Application Note: AN.MWIEC.05

Sigma7-FT62 High Speed Output Applications via Y_DigitalCamSwitch

Applicable Products: MotionWorks IEC, 3000 Series MPiec Controllers, and Sigma7-FT62 SERVOPACKs

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Application Highlights

Industry: High speed/precision automation

Features: Function block enabled line driver or photocoupler high speed outputs

Performance: Sigma7-FT62 SERVOPACK delivers outputs with high speed 1 µs response time/5 µs variation and standard speed 1 ms response time/125 µs variation

Product Used

Component	Product and Model Number
Software	MotionWorks IEC with PLCopen toolbox v340 or higher
Controller	3000 Series MPiec Controllers
SERVOPACK	Sigma7-FT62

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Function Block Overview

This document details how to use high speed outputs within the Sigma7-FT62 SERVOPACK via the Y_DigitalCamSwitch function block shown in **Fig. 1**. This function block is useful for rotary applications requiring electronic output signals corresponding to specific positions or angles within a machine cycle. The block will automatically convert from user units to encoder reference units, perform cyclic recalculation and update of trigger positions, and manage the absolute encoder offset on startup. FT62 specifically augments this block by adding extremely high speed/low variance outputs, able to trigger an output 1 μs after passing the specified position. Y_DigitalCamSwitch can automatically detect if the configured drives are FT62 type, and will change its functionality accordingly. The high speed outputs can be used in various applications such as high speed camera triggering, precision valve timing, and other high speed I/O control operations.
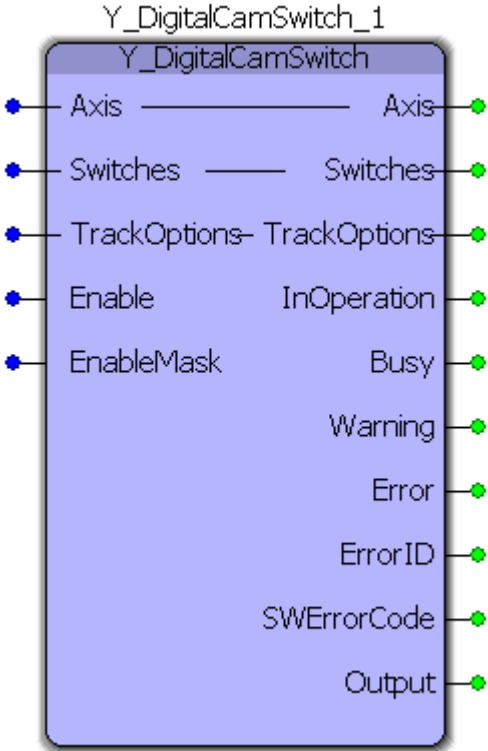

Figure 1: Y_DigitalCamSwitch function block

Wiring

Refer to the Sigma7-FT62 user manual (SIEP S800001 95A) for help with wiring the outputs. It is important to note that the high speed outputs (HSO1, HSO2) support 5 VDC signals while the standard speed outputs (SO1, SO2, SO3) can handle signals up to 30 VDC.

Function Block Relation to Firmware Function

Y_DigitalCamSwitch	Sigma7_FT62
Switches.LastSwitch	N/A
Switches.MachineCycle	N/A
Switches.MasterType	N/A
Switches.Switch[x].TrackNumber	OutputFunction
Switches.Switch[x].AxisDirection	OutputFunction
Switches.Switch[x].CamSwitchMode	Pn660
Switches.Switch[x].Duration	OutputTime
Switches.Switch[x].Distance	(Will be supported in future release)
Switches.Switch[x].FirstOnPosition	OutputPosition
Switches.Switch[x].LastOnPosition	N/A
TrackOptions.Track[x].OnCompensationScaler	OutputPositionCompensation
TrackOptions.Track[x].OffCompensationScaler	N/A
TrackOptions.Track[x].Value	N/A

Table 1: Y_DigitalCamSwitch and Sigma7-FT62 input variable relationships

Table 1 describes the input variable relationships between Y_DigitalCamSwitch and Sigma7-FT62. Switches is of the data type CamSwitch_Ref, TrackOptions is a Track_Struct, and 'x' is an integer value between 0 and 31. Y_DigitalCamSwitch acts as a wrapper to make the implementation of Sigma7-FT62 high speed outputs significantly simpler, therefore FT62 variables found within the user manual will not be directly used within a MotionWorks IEC application. However, it will be useful to know the internal variable relationships to assist in cross-referencing Y_DigitalCamSwitch documentation with the FT62 user manual during application development.

