PCM-17 APPLICATION MODULE
OPERATORS MANUAL
SETUP AND PROGRAMMING

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1.1 PCM-17 MODULE OVERVIEW

The PCM-17 module is designed to control a system where randomly introduced products must be accurately placed on a mechanism that runs a measurable repeating cycle .

1.1.1 BASIC OPERATION

1 shows a machine where product enters an infeed belt on a random basis. The PCM-17 will adjust the infeed conveyor (follower axis) velocity in order to deliver each product to the correct position on the lug conveyor or Master Axis. The distance from lug to lug on the Master Axis is called the *master cycle length.* The *master cycle length* is defined as a 360 degree cycle (see 3).

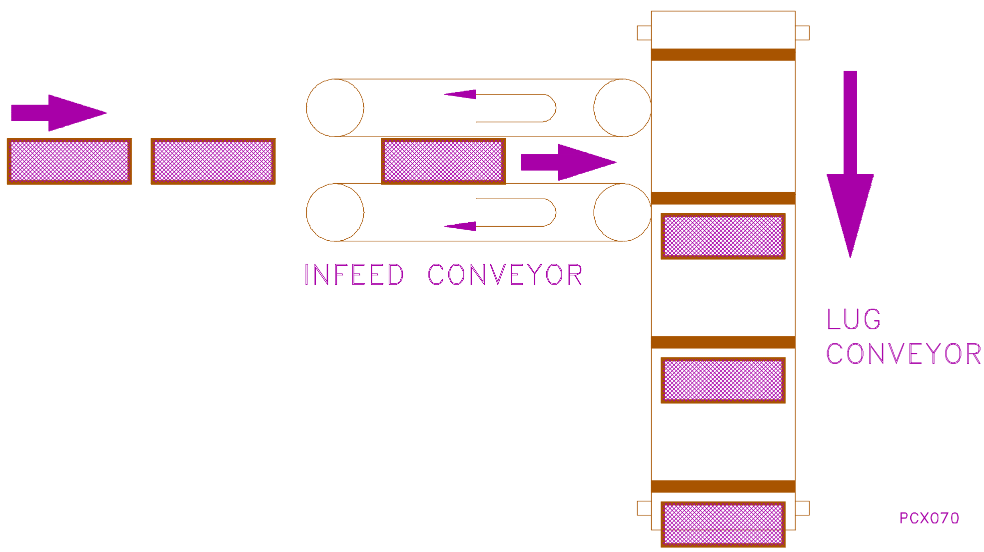


Figure 1 Random Infeed Control

In 2, a master cycle sensor signals the beginning of each master cycle and an SCS-x sync encoder tracks the instantaneous position through each master cycle. An infeed sensor is used to signal the arrival of a product on the infeed conveyor and the drive notes the position (Infeed Angle) of the Master Axis at the moment the product is introduced.

The drive then calculates and executes a *correction profile* that will deliver the product to the programmed position (Target Angle) on the Master Axis conveyor. Any variations in master axis velocity will be monitored through the SCS-2 encoder and the infeed conveyor velocity will be synchronized accordingly.

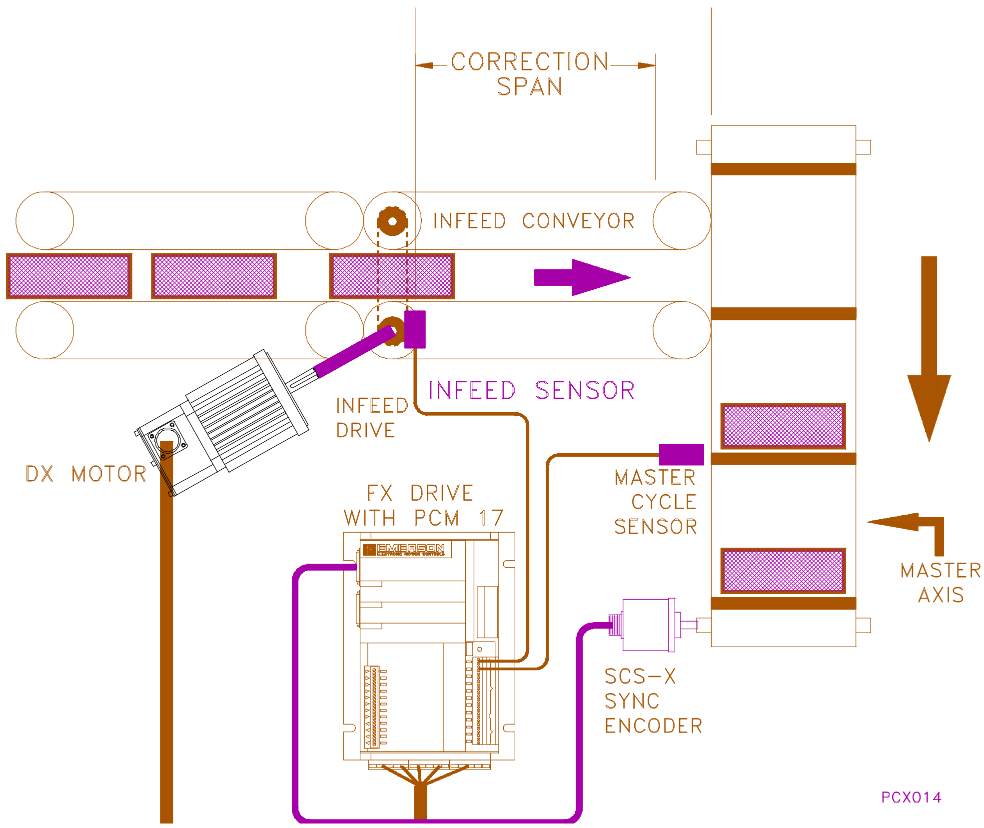


Figure 2 Random Infeed Application

The *infeed span* is the distance on the infeed conveyor measured from the infeed sensor to the point where effective position control of the product terminates as it leaves the infeed belt.

The *correction span* is that portion of the infeed span where a *correction profile* is executed in order to match the product with the Target Angle. This assures that each product will be correctly placed on the Master Axis. The Target Angle may be altered while the system is running to adjust product placement on the master axis. The drive calculates a new correction profile each time a product is introduced.

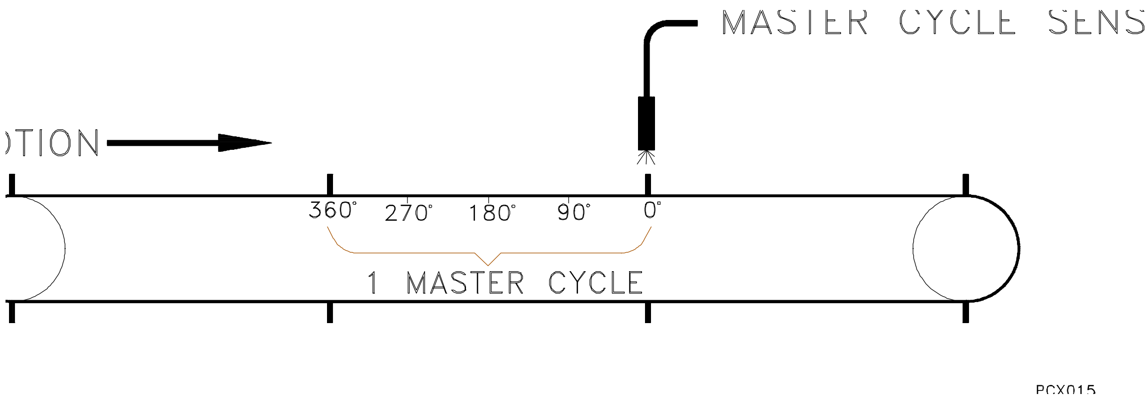


Figure 3 Cycles on a Lug Conveyor (Master Axis of Motion)

Some applications may not require a master cycle sensor however, these cases would require a 100% accurate master cycle with absolute repeatability, no slippage, and no accumulated error. If these conditions are met the machine can be manually set at its zero position (master axis start position), the drive would recive a signal form the zero master cycle input to define a zero point.

The system would then be able to deliver products to the programmed position on the master axis based on the sync encoder output.In cases where more than one product is placed between the lugs, the master cycle can be electronically divided into two or more equal sub-cycles.

1.2 SETUP AND PROGRAMMING

The following chart shows the PCX 6.X menu hierarchy when a PCM-17 application module is attached to the basic drive.

