually travel will actually be this value plus up to one Master Length because of the position of the Master cycle. It will be unique to the Master and Follower cycle combination used. The command is query only.

FN1 - Follower Cycles Per Follower Sensor

This command sets the number of Follower cycles which occur between two successive *Zero Follower Cycle* inputs. The *Follower Cycle Length* entered should be the average distance between Follower sensor inputs. The average *Follower Cycle Length* is divided by this value for the running *Follower Cycle Length*. The *Working Segment* and *Working Offset* use the running *Follower Cycle Length*.

It must be set using a serial command on a individual cycle basis and may be changed only outside of a cycle. The range is from 1 to 127.

It is not uploaded or downloaded by PCX.

See *Cycle Inter-Relationships,* the *FM13* serial command and *Terminology.*

Following is an example of changing an operational flag:

CY = 2   Select cycle two for editing.

FN1?   Query the *Follower Cycles Per Follower Sensor* on Follower
FN1 = 1   cycle 2 and PCX returns the current *Follower Cycles Per Follower Sensor* for Follower cycle 2:

FN1 = 3   Change the *Follower Cycles Per Follower Sensor* to 3 on Follower cycle 2.

KC4 - Total Cycle Count

This command returns the total number of Followers cycles executed since the Master processing was last reset. See *Follower Flags*.

MF - Master Cycle Flags

The *Master Cycle Flags* are a bit map in hexadecimal containing selections for the control of operational and starting modes. More than one flag may be set or cleared at a time as the flags are additive. It is on a individual cycle basis.

Master Defined By Sensor	0x01
Disable Reset of Master Cycle 0 (Zero)	0x20

Following is an example of changing a operational flag:

CY = 0   Select cycle zero for editing.

MF?   Query the Master flags on cycle 0 and PCX returns the
MF = 1   current flags for cycle 0:

The *Master Cycle* is defined by sensor.

The *Reset of Master Cycle 0* is enabled.

MF = 21   Adding 0x20 to the current value will *Disable Reset of Master Cycle 0* on cycle zero.

The *Master Cycle Flags* are uploaded and downloaded by PCX.

Master Cycle Defined By Sensor 0x01

This command specifies if this *Master Cycle* definition is defined by sensor. It is available from Master Cycles screen.

Disable Reset of Master Cycle Zero 0x20

This command allows the user to disable the Resetting the *Master Cycle Processing* for *Master Cycle* zero when the first Follower cycle after power-up is started.

Normal operation:

Upon starting of the first Follower cycle after power up, *Master Cycle zero* will cause the PCM-22 to cause the *Master Cycle zero* default information to be loaded. This would overwrite any "learned" information and cause *Master Cycle zero* to behave like all other Master cycles. This is done because *Master Cycle zero* is used when the FX/PCM-22 is first powered-up and may learn some random Master information which may not be usable when the Follower cycle is started.

This is only supported in Master defined by sensor mode. The default setting for the *Disable Reset of Master Cycle 0* flag is "off".

ML11 - Current Master Length In Master Steps

This is the executing Master Length or product length in Master steps. This value the same as FM12. The command is query only.

PH4 - Minimum Master Velocity For I/O Profile Adjustments

This parameter disables I/O profile adjustments below a certain Master speed in steps per second. It does not affect serial commands. This parameter is used for all Follower cycles. The default value is zero, which allows adjustment at any velocity. The maximum value is 65,535 steps per second. It is uploaded and downloaded by PCX.

TC5 - Working Ratio Change Increment

The *Working Ratio Change Increment* value is used increment the *Working Ratio* when the *Working Ratio Increment* and *Working Ratio Decrement* input functions are toggled, 118 and 119 respectively.

It must be set using a serial command on a individual cycle basis. The default value is 0.01000 and the maximum value is 0.65535. Values are entered without decimal points. It is not uploaded or downloaded by PCX.