TrackNumber

FT62 high speed output hardware allows for five separate output tracks; three photocoupler outputs (SO1, SO2, SO3) and two line driver outputs (HSO1, HSO2). These configurable outputs correspond to five different output terminals within the SERVOPACK CN1 I/O signal connector. Each track can contain any quantity of individual output positions ranging from 0 to 32. All of the outputs within a single track will have their active signals combined through a logical OR function. No more than 32 total output positions can be configured between all five output tracks. Changing the track of an

output while running will cause the function block to display a persistent 10222 error code (RebootRequiredError). This error will remain until the controller is power cycled, physically or programmatically, to complete the non-volatile memory writing process.

Fig. 2 gives a visual representation of these tracks as rotating wheels, each with its own configured outputs. Note that this figure only applies to a rotary application. Consider the wheels as completing one machine cycle per rotation. Each track output, (i.e the logically ORed collection of all of its configured outputs) will become active when the leading edge of one of its configured output positions meets the red line indicating the current position of the axis. They will return to inactivity when the red line is not intersecting any configured outputs on a given track.
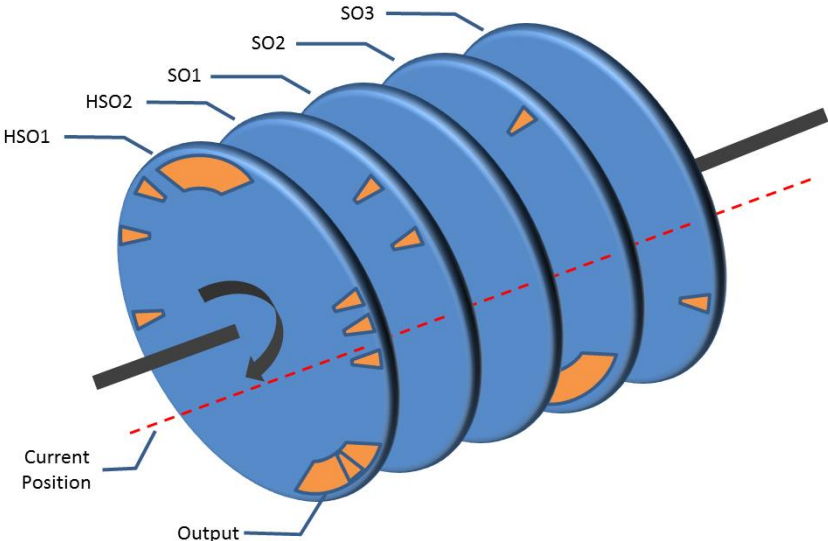
Figure 2: Illustration of tracks and outputs

TrackNumber Definition	
Value	Output Terminal
INT#0	Disabled
INT#1	HSO1
INT#2	HSO2
INT#3	SO1
INT#4	SO2
INT#5	SO3

Figure 3: List of all TrackNumber Options

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CamSwitchMode

CamSwitchMode determines how output length is defined and the output signal logic. The four available CamSwitchModes shown in **Fig. 4** are Position and Time in both active high and active low signal logic. These correspond to Distance and Time modes in Sigma7-FT62. In the user manual it is stated that this mode is set by writing Pn660, however Y_DigitalCamSwitch will handle all parameter writing internally, therefore no external code will be necessary. For the time being, only time mode is supported.

CamSwitchMode Selection	
Value	Selected Mode
INT#0	Position Mode – Active High (not supported)
INT#1	Time Mode – Active High
INT#2	Position Mode – Active Low (not supported)
INT#3	Time Mode – Active Low

Figure 4: List of all CamSwitchMode options

In Time mode, the duration that an output is active will remain constant, regardless of axis speed. FirstOnPosition and Duration inputs are required to define the output position and length.

Changing the signal polarity will cause the function block to display a persistent 10222 error code (RebootRequiredError). This error will remain until the controller is power cycled, physically or programmatically, to complete the memory writing process.

FirstOnPosition / Duration

These Y_DigitalCamSwitch variables are used to uniquely define the position and length of an output signal.

FirstOnPosition designates where the output will become active within a machine cycle and is defined in user units. FirstOnPosition must be defined for both CamSwitchMode options.

Duration designates the duration that the output will remain active after FirstOnPosition is passed and is defined in microseconds (µs) if using line driver outputs and milliseconds (ms) if using photocoupler outputs.

