LINZ CENTER OF MECHATRONICS GMBH

Project Documentation DemoApplication

October 21, 2016

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Part I

X2C Model

1 Version Information

1.1 X2C

- X2Cfull: Version 1037

1.2 Operating System

- OS: Windows 7 6.1

1.3 Scilab

- Scilab: Version 5.5.1.1412169962
- Java: Version 1.6.0_41

2 Model Structure

2.1 Xcos Model

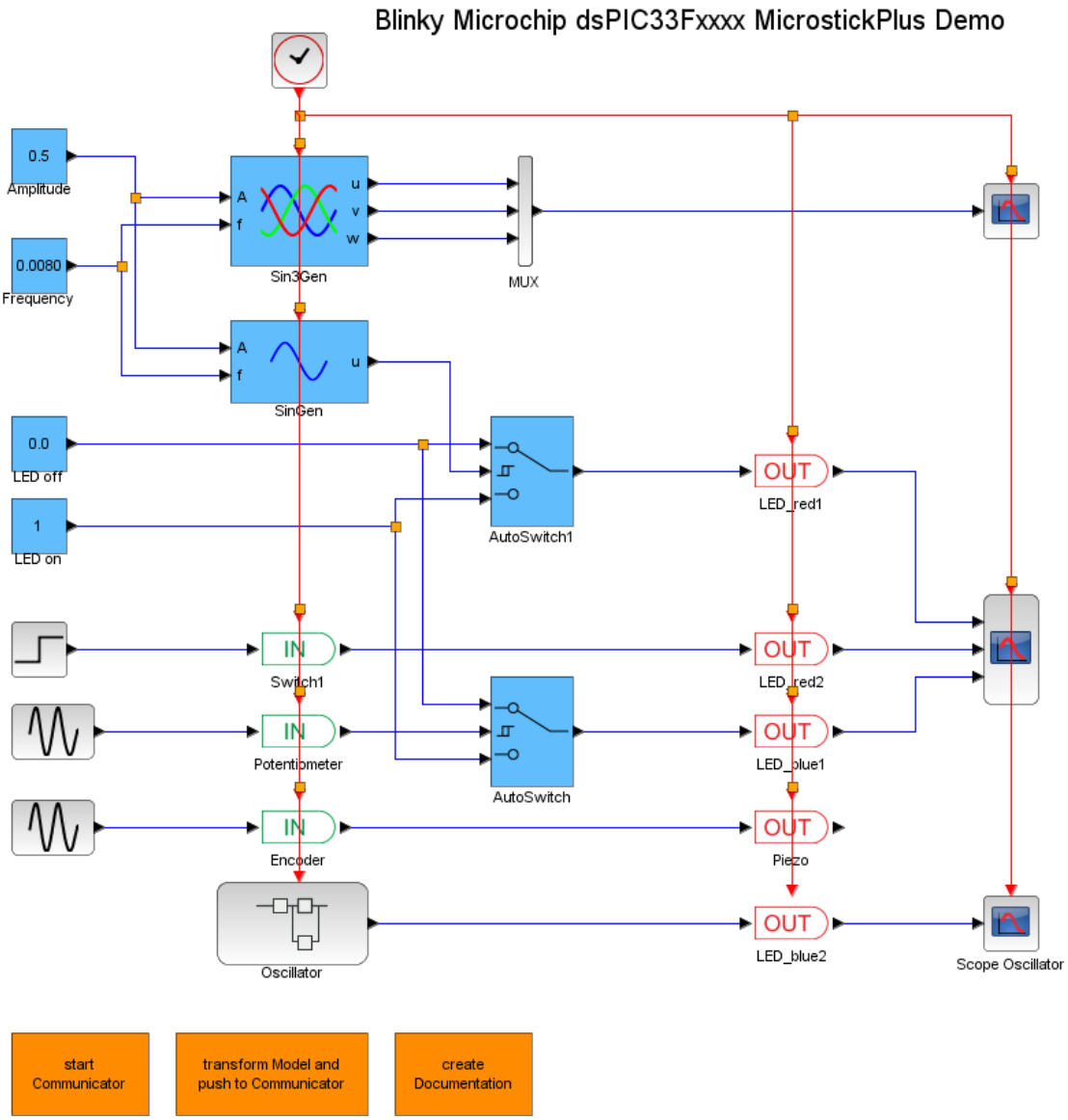


Figure 1: DemoApplication

2.2 Subsystems

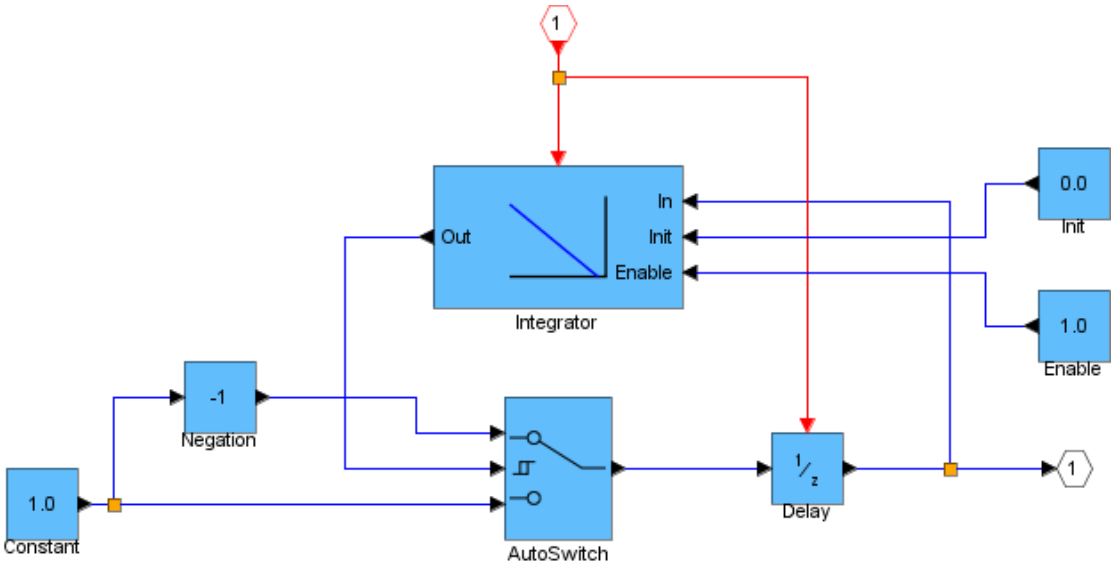


Figure 2: DemoApplication_Oscillator

3 Model Parameter

3.1 Sample Time

Sample Time	
T_S	$100\mu s$

3.2 Scilab Parameter

```
// File with model parameters such as sample time, scaling factors, etc...
//
// Copyright (c) 2016, Linz Center of Mechatronics GmbH (LCM) http://www.lcm.at/
// All rights reserved.
//
// $LastChangedRevision: 1015 $
// $LastChangedDate:: 2016-09-01 15:18:35 +0200#$
//
// This file is part of X2C. http://www.mechatronic-simulation.org/

// Sampling time
X2C_sampleTime = 100e-6;    // 10kHz sampling frequency