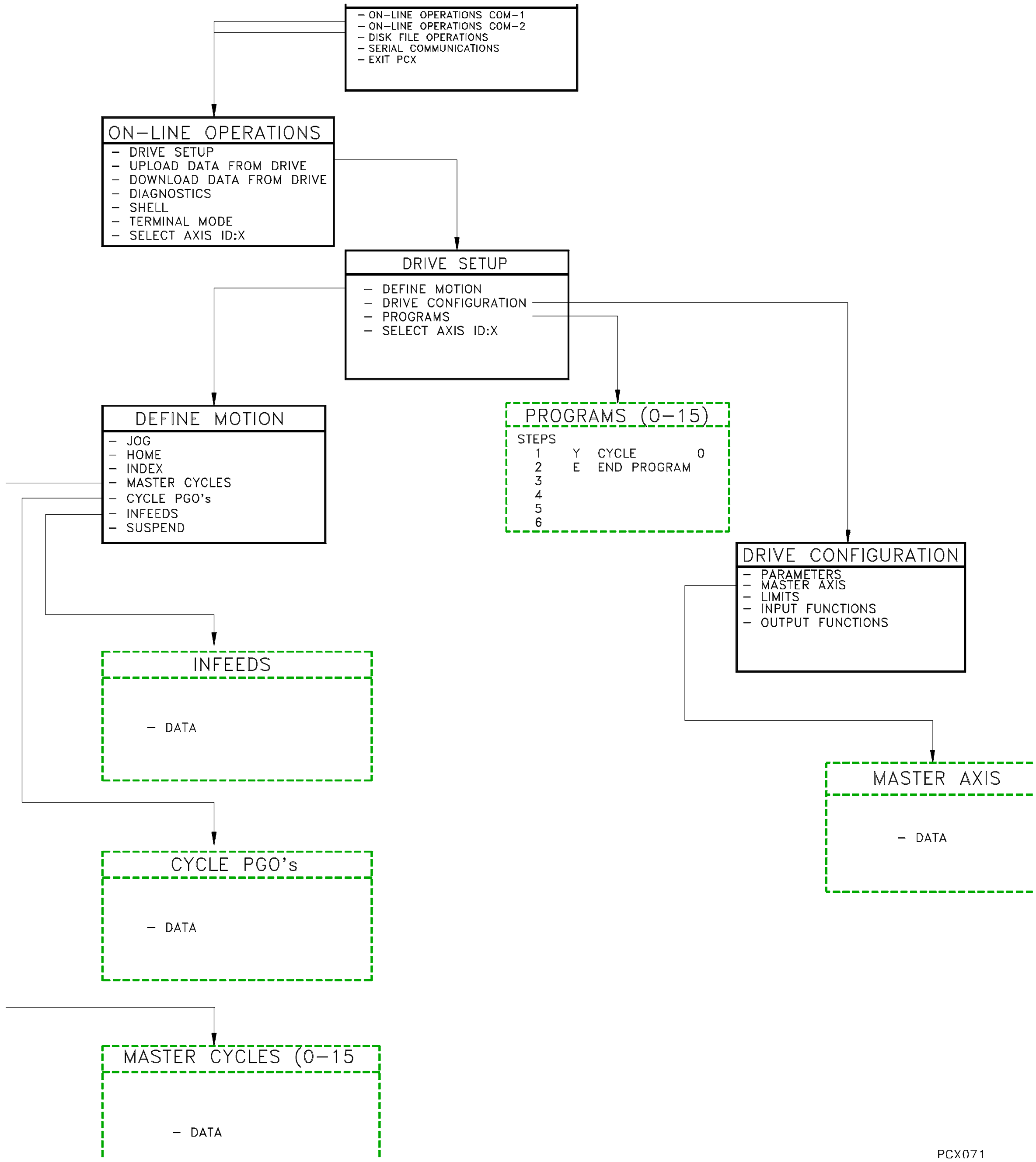


Figure 4 PCX 6 Menu Hierarchy (With PCM-17)

1.2.1 MASTER AXIS SETUP

When configuring your system with a PCM-17, the first step is to define the Master Axis. The Master Axis is typically an Emerson SCS-x encoder which produces 4000 steps per revolution. It can also be a customer supplied encoder of any line density yielding the appropriate steps per revolution.

The "Master Axis" setup screen is accessed from the "Drive Configuration" screen. To access the master axis setup screen, highlight the master axis selection by using the Up/Down arrow keys, then press the <Enter> key. This screen contains information needed to establish a relationship between the external encoder and the follower axis.

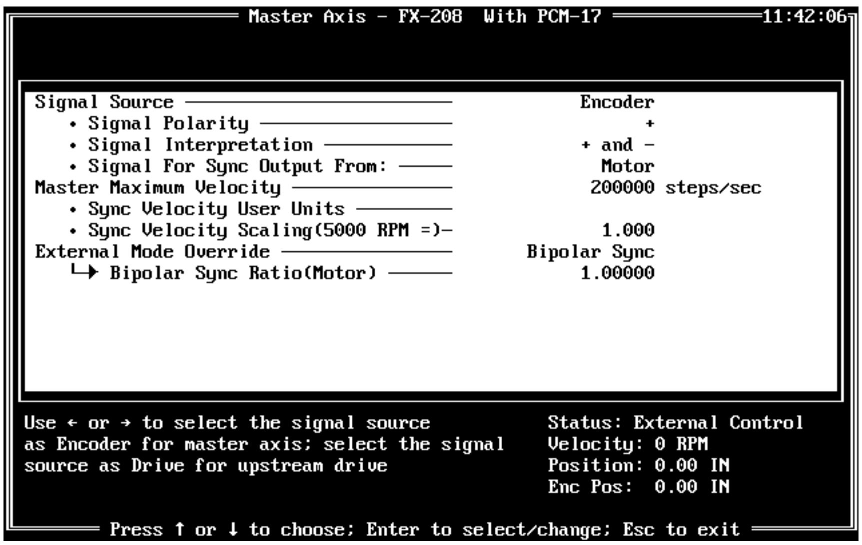


Figure 5 Master Axis Screen

1.2.1.1 MASTER AXIS SCREEN DEFINITIONS

Signal Source

Using the (+) or (-) keys to toggle between **Drive** and **Encoder**, the user selects the origination of the signals used to determine the positional information of the **Master Axis**.

Signal Polarity

Defines the direction of the synchronization encoder that corresponds to a positive master position change. Clockwise is indicated with a (+), counterclockwise is indicated with a (-). Perspective is looking at the encoder shaft.

Signal Interpretation

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

The following signal interpretation modes do not apply to the slip compensation or bipolar sync modes of operation. Signal interpretation modes apply only to ratio synchronization.

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 same 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 conveyor 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. For example, the master stops, then inadvertently backs up due to conveyor slack, etc.

Signal For Sync Output From:

Use the arrow keys to toggle between the choices. If the user selects *Motor*, the amplifier will output a sync signal based on the performance of its own motor. If the user selects *Upstream Drive*, the amplifier will output a signal that comes from the motor of the preceding amplifier.

Note: Encoder pulses are passed to all amplifiers in the synchronization chain. The answer to this question has no effect on the encoder signal.

Master Maximum Velocity

The **Master Maximum Velocity** is the maximum frequency that the **Master Axis** signal source is expected to produce. To calculate the master maximum velocity use the following formula:

Master Maximum Velocity (in steps per sec) =

$$\frac{\text{Master's Drives Max Velocity (RPM)} \times \text{Master Steps/Rev}}{\text{60 Second/Minutes}}$$

Master's Steps/Rev = Encoder Line Density **X** 4 (If Encoder is master)
Master's Steps/Rev = 4096 (If Drive is Master)

Note: 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.

Sync Velocity User Units

Sets the units to be associated with all Sync velocities.

Sync Velocity Scaling (Max RPM Equals)

This parameter sets the sync velocity to equate to the maximum velocity of the drive. When an index is running in Sync Time Base the velocity is specified in user units (see Distance User Units in the Drive Parameters screen).

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 it's current operating mode and default to the mode selected with this parameter. Use the arrow keys to toggle between the three modes of operation which are Analog Velocity, Analog Torque or Bi-Polar Sync.

Analog Velocity/Torque

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

Bi-polar Sync

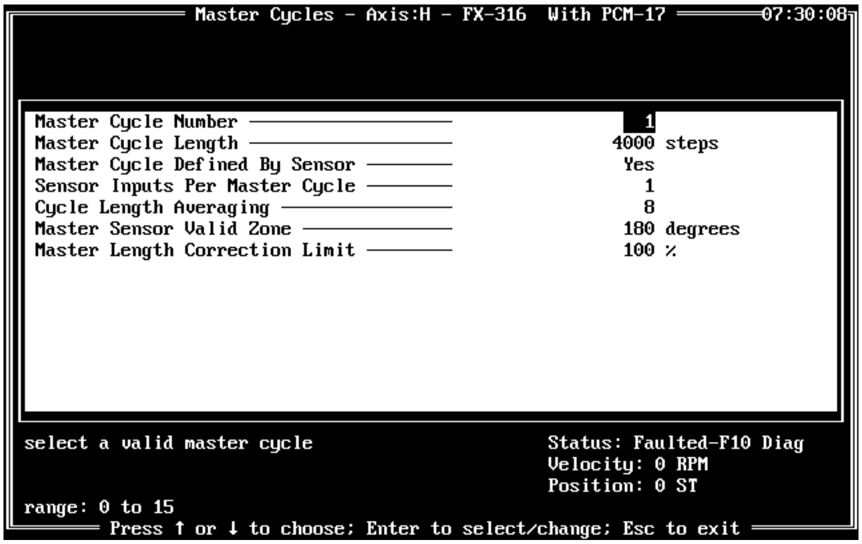
When set to bi-polar sync, this parameter allows for bi-polar ratioing of the sync encoder to the drive motor.

