

Example Code Manual

Example Code Manual for Linear Flying Shear on MP2000iec Sigma-5 demo using Camming

Applicable Product: MP2000iec, MotionWorks IEC

Subject: Example Code Manual	Product: MP2000iec	Doc#: EM.MCD.09.095
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Application Overview

This document explains how to demonstrate the linear flying shear application with camming on the MP2000iec – Sigma-5 demo box. The algorithm and core program elements are explained in detail.

Application Highlights:

Industry: Automation industry using electronic camming for registration based applications
 Major Features: Electronic camming, cam shifts on the fly based on high speed registration

Products Used:

Component	Product and Model Number
Servopack	Sigma-5 MECHATROLINK II Rotary type
Motor	SGMAV, SGMJV
Controller	MP2000iec
Software	MotionWorks IEC, CamTool

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Application Explanation

The sample code explained in this manual simulates the linear flying shear application as shown in Figure 1 below. The conveyor is the master. The ball screw unit is the slave that cams to the master axis based on a registration mark. The cutting axis shown in the figure has not been incorporated into the sample code.

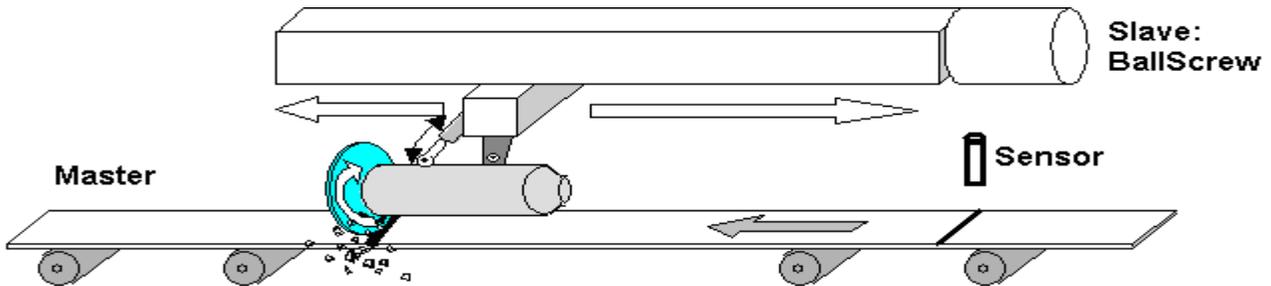


Figure 1: Linear Flying shear unit

The relation between the master and slave is given by the following profile (figure 2).

