RecordingTriggers

IEC 61131 Library for ACSELERATOR RTAC® Projects

SEL Automation Controllers

Table of Contents

RTAC LIBRARY

RecordingTriggers

Introduction

This library provides various function blocks to detect specific conditions in analog and digital signals to initiate the capture of data in oscillography recording devices, such as RTAC Recording Groups or SEL-2245 analog input modules.

Supported Firmware Versions

You can use this library on any device configured using ACSELERATOR RTAC® SEL-5033 Software with firmware version R143 or higher.

Versions 3.5.0.3 and older can be used on RTAC firmware version R132 and higher.

Enumerations

Enumerations make code more readable by allowing a specific number to have a readable textual equivalent.

enum_DigitalTriggerModes

This enumeration defines the operating mode of the fb_DigitalTrigger function block.

Enumeration	Description
LEVEL	Level mode
RISING_EDGE	Rising-Edge mode
FALLING_EDGE	Falling-Edge mode
RISING_FALLING_EDGE	Rising/Falling-Edge mode

Function Blocks

fb_HighThreshold (Function Block)

This function block monitors the value of an analog signal and compares it against a predefined threshold value to detect if the signal is above the threshold. This function block has two operating modes. The operating mode is selected by setting the initialization argument *risingEdgeMode* to TRUE or FALSE when the function block is instantiated.

1. Level mode: The output of the function block asserts when the value of the analog signal first becomes greater than or equal to the threshold value. The output of the function block remains asserted until the value of the signal becomes less than or equal to the threshold value minus the hysteresis value.
2. Rising-Edge mode: The output of the function block asserts for one RTAC processing interval when the value of the analog signal first becomes greater than or equal to the threshold value.

Initialization Inputs

Name	IEC 61131 Type	Description
risingEdgeMode	BOOL	Defines the operating mode of the function block. When TRUE, the function block is in Rising-Edge mode. When FALSE, the function block is in Level mode.

Inputs

Name	IEC 61131 Type	Description
EN	BOOL	Default=TRUE. Enables the function block.
InSignal	REAL	Analog signal to observe.
Threshold	REAL	Minimum value of the analog signal required to assert the trigger output of the function block.

Properties

Name	IEC 61131 Type	Access	Description
Hysteresis	REAL	R/W	The value of the hysteresis. Write to this property to set the value of the hysteresis when in Level mode.

Properties are internal values made visible through Get and Set accessors. Access is defined as R (read), W (write), or R/W (read/write).

Outputs

Name	IEC 61131 Type	Description
ENO	BOOL	The function block is enabled.
TriggerOut	BOOL	High-threshold condition is detected.

Processing

- Compare *InSignal* to *Threshold*.
- If the function block was initialized in Rising-Edge mode(*risingEdgeMode* = TRUE):
  - If *InSignal* becomes greater than or equal to *Threshold*, then assert *TriggerOut* for one RTAC processing interval.
- If the function block was initialized in Level mode *risingEdgeMode* = FALSE):
  - If *InSignal* becomes greater than or equal to *Threshold*, then assert *TriggerOut*.
  - If *TriggerOut* is asserted AND *InSignal* becomes less than or equal to (*Threshold-Hysteresis*), then deassert *TriggerOut*.

fb_LowThreshold (Function Block)

This function block monitors the value of an analog signal and compares it against a predefined threshold value to detect if the signal is below the threshold. This function block has two operating modes. The operating mode is selected by setting the initialization argument *risingEdgeMode* to TRUE or FALSE when the function block is instantiated.

1. Level mode: The output of the function block asserts when the value of the analog signal first becomes less than or equal to the threshold value. The output of the function block remains asserted until the value of the signal becomes greater than or equal to the threshold value plus the hysteresis value.
2. Rising-Edge mode: The output of the function block asserts for one RTAC processing interval when the value of the analog signal first becomes less than or equal to the threshold value.