// Scaling factors

// Controller parameters
```

Listing 1: ModelParameter.sce

4 Mask Parameter

Constant: Amplitude	
Value	0.5
Used Implementation	FiP16

AutoSwitch: AutoSwitch	
Thresh_up	0.6
Thresh_down	0.4
Used Implementation	FiP16

AutoSwitch: AutoSwitch1	
Thresh_up	0.0
Thresh_down	0.0
Used Implementation	FiP16

Constant: Frequency	
Value	0.0080
Used Implementation	FiP16

Constant: LED off	
Value	0.0
Used Implementation	FiP16

Constant: LED on	
Value	1.0
Used Implementation	FiP16

AutoSwitch: Oscillator__AutoSwitch	
Thresh_up	0.5
Thresh_down	-0.5
Used Implementation	FiP16

Constant: Oscillator__Constant	
Value	1.0
Used Implementation	FiP16

Delay: Oscillator__Delay	
ts_fact	1.0
Used Implementation	FiP16

Constant: Oscillator__Enable	
Value	1.0
Used Implementation	FiP8

Constant: Oscillator__Init	
Value	0.0
Used Implementation	FiP16

I: Oscillator__Integrator	
Ki	50.0
ts_fact	1.0
Used Implementation	FiP16

Negation: Oscillator__Negation	
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 File Index