Bi-polar Sync Ratio (motor)

The Bipolar Sync Ratio is the relationship of the Follower Axis position to the Master axis position. If the Bipolar Sync Ratio is set to 3, for every 1 count of the Master Axis, there will be 3 counts of the Follower Axis. Thus, the Bipolar Sync Ratio would be 3:1. This ratio is used for Bipolar Sync mode.

1.2.2 MASTER CYCLE SETUP

After the defining the *Master Axis* information, the next step is to define the Master Cycle. A FX Series amplifier with a PCM-17 has the capability of storing 16 (0-15) Master Cycles. Shown below is a sample screen used to setup Master Cycle 0.



1.2.2.1 MASTER CYCLE SCREEN DESCRIPTIONS

Master Cycle Number

Up to 16 (0-15) different Master Cycles can be defined. These Master Cycles can be used with any Infeed. In some processes only one Master Cycle is defined. This Master Cycle can be used in conjunction with all 16 Infeeds.

Master Cycle Length

This entry defines the length of the Master Cycle in steps. This is the distance that a master positioning drive, SCS-X encoder, or customer supplied encoder rotates through each Master Cycle. This parameter is measured in steps.

NOTE: **1 revolution of SCS-X encoder = 4000 steps. 1 revolution of a master positioning amplifier = 4096. 1 revolution of a customer supplied encoder is 4 * the encoder line count.**

Master Cycle Defined by Sensor

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

Note: If NO is entered here, the last four master cycle parameters will not apply.

Sensor Inputs per Cycle

Allows the operator to vary the length of the cycle in terms of the number of sensor inputs required to measure one cycle i.e., 360° may equal one input or it may require the passing of 4 lugs (inputs) to complete one 360° cycle. This allows the Master Cycle to be divided into smaller sections. Two smaller divisions of the Master Cycle may not be greater than an equal number of steps per 1 Master Cycle.

Master Cycle Length Averaging

The amplifier will average the distance measured between successive Master Cycle Sensor input signals over a set number of cycles. For example, if (8) is entered for the value, the unit will average the last eight cycle length measurements to establish the current cycle length. The current cycle length is then used to make any required phase angle adjustment on the next cycle. This feature is employed to stabilize the measured cycle length when minor variations in Master Cycle length occur.

Master Sensor Valid Zone

An area on both sides of the defined zero degree position in which a Zero Master Cycle Sensor input signal will be considered valid. For example; if the operator enters ±10° here, any input signal which appears on the Zero Master Cycle Sensor input which appears before -10° or after +10° will be ignored. This is useful in applications where registration marks are printed in the same feed path as other printing (such as advertising, logos, instructions, etc.). The amplifier will ignore all inputs and outputs except those which appear within the valid zone.

Master Length Correction Limit

This parameter limits the amount of correction made when master length error is detected. For example; if set ot 50%, the drive will use 50% of the error length to correct the master length.

1.2.3 SETTING UP INFEED PARAMETERS

The next step is to define the infeed cycle(s). The infeed span and the correction span are defined in user units, however, the PCM-17 treats the infeed span as a 360° cycle. The cycle starts when an infeed sensor event occurs and ends when the infeed device has moved the distance of one infeed span. The system will store 16 infeeds (0 to 15) any Master Cycle can be attached to any Infeed. Following is a sample set-up for infeed #0.

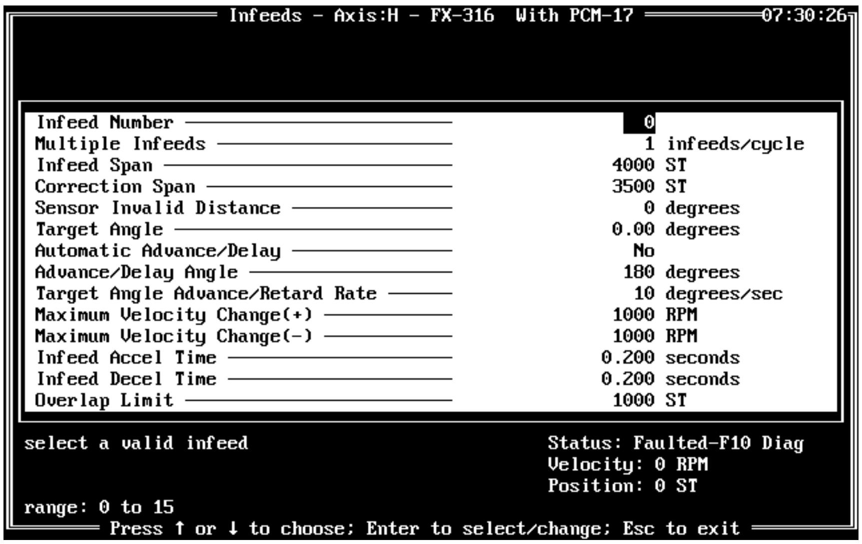


Figure 7 Infeeds Screen

1.2.3.1 INFEEDS SCREEN

DESCRIPTIONS

Infeed Number

Each Infeed requires that a Master Cycle be attached. The same Master Cycle can be used for all 16 Infeeds.

Multiple Infeeds

This parameter allows the system to divide the Master Cycle into as many as 24 equal subcycles. Each subcycle has its own zero point allowing the infeed controller to place as many as 24 products into each Master Cycle.

Infeed Span

The *Infeed Span* is the distance (in user units) on the infeed conveyor measured from where the infeed sensor detects an incoming product to where effective control of the product terminates as it leaves the infeed belt.

Correction Span

The correction span is that portion of the infeed span where the correction profile is executed in order to place each product at the programmed Target Angle on the Master Axis. The product must remain under control during execution of the entire correction profile.

Sensor Invalid Distance

Measured in degrees of the infeed cycle, this is a distance immediately following the initial infeed sensor event during which any signal on the infeed sensor line will be ignored. For example: if this was an application where the product had through holes, several false sensor events could occur after the initial sensor event . The system would respond only to the initial signal and would ignore those inputs that occured in the invalid zone.

Target Angle

Measured in degrees of the Master Cycle, the Target Angle is the position on the Master Axis where product is to be delivered. The position can be any value from 0 to 360 degrees, and may be altered while the amplifier is running. Changes can be made through the I/O, through a T-21, or through the use of ASCII commands. To view Target Angle changes while in PCX, exit from the Infeed screen and then re-enter.

Automatic Advance/Delay

If answered YES this feature will cause the system to attempt a positive correction profile whenever possible. The drive calculations will include the Master Axis velocity. If the Infeed Angle is such that positive correction is not achievable then the drive will calculate a negative profile and the product will be delivered into the next Master Cycle. If answered NO the drive will generate profiles based on the Advance/Delay Angle discussed below.

Advance/Delay Angle

Measured in degrees of the Master Axis, this position is essentially a decision point for the drive. Any product whose Infeed Angle is less than this value will be given a positive correction profile, any product with an Infeed Angle that is greater will recieve a negative correction and will be placed in the next master cycle. The decision is based on position.

Target Angle Advance/Retard Rate

A signal on the Target Angle Advance or Retard Input will cause the programmed Target Angle to change. This parameter establishes the rate at which this change occurs. It is defined in degrees of the Master Axis.

Maximum Velocity Change (+)

Defines the maximum amount of velocity that can be added to the *base ratio velocity* in any attempt to generate a positive correction profile.

Maximum Velocity Change (-)

Defines the maximum amount of velocity that can be subtracted from the base ratio velocity in any attempt to generate a negative correction profile.

Maximum Infeed Acceleration Rate

The acceleration rate employed any time an increase in the velocity of the infeed drive is required.

Maximum Infeed Deceleration

The deceleration rate employed any time a decrease in the velocity of the infeed drive is required.

Overlap Limit

This feature can be used to indicate that a new product has entered the overlap zone before the current product has exited an overlap limit output (if used) would be activated. The overlap limit value is the infeed span minus the overlap zone. The overlap zone is measured from the end of infeed span backwards (see 8).