Initialization Inputs

Name	IEC 61131 Type	Description
risingEdgeMode	BOOL	Defines the operating mode of the function block. When TRUE, the function block is in Rising-Edge mode. When FALSE, the function block is in Level mode.

Inputs

Name	IEC 61131 Type	Description
EN	BOOL	Default=TRUE. Enables the function block.
InSignal	REAL	Analog signal to observe.
Threshold	REAL	Maximum value of the analog signal required to assert the trigger output of the function block.

Properties

Name	IEC 61131 Type	Access	Description
Hysteresis	REAL	R/W	The value of the hysteresis. Write to this property to set the value of the hysteresis when in Level mode.

Properties are internal values made visible through Get and Set accessors. Access is defined as R (read), W (write), or R/W (read/write).

Outputs

Name	IEC 61131 Type	Description
ENO	BOOL	The function block is enabled.
TriggerOut	BOOL	Low threshold condition is detected.

Processing

- Compare *InSignal* to *Threshold*.
- If the function block was initialized in Rising-Edge mode(*risingEdgeMode* = TRUE):
  - If *InSignal* becomes less than or equal to *Threshold*, then assert *TriggerOut* for one RTAC processing interval.
- If the function block was initialized in Level mode *risingEdgeMode* = FALSE):
  - If *InSignal* becomes less than or equal to *Threshold*, then assert *TriggerOut*.
  - If *TriggerOut* is asserted AND *InSignal* becomes greater than or equal to (*Threshold+Hysteresis*), then deassert *TriggerOut*.

fb_RateOfChange (Function Block)

This function block monitors the value of an analog signal to detect if the signal rate-of-change exceeds a user-defined rate over a user-defined time period. The analog signal is sampled at fixed intervals determined by *SamplingPeriod* and its magnitude is compared to the previous sample. If the absolute value of the difference differs by *RateOfChange* or more, the output of the function block asserts. This function block has two operating modes. The operating mode is selected by setting the initialization argument *risingEdgeMode* to True or False when the function block is instantiated.

- Level mode: The output of the function block asserts when the rate-of-change condition is detected, and remains asserted until the rate-of-change condition clears.
- Rising-Edge mode: The output of the function block asserts for one RTAC processing interval when a rate-of-change condition is first detected. The output will not assert again until the rate-of-change condition clears and a new rate-of-change is detected.

Because the sampling is done at fixed intervals, if an analog signal transition exceeds the *RateOfChange* value and returns below *RateOfChange* in between two consecutive samples, the trigger output will not assert for this condition.

Initialization Inputs

Name	IEC 61131 Type	Description
risingEdgeMode	BOOL	Defines the operating mode of the function block. When TRUE, the function block is in Rising-Edge mode. When FALSE, the function block is in Level mode.

Inputs

Name	IEC 61131 Type	Description
EN	BOOL	Default=TRUE. Enables the function block.
InSignal	REAL	Analog signal to observe.
RateOfChange	REAL	Minimum change of the analog signal over a *SamplingPeriod* time required to set the trigger output of the function block.
SamplingPeriod	TIME	Time period at which the analog signal is sampled to detect a rate-of-change condition. This input should be set to a multiple of the RTAC processing scan time on which this object is instantiated.

Outputs

Name	IEC 61131 Type	Description
ENO	BOOL	The function block is enabled.
TriggerOut	BOOL	A rate-of-change condition is detected.
Sample_DN	BOOL	This output asserts for one RTAC processing cycle when the analog signal is sampled and the rate-of-change calculation logic is executed.