5.1 File List

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

Hardware.h
Hardware initialization 8

Main.h
Main application 9

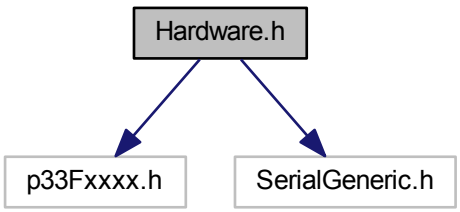
6 File Documentation

6.1 Hardware.h File Reference

Hardware initialization.

```
#include <p33Fxxxx.h>
#include "SerialGeneric.h"
```

Include dependency graph for Hardware.h:



Functions

- void initHardware (void)
  Hardware initialization.
- void initSerial (tSerial *serial)
  Initialization of serial interface.

6.1.1 Detailed Description

Hardware initialization.

6.1.2 Function Documentation

6.1.2.1 void initHardware (void)

Hardware initialization.

- Configuration of oscillator
  - Internal oscillator (fast RC oscillator with PLL)
  - fCY = 40MHz
- Configuration of serial port
  - Baudrate: 115.2kB/s
  - Data bits: 8
  - Parity: none
  - Stop bits: 1
- Configuration of IO ports
- Configuration of ADC
  - 10 bit mode
  - internal RC clock source
  - continuous sampling and auto conversion
- Configuration of QEP unit
- Configuration of Timer 1 unit for sampling time (100us)
- Configuration of Timer 2 unit for compare unit (PWM)
- Configuration of compare unit for PWM

6.1.2.2 void initSerial (tSerial * *serial*)

Initialization of serial interface.

Parameters

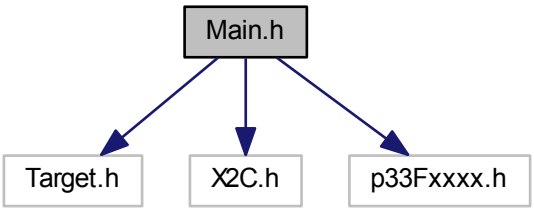
serial	Serial interface object.

6.2 Main.h File Reference

Main application.

```
#include "Target.h"
#include "X2C.h"
#include <p33Fxxxx.h>
```

Include dependency graph for Main.h:



Functions

- int main (void)

  Main function.
- void mainTask (void)

  Main control task.

6.2.1 Detailed Description

Main application.

6.2.2 Function Documentation

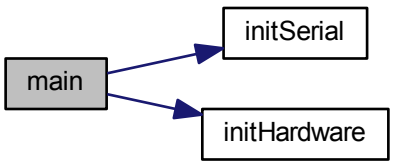
6.2.2.1 int main (void)

Main function.
Returns

The main function will never return due to the never ending loop.

- initialize "integrated monitor":
  - configuration of LNet protocol:
    - Node-ID: 1
    - Buffer size: 255
- initialize serial interface
- initialize hardware
- initialize X2C
- never ending loop -> interrupt driven algorithm

Here is the call graph for this function:



6.2.2.2 void mainTask (void)

Main control task.
Calling rate = 100us

- assign inports
- update X2C
- update outports

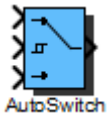
Part III

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	
Thresh_up	Threshold level for rising switch signal
Thresh_down	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:

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

Name FiP8
ID 128
Revision 0.1
C filename AutoSwitch_FiP8.c
H filename AutoSwitch_FiP8.h

8 Bit Fixed Point Implementation

Controller Parameters	
Thresh_up	Threshold level for rising switch signal
Thresh_down	Threshold level for falling switch signal
Status	Current hysteresis state

Data Structure:

```
typedef struct {
      uint16          ID;
      int8            *In1;
      int8            *Switch;
      int8            *In3;
      int8            Out;
      int8            Thresh_up;
      int8            Thresh_down;
      int8            Status;
} AUTOSWITCH_FIP8;
```

Implementation: FiP16

Name FiP16
ID 129
Revision 0.1
C filename AutoSwitch_FiP16.c
H filename AutoSwitch_FiP16.h

16 Bit Fixed Point Implementation

Controller Parameters	
Thresh_up	Threshold level for rising switch signal
Thresh_down	Threshold level for falling switch signal
Status	Current hysteresis state