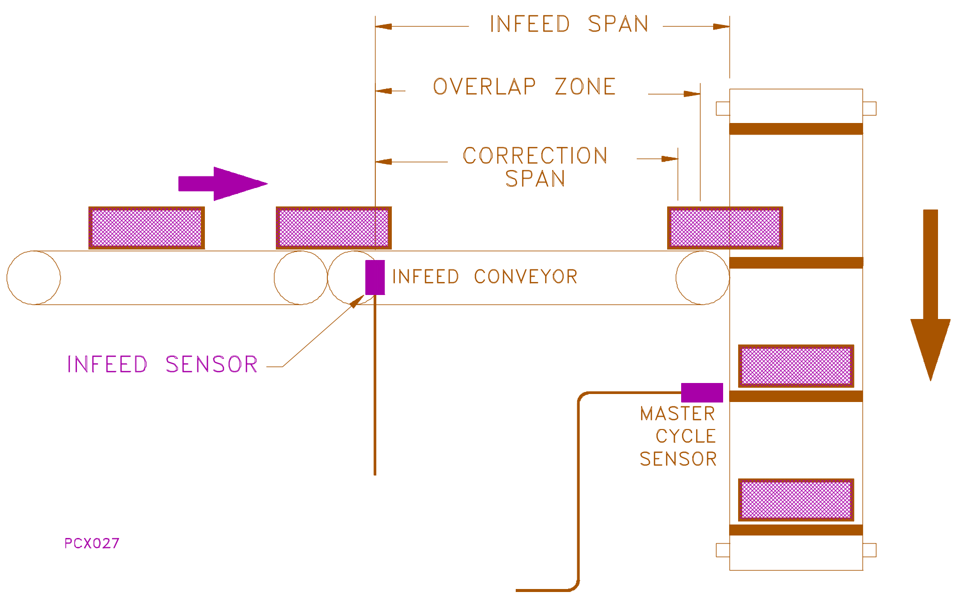


Figure 8 Overlap Limit

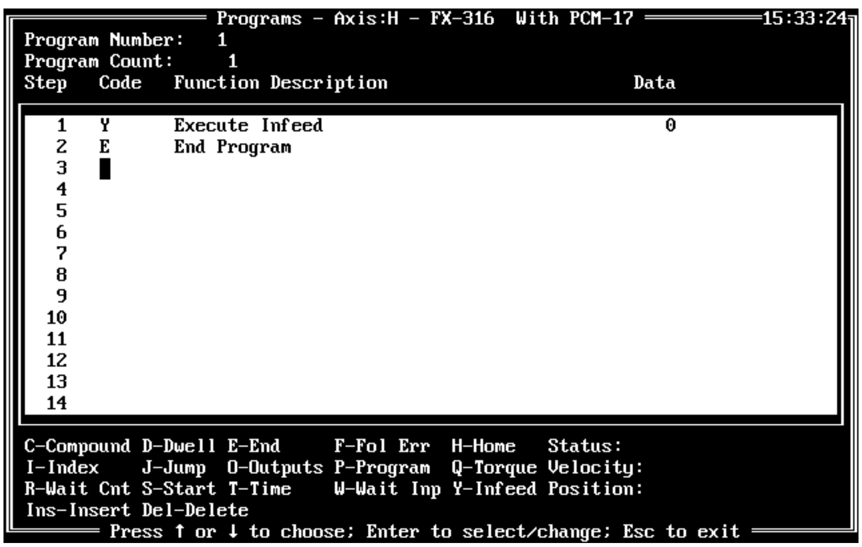
Master Cycle Number

When the Infeed executes, this is the Master Cycle that will be used to determine where the product will be placed.

1.2.4 PCM-17 PROGRAM SETUP

The last step is to load the *Infeed* information into a program. The amplifier can retain up to 16 (0-15) Programs. The following depicts the "Program" screen. Infeed can only be initiate when it is a step in the program. Because of the additional memory on the PCM-17 there will be 64 standard indexes available and 500 steps available in each program.

When the program reaches the Cycle ("Y", Execute Cycle) step, the defined Infeed then begins. Infeeds do not have counts and will run until stopped. Program count has no effect except that the count must be greater than 1 to enable the program to execute. No steps after the Cycle step will ever be executed.



1.2.5 INPUTS/OUTPUTS

The following logic control functions are added to the Input and Output screens any time a PCM-17 Module is employed.

1.2.5.1 INPUTS

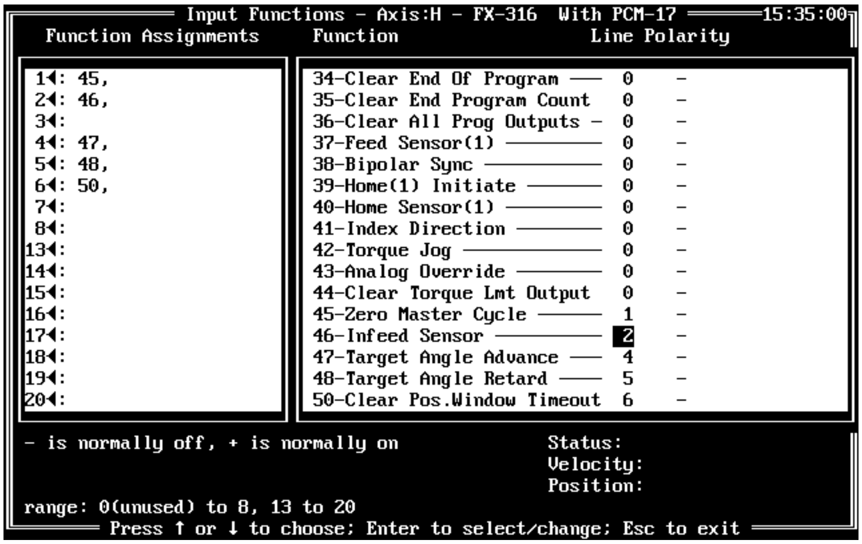


Figure 10 Input Functions Screen

<u>FUNCTION#</u> **<u>DESCRIPTION</u>**

45 **<u>Zero Master Cycle</u>**

Establishes *master zero degree* point each each cycle.

46 **Infeed Sensor**

Signals the drive that a product is entering the system.

47 **Target Angle Advance**

Target angle decreases at the programmed *Target Angle* or *Advance/Retard* rate.

48 **Target Angle Retard**

Target angle increases at the programmed *Target Angle* at the *Advance/Retard* rate.

1.2.5.2 OUTPUTS

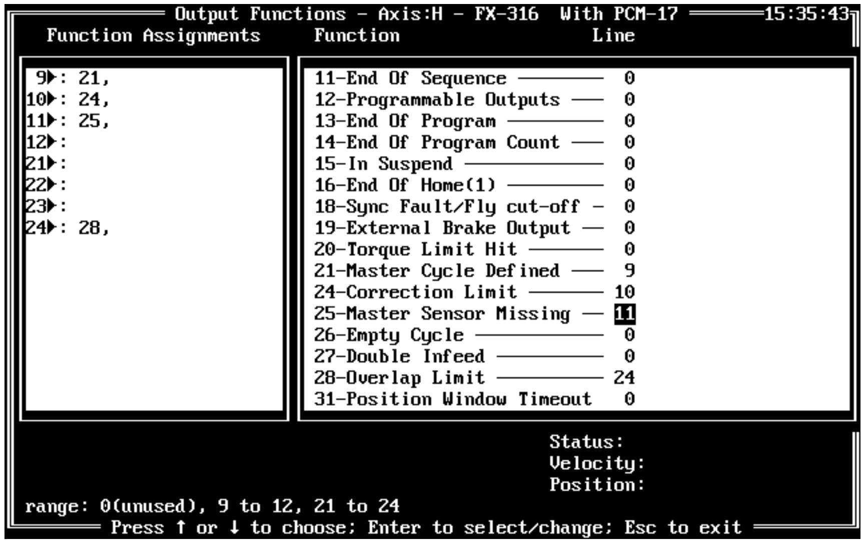


Figure 11 Output Functions Screen

FUNCTION# **DESCRIPTION**

21 **Master Cycle Defined**

Output turns on once the master cycle is defined after power up.

23 **Correction Limit**

Output turns on any time a product enters the system at such an infeed angle that the system cannot achieve the programmed target angle at the speed that the Master Axis is running.

25 **Master Cycle Missing**

Output turns on once the master cycle sensor input fails to appear after a master cycle distance is moved. The amount of distance after the expected position before the output comes on is programmed in dumb terminal mode with a default setting of 180°.

26 **Empty Cycle**

Output comes on any time a master cycle goes by without a product being inserted.