Appendix B

PCX Cycle Screens to FX Command Cross Reference

PCM-22 Master Cycles Screen

```
Screen Parameter                              Serial Command
Master Cycle Number ------------------   CY
Master Cycle Length -----------------    ML0
   +-> Master Length Upper Limit ------   ML9
   +-> Master Length Lower Limit ------   ML10
Master Phase Distance ---------------    TA
Master Cycle Defined by Sensor---------   MF
   +-> Cycle Length Averaging ---------   MS
   +-> Master Sensor Valid Zone -------   MZ
   +-> Master Length Correction Limit--   PH3
```

PCM-22 Follower Cycles Screen

<u>Screen Parameter</u>	<u>Serial Command</u>
Cycle Number -------------------------	CY
Follower Cycle Length ----------------	FL0
- Follower Length Correction Limit -	PH2
- Follower Length Upper Limit ------	FL9
- Follower Length Lower Limit ------	FL10
Cycle Defined By a Registration Sensor-	FF
+-> Follower Sensor Valid Zone (+/-)-	FZ
+-> Follower Cycles Per Master Cycle	FN0
+-> Follower Sensor Averaging ------	PA
Phase Correction Limit ---------------	PH1
Phase Distance Error Limit (+)---------	PP
Phase Distance Error Limit(-) ---------	PN
Phase Correction Deadband -------------	PH0
Length Change Increment --------------	TC2
Master Cycle Number ------------------	FT
Batch Count --------------------------	KC3
Cycle Count --------------------------	KC2
Working Segment Width ----------------	FM0
- Working Ratio -------------------	FM2
- Working Offset ------------------	FM1
- Upper Working Segment Limit Width-	FM3
- Lower Working Segment Limit Width-	FM4
- Upper Working Ratio Limit --------	FM5
- Lower Working Ratio Limit --------	FM6
Offset/Phase Fine Increment -----------	TC0
Offset/Phase Coarse Increment ---------	TC1

Appendix C

Master Signal Components

Encoder Operation

The SCS-2, 3 and 4 sync encoders are two channel amplified sine wave encoders. Each of the channels has 1000, 2500 and 3000 lines respectively. The inputs are A, A {complement}, B and B {complement}. Quadrature encoding of these two signals produces a signal whose frequency is 4 times the line count. One revolution of the sync encoder produces the equivalent of 4000, 10,000 and 12,000 counts (steps) per revolution respectively.
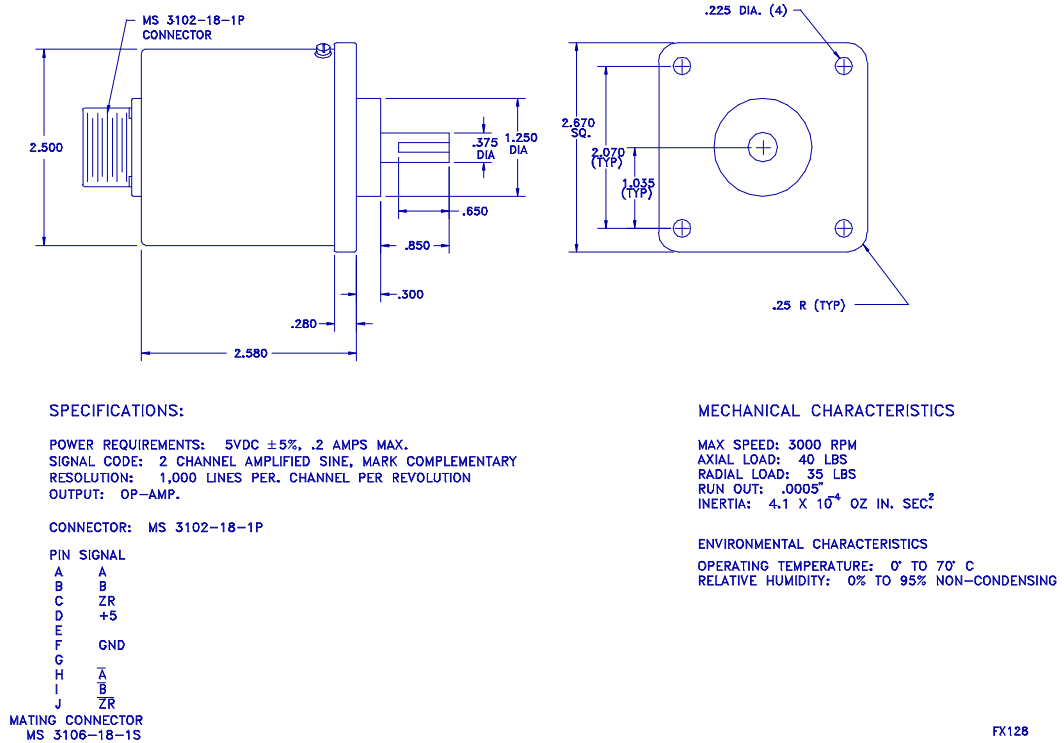
Figure 31   *SCS-2,3 and 4 Encoder Mechanical/Electrical Information.*