Processing

The following logic is performed every *SamplingPeriod* time interval *k*):

- Calculate the analog input change:

$$Delta_k = |InSignal_k - InSignal_{k-1}|$$

- Assert Sample_DN for one RTAC processing interval.
- If the function block was initialized in Rising-Edge mode *RisingEdge* = TRUE):
  - If $Delta_k \geq RateOfChange$, then assert *TriggerOut* for one RTAC processing interval.
- If the function block was initialized in Level mode *RisingEdge* = FALSE):
  - If $Delta_k \geq RateOfChange$, then assert *TriggerOut*.
  - If *TriggerOut* is asserted AND $Delta_k$ < RateOfChange, then deassert *TriggerOut*.

fb_DigitalTrigger (Function Block)

This function block monitors the status of a digital signal. The operation of the output of the function block depends on the operating mode. This function block has four operating modes. The operating mode is selected by setting the initialization argument *OpMode* to the correspondent enumerated value (see *Enumerations on page 3*) when the function block is instantiated. The supported operating modes are listed below.

- Rising-Edge Mode: The output of the function block asserts for one RTAC processing interval when the monitored digital signal changes from FALSE to TRUE.
- Falling-Edge Mode: The output of the function block asserts for one RTAC processing interval when the monitored digital signal changes from TRUE to FALSE.
- Rising-/Falling-Edge Mode: The output of the function block asserts for one RTAC processing interval when a change of state is detected in the monitored digital signal.
- Level Mode: The output of the function block remains asserted as long as the input signal is asserted.

Initialization Inputs

Name	IEC 61131 Type	Description
OpMode	enum_DigitalTriggerModes	Defines the operating mode of the function block.

Inputs

Name	IEC 61131 Type	Description
EN	BOOL	Default=TRUE. Enables the function block.
InSignal	BOOL	Digital signal to observe.

Outputs

Name	IEC 61131 Type	Description
ENO	BOOL	The function block is enabled.
TriggerOut	BOOL	Trigger condition is detected.

Processing

- If the function block was initialized in Rising-Edge mode (*OpMode* = *RISING_EDGE*):
  - If *InSignal* changes from FALSE to TRUE, then assert *TriggerOut* for one RTAC processing interval.
- If the function block was initialized in Falling-Edge mode *OpMode* = *FALLING_EDGE*):
  - If *InSignal* changes from TRUE to FALSE, then assert *TriggerOut* for one RTAC processing interval.
- If the function block was initialized in Rising-/Falling-Edge mode *OpMode* = *RISING_FALLING_EDGE*):
  - If a change of state is detected on *InSignal*, then assert *TriggerOut* for one RTAC processing interval.
- If the function block was initialized in Level mode (*OpMode* = *LEVEL*):
  - If *InSignal* asserts, then *TriggerOut* is asserted.
  - If *InSignal* deasserts, then *TriggerOut* is deasserted.

Benchmarks

Benchmark Platforms

The benchmarking tests recorded for this library are performed on the following platforms.

- SEL-3505
  - R139-V0 firmware
- SEL-3530
  - R139-V0 firmware
- SEL-3555
  - Dual-core Intel i7-3555LE processor
  - 4 GB ECC RAM
  - R139-V0 firmware

Benchmark Test Descriptions

The posted time is the average execution time of 1000 consecutive calls to the following function blocks.

This testing is performed on the following function blocks:

- fb_HighThreshold
- fb_LowThreshold
- fb_RateOfChange
- fb_DigitalTriggers

Execution Time of High-Threshold Function Block

fb_HighThreshold. The time necessary to determine if a high-threshold condition occurred.

Execution Time of Low-Threshold Function Block

fb_LowThreshold. The time necessary determine if a low-threshold condition occurred.

Execution Time of Rate of Change Function Block

fb_RateOfChange. The time necessary determine if a rate-of-change condition occurred.

Execution Time of Digital Triggers Function Block

The time necessary to determine if a digital trigger condition occurred.

Benchmark Results

Operation Tested	Platform (time in μs)		
	SEL-3505	SEL-3530	SEL-3555
fb_HighThreshold	1	1	1
fb_LowThreshold	2	1	1
fb_RateOfChange	2	1	1
fb_DigitalTriggers	1	1	1

Examples

These examples demonstrate the capabilities of this library. Do not mistake them as suggestions or recommendations from SEL.