27 **Double Infeed**

Output comes on any time a new product enters the correction span prior to the time the previous product exits the correction span.

28 **Overlap Limit**

Output comes on any time a new product enters the overlap zone before the current product has exited an overlap limit output (if used) would be activated. The overlap limit value is the infeed span minus the overlap zone. The overlap zone is measured from the end of infeed span backwards (see 12).

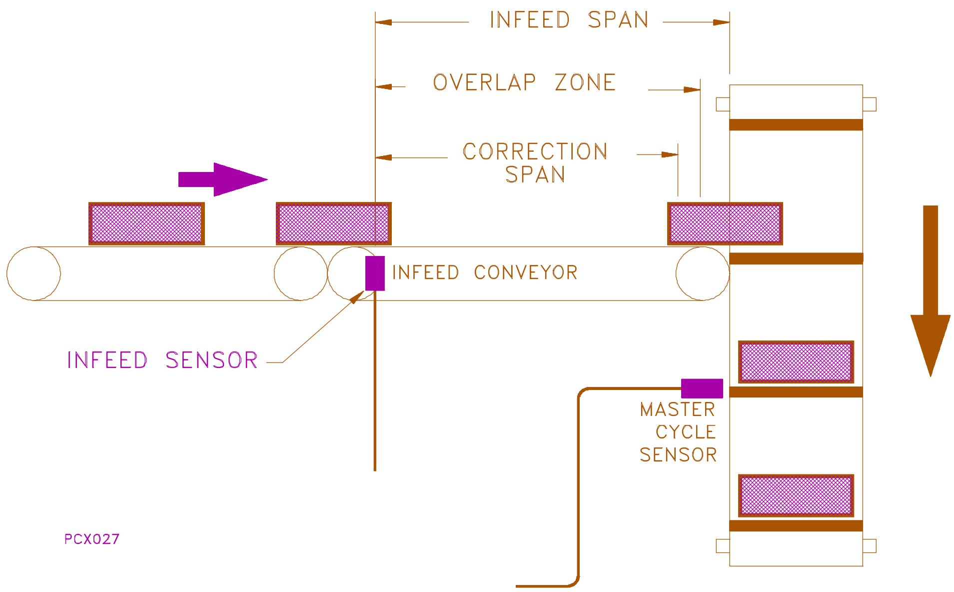


Figure 12 Overlap Limit Output

1.3 PCM-17 OPERATION

1.3.1 START UP SEQUENCE #1

Master Cycle defined by a sensor.

When the drive initially recieves the instruction to run the infeed cycle the system waits for the master cycle sensor event and then begins the infeed cycle.

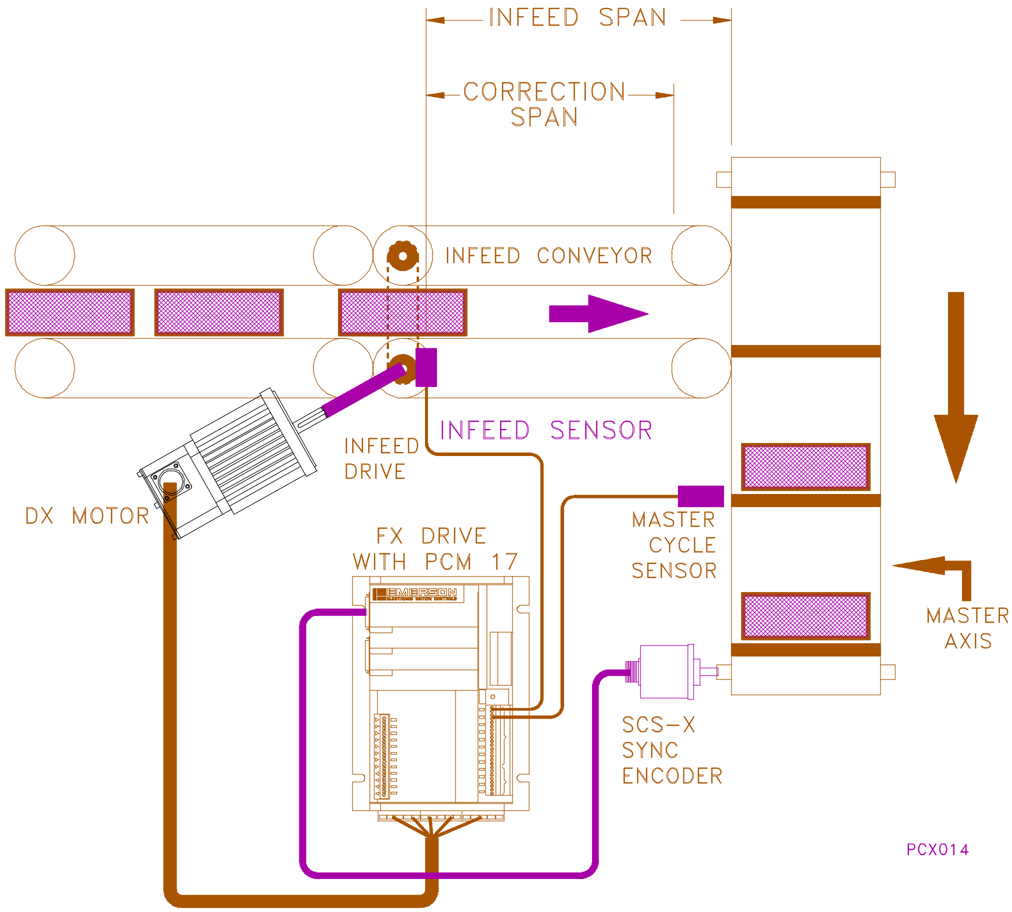


Figure 13 Random Infeed control using DX-Drive with PCM-17.

1.3.2START UP SEQUENCE #2

Master Cycle is NOT defined by a sensor.

when the drive recieves the infeed cycle instruction the system waits until a signal appears on the Zero Master Cycle input, and then proceeds to run the infeed cycle. This signal could come from a PLC or a manual switch.

Once the Master Axis Zero is established the system begins to run at a velocity that is ratioed to the Master Axis. This is called the Base Ratio, and is derived at by the following formula:

BASE RATIO = (INFEED SPAN in units) ÷ (MASTER CYCLE LENGTH in steps)

Upon receipt of the an Infeed Sensor signal the drive notes the Infeed Angle of the Master Axis and compares it with the Target Angle. The drive calculates a Correction Profile which causes the product to move through the Infeed Span and match up with the Target Angle. This profile is added to the base ratio velocity and the Infeed delivers the product to the Master.

The timing of the product entry determines the required amount of velocity change from the base ratio. If the product frequency and timing are perfectly matched with the Master Cycle then no velocity adjustments are required and the system runs at Base Ratio velocity. 14 illustrates the relationship between Error Angle and Correction Profile velocities.

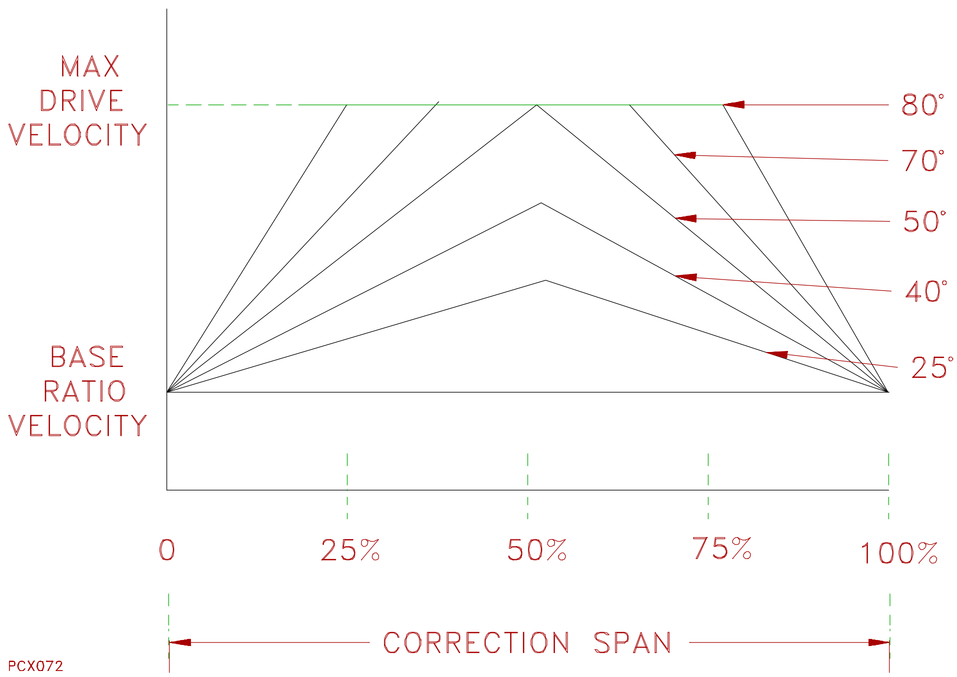


Figure 14 Correction Profile as a function of Error Angle

The correction profile is determined by the following formula:

$$E\,\mu_{o}\,\grave{o}^{t}\,ndt$$

Where τ = time duration of correction profile
and _ = Error Angle (target angle minus infeed angle)

The area under the curve for the velocity correction profile is directly proportional to the Error Angle measured at the introduction of each product within the constraint defined for ±*Maximum Velocity Change* and *Maximum Infeed Accel/Decel* values entered in the *Infeed* screen.