Data Structure:

```
typedef struct {
      uint16          ID;
      int16           *In1;
      int16           *Switch;
      int16           *In3;
```

```
    int16           Out;
    int16           Thresh_up;
    int16           Thresh_down;
    int8            Status;
} AUTOSWITCH_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	130
Revision	0.1
C filename	AutoSwitch_FiP32.c
H filename	AutoSwitch_FiP32.h

32 Bit Fixed Point Implementation

Controller Parameters	
Thresh_up	Threshold level for rising switch signal
Thresh_down	Threshold level for falling switch signal
Status	Current hysteresis state

Data Structure:

```
typedef struct {
    uint16          ID;
    int32           *In1;
    int32           *Switch;
    int32           *In3;
    int32           Out;
    int32           Thresh_up;
    int32           Thresh_down;
    int8            Status;
} AUTOSWITCH_FIP32;
```

Implementation: Float32

Name	Float32
ID	131
Revision	0.1
C filename	AutoSwitch_Float32.c
H filename	AutoSwitch_Float32.h

32 Bit Floating Point Implementation

Controller Parameters	
Thresh_up	Threshold level for rising switch signal
Thresh_down	Threshold level for falling switch signal
Status	Current hysteresis state

Data Structure:

```
typedef struct {
      uint16          ID;
      float32         *In1;
      float32         *Switch;
      float32         *In3;
      float32         Out;
      float32         Thresh_up;
      float32         Thresh_down;
      int8            Status;
} AUTOSWITCH_FLOAT32;
```

Implementation: Float64

Name	Float64
ID	132
Revision	0.1
C filename	AutoSwitch_Float64.c
H filename	AutoSwitch_Float64.h

64 Bit Floating Point Implementation

Controller Parameters	
Thresh_up	Threshold level for rising switch signal
Thresh_down	Threshold level for falling switch signal
Status	Current hysteresis state

Data Structure:

```
typedef struct {
      uint16          ID;
      float64         *In1;
      float64         *Switch;
      float64         *In3;
      float64         Out;
      float64         Thresh_up;
      float64         Thresh_down;
      int8            Status;
} AUTOSWITCH_FLOAT64;
```

Block: Constant

Outports	
Out	Constant output

Mask Parameters	
Value	Constant factor

Description:

Constant value.

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

Name	FiP8
ID	48
Revision	0.3
C filename	Constant_FiP8.c
H filename	Constant_FiP8.h

8 Bit Fixed Point Implementation

Controller Parameters	
K	Constant factor

Data Structure:

```
typedef struct {
      uint16          ID;
      int8            Out;
      int8            K;
} CONSTANT_FIP8;
```

Implementation: FiP16

Name	FiP16
ID	49
Revision	0.3
C filename	Constant_FiP16.c
H filename	Constant_FiP16.h

16 Bit Fixed Point Implementation

Controller Parameters	
K	Constant factor

Data Structure:

```
typedef struct {
      uint16          ID;
      int16           Out;
      int16           K;
} CONSTANT_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	50
Revision	0.3
C filename	Constant_FiP32.c
H filename	Constant_FiP32.h

32 Bit Fixed Point Implementation

Controller Parameters	
K	Constant factor

Data Structure:

```
typedef struct {
      uint16          ID;
      int32           Out;
      int32           K;
} CONSTANT_FIP32;
```

Implementation: Float32

Name	Float32
ID	51
Revision	0.1
C filename	Constant_Float32.c
H filename	Constant_Float32.h

32 Bit Floating Point Implementation

Controller Parameters	
K	Constant factor

Data Structure:

```
typedef struct {
      uint16          ID;
      float32         Out;
      float32         K;
} CONSTANT_FLOAT32;
```

Implementation: Float64

Name	Float64
ID	52
Revision	0.1
C filename	Constant_Float64.c
H filename	Constant_Float64.h

64 Bit Floating Point Implementation

Controller Parameters	
K	Constant factor

Data Structure:

```
typedef struct {
      uint16          ID;
      float64         Out;
      float64         K;
} CONSTANT_FLOAT64;
```

Block: Delay

Inports	
In	Input In(k)

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

Mask Parameters	
ts_fact	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:

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

Name	FiP16
ID	3425
Revision	0.1
C filename	Delay_FiP16.c
H filename	Delay_FiP16.h

