Project Documentation DemoApplication

May 3, 2023

Contents

Part I

X2C Model

1 Version Information

1.1 X2C

- X2C Development: Version 6.4.2826

1.2 Operating System

- OS: Windows 10 10.0

1.3 Scilab

- Scilab: Version 6.1.1.1626343451
- Java: Version 1.8.0_292

2 Model Structure

2.1 Xcos Model

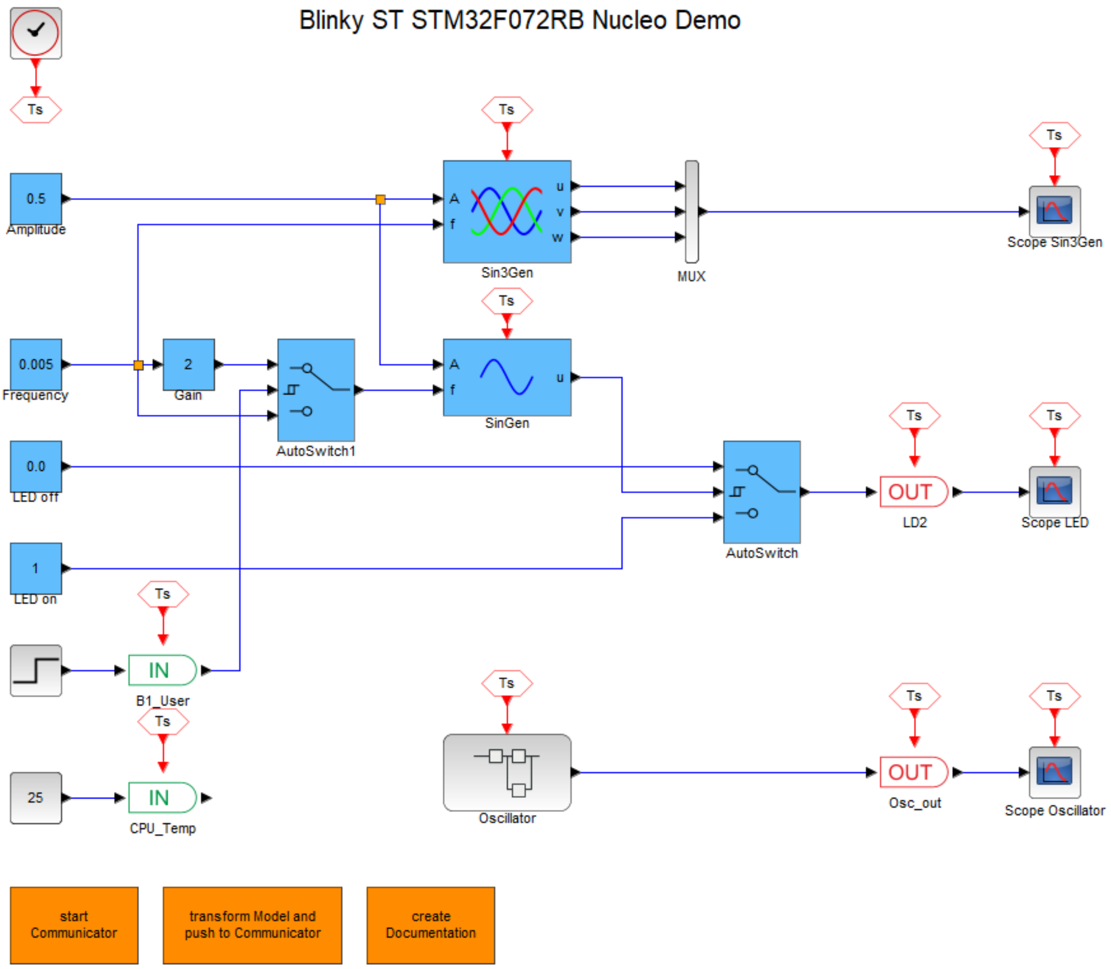


Figure 1: DemoApplication

2.2 Subsystems

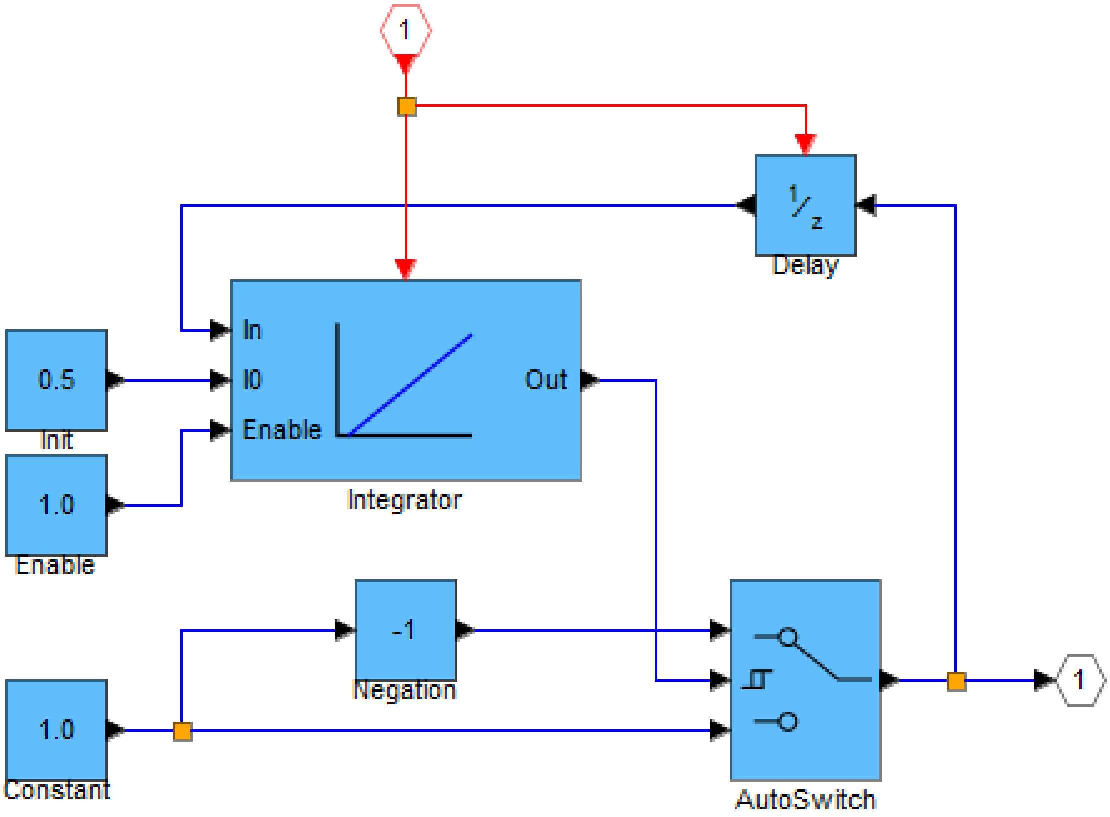


Figure 2: Oscillator

3 Model Parameter

3.1 Sample Time

Sample Time	
T_S	$100 \mu s$

4 Mask Parameter

4.1 Inports

4.1.1 Inports with auto generated ID

B1_User	
Block Type	Inport - int16
ts_fact	1.0
Simulation Gain	1.0
Simulation Offset	0.0

CPU_Temp	
Block Type	Inport - float32
ts_fact	1.0
Simulation Gain	1.0
Simulation Offset	0.0

4.2 Outports

4.2.1 Outports with auto generated ID

LD2	
Block Type	Outport - int16
ts_fact	1.0
Simulation Gain	1.0
Simulation Offset	0.0

Osc_out	
Block Type	Outport - int16
ts_fact	1.0
Simulation Gain	1.0
Simulation Offset	0.0

4.3 Blocks

4.3.1 Blocks with auto generated ID

Amplitude	
Block Type	Constant - FiP16
Value	0.5

AutoSwitch	
Block Type	AutoSwitch - FiP16
Thresh_up	0.0
Thresh_down	0.0

AutoSwitch1	
Block Type	AutoSwitch - FiP16
Thresh_up	0.5
Thresh_down	0.5

Frequency	
Block Type	Constant - FiP16
Value	0.005

Gain	
Block Type	Gain - FiP16
Gain	2.0

LED off	
Block Type	Constant - FiP16
Value	0.0

LED on	
Block Type	Constant - FiP16
Value	1.0

Oscillator/AutoSwitch	
Block Type	AutoSwitch - FiP16
Thresh_up	0.5
Thresh_down	-0.5