The percentage of the correction span used for acceleration compared to deceleration is defined by the *Correction Span Accel/Decel* ratio in PCX screen titled INFEED (see page 14).

The drive will use a positive correction profile or a negative correction profile to achieve the desired target angle depending on the amount of Error Angle. If the angle is less than the Advance/Delay Angle setting (see INFEED screen page 15) the system will execute a positive correction. If the Error Angle is greater than the Advance/Delay Angle setting the system will execute a negative correction profile.

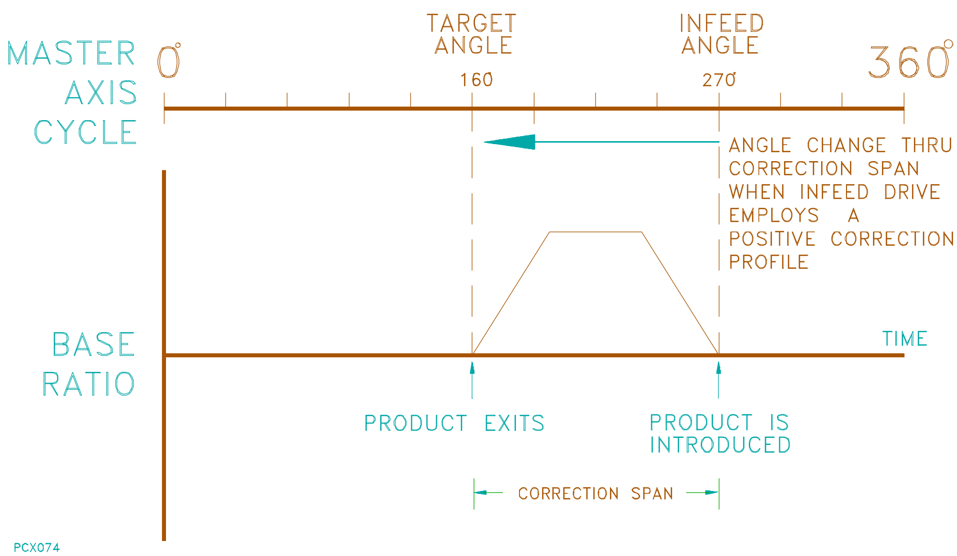


Figure 15 Positive correction profile is employed to achieve programmed exit angle of 160°. Note error angle = -110° (160° minus 270°).

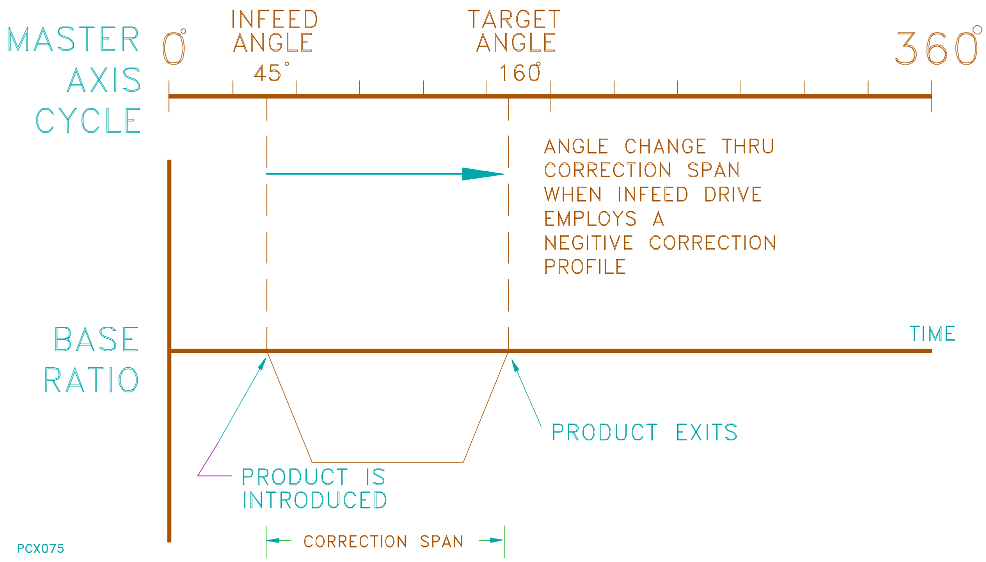


Figure 16 Negative correction profile is employed to achieve programmed exit angle of 160°. Note error angle = +115° (160° -45°).

It should be noted that the Infeed drive always returns to the base ratio as the product reaches the end of the correction span. Normally, a new product should not be introduced prior to the time that the current product exits the system (completion of the Infeed Span). If a new product is introduced before the current product exits the *Double Infeed* output will come on and the system will stay at base ratio velocity until the next infeed signal is received.

The system attempts to properly position a product on every master axis' cycle. If a products is not provided at the completion of an Infeed or if it is introduced at too much of a delay from the previous product and a cycle is not filled, the *Empty Cycle* output comes on.

Depending on the speed of the master axis there may be some infeed angles at which no correction is possible. Any product introduced at such an angle will cause the *Correction Limit Output* to come on. This output will turn off at the completion of the current Infeed cycle.

1.3.3 PRODUCT SEPARATION

17 shows a technique that is commonly used to insure that product entry will be of a frequency that approximates the frequency of the master cycle. Feed conveyor #1 is slaved to the master while conveyor #2 is slaved to conveyor #1. The mechanical ratio between #1 and #2 causes #2 to have the higher velocity. This assures product separation for the Infeed conveyor and also maintains an acceptable frequency match between product entry and the Master Axis.

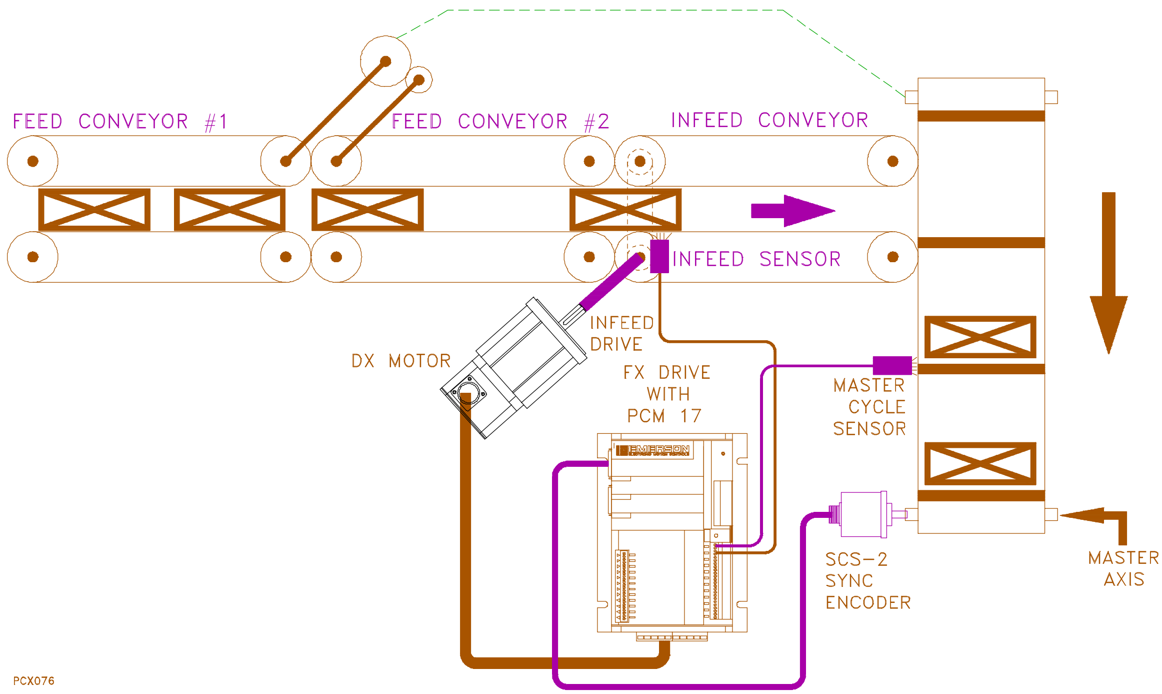


Figure 17 Product separation using two upstream slaved friction conveyors.