Encoder to Drive Cables

If an external encoder is used as a Master signal source, the connection of the external encoder to the first axis is accomplished with the MSC-XXX cable. As many as 10 axes can be synchronized to a single encoder.
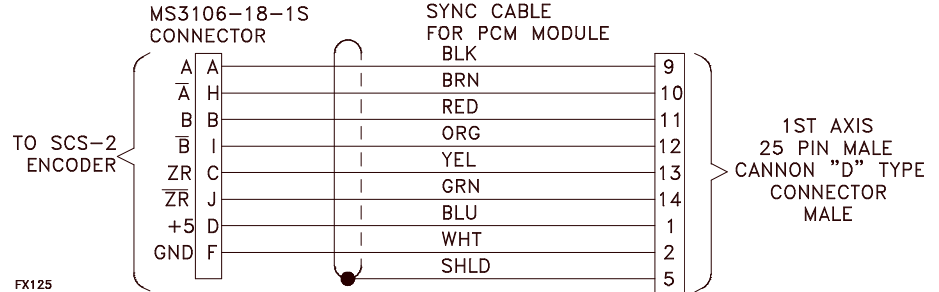
Figure 32   MSC-XXX Encoder Cable Wiring Diagram

The MSC-XXX cable is provided in different lengths.

MSC-015 = 15 feet

MSC-025 = 25 feet

MSC-050 = 50 feet

Drive to Drive Cables

For some applications another digital drive could be the Master signal source. This is the purpose of the second connector on the PCM. The first axis can provide the synchronization signal for the second axis. The SSC-XXX cable is a symmetrical cable and its ends can be interchanged.
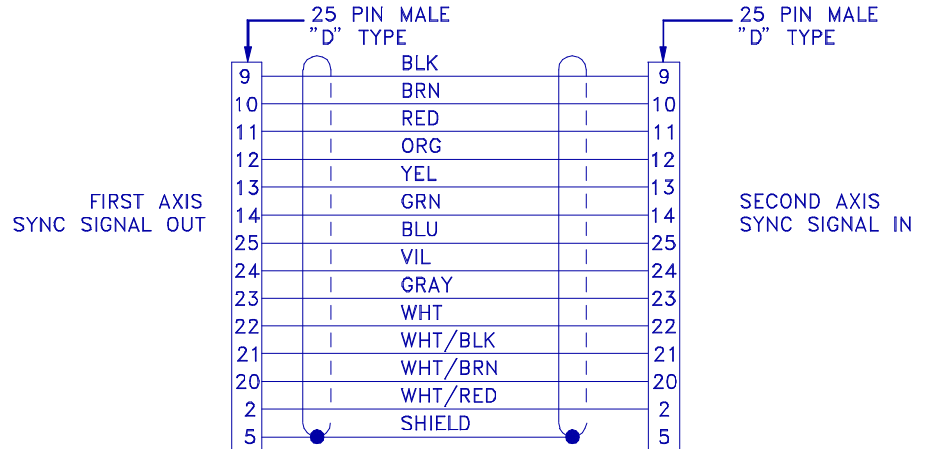
Figure 33   SSC-XXX Cable Wiring Diagram

The SSC-XXX cable and is available in different lengths.

SSC-003 = 3 feet

SSC-006 = 6 feet

SSC-010 = 10 feet

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