Oscillator/Constant	
Block Type	Constant - FiP16
Value	1.0

Oscillator/Delay	
Block Type	Delay - FiP16
ts_fact	1.0

Oscillator/Enable	
Block Type	Constant - Bool
Value	1.0

Oscillator/Init	
Block Type	Constant - FiP16
Value	0.5

Oscillator/Integrator	
Block Type	I - FiP16
Ki	50.0
ts_fact	1.0

Oscillator/Negation	
Block Type	Negation - FiP16

Sin3Gen	
Block Type	Sin3Gen - FiP16
fmax	1000.0
Offset	0.0
ts_fact	1.0

SinGen	
Block Type	SinGen - FiP16
fmax	1000.0
Offset	0.0
Phase	0.0
ts_fact	1.0

Part II

Frame Program Documentation

5 File Index

5.1 File List

Here is a list of all documented files with brief descriptions:

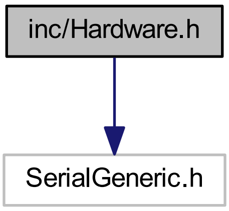
6 File Documentation

6.1 inc/Hardware.h File Reference

Hardware configuration.

`#include "SerialGeneric.h"`

Include dependency graph for Hardware.h:



Functions

- void initSerial (tSerial ∗serialSTM32)

  Initialization of serial interface.
- float32 calculateCpuTemperature (int16 adcValue)

  Routine to calculate temperature from internal temperature sensor.

6.1.1 Detailed Description

Hardware configuration.

6.1.2 Function Documentation

6.1.2.1 float32 calculateCpuTemperature (int16 *adcValue*)

Routine to calculate temperature from internal temperature sensor.
NOTE: Internal temperature sensor measurement is not very accurate. Factory calibration has +/-10mV voltage reference tolerance and +/-5°C temperature reference tolerance. Additionally, linearity over temperature is specified with +/-2°C.

Parameters

adcValue	ADC result from internal temperature sensor channel

Returns

CPU temperature in degree Celsius

6.1.2.2 void initSerial (tSerial $*$ ***serialSTM32***)

Initialization of serial interface.

- hook serial functions

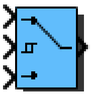
Part III

Used X2C-Blocks

7 Project Specific Blocks

8 Internal Library Blocks

Block: AutoSwitch



Inports	
In1	Input #1
Switch	Input #2: Threshold signal
In3	Input #3

Outports	
Out	Either value of input #1 or input #3 dependent on value of input #2

Mask Parameters		
Name	**ID**	**Description**
Thresh_up	1	Threshold level for rising switch signal
Thresh_down	2	Threshold level for falling switch signal

Description:

Switch between In1 and In3 dependent on Switch signal:
Switch signal rising: Switch >= Threshold up –> Out = In1
Switch signal falling: Switch < Threshold down –> Out = In3

Implementations:

FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation
Float64	64 Bit Floating Point Implementation

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In1	int16
Switch	int16
In3	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In1	int32
Switch	int32
In3	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In1	float32
Switch	float32
In3	float32

Outports Data Type	
Out	float32

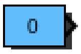
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In1	float64
Switch	float64
In3	float64

Outports Data Type	
Out	float64

Block: Constant



Outports	
Out	Constant output

Mask Parameters		
Name	**ID**	**Description**
Value	1	Constant factor

Description:

Constant value.

Implementations:

Bool	Boolean Implementation
Int8	8 Bit Integer Implementation
Int16	16 Bit Integer Implementation
Int32	32 Bit Integer Implementation
FiP8	8 Bit Fixed Point Implementation
FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation
Float64	64 Bit Floating Point Implementation

Implementation: Bool

Boolean Implementation

Outports Data Type	
Out	bool

Implementation: Int8

8 Bit Integer Implementation

Outports Data Type	
Out	int8

Implementation: Int16

16 Bit Integer Implementation

Outports Data Type	
Out	int16

Implementation: Int32

32 Bit Integer Implementation

Outports Data Type	
Out	int32

Implementation: FiP8

8 Bit Fixed Point Implementation

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

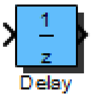
Outports Data Type	
Out	float32

Implementation: Float64

64 Bit Floating Point Implementation

Outports Data Type	
Out	float64

Block: Delay



Inports	
In	Input In(k)

Outports	
Out	Output Out(k)=In(k-1)

Mask Parameters		
Name	**ID**	**Description**
ts_fact	1	Multiplication factor of base sampling time (in integer format)

Description:

Output delay by one sample time interval.

This block can be used to enable feedback loops in the model.