1.3.4 GATING

Occasionally a gating system is used to control the timing of product introduction into the infeed conveyor. The gate is mechanically connected to the master axis such that it releases the product at approximately the same time each cycle of the master. This allows a much higher speed of operation of the system as it prevents the introduction of products at angles which do not yield solutions. Generally the closer that product introduction can come to ideal the faster the system can operate.

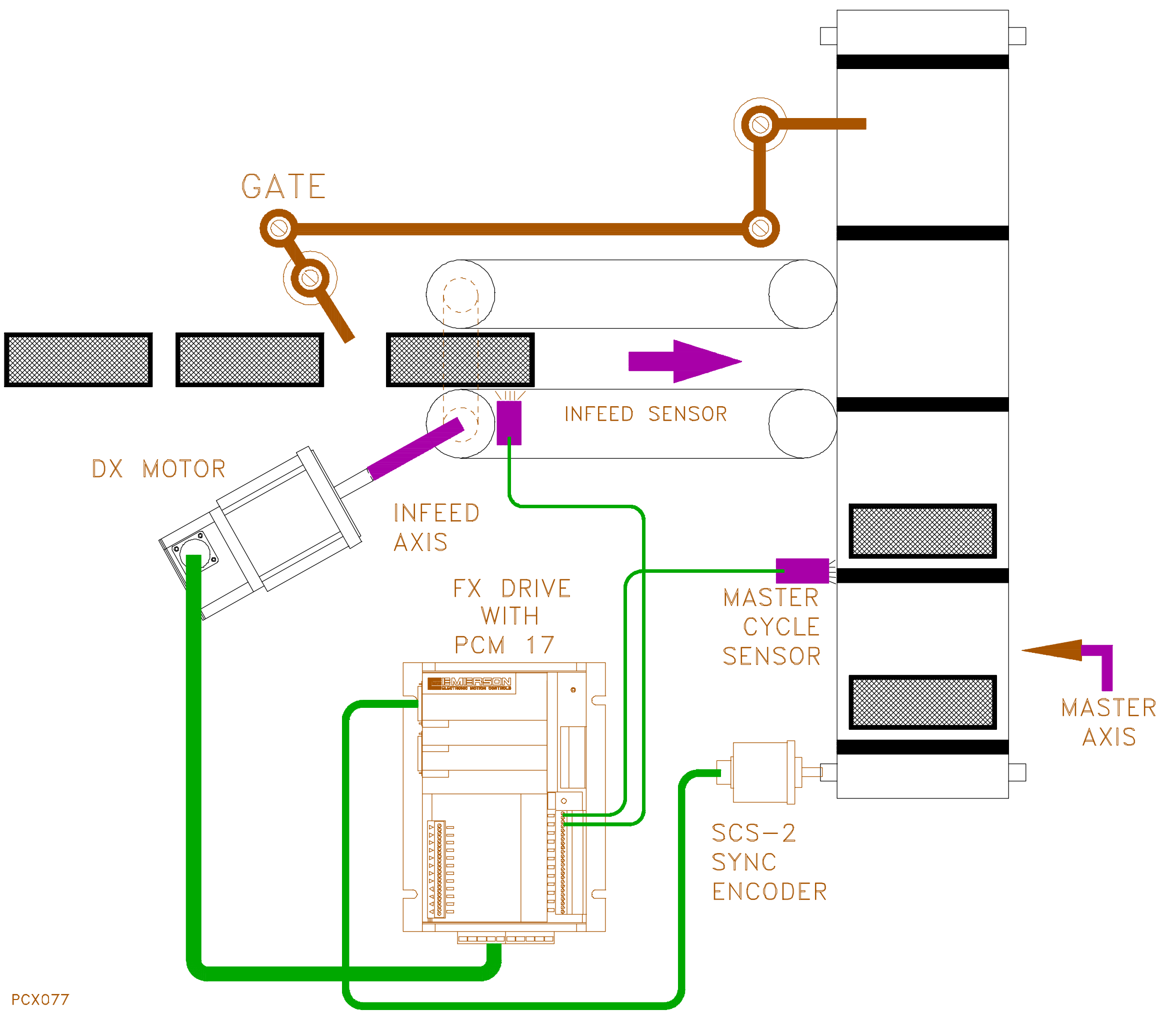


Figure 18 Random Infeed control with gated product introduction.

Another method for increasing system efficiency is to employ a conveyor downstream from the Infeed conveyor. This conveyor is simply slaved to the master conveyor. This allows the correction span to equal the entire length of the Infeed span providing greater correction capability for a given size infeed drive.

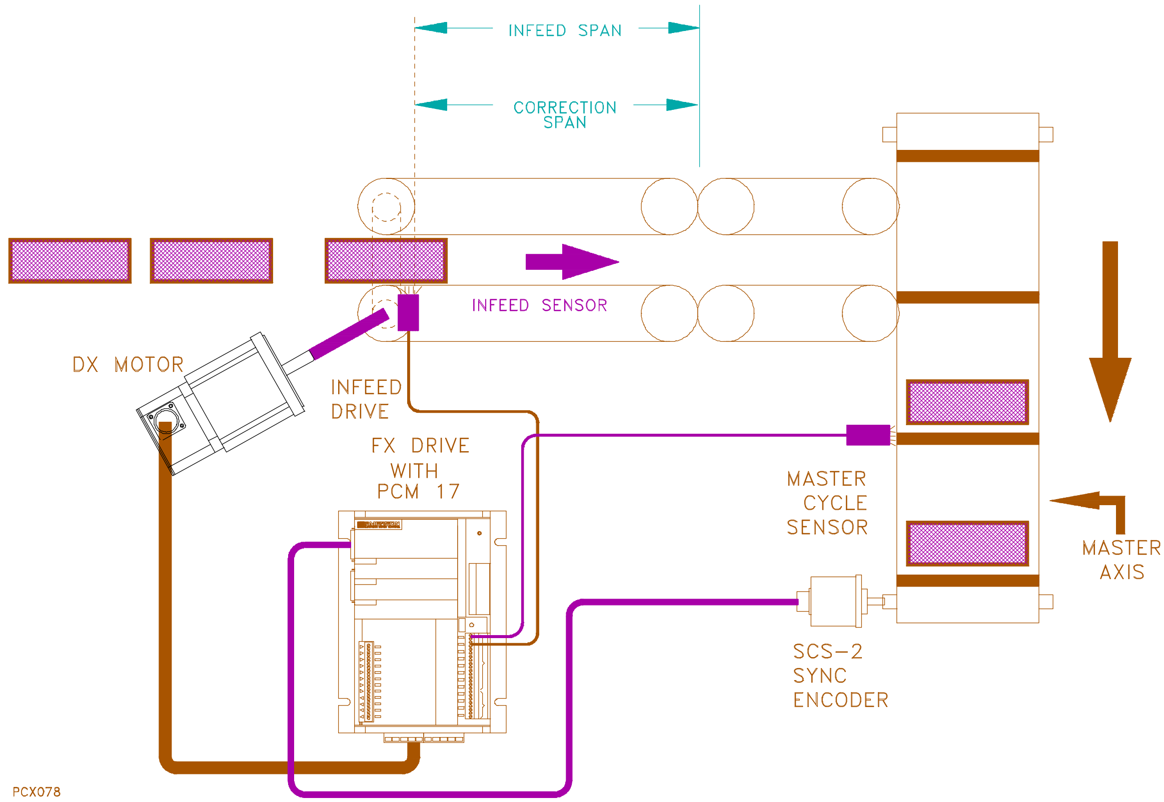


Figure 19

1.3.5 MULTIPLE INFEED DRIVE SYSTEM

In some applications, products are introduced completely at random or at such high line speeds that gating cannot be employed. By employing two or more Infeed drives in series, speed adjustments can be made to two or more products simultaneously greatly increasing the system's overall throughput. Use of multiple infeed drives allows speed in excess of 600 infeeds per minute.