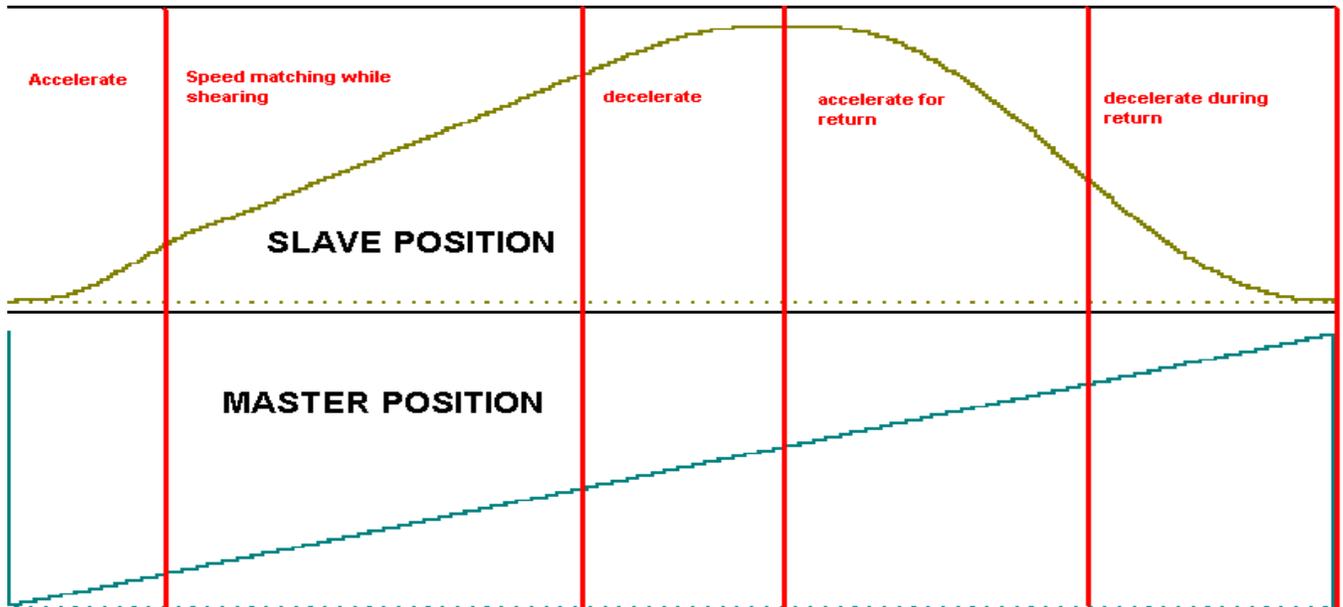


Figure 2: Stages of slave cam profile

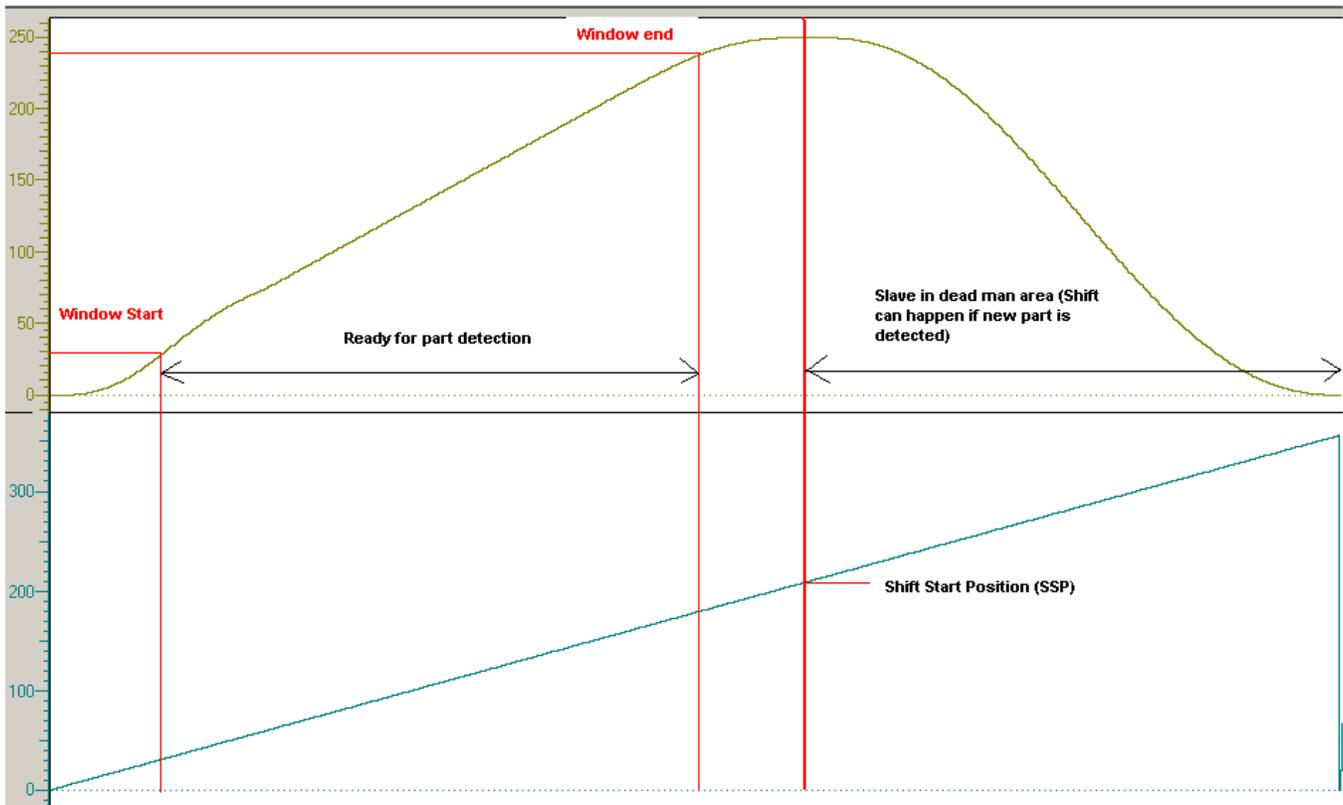


Figure 3: Critical positions on the cam master slave profile

Figure 3 details the critical points on the master and slave profiles. The algorithm followed to execute the linear flying shear is shown in Figure 4. The algorithm starts with the shear axis (slave) at the home position and the master axis running at a constant velocity. The slave axis waits for a registration mark from a part or on the master axis. This triggers a shift in the master position such that the start of the cam cycle comes by when the registration mark reaches the slave home position after covering the sensor to start distance (SSD). Once the slave cams in and is synchronized, the window for capturing next registration latches opens up (when the slave passes 30 mm of travel in the forward direction). If a registration is captured when the window for capture is open, the position is stored and the calculation for phase and master distance is performed. The shift cannot start immediately because when the shearing process is in progress, the slave and master need to be in tight sync. Only after the shear is done, can the shift for the next part start. This is determined using a dead man area on the slave's position profile (user defined).

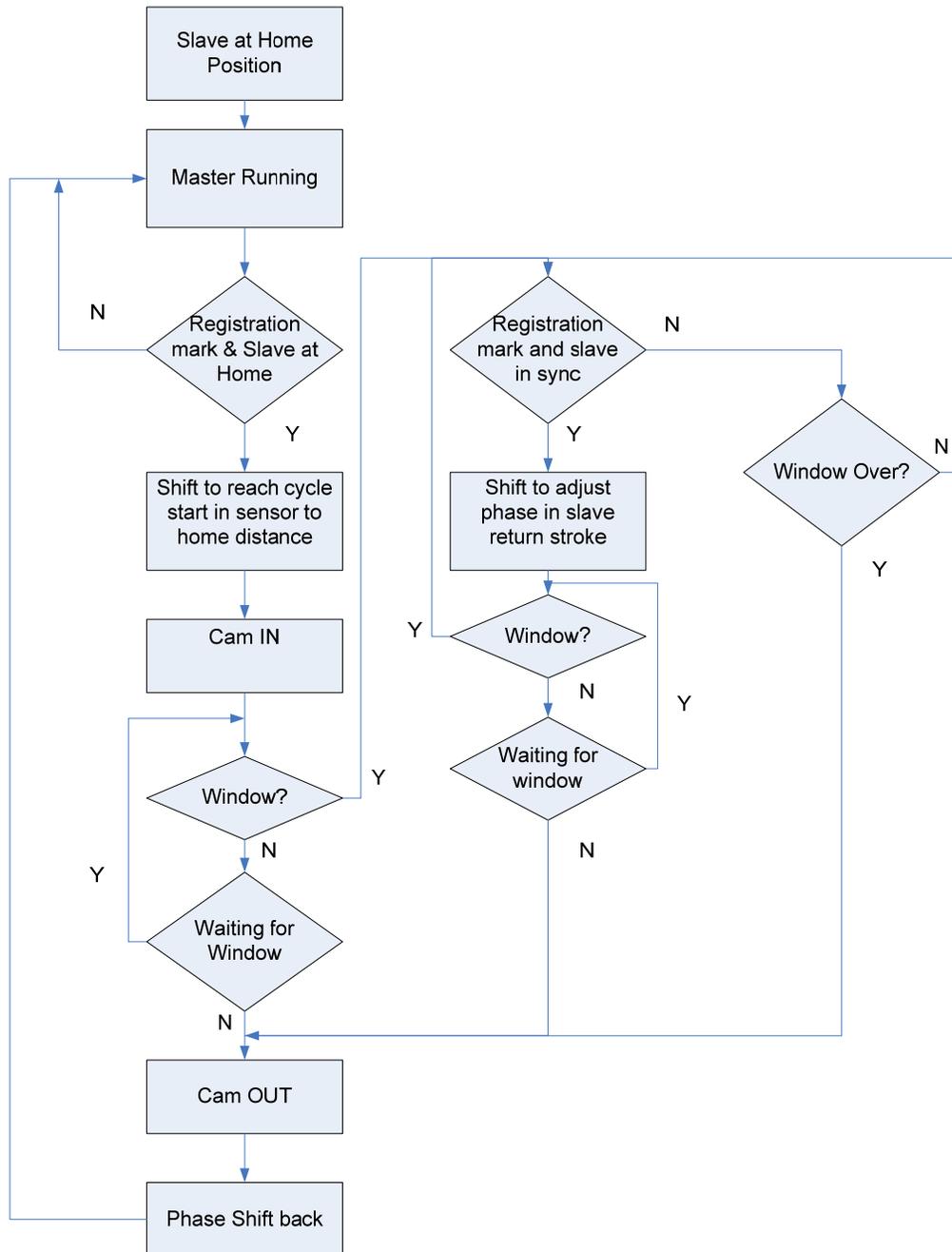


Figure 4: Linear flying shear algorithm

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The phase is calculated by noting the difference in two consecutive latches on a 360 degree cycle. The master distance is calculated as $(SSD - (SSP - \text{Master shifted position}))$ where SSD is distance the part has to travel to get to the shear home position. SSP is the shift start position which is the position on the master from where the shift can start. This is shown in Figure 5.

