X2C

LINZ CENTER OF MECHATRONICS GMBH

Project Documentation Blinky_dsPIC33CK_Curiosity

July 24, 2020

Contents

Part I

X2C Model

1 Version Information

1.1 X2C

- X2C: Version 6.2.1984

1.2 Operating System

- OS: Windows 8 6.2

1.3 Scilab

- Scilab: Version 5.5.2.1427793548
- Java: Version 1.6.0_41

2 Model Structure

2.1 Xcos Model

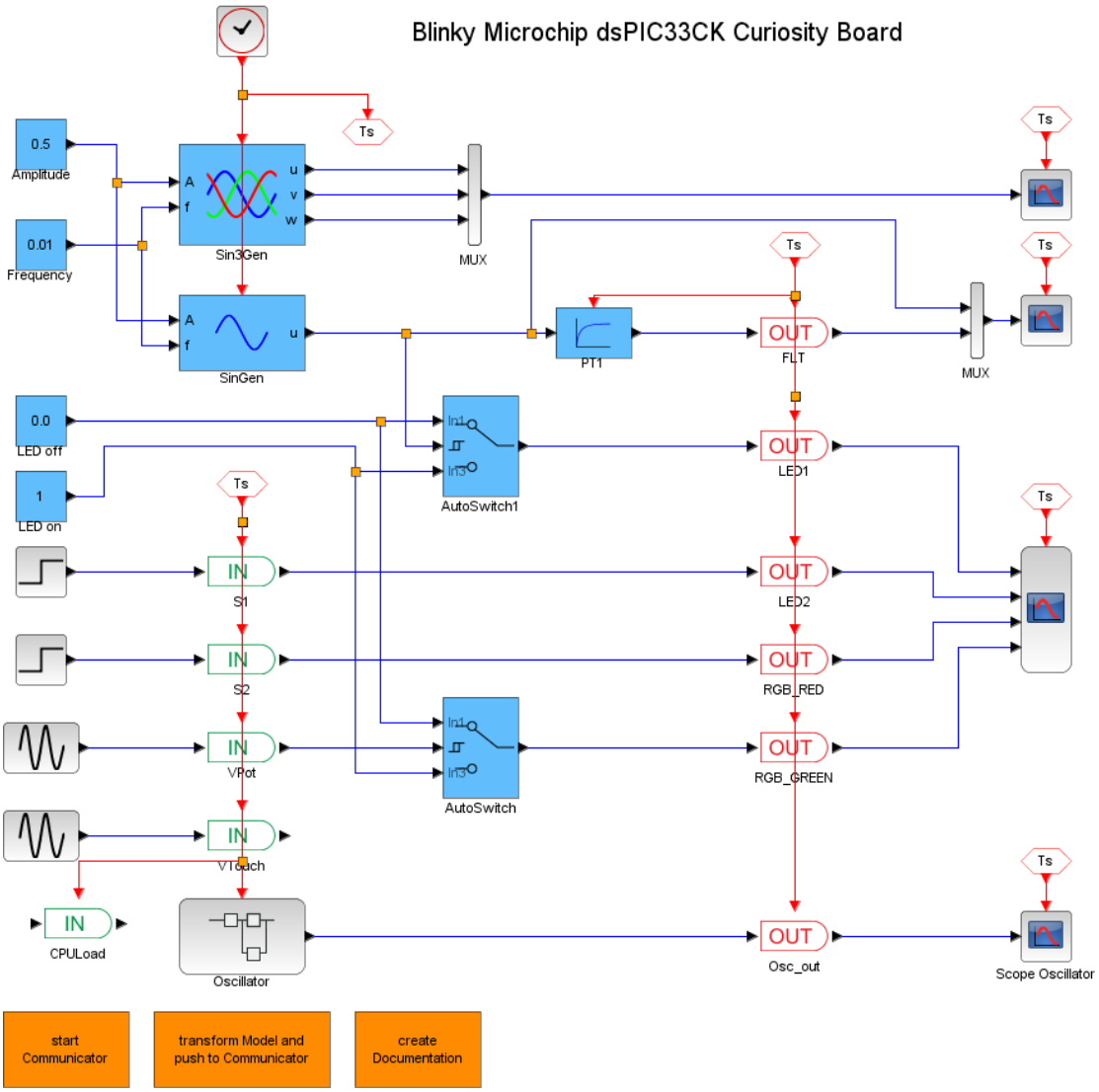

Figure 1: Blinky_dsPIC33CK_Curiosity

2.2 Subsystems

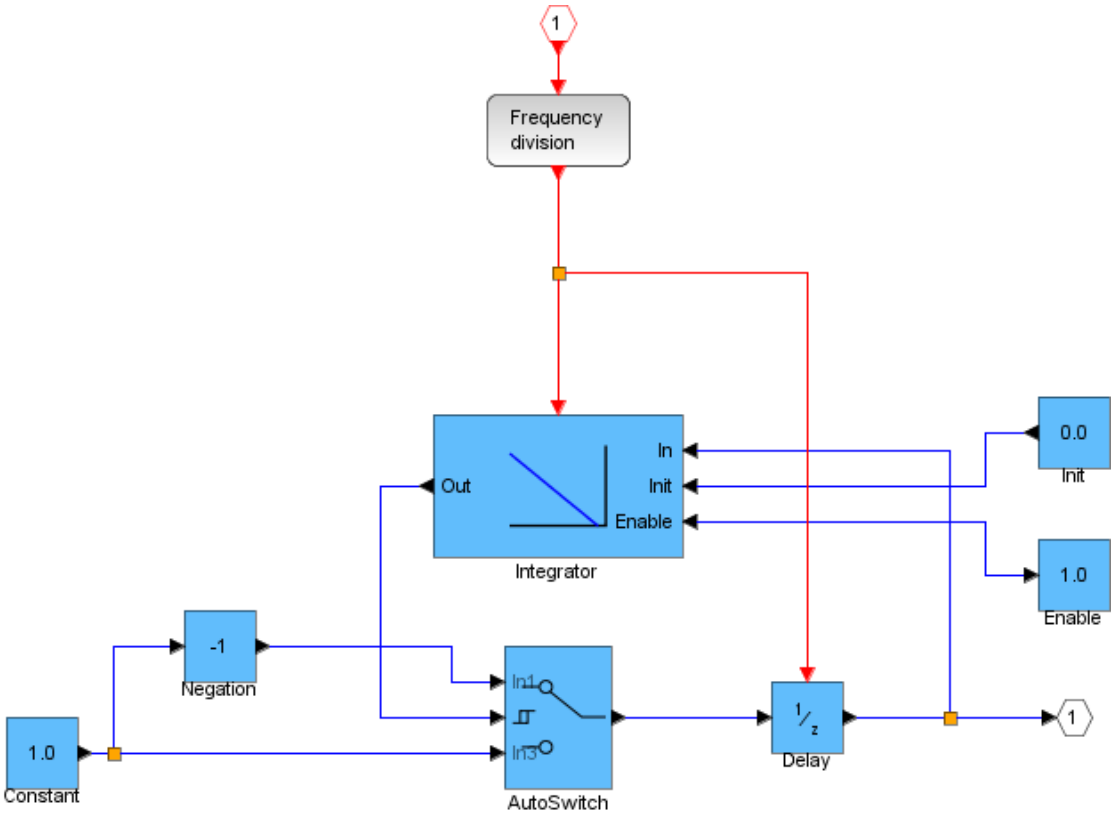

Figure 2: Blinky_dsPIC33CK_Curiosity_Oscillator

3 Model Parameter

3.1 Sample Time

Sample Time	
T_S	$100\mu s$

3.2 Scilab Parameter

```
// Scilab script file to store Model parameters
// This file is automatically executed by initProject.sce
// initScript.sce and this script is executed automatically, if model is opened from MPLAB X MCC

// Simulation settings
endTime      = 5;
stepSize     = 1.0E-2;
// X2C_sampleTime = 1.0E-4;

//****** User variables example *******//
// voltage = 24;
// maxCurrent = 10;
// powerLimit = voltage * maxCurrent;
```

Listing 1: ModelParameter.sce