16 Bit Fixed Point Implementation

Controller Parameters	
In_old	Input value from previous cycle

Data Structure:

```
typedef struct {
    uint16        ID;
```

```
    int16           *In;
    int16           Out;
    int16           In_old;
} DELAY_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	3426
Revision	0.1
C filename	Delay_FiP32.c
H filename	Delay_FiP32.h

32 Bit Fixed Point Implementation

Controller Parameters	
In_old	Input value from previous cycle

Data Structure:

```
typedef struct {
    uint16          ID;
    int32           *In;
    int32           Out;
    int32           In_old;
} DELAY_FIP32;
```

Implementation: Float32

Name	Float32
ID	3427
Revision	0.1
C filename	Delay_Float32.c
H filename	Delay_Float32.h

32 Bit Floating Point Implementation

Controller Parameters	
In_old	Input value from previous cycle

Data Structure:

```
typedef struct {
    uint16          ID;
    float32         *In;
    float32         Out;
    float32         In_old;
} DELAY_FLOAT32;
```

Implementation: Float64

Name	Float64
ID	3428
Revision	0.1
C filename	Delay_Float64.c
H filename	Delay_Float64.h

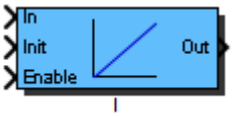
64 Bit Floating Point Implementation

Controller Parameters	
In_old	Input value from previous cycle

Data Structure:

```
typedef struct {
      uint16          ID;
      float64         *In;
      float64         Out;
      float64         In_old;
} DELAY_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	
Ki	Integral Factor
ts_fact	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):

$$G(z) = K_I T_s \frac{1}{z-1}$$

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

Name FiP8
ID 3200
Revision 1.0
C filename I_FiP8.c
H filename I_FiP8.h

8 Bit Fixed Point Implementation

Controller Parameters	
b0	Integral coefficient
sfr	Shift factor for I coefficient b0
i_old	Integrator value from previous cycle
enable_old	Enable value of previous cycle

Data Structure:

```
typedef struct {
      uint16          ID;
      int8            *In;
      int8            *Init;
      int8            *Enable;
      int8            Out;
      int8            b0;
      int8            sfr;
      int16           i_old;
      int8            enable_old;
} I_FIP8;
```

Implementation: FiP16

Name FiP16
ID 3201
Revision 1.0
C filename I_FiP16.c
H filename I_FiP16.h

16 Bit Fixed Point Implementation

Controller Parameters	
b0	Integral coefficient
sfr	Shift factor for I coefficient b0
i_old	Integrator value from previous cycle
enable_old	Enable value of previous cycle

Data Structure:

```
typedef struct {
```

```
    uint16          ID;
    int16           *In;
    int16           *Init;
    int8            *Enable;
    int16           Out;
    int16           b0;
    int8            sfr;
    int32           i_old;
    int8            enable_old;
} I_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	3202
Revision	1.0
C filename	I_FiP32.c
H filename	I_FiP32.h

32 Bit Fixed Point Implementation

Controller Parameters	
b0	Integral coefficient
sfr	Shift factor for I coefficient b0
i_old	Integrator value from previous cycle
enable_old	Enable value of previous cycle

Data Structure:

```
typedef struct {
    uint16          ID;
    int32           *In;
    int32           *Init;
    int8            *Enable;
    int32           Out;
    int32           b0;
    int8            sfr;
    int64           i_old;
    int8            enable_old;
} I_FIP32;
```

Implementation: Float32

Name	Float32
ID	3203
Revision	0.1
C filename	I_Float32.c
H filename	I_Float32.h

32 Bit Floating Point Implementation

Controller Parameters	
b0	Integral coefficient
i_old	Integrator value from previous cycle
enable_old	Enable value of previous cycle

Data Structure:

```
typedef struct {
      uint16          ID;
      float32         *In;
      float32         *Init;
      int8            *Enable;
      float32         Out;
      float32         b0;
      float32         i_old;
      int8            enable_old;
} I_FLOAT32;
```

Implementation: Float64

Name Float64
ID 3204
Revision 0.1
C filename I_Float64.c
H filename I_Float64.h

64 Bit Floating Point Implementation

Controller Parameters	
b0	Integral coefficient
i_old	Integrator value from previous cycle
enable_old	Enable value of previous cycle

Data Structure:

```
typedef struct {
      uint16          ID;
      float64         *In;
      float64         *Init;
      int8            *Enable;
      float64         Out;
      float64         b0;
      float64         i_old;
      int8            enable_old;
} I_FLOAT64;
```

Block: Negation

Inports	
In	Input

Outports	
Out	Negated input value

Description:

Negation of input signal.

Calculation:

$$Out = -In$$

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

Name	FiP8
ID	5040
Revision	0.1
C filename	Negation_FiP8.c
H filename	Negation_FiP8.h

8 Bit Fixed Point Implementation

Data Structure:

```
typedef struct {
    uint16          ID;
    int8            *In;
    int8            Out;
} NEGATION_FIP8;
```

Implementation: FiP16

Name	FiP16
ID	5041
Revision	0.1
C filename	Negation_FiP16.c
H filename	Negation_FiP16.h

16 Bit Fixed Point Implementation

Data Structure:

```
typedef struct {
    uint16          ID;
    int16           *In;
    int16           Out;
} NEGATION_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	5042
Revision	0.1
C filename	Negation_FiP32.c
H filename	Negation_FiP32.h

32 Bit Fixed Point Implementation

Data Structure:

```
typedef struct {
    uint16          ID;
    int32           *In;
    int32           Out;
} NEGATION_FIP32;
```

Implementation: Float32

Name	Float32
ID	5043
Revision	0.1
C filename	Negation_Float32.c
H filename	Negation_Float32.h

32 Bit Floating Point Implementation

Data Structure:

```
typedef struct {
    uint16          ID;
    float32         *In;
    float32         Out;
```

```
} NEGATION_FLOAT32;
```

Implementation: Float64

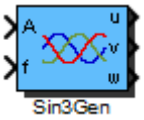
Name	Float64
ID	5044
Revision	0.1
C filename	Negation_Float64.c
H filename	Negation_Float64.h

64 Bit Floating Point Implementation

Data Structure:

```
typedef struct {
    uint16          ID;
    float64         *In;
    float64         Out;
} NEGATION_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	
fmax	Maximum Frequency in Hz
Offset	Offset
ts_fact	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:

$$\begin{aligned} u_k &= A_k \cdot \sin\left(2f_k \cdot f_{max} \cdot kT_S\right) + A_{Offset} \\ v_k &= A_k \cdot \sin\left(2f_k \cdot f_{max} \cdot kT_S - \frac{2\pi}{3}\right) + A_{Offset} \\ w_k &= A_k \cdot \sin\left(2f_k \cdot f_{max} \cdot kT_S + \frac{2\pi}{3}\right) + A_{Offset} \end{aligned}$$

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):

$$\begin{aligned} u_k &= A_k \cdot \sin\left(2\pi f_k \cdot kT_S\right) + A_{Offset} \\ v_k &= A_k \cdot \sin\left(2\pi f_k \cdot kT_S - \frac{2\pi}{3}\right) + A_{Offset} \\ w_k &= A_k \cdot \sin\left(2\pi f_k \cdot kT_S + \frac{2\pi}{3}\right) + A_{Offset} \end{aligned}$$

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

Name	FiP8
ID	432
Revision	1.0
C filename	Sin3Gen_FiP8.c
H filename	Sin3Gen_FiP8.h

8 Bit Fixed Point Implementation

Controller Parameters	
delta_phi	Angle increment
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
     uint16          ID;
     int8            *A;
     int8            *f;
     int8            u;
     int8            v;
     int8            w;
     int8            delta_phi;
     int8            offset;
     int8            phi;
} SIN3GEN_FIP8;
```

Implementation: FiP16

Name	FiP16
ID	433
Revision	1.0
C filename	Sin3Gen_FiP16.c
H filename	Sin3Gen_FiP16.h

16 Bit Fixed Point Implementation

Controller Parameters	
delta_phi	Angle increment
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
      uint16          ID;
      int16           *A;
      int16           *f;
      int16           u;
      int16           v;
      int16           w;
      int16           delta_phi;
      int16           offset;
      int16           phi;
} SIN3GEN_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	434
Revision	1.0
C filename	Sin3Gen_FiP32.c
H filename	Sin3Gen_FiP32.h