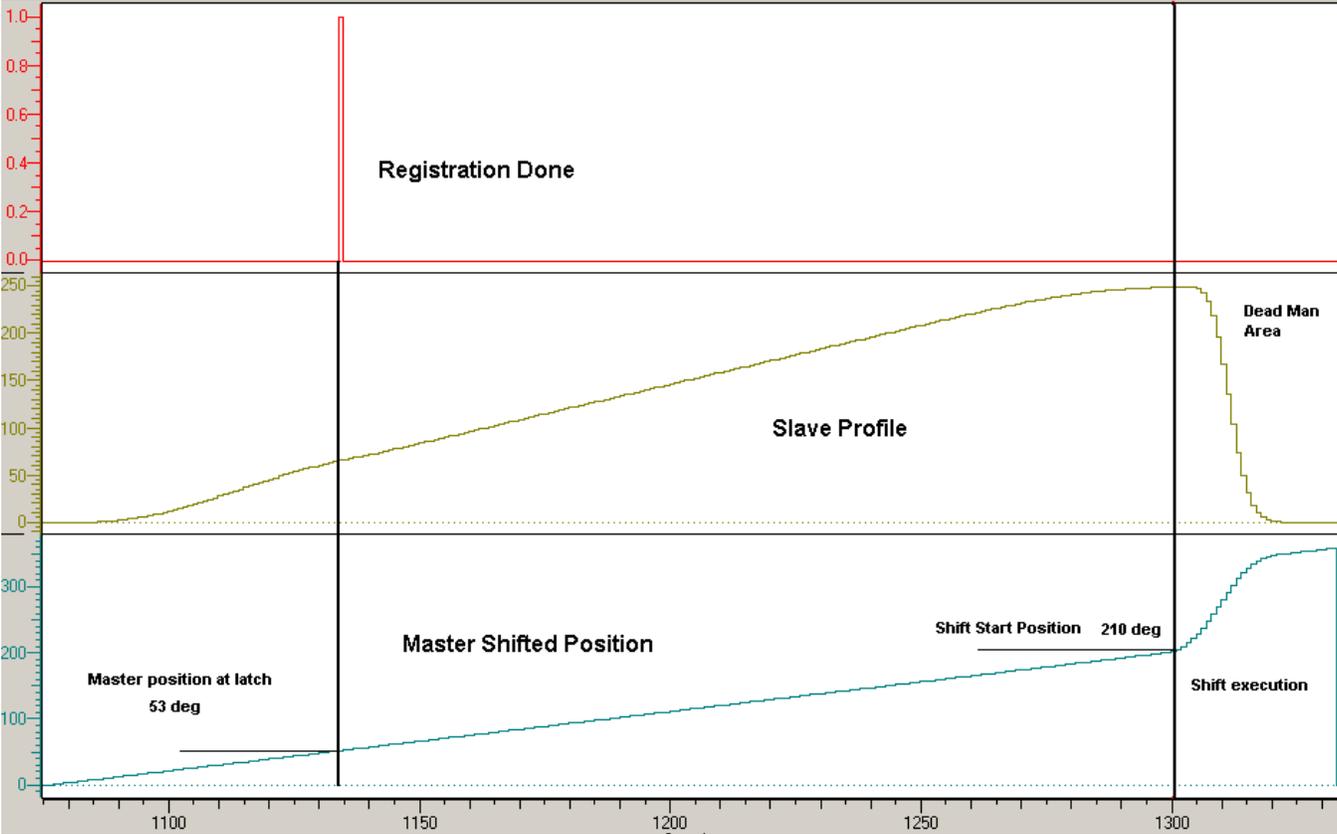


Figure 5: Implementation of cam shift

Figure 6 is an illustration of continuous part registration at unequal intervals. Shift one is executed for the first latch (registration) seen in figure 6. Since the second registration was very early in a cycle, the shift to get the slave back to home position is very large. This large shift over a small distance causes the slave to return back to home in a very fast move on the return stroke as can be seen from shift 2. Since the third registration happens almost at the end of the window, the phase shift is small and it has more distance over which to implement the shift. It can be seen from Figure 6 that the third shift does not cause a major change in the cam profile.

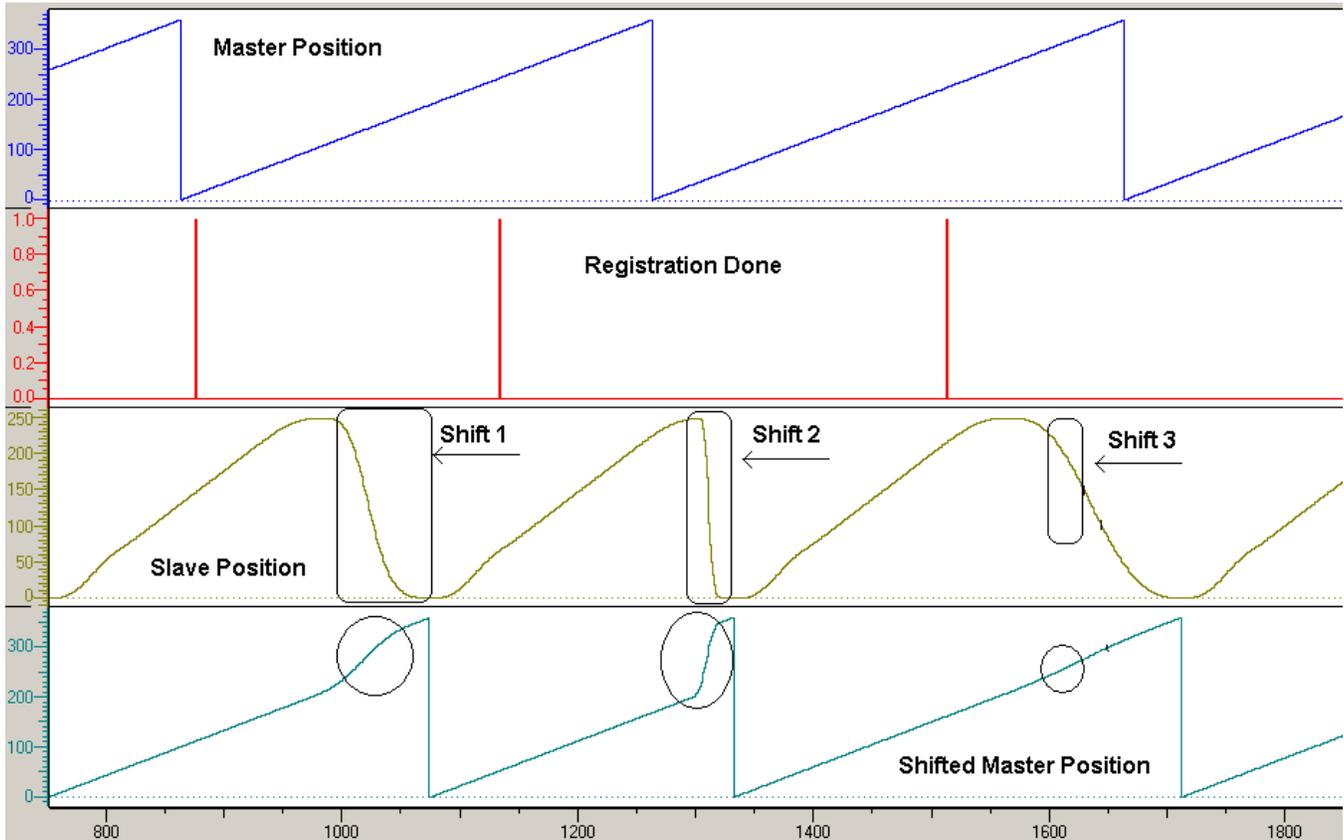


Figure 6: Multiple continuous registrations at unequal intervals

Figure 7 is an illustration of a first part detection or part detection after a cam out. It can be seen that at part detection, the master position is 32 degrees. Sensor to home distance is 180 degrees. This means that the cam cycle will have to start when the actual master position is $32 + 180 = 212$ degrees. This first part shift can be seen in Figure 7. If a part is not detected in the window area, a cam out is commanded and after the cam out is done, a phase shift to negate all cumulative phase shifts is carried out so that the total shift becomes zero and the master position and shifted master position match up as can be seen at the end of the profiles in figure 7.