4 Mask Parameter

Constant: Amplitude	
Value	0.5
Used Implementation	FiP16

AutoSwitch: AutoSwitch	
Thresh_up	0.3
Thresh_down	-0.3
Used Implementation	FiP16

AutoSwitch: AutoSwitch1	
Thresh_up	0.0
Thresh_down	0.0
Used Implementation	FiP16

Constant: Frequency	
Value	0.01
Used Implementation	FiP16

Constant: LED off	
Value	0.0
Used Implementation	FiP16

Constant: LED on	
Value	1.0
Used Implementation	FiP16

AutoSwitch: AutoSwitch	
Thresh_up	0.5
Thresh_down	-0.5
Used Implementation	FiP16

Constant: Constant	
Value	1.0
Used Implementation	FiP16

Delay: Delay	
ts_fact	3.0
Used Implementation	FiP16

Constant: Enable	
Value	1.0
Used Implementation	Bool

Constant: Init	
Value	0.0
Used Implementation	FiP16

I: Integrator	
Ki	30.0
ts_fact	3.0
Used Implementation	FiP16

Negation: Negation	
Used Implementation	FiP16

PT1: PT1	
V	1.0
fc	10.0
ts_fact	1.0
method	zoh
Used Implementation	FiP16

Sin3Gen: Sin3Gen	
fmax	1000.0
Offset	0.0
ts_fact	1.0
Used Implementation	FiP16

SinGen: SinGen	
fmax	1000.0
Offset	0.0
Phase	0.0
ts_fact	1.0
Used Implementation	FiP16