Implement the best practices of your organization when using these libraries. As the user of this library, you are responsible for ensuring correct implementation and verifying that the project using these libraries performs as expected.

fb_HighThreshold: Rising-Edge Mode

Objective

A user is using an Axion DC analog input module to read an analog signal. The user wants to assert RTAC Output OUT201 when the value of the analog signal exceeds 75.

Assumptions

This example assumes that there is an Axion analog input module configured in the RTAC project.

Solution

To assert Output OUT201 when the analog signal is greater than or equal to 75, the user can create a program as shown in *Code Snippet 1*.

Code Snippet 1 Rising-Edge Mode

```
PROGRAM Example_HighThreshold
VAR
HighTrigger_pulse: fb_HighThreshold(risingEdgeMode := TRUE)
:= (EN:= TRUE, Threshold := 75);
END_VAR
```

```
HighTrigger_pulse(InSignal := SEL_16AI_1_ECAT.INPUT_VALUE_001.instMag);

//Assert OUT201 if the function block output has triggered:
IF HighTrigger_pulse.TriggerOut THEN
SystemTags.OUT201.operSet.ctlVal := TRUE;
SystemTags.OUT201.operClear.ctlVal := FALSE;
END_IF
```

fb_HighThreshold: Level Mode

Objective

A user is using an Axion DC analog input module to read an analog signal. The user wants to assert the Alarm variable when the value of the analog signal exceeds 100. The Alarm variable deasserts when the analog signal drops to 95 or below.

Assumptions

This example assumes that there is an Axion analog input module configured in the RTAC project, and a global variable named Alarm exists in the project.

Solution

To assert the Alarm variable when the analog signal is greater than or equal to 100, and deassert the variable when the analog signal drops to 95 or below, the user can create a program as shown in *Code Snippet 2*.

Code Snippet 2 Level Mode

```
PROGRAM Example_HighThreshold
VAR
HighTrigger_level: fb_HighThreshold(risingEdgeMode := FALSE)
:= (EN:= TRUE, Threshold := 100, Hysteresis:=5);
END_VAR
```

```
HighTrigger_level(InSignal := SEL_16AI_1_ECAT.INPUT_VALUE_001.instMag);

//Assert Level if the function block output has triggered:
IF HighTrigger_level.TriggerOut THEN
Alarm := TRUE;
ELSE
Alarm := FALSE;
END_IF
```

fb_LowThreshold: Rising-Edge Mode

Objective

A user is using an Axion DC analog input module to read an analog signal. The user wants to assert RTAC Output OUT201 when the value of the analog signal drops below 50.

Assumptions

This example assumes that there is an Axion analog input module configured in the RTAC project.

Solution

To assert Output OUT201 when the analog signal is less than or equal to 50, the user can create a program as shown in *Code Snippet 3*.

Code Snippet 3 Rising-Edge Mode

```
PROGRAM Example_LowThreshold
VAR
LowTrigger_pulse: fb_LowThreshold(risingEdgeMode := TRUE)
:= (EN:= TRUE, Threshold := 50);
END_VAR
```

```
LowTrigger_pulse(InSignal := SEL_16AI_1_ECAT.INPUT_VALUE_001.instMag);

//Assert OUT201 if the function block output has triggered:
IF LowTrigger_pulse.TriggerOut THEN
SystemTags.OUT201.operSet.ctlVal := TRUE;
SystemTags.OUT201.operClear.ctlVal := FALSE;
END_IF
```

fb_LowThreshold: Level Mode

Objective

A user is using an Axion DC analog input module to read an analog signal. The user wants to assert the Alarm variable when the value of the analog signal drops below 25. The Alarm variable deasserts when the analog signal becomes equal to 28 or higher.