32 Bit Fixed Point Implementation

Controller Parameters	
delta_phi	Angle increment
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
      uint16          ID;
      int32           *A;
      int32           *f;
      int32           u;
      int32           v;
      int32           w;
      int32           delta_phi;
      int32           offset;
      int32           phi;
} SIN3GEN_FIP32;
```

Implementation: Float32

Name Float32
ID 435
Revision 0.1
C filename Sin3Gen_Float32.c
H filename Sin3Gen_Float32.h

32 Bit Floating Point Implementation

Controller Parameters	
delta_phi	Angle increment
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
      uint16          ID;
      float32         *A;
      float32         *f;
      float32         u;
      float32         v;
      float32         w;
      float32         delta_phi;
      float32         offset;
      float32         phi;
} SIN3GEN_FLOAT32;
```

Implementation: Float64

Name Float64
ID 436
Revision 0.1
C filename Sin3Gen_Float64.c
H filename Sin3Gen_Float64.h

64 Bit Floating Point Implementation

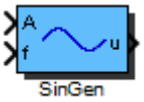
Controller Parameters	
delta_phi	Angle increment
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
      uint16          ID;
      float64         *A;
      float64         *f;
```

```
    float64         u;
    float64         v;
    float64         w;
    float64         delta_phi;
    float64         offset;
    float64         phi;
} SIN3GEN_FLOAT64;
```

Block: SinGen



Inports	
A	Amplitude
f	Frequency

Outports	
u	Sine wave output

Mask Parameters	
fmax	Maximum Frequency in Hz
Offset	Offset
Phase	Phase [-Pi..Pi]
ts_fact	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:

$$u_k = A_k \cdot \sin\left(2f_k \cdot f_{max} \cdot kT_S + \phi_{Phase}\right) + A_{Offset}$$

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):

$$u_k = A_k \cdot \sin\left(2\pi f_k \cdot kT_S + \phi_{Phase}\right) + A_{Offset}$$

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

Name FiP8
ID 416
Revision 1.0
C filename SinGen_FiP8.c
H filename SinGen_FiP8.h

8 Bit Fixed Point Implementation

Controller Parameters	
delta_phi	Angle increment
phase	Angle offset
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
      uint16          ID;
      int8            *A;
      int8            *f;
      int8            u;
      int8            delta_phi;
      int8            phase;
      int8            offset;
      int8            phi;
} SINGEN_FIP8;
```

Implementation: FiP16

Name FiP16
ID 417
Revision 1.0
C filename SinGen_FiP16.c
H filename SinGen_FiP16.h

16 Bit Fixed Point Implementation

Controller Parameters	
delta_phi	Angle increment
phase	Angle offset
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
      uint16          ID;
      int16           *A;
      int16           *f;
```

```
    int16           u;
    int16           delta_phi;
    int16           phase;
    int16           offset;
    int16           phi;
} SINGEN_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	418
Revision	1.0
C filename	SinGen_FiP32.c
H filename	SinGen_FiP32.h

32 Bit Fixed Point Implementation

Controller Parameters	
delta_phi	Angle increment
phase	Angle offset
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
    uint16          ID;
    int32           *A;
    int32           *f;
    int32           u;
    int32           delta_phi;
    int32           phase;
    int32           offset;
    int32           phi;
} SINGEN_FIP32;
```

Implementation: Float32

Name	Float32
ID	419
Revision	0.1
C filename	SinGen_Float32.c
H filename	SinGen_Float32.h

32 Bit Floating Point Implementation

Controller Parameters	
delta_phi	Angle increment
phase	Angle offset
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
      uint16        ID;
      float32       *A;
      float32       *f;
      float32       u;
      float32       delta_phi;
      float32       phase;
      float32       offset;
      float32       phi;
} SINGEN_FLOAT32;
```

Implementation: Float64

Name	Float64
ID	420
Revision	0.1
C filename	SinGen_Float64.c
H filename	SinGen_Float64.h

64 Bit Floating Point Implementation

Controller Parameters	
delta_phi	Angle increment
phase	Angle offset
offset	Amplitude offset
phi	Current angle

Data Structure:

```
typedef struct {
      uint16        ID;
      float64       *A;
      float64       *f;
      float64       u;
      float64       delta_phi;
      float64       phase;
      float64       offset;
      float64       phi;
} SINGEN_FLOAT64;
```