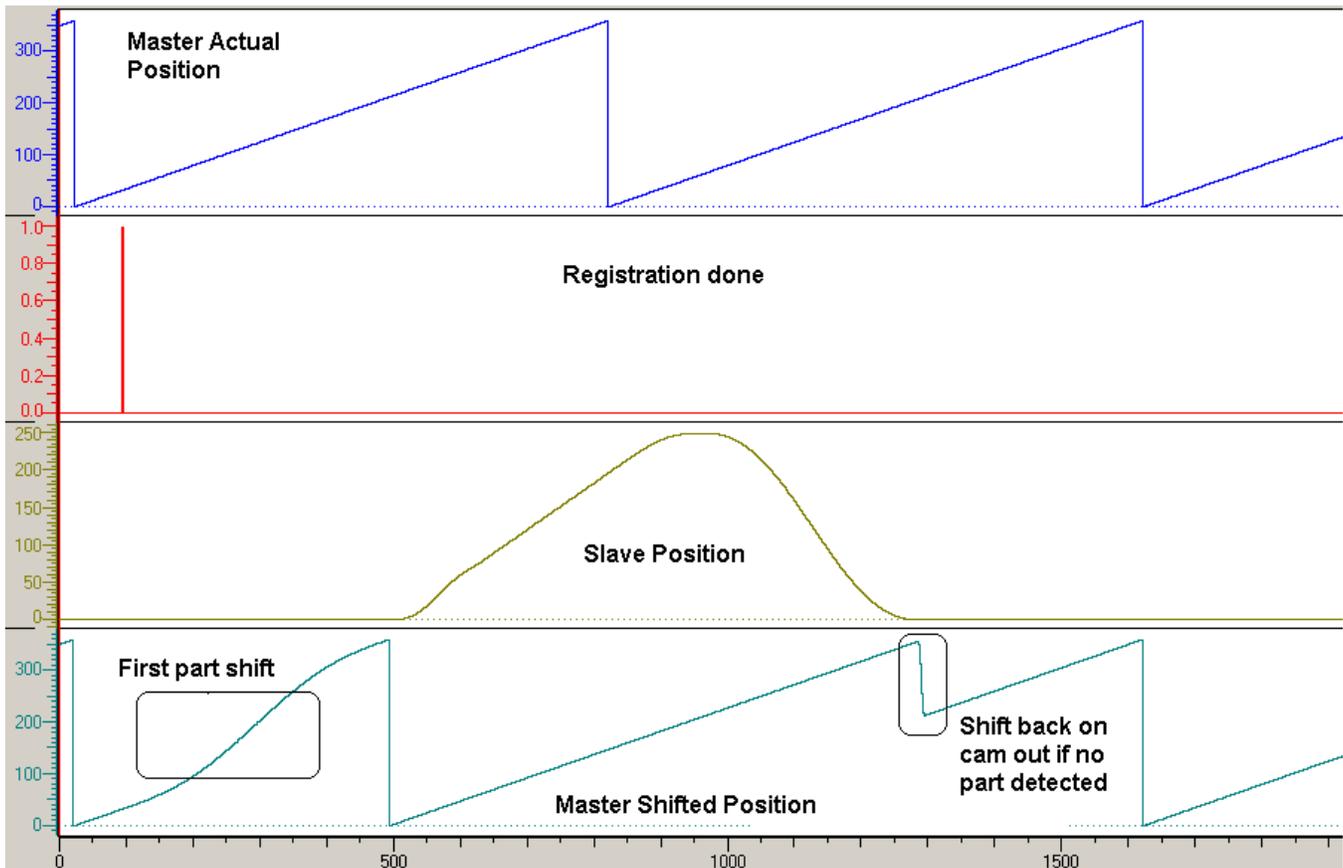


Figure 7: First part detection or part detection after a cam out

Demo Instructions:

The master axis (Left axis) is configured to be in rotary mode with a 360 degree cycle. (1 rev or motor = 360 user units). The slave axis is configured as a linear axis with 1 rev of the motor = 100 mm of linear travel.

- 1) Make sure the servo axes on the demo case are tuned for improved performance
- 2) Manually orient the slave shear axis (right axis) such that the arrow points up. Flip SI5 switch on and off to set that position as the home position for the slave axis. The position at which the master (left axis) is will be set as its zero position too. The orientation of the master axis does not matter in this step.

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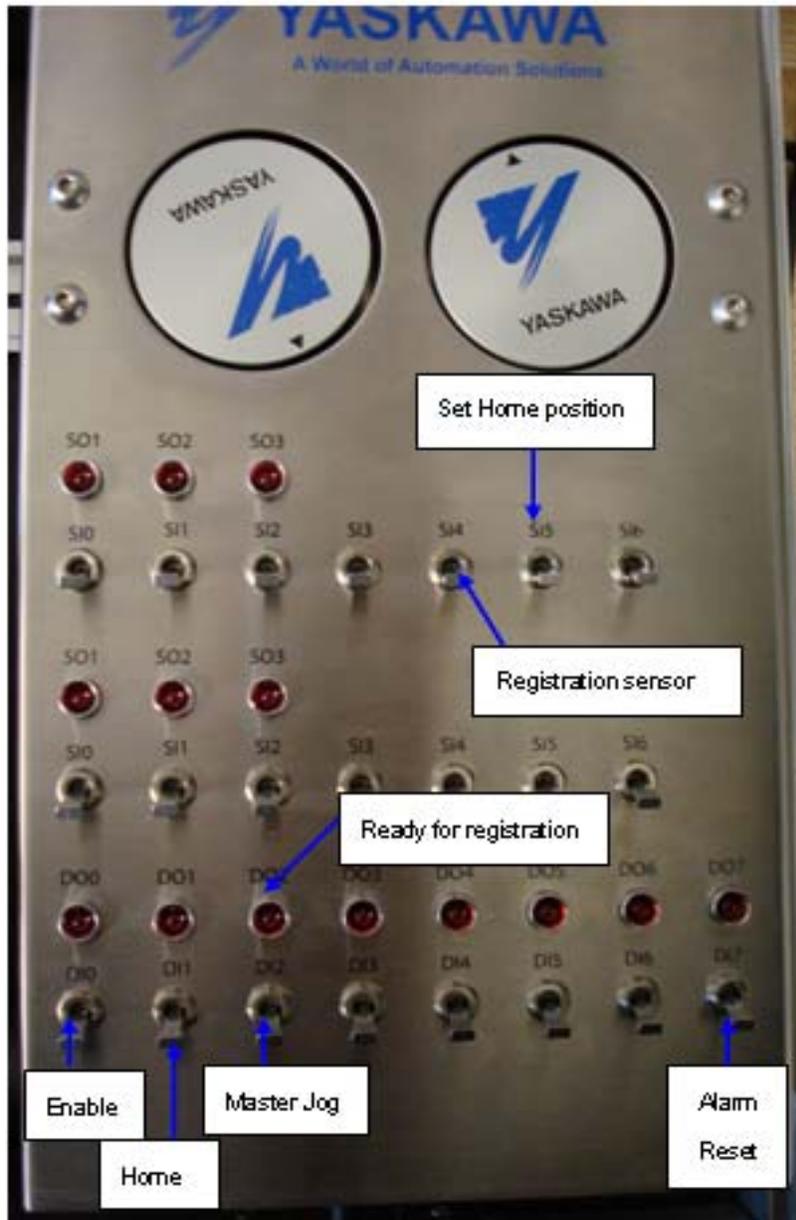


Figure 8: Demo case controls for sample program

3) Enable the servos using DI0. Leave DI0 on

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- 4) Flip DI1 on and off. This is to home the slave axis. On starting up, the slave axis is already in its home position.
 - 5) Turn on DI2. This will start the master axis jog. The master axis will jog at 90 degrees /second. To stop the master jog, turn DI2 off.
 - 6) When DO2 lights up, it is an indication that the controller program is ready for registration.
 - 7) Flip SI4 on the first row on and off. This simulates a part or registration mark. DO2 will turn off. The slave axis will wait for the master axis to turn 180 degrees (distance from sensor to shear's home) from where the mark was seen and then start the cam profile. The slave axis travel one way is 250 mm or 2.5 revs on the demo. When the slave passes 30 mm travel, DO2 turns on and indicates that the system is ready for another mark. DO2 will be on until the window is closed (240 mm on the slave). The slave's shift in profile during the travel back to home will depend on when the registration was seen in the cycle. If the part was detected early (closer to 30 mm), the move back on the slave will be rapid. If the part was detected later (closer to 240 mm), the move back will be slow.
- If a part is not detected while the slave is synchronized to the master and the window is over (DO2 turns off), the slave cams out and stays at the home position until the next part comes along. The system will be ready for registrations (DO2 on) as soon as the cam out is done.

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Program Explanation:

The various POU's in the sample project are explained in this section.

Initialize: This POU runs for the first scan and initializes the axis IDs and other relevant application parameters like sensor to start distance, shift start distance and cycle.

Enable: The Enable POU controls the enabling of the two axes. There is a reset alarms control in this PO.

Monitor: The Monitor POU has function blocks that monitor parameters like master position, slave position, master shifted position and unmodularized (raw) master position

Home: The Home POU controls how the user defines the home position for the slave. Home position for the master is not significant because the master is a rotary infinite axis. After a home position is set once in a run, the slave axis can be commanded to go to that home position at any instant using a MC_MoveAbsolute block.