Implementations:

Bool	Boolean Integration
FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation
Float64	64 Bit Floating Point Implementation

Implementation: Bool

Boolean Integration

Inports Data Type	
In	bool

Outports Data Type	
Out	bool

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In	float32

Outports Data Type	
Out	float32

Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: Gain

Inports	
In	Input

Outports	
Out	Amplified input

Mask Parameters		
Name	**ID**	**Description**
Gain	1	Gain factor in floating point format

Description:

Amplification of input by gain factor.

Implementations:

FiP8	8 Bit Fixed Point Implementation
FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation
Float64	64 Bit Floating Point Implementation

Implementation: FiP8

8 Bit Fixed Point Implementation

Inports Data Type	
In	int8

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In	float32

Outports Data Type	
Out	float32

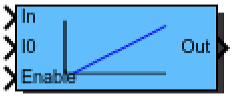
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: I



Inports	
In	Control error input
I0	Integral value which is loaded at initialization function call
Enable	Enable == 0: Deactivation of block; Out set to 0 Enable 0->1: Preload of integral part Enable == 1: Activation of block

Outports	
Out	Control value

Mask Parameters		
Name	**ID**	**Description**
Ki	1	Integral Factor
ts_fact	2	Multiplication factor of base sampling time (in integer format)

Description:

I controller:
G(s) = Ki/s = 1/(Ti*s)

Each fixed point implementation uses the next higher integer datatype for the integrational value storage variable.
A rising flank at the *Enable* inport will preload the integrational part with the value present on the *Init* inport.

Transfer function (zero-order hold discretization method):

$$G(z) = K_{\mathrm{i}} T_{\mathrm{s}} \frac{1}{z-1}$$

8.0.0.1 Developer note:

The source code of block *ILimit* is used.

Implementations:

FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation
Float64	64 Bit Floating Point Implementation

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In	int16
I0	int16
Enable	bool

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In	int32
I0	int32
Enable	bool

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In	float32
I0	float32
Enable	bool

Outports Data Type	
Out	float32

Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64
I0	float32
Enable	bool

Outports Data Type	
Out	float64

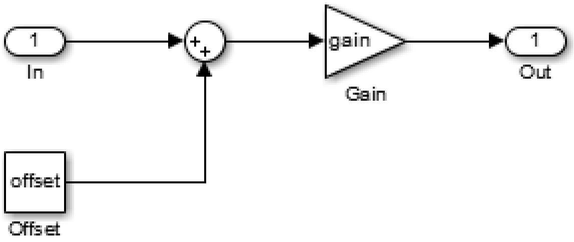
Block: Inport

Inports	
IN	Signal from frame program

Mask Parameters	
ts_fact	Multiplication factor of base sampling time (in integer format)
Gain	Gain value used in simulation
Offset	Offset value used in simulation

Description:

Serves as interface to the frame program. The input of this block is intended for simulation purposes and can be left unconnected if not used. Also the parameters *Gain* and *Offset* are only used during simulation. The schematic for simulation can be seen in the figure below.
Note: Currently, *Gain* and *Offset* parameters are only available in Matlab/Simulink.



Data Types:

int8	8 Bit Fixed Point
int16	16 Bit Fixed Point
int32	32 Bit Fixed Point
float32	32 Bit Floating Point
float64	64 Bit Floating Point

Block: Negation

Inports	
In	Input

Outports	
Out	Negated input value

Description:

Negation of input signal.

Calculation:

$$\mathrm{Out} = -\mathrm{In}$$

Implementations:

FiP8	8 Bit Fixed Point Implementation
FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation
Float64	64 Bit Floating Point Implementation

Implementation: FiP8

8 Bit Fixed Point Implementation

Inports Data Type	
In	int8

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In	float32

Outports Data Type	
Out	float32

Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: Outport

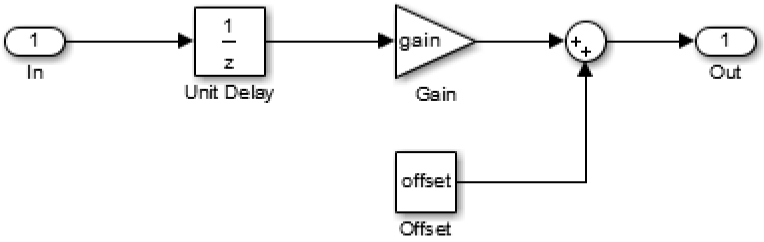
OUT
Outport

Outports	
OUT	Signal to frame program

Mask Parameters	
ts_fact	Multiplication factor of base sampling time (in integer format)
Gain	Gain value used in simulation
Offset	Offset value used in simulation

Description:

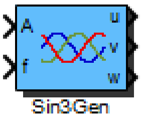
Serves as interface to the frame program. The output of this block is intended for simulation purposes and can be left unconnected if not used. Also the parameters *Gain*, and *Offset* are only used during simulation. The schematic for simulation can be seen in the figure below. The Unit Delay block is only used during simulation and should reflect the time delay caused by a discrete controller.
Note: Currently, *Gain* and *Offset* parameters are only available in Matlab/Simulink.