Assumptions

This example assumes that there is an Axion analog input module configured in the RTAC project, and a global variable named Alarm exists in the project.

Solution

To assert the Alarm variable when the analog signal is less than or equal to 25, and deassert the variable when the analog signal becomes greater than or equal to 28, the user can create a program as shown in *Code Snippet 4*.

Code Snippet 4 Level Mode

```
PROGRAM Example_LowThreshold
VAR
LowTrigger_level: fb_LowThreshold(risingEdgeMode := FALSE)
:= (EN:= TRUE, Threshold := 25, Hysteresis:=3);
END_VAR
```

Code Snippet 4 Level Mode (Continued)

```
LowTrigger_level(InSignal := SEL_16AI_1_ECAT.INPUT_VALUE_001.instMag);

//Assert Level if the function block output has triggered:
IF LowTrigger_level.TriggerOut THEN
Alarm := TRUE;
ELSE
Alarm := FALSE;
END_IF
```

fb_RateOfChange

Objective

A user is using a Modbus client on the RTAC to read a temperature value from the field. The user wants to assert the RTAC output OUT201 when the rate-of-change of the temperature exceeds 10°C per minute.

Assumptions

This example assumes that there is a Modbus client in the RTAC project, and it is configured to read a temperature, in Celsius, from a measurement device installed on the field. The name of the Modbus client in the project is *myModbus_MODBUS* and the temperature of interest is mapped in the Modbus Holding Register Address 0.

Solution

To assert Output OUT201 when the rate-of-change of the temperature is greater than or equal to 10°C per minute, the user can create a program as shown in *Code Snippet 5*:

Code Snippet 5 Rate-of-Change Example

```
PROGRAM Example_RateOfChange
VAR
TemperatureRoC: fb_RateOfChange(risingEdgeMode := FALSE)
:= (EN:=TRUE, RateOfChange:=10, SamplingPeriod:=T#1M);
END_VAR
```

```
TemperatureRoC(InSignal := myModbus_MODBUS.HREG_00000.Status.stVal);
//Assert OUT201 if the function block output has triggered:
IF TemperatureRoC.TriggerOut THEN
SystemTags.OUT201.operSet.ctlVal := TRUE;
SystemTags.OUT201.operClear.ctlVal := FALSE;
ELSE
SystemTags.OUT201.operSet.ctlVal := FALSE;
SystemTags.OUT201.operClear.ctlVal := TRUE;
END_IF
```

fb_DigitalTrigger

Objective

A user is monitoring the status of a circuit breaker using a digital input channel in the RTAC. The user wants to generate an oscillography event file when the circuit breaker trips or closes (rising edge and falling edge).

Assumptions

This example assumes the following:

- The circuit breaker is wired to the Digital Input IN201.
- The oscillography is generated by using an RTAC recording group. The name of the recording group in the RTAC project is *recGroup*.

Solution

To trigger the recording group when a change of state occurs on Input IN201 , the user can create a program as shown in *Code Snippet 6*.

Code Snippet 6 DigitalTrigger Example

```
PROGRAM Example_DigitalTrigger
VAR
BreakerStatusChange: fb_DigitalTrigger(OpMode := RISING_FALLING_EDGE)
:= (EN:= TRUE);
END_VAR
```

```
BreakerStatusChange(InSignal := SystemTags.IN201.stVal);

//Trigger Recording Group:
recGroup_POU.Event_Trigger := BreakerStatusChange.TriggerOut;
```

Release Notes

Version	Summary of Revisions	Date Code
3.5.1.0	➤ Allows new versions of ACSELERATOR RTAC to compile projects for previous firmware versions without SEL IEC types "Cannot convert" messages. ➤ Must be used with R143 firmware or later.	20180921
3.5.0.2	➤ Initial release of high-threshold function block. ➤ Initial release of low-threshold function block. ➤ Initial release of rate-of-change function block. ➤ Initial release of digital trigger function block.	20170908