Production:

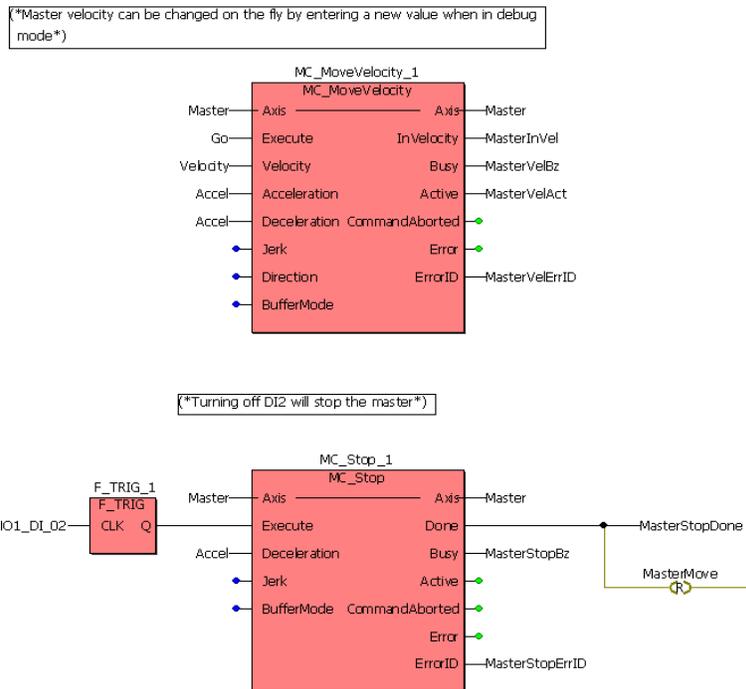
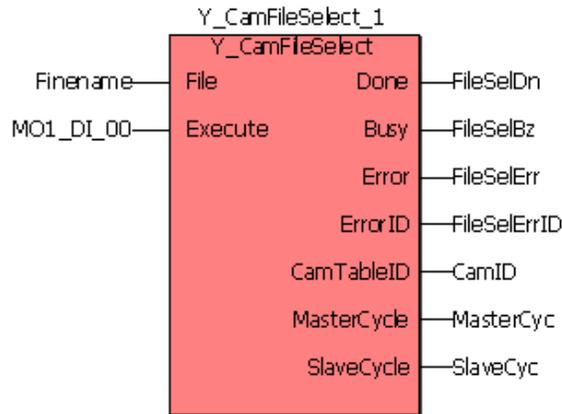


Figure 9: Master move control

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Master axis move can be controlled using a MC_MoveVelocity FB. The velocity can be adjusted on the fly using the velocity variable. The master is brought to a stop using MC_Stop.



(*If in a cam cycle, window to start looking for registration is when the shear is 30 mm in its cycle and the window closes when it is 240 mm in its cycle. *)

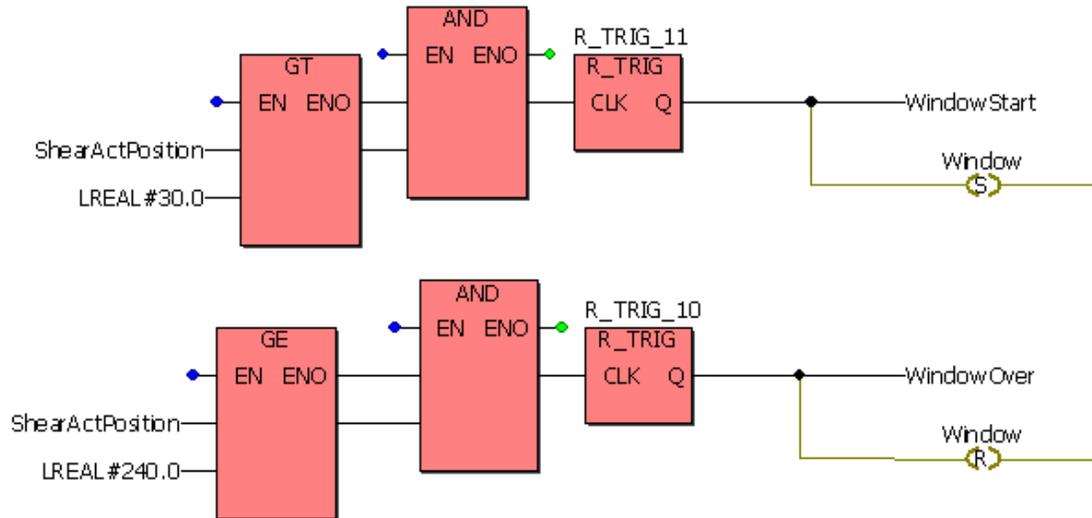


Figure 10: Cam file select and window for registration

The cam profile for the shear axis (slave) is loaded as a csv file from the controller memory to the ProconOS

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memory for cam calculation using Y_CamFileSelect. Window for registration is defined based on actual position on the shear axis using GE blocks.

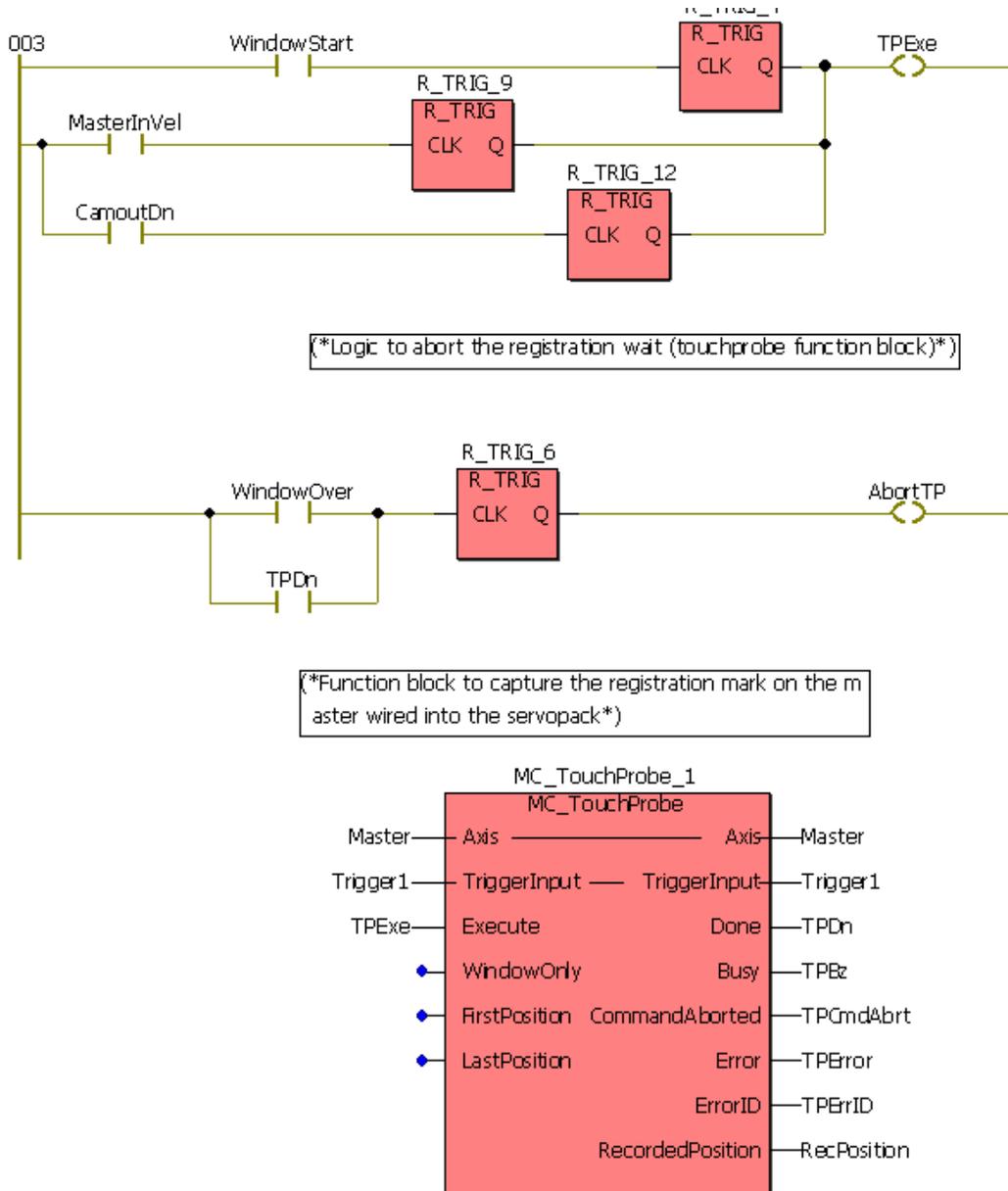


Figure 11: Logic for executing registration latch

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Figure 11 is a screen shot of the logic that executes the MC_TouchProbe FB to capture a registration. The three scenarios in which it needs to be triggered are