OnCompensationScaler/OffCompensationScaler

OnCompensationScaler is set to compensate for latency in the hardware of a machine. It can be set

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to cause the output to lead or lag behind the raw output signal and is defined in user units. This value is usually set after some machine latency has been observed and measured. Note that OnCompensationScaler is a distance value, so compensating for a delay in time will only work well if the speed of the axis is relatively constant or some external calculation is performed to determine the required compensation value for a given speed. OffCompensationScaler is not used with FT62 outputs and will not be discussed here.

Changing Parameters

The following factors must be considered when configuring a high speed output application to ensure that the function block can complete the parameter writing process with no errors or unexpected behavior.

First, the Mechatrolink update rate must be fast enough, or the maximum axis velocity slow enough, that Y_DigitalCamSwitch has enough time to send all of the new information to the Sigma7-FT62 SERVOPACK. It is important for the user to understand that it takes exactly 6 Mechatrolink scans for one new position to be written to the servopacks. Therefore, for every extra output configured, 6 more Mechatrolink scans of write time per machine cycle will be required.

Second, the application task rate must be fast enough that all necessary commands can be sent to begin writing new positions to the SERVOPACK before the next position is required. Y_DigitalCamSwitch requires 2 scans to complete sending all of the commands to begin writing a single position to the SERVOPACK.

Third, Y_DigitalCamSwitch only begins the process to write new positions once half of the machine cycle has been completed. This is so that if the axis changes direction, the old position can be reused for outputs again without a new position being written. The halfway point was the best place to update the position because it would give equal time for positions in either direction to be rewritten if they required an update. If these conditions are not met, behavior will be unpredictable and outputs may cease to operate.

The following equation permutations found in **Eq.1**, **Eq.2**, and **Eq.3** will assure that these conditions are met.

$$Machine\ Cycle\ Duration/2 > Number\ of\ Outputs * (2 * Task\ Rate + 6 * Mechatrolink\ Rate)$$
Equation 1: Machine cycle duration condition

$$Mechatrolink\ Rate < \frac{\frac{(Machine\ Cycle\ Duration/2)}{Number\ of\ Outputs} - (2 * Task\ Rate)}{6}$$

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Equation 2: Worst case model for allowable Mechatrolink rates

$$Task\ Rate < \frac{\frac{(Machine\ Cycle\ Duration/2)}{Number\ of\ Outputs} - (6 * Mechatrolink\ Rate)}{2}$$

Equation 3: Worst case model for allowable task rates

It is important to note that the durations calculated above are necessary just to complete basic cyclic position updates. Writing additional parameters will take additional time which will need to be factored in to the final calculations for machine cycle duration, Mechatrolink rate, and task rate. **Eq.4** considers the duration required to write extra parameters. The additional equation permutations can be derived from **Eq.4**.

$$Machine\ Cycle\ Duration/2 > Number\ of\ Outputs * (2 * Task\ Rate$$
$$+ 6 * Mechatrolink\ Rate * Quantity\ of\ Parameters\ Changed)$$

Equation 4: Generalized duration equation

Rotary Application Example

Overview

This section will provide an example of how to configure a high speed camera triggering application on the Sigma7-FT62 SERVOPACK using the Y_DigitialCamSwitch function block. The machine in this scenario will use a conveyor belt to pass objects with known separation and position beneath a camera. The camera will take two pictures at specified positions as the object passes. It is known that only one object will pass beneath the camera per machine cycle of the conveyor belt.

Basic data setup

Fig.5 shows the structured text code which configures the outputs to match the following specifications. This application will use two high speed outputs, each mapped to a single high speed output track wired into the camera's trigger input. It is known that the camera requires a pulse of 500 µs to register a trigger; therefore Duration mode will be used to ensure that the output pulse is always the correct length, regardless of axis speed. The outputs will be triggered when the conveyor belt axis passes 90.5˚ and 92.5˚ within its 360˚ machine cycle. It is known that the conveyor axis will only be traveling in the positive direction, so the passing direction can be set to trigger outputs in either the positive direction or both directions. After rebooting and running the system, it was found that the camera pictures were taken slightly later than expected due to some internal system latency. A small positive compensation value was added to correct for this delay at the expected speed for the