Data Types:

int8	8 Bit Fixed Point
int16	16 Bit Fixed Point
int32	32 Bit Fixed Point
float32	32 Bit Floating Point
float64	64 Bit Floating Point

Block: Sin3Gen



Inports	
A	Amplitude
f	Frequency

Outports	
u	Sine wave output phase u
v	Sine wave output phase v
w	Sine wave output phase w

Mask Parameters		
Name	**ID**	**Description**
fmax	1	Maximum Frequency in Hz
Offset	2	Offset
ts_fact	3	Multiplication factor of base sampling time (in integer format)

Description:

Generation of a 3 sine waves with amplitude (A) and frequency (f).

Calculation fixed point implementation:

$$\begin{aligned}
u_k &= A_k \sin\left(2 f_k f_{\max} k T_{\mathrm{s}}\right) + A_{\mathrm{offset}} \\
v_k &= A_k \sin\left(2 f_k f_{\max} k T_{\mathrm{s}} - \frac{2\pi}{3}\right) + A_{\mathrm{offset}} \\
w_k &= A_k \sin\left(2 f_k f_{\max} k T_{\mathrm{s}} + \frac{2\pi}{3}\right) + A_{\mathrm{offset}}
\end{aligned}$$

For sine calculation a lookup table with 256 entries is used. This results in a short computation time but with the downside of reduced accuracy for the FiP32 implementation.

Calculation floating point implementation (parameter *f_max* is ignored):

$$\begin{aligned}
u_k &= A_k \sin\left(2\pi f_k k T_{\mathrm{s}}\right) + A_{\mathrm{offset}} \\
v_k &= A_k \sin\left(2\pi f_k k T_{\mathrm{s}} - \frac{2\pi}{3}\right) + A_{\mathrm{offset}} \\
w_k &= A_k \sin\left(2\pi f_k k T_{\mathrm{s}} + \frac{2\pi}{3}\right) + A_{\mathrm{offset}}
\end{aligned}$$

Implementations:

FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation
Float64	64 Bit Floating Point Implementation

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
A	int16
f	int16

Outports Data Type	
u	int16
v	int16
w	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
A	int32
f	int32

Outports Data Type	
u	int32
v	int32
w	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
A	float32
f	float32

Outports Data Type	
u	float32
v	float32
w	float32

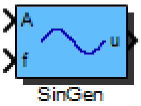
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
A	float64
f	float64

Outports Data Type	
u	float64
v	float64
w	float64

Block: SinGen



Inports	
A	Amplitude
f	Frequency

Outports	
u	Sine wave output

Mask Parameters		
Name	**ID**	**Description**
fmax	1	Maximum Frequency in Hz
Offset	2	Offset
Phase	3	Phase [-Pi..Pi]
ts_fact	4	Multiplication factor of base sampling time (in integer format)

Description:

Generation of a sine wave with amplitude (A) and frequency (f).

Calculation fixed point implementation:

$$u_k = A_k \sin\left(2 f_k f_{\text{max}} k T_{\text{s}} + \phi_{\text{phase}}\right) + A_{\text{offset}}$$

For sine calculation a lookup table with 256 entries is used. This results in a short computation time but with the downside of reduced accuracy for the FiP32 implementation.

Calculation floating point implementation (parameter *f_max* is ignored):

$$u_k = A_k \sin\left(2\pi f_k k T_{\text{s}} + \phi_{\text{phase}}\right) + A_{\text{offset}}$$

Implementations:

FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation
Float64	64 Bit Floating Point Implementation

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
A	int16
f	int16

Outports Data Type	
u	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
A	int32
f	int32

Outports Data Type	
u	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
A	float32
f	float32

Outports Data Type	
u	float32

Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
A	float64
f	float64

Outports Data Type	
u	float64