- a) when the machine is started the first time (master in velocity)
- b) When the cam is engaged but the window feature is active
- c) When the cam is active but no part was detected in the window and cam out is executed

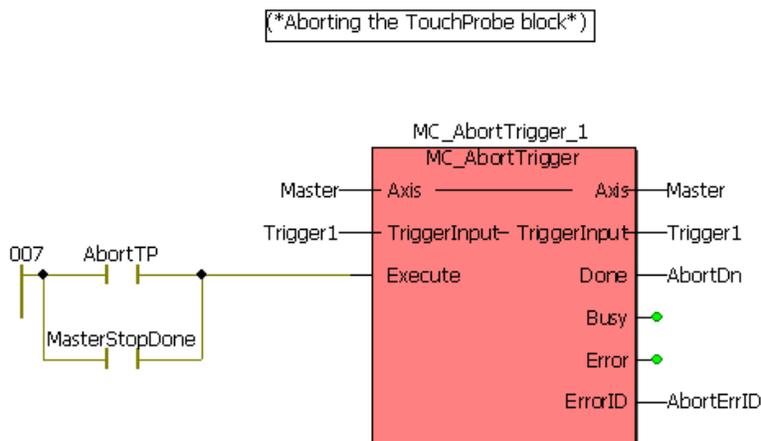


Figure 12: Trigger abort block

The touch probe functionality is aborted as soon as a part is detected, or if the master stops its move or if the window is over.

(*Capturing unmodularised registered position of the master*)

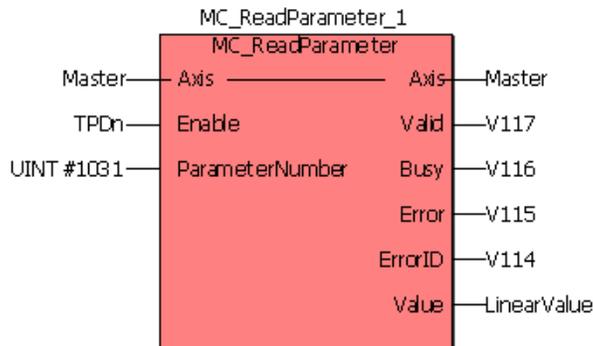


Figure 13: Capturing the raw position of the registration latch

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As seen from Figure 13, parameter 1031 is used to capture the raw master position when the latch was triggered.

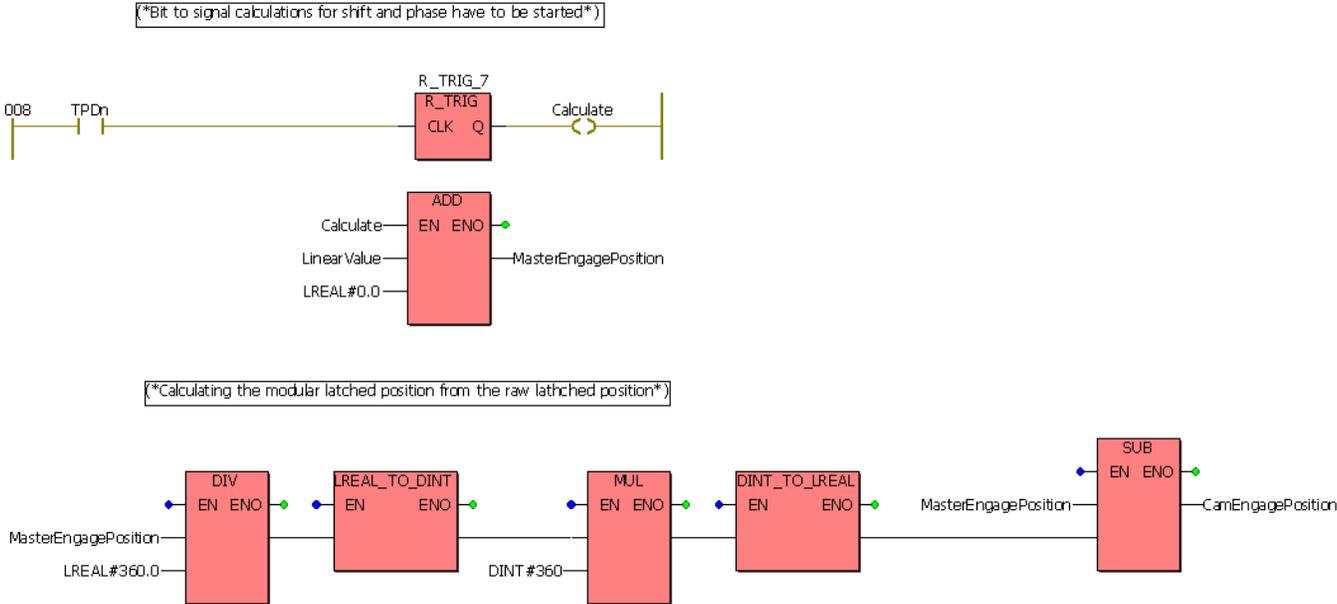


Figure 14: Calculating the modular master position corresponding to the raw master position

The modular master position is required to make a shift when a part is detected when the slave is not synchronized and at home. (In order to start a new cam relation). This is shown in Figure 14. The bit 'calculate' is used to trigger this calculation.

The shift for the first part detected is different for parts detected while the slave is in sync with the master. The phase shift and distance calculation are as shown in Figure 15

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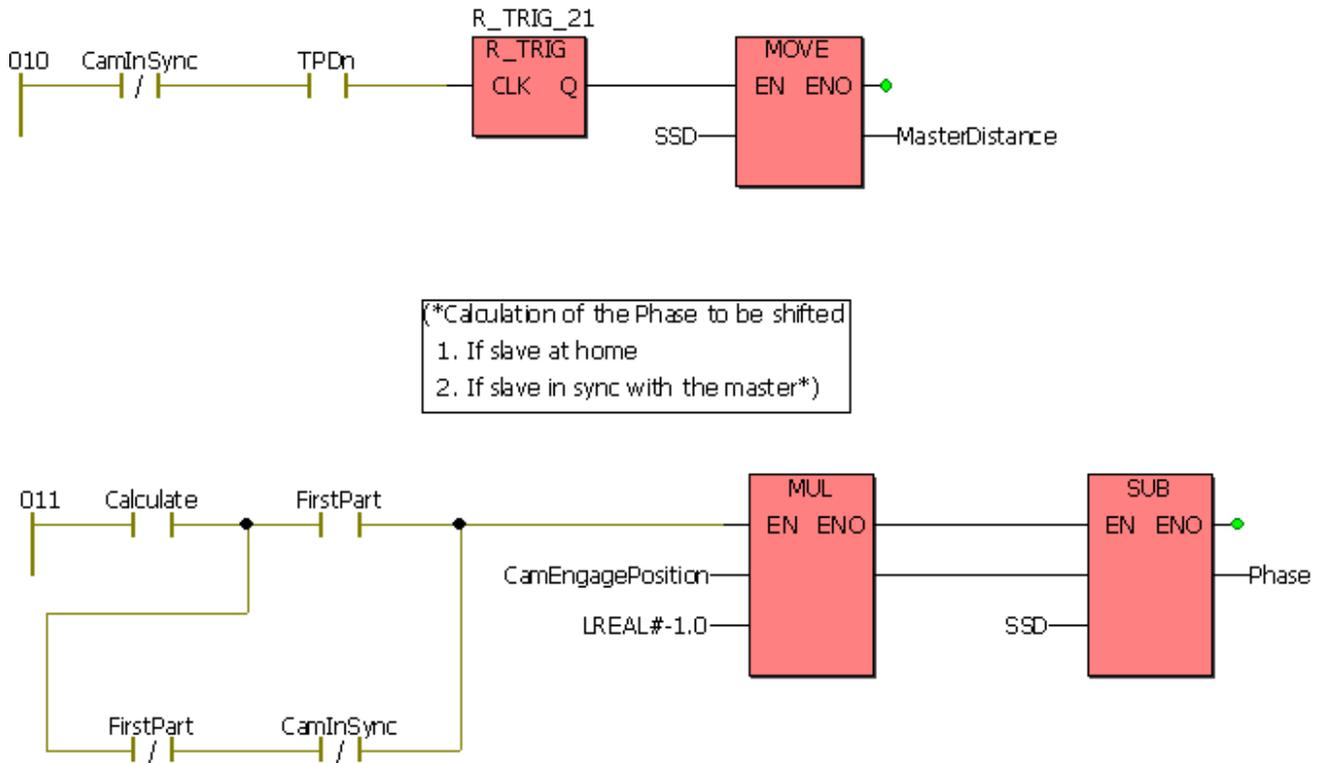
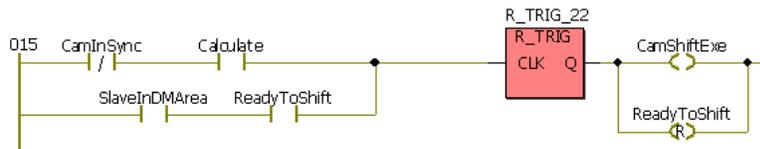