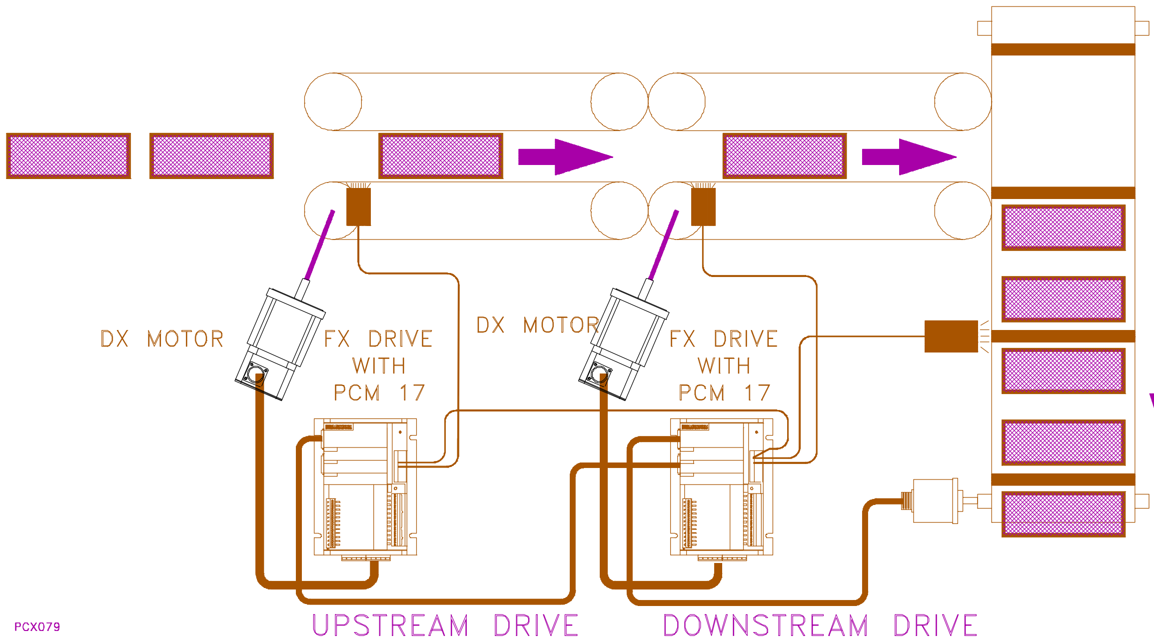


Figure 20 Multiple Infeed Drive System

In a multiple infeed drive system the operator must program a Target Angle setting in the upstream drive which will yield the ideal Infeed Angle for the downstream drive. If the upstream drive can succesfully position the product at the Target Angle, the downstream drive can continue to run at its base ratio velocity. However if the upstream drive cannot succesfully complete an adequate correction profile, the product will be delivered to the downstream drive at an Infeed Angle that differs from the Target Angle and the downstream drive would then be required to run a correction profile to place the product on the Master Axis conveyor. This double correction profile is illustrated in 18 and 19.

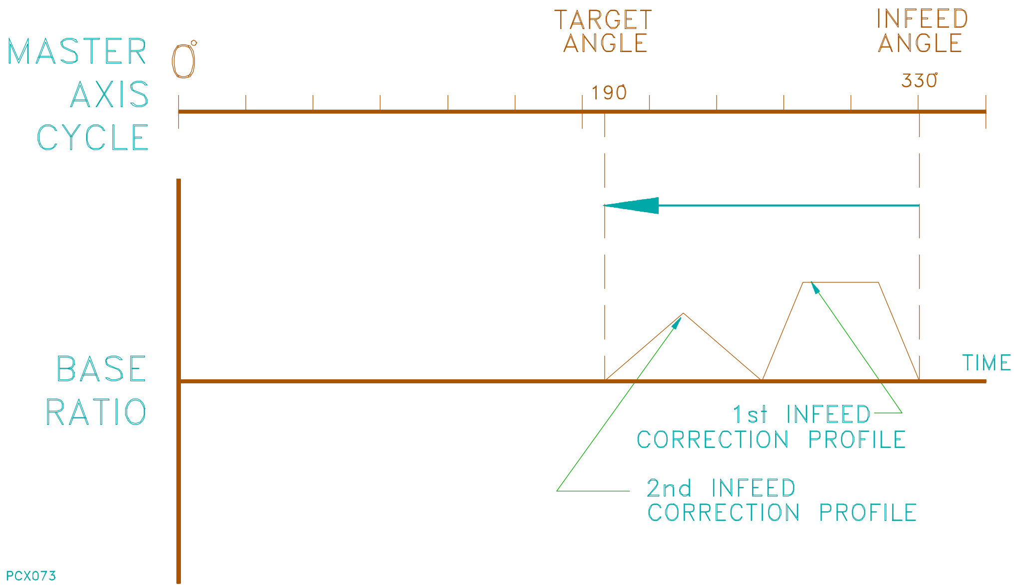


Figure 21 Multiple Infeed System corrects the product's position from 330° to programmed target angle of 190° by executing consecutive positive correction profiles.

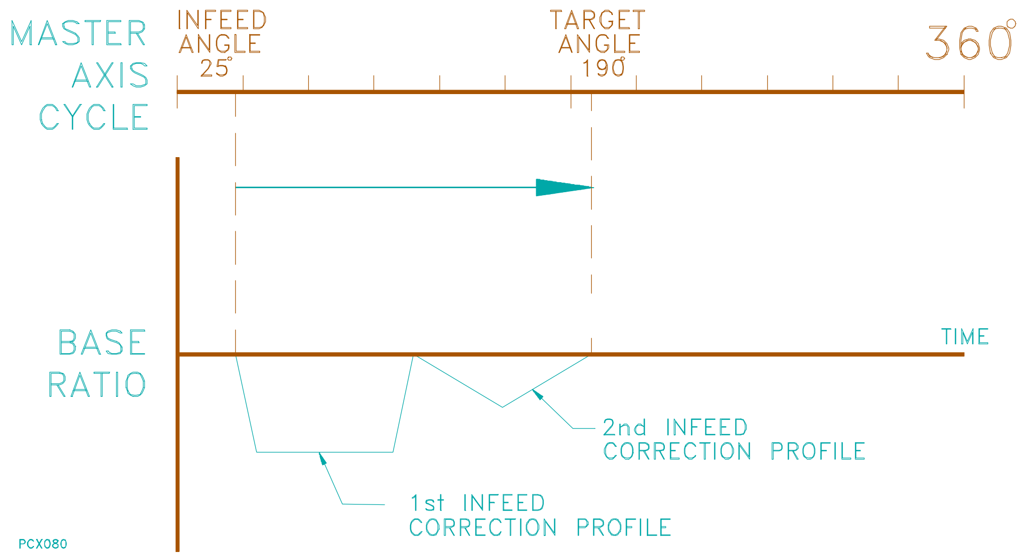


Figure 22 Multiple Infeed System corrects the product's position from 25° to programmed target angle of 190° by executing consecutive negative correction profiles.

In designing a system using multiple infeed drives the operator must evaluate whether or not, at maximum line speed, if potential exists for the product to enter the most down-feed drive within an angle which does not yield a solution. If this potential exists the operator must either lower the line speed or accept occasional jams. An alternative is to add an additional upstream infeed drive to accomplish additional angle correction prior to the product reaching the last infeed drive. No additional communications or special set up sequences are required to properly implement a multiple infeed drive system.

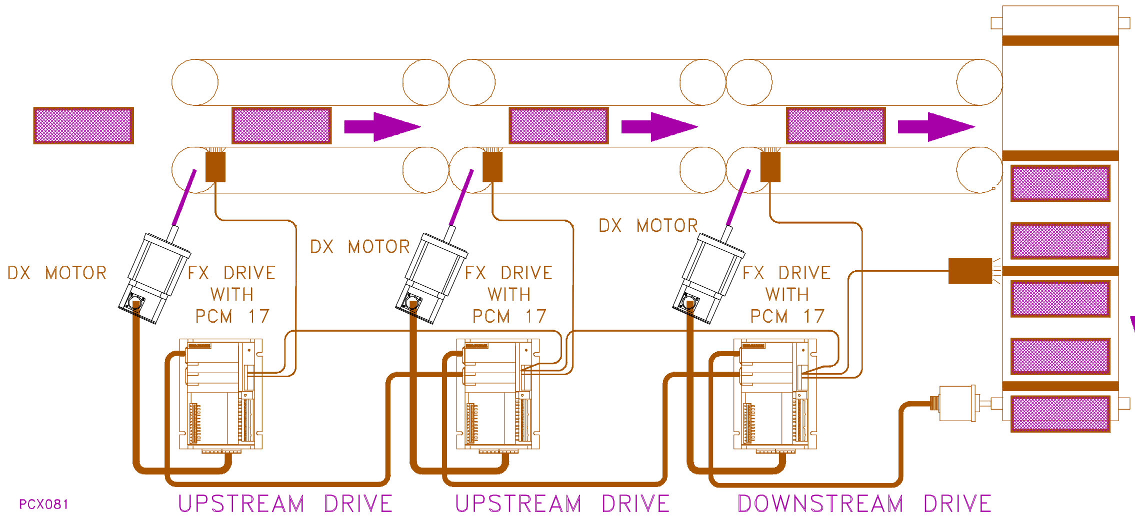


Figure 23 Multiple Infeed System Using 3 Infeed Drives

I n d e x