machine. **Fig.6** shows the Y_DigitalCamSwitch function block connected to the required input values. Note that EnableMask is not required when using Sigma7-FT62 outputs.

```
CameraSwitch.Switch[0].AxisDirection := INT#1;          (* Forward direction *)
CameraSwitch.Switch[0].CamSwitchMode := INT#1;          (* Time mode – Active high *)
CameraSwitch.Switch[0].FirstOnPosition := LREAL#90.0;   (* Output position in user units *)
CameraSwitch.Switch[0].Duration := DINT#500;               (* Output Duration in us *)
(* CameraSwitch.Switch[0].Distance – Time mode does not use Distance *)
CameraSwitch.Switch[0].TrackNumber := INT#1;            (* Output on the HSO1 track *)

CameraSwitch.Switch[1].AxisDirection := INT#1;          (* Forward direction *)
CameraSwitch.Switch[1].CamSwitchMode := INT#1;          (* Time mode – Active high *)
CameraSwitch.Switch[1].FirstOnPosition := LREAL#92.5;   (* Output position in user units *)
CameraSwitch.Switch[1].Duration                         (* Output Duration in us *)
(* CameraSwitch.Switch[1].Distance – Time mode does not use Distance *)
CameraSwitch.Switch[1].TrackNumber := INT#1;            (* Output on the HSO1 track *)

CameraTrackOptions.Track[1].OnCompensationScaler := LREAL#0.005; (* Compensation in user units *)
```

Figure 5: Example code to configure outputs for rotary application
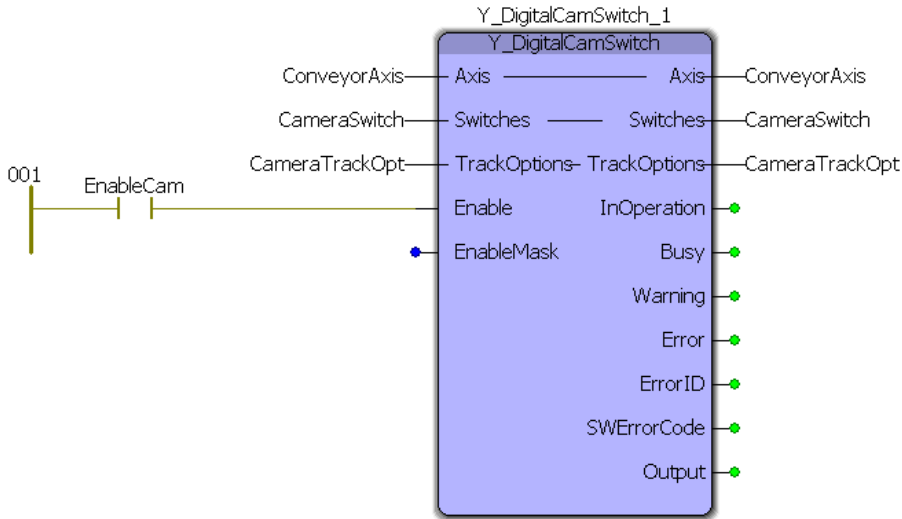
Figure 6: Y_DigitalCamSwitch with required inputs

Cyclic Position Update

In a cyclic application, every time an output position is passed, a new adjusted position must be written to the servopack. This new position will be adjusted by one machine cycle to account for the rotation of the axis. Luckily, Y_DigitalCamSwitch handles this operation internally so no additional code is necessary.

In our camera application we will use a Mechatrolink rate of 0.5 ms and a task rate of 4 ms. If the maximum axis speed is set to 2000 rpm, then the minimum machine cycle duration will be 30 ms. Using **Eq.1** it can be seen that these settings are well within the acceptable range.

Changing Parameters

Suppose that it has been detected that an object is not at the expected position on the conveyor belt. Taking pictures at 90.5˚ and 92.5˚ will no longer capture the desired data. The positions must be changed without stopping the machine. Making this change is as simple as changing the FirstOnPosition value in the input structure. Y_DigitalCamSwitch will detect the difference and send the new value to the SERVOPACK. CamSwitchMode, FirstOnPosition, Duration, and OnCompensationScaler can all be changed on the fly with no special considerations other than the added parameter write duration discussed in **Eq.4**. However, changing TrackNumber or the signal logic will require the controller to be power cycled before high speed output function can be restored.

Important Function Notes

- FirstOnPosition cannot be changed by more than 1/8 machine cycle within a single cycle, or there will be an error. This is to protect the internal state logic from becoming unstable.
- To set a new FirstOnPosition for the next cycle, it must be updated within the first half of the current cycle. Otherwise one complete cycle will pass before the position is updated.
- If an output Duration is set improperly such that an output is active long enough to be triggered again while still active, FT62 functionality will hang up and no more pulses will appear. A system reboot will be required to restore FT62 functionality.
- Do not set positions which exceed one complete machine cycle (i.e. 720 degrees in a 360 degree application). This will cause an error.
- It is not possible to accurately monitor the outputs within MotionWorks IEC due to the timing restrictions imparted by having a set application task time. The time between task scans is incredibly large in comparison to the response time of these high speed outputs.