Figure 15: Calculating the master distance and phase shift for the first part in production.

Figure 16 details the logic for executing the cam shift block for the first part. Figure 17 is the cam in function block to engage the cam at the start location after a shift has been done to the master position.



(*Cam shift*)

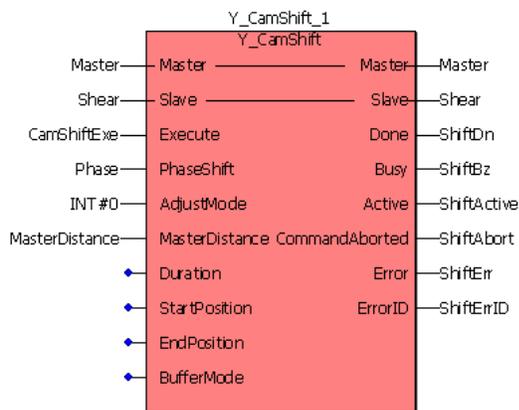


Figure 16: Cam Shift for the first part

(*Cam In to engage a slave when the slave is at home and disengaged*)

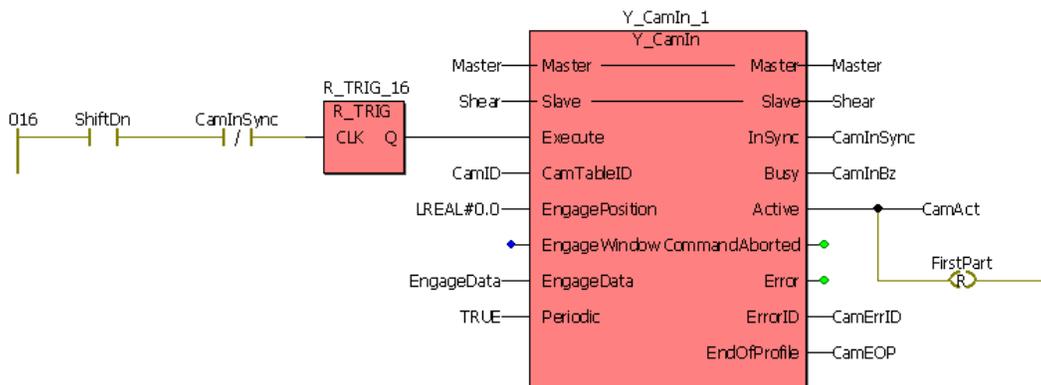


Figure 17: Cam in function block

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(*Logic to determine if a part has been detected within the window. If no part is detected in the window, a camout is commanded*)

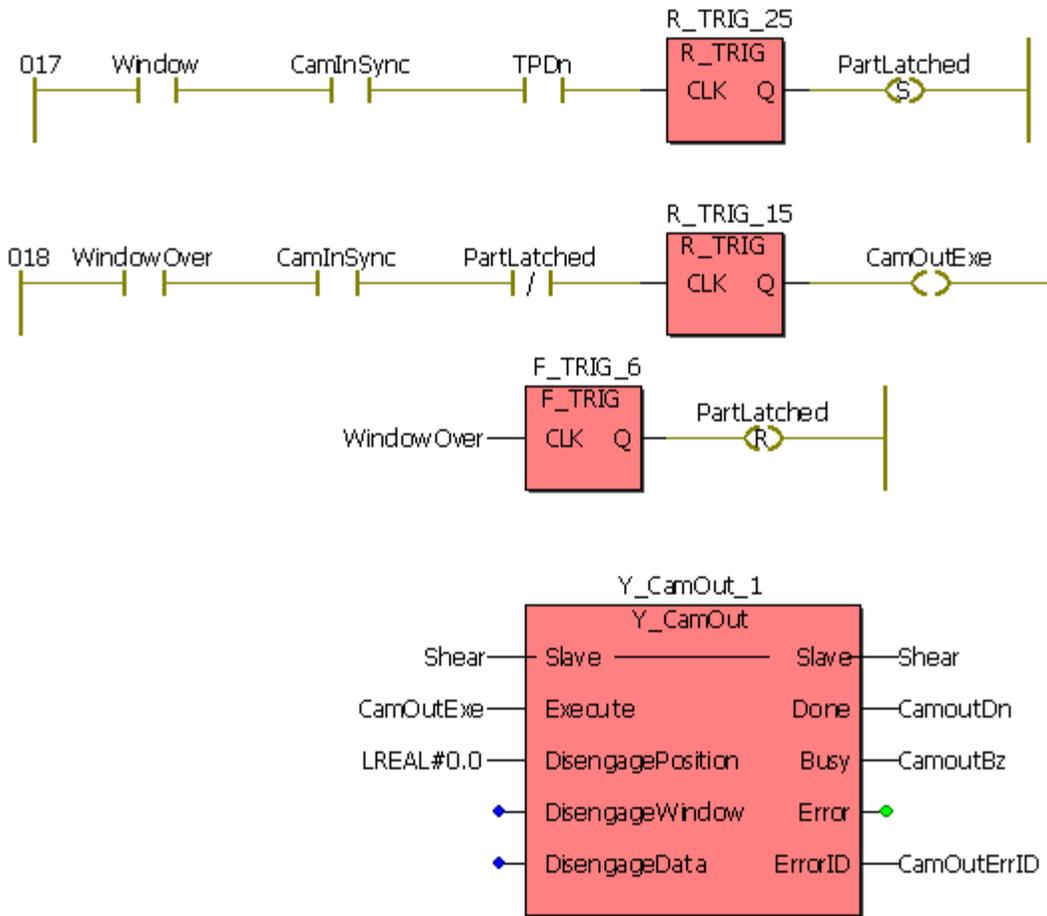
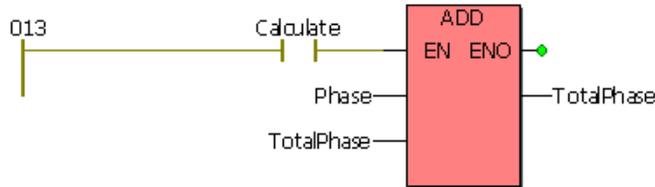


Figure 18: Logic to decide on cam disengage

Figure 18 shows the logic to determine if a cam out needs to be executed. A cam out is executed if no part is detected within the window of an existing cam cycle. If no part is detected, a cam out is issued and a shift back is commanded such that there is no phase shift in the master's position after the cam out is done. This is shown in Figure 19.