Part II
Frame Program Documentation

5 Data Structure Index

5.1 Data Structures

Here are the data structures with brief descriptions:

6 Data Structure Documentation

6.1 _TMR_OBJ_STRUCT Struct Reference

6.1.1 Detailed Description

Section: Data Type DefinitionsTMR Driver Hardware Instance Object
@Summary Defines the object required for the maintenance of the hardware instance.
@Description This defines the object required for the maintenance of the hardware instance.
This object exists once per hardware instance of the peripheral.
Remarks: None.
The documentation for this struct was generated from the following file:

- tmr1.c

7 Example Documentation

7.1 C:/_bitbucket/x2c_demos/blinky_dspic33ck_curiosity/mcc_generated_files/reset.h

It handles the reset cause by clearing the cause register values. Its a weak function user can override this function.

Returns

None

```
RESET_CauseHandler();
/*
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*/
#ifndef RESET_H
#define RESET_H
```

```
#include <stdint.h>
#include "reset_types.h"
uint16_t RESET_GetCause(void);
void __attribute__ ((weak)) RESET_CauseHandler(void);
void RESET_CauseClearAll();
#endif  /* RESET_H */
```

7.2 C:/_bitbucket/x2c_demos/blinky_dspic33ck_curiosity/mcc_generated_files/system.h

Initializes the CPU core control register.

```
SYSTEM_CORCONInitialize();
```

```
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*/
#ifndef _XTAL_FREQ
#define _XTAL_FREQ  100000000UL
#endif
#define WDT_CLR_KEY 0x5743
#include "xc.h"
#include "stdint.h"
#include "system_types.h"
#ifndef SYSTEM_H
#define SYSTEM_H
inline static void SYSTEM_CORCONInitialize()
{
    CORCON = (CORCON & 0x00F2) | CORCON_MODE_PORVALUES;    // POR value
}
inline static void SYSTEM_CORCONModeOperatingSet(SYSTEM_CORCON_MODES modeValue)
{
    CORCON = (CORCON & 0x00F2) | modeValue;
}
inline static void SYSTEM_CORCONRegisterValueSet(uint16_t value)
{
    CORCON = value;
}
inline static uint16_t SYSTEM_CORCONRegisterValueGet(void)
{
    return CORCON;
}
inline static uint32_t SYSTEM_DeviceIdRegisterAddressGet(void)
{
    return __DEVID_BASE;
}
void SYSTEM_Initialize(void);
#endif  /* SYSTEM_H */
```

7.3 C:/_bitbucket/x2c_demos/blinky_dspic33ck_curiosity/mcc_generated_files/watchdog.h

Enables Watch Dog Timer (WDT) using the software bit.

```
WATCHDOG_TimerSoftwareEnable();
```

```
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```

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*/
#ifndef WATCHDOG_H
#define WATCHDOG_H
#define WATCHDOG_CLR_KEY 0x5743
inline static void WATCHDOG_TimerSoftwareEnable(void)
{
    WDTCONLbits.ON = 1;
}
inline static void WATCHDOG_TimerSoftwareDisable(void)
{
    WDTCONLbits.ON = 0;
}
inline static void WATCHDOG_TimerClear(void)
{
    WDTCONH = WATCHDOG_CLR_KEY;
}
#endif  /* WATCHDOG_H */
```

Part III
Used X2C-Blocks

8 Project Specific Blocks

9 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

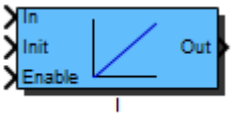
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: I



Inports	
In	Control error input
Init	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):

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

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
Init	int8
Enable	bool

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In	int16
Init	int16
Enable	bool

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In	int32
Init	int32
Enable	bool

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In	float32
Init	float32
Enable	bool

Outports Data Type	
Out	float32

Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64
Init	float64
Enable	bool

Outports Data Type	
Out	float64

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

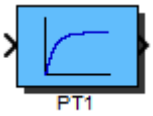
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: PT1



Inports	
In	Input In(k)

Outports	
Out	Output Out(k)

Mask Parameters		
Name	**ID**	**Description**
V	1	Gain
fc	2	Cut off frequency of low pass filter
ts_fact	3	Multiplication factor of base sampling time (in integer format)
method	4	Discretization method

Description:

First order low pass:
G(s) = V/(s/w + 1)

Due to limited value range in the 8 bit fixed point implementation rather high deviations from expected output values may occur.

9.0.0.1 Developer note:

The source code of block *TF1* is used.

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

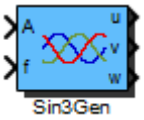
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: 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

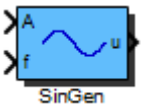
Implementation: Float64

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:

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

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):

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

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