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(*Cam shift block to clear the accumulated shifted profile of the master to the actual master modularized profile. Executed when no part is in the buffer and cam out occurs*)

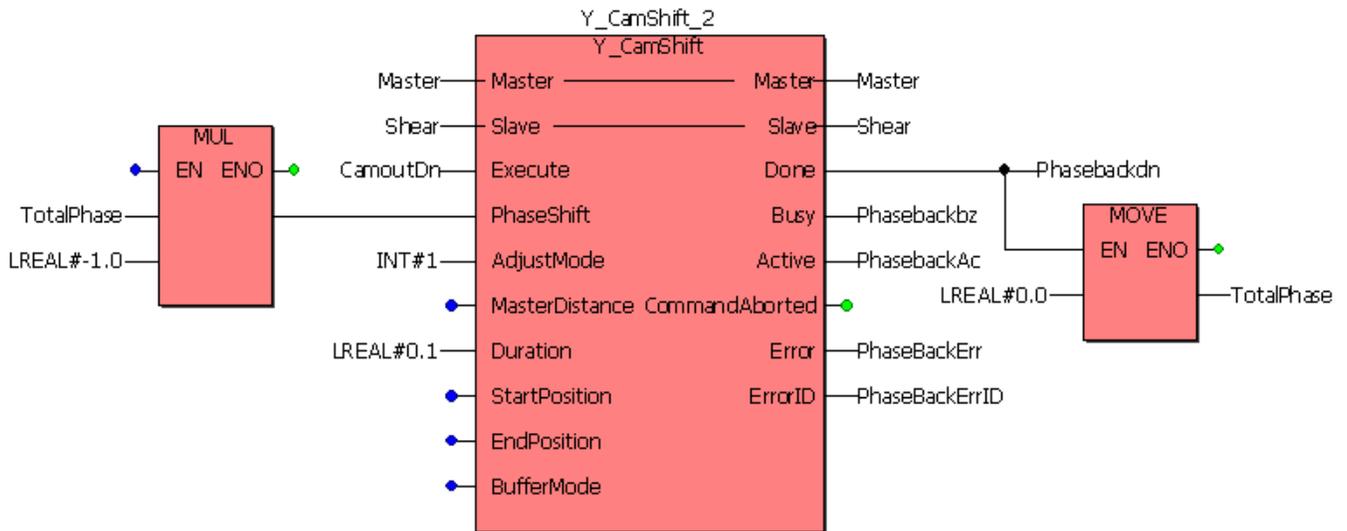


Figure 19: Total phase shift back to cancel accumulative shifts

If a part is detected when the slave is in the window area, the phase shift is calculated based on the difference in master position between two adjacently detected parts on the scale of one cam cycle. This position difference will be the shift to be incorporated in such a case. This is shown in Figure 20. Figure 21 illustrates how the master distance and phase calculations are done when the slave is in sync and a shift has to be performed for a new registration. Figure 22 describes the logic to decide when the shift should be executed for a new registration while the slave is cammed.

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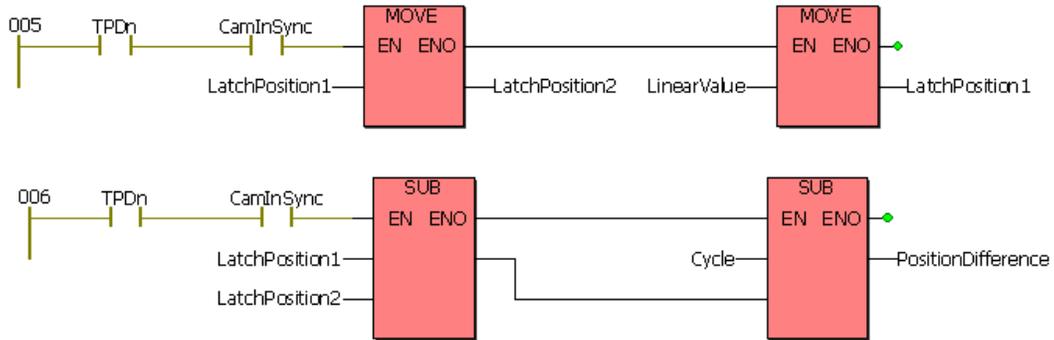


Figure 20: Phase shift if part detected while slave is in sync

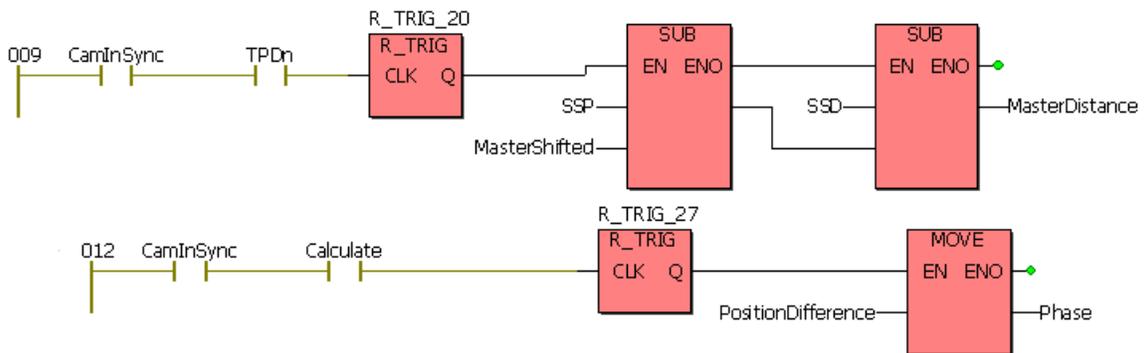


Figure 21: Master distance and phase for shift while slave is in sync

(*Logic to determine when the shift is to be executed. Shift is executed when the slave is in the dead man area (after the sync region is over)*)

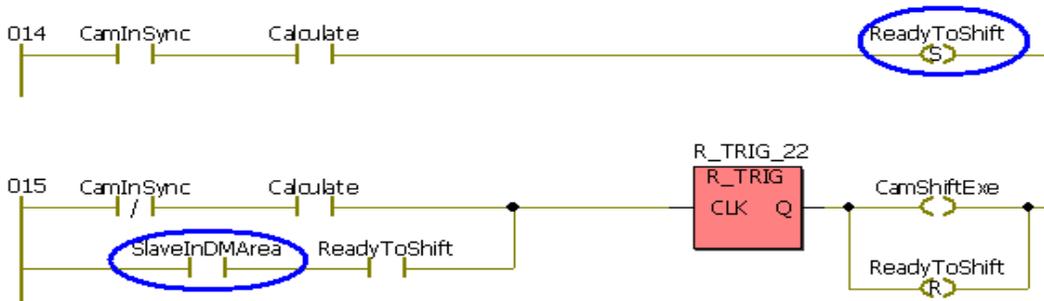


Figure 22: Logic to activate shift while slave is in dead man area

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Figure 23 contains logic that displays when the controller is ready to accept new registration inputs.

(*Logic to display when the latch is ready to be triggered. DO 2 is used*)

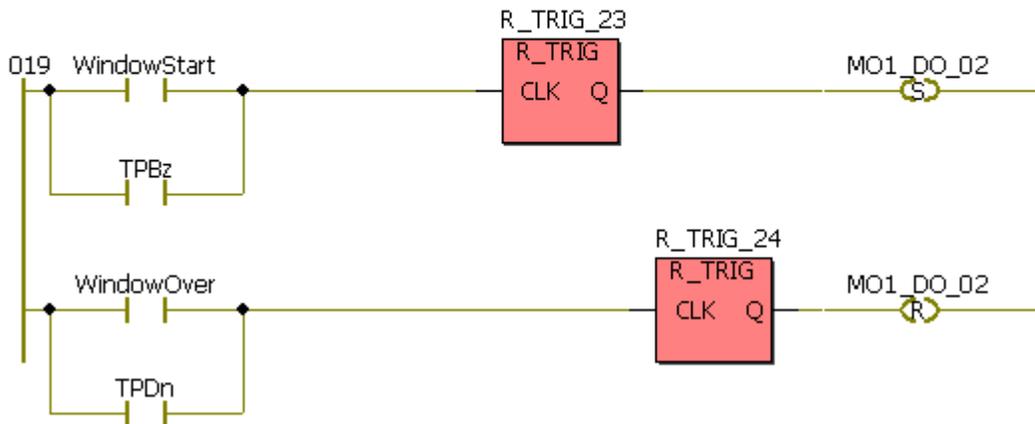


Figure 23: Logic to display 'ready for registration' variable