LINZ
CENTER OF
MECHATRONICS
GMBH

Project Documentation DemoApplication

February 27, 2017

Contents

Part I

X2C Model

1 Version Information

1.1 X2C

- X2Cfull: Version 1105

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

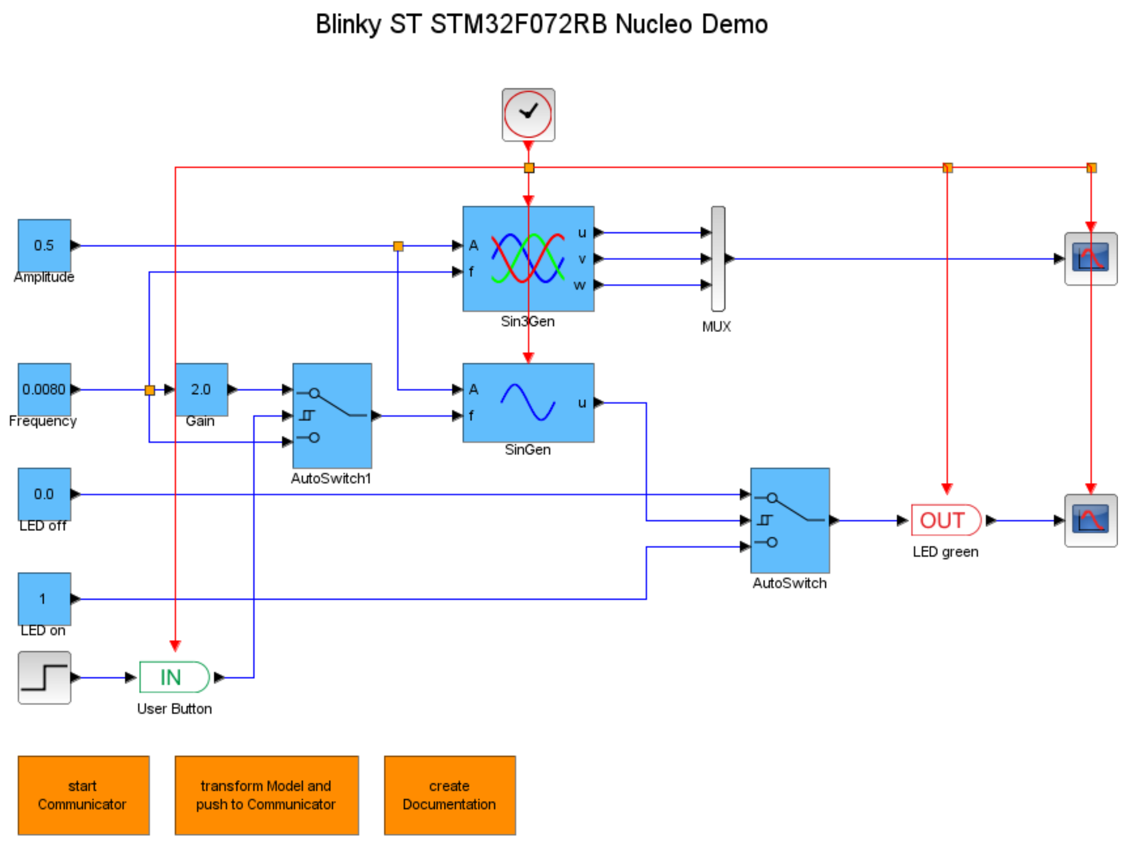


Figure 1: DemoApplication

2.2 Subsystems

3 Model Parameter

3.1 Sample Time

Sample Time	
T_S	$100\mu s$

4 Mask Parameter

Constant: Amplitude	
Value	0.5
Used Implementation	FiP16

AutoSwitch: AutoSwitch	
Thresh_up	0.0
Thresh_down	0.0
Used Implementation	FiP16

AutoSwitch: AutoSwitch1	
Thresh_up	0.5
Thresh_down	0.5
Used Implementation	FiP16

Constant: Frequency	
Value	0.0080
Used Implementation	FiP16

Gain: Gain	
Gain	2.0
Used Implementation	FiP16

Constant: LED off	
Value	0.0
Used Implementation	FiP16

Constant: LED on	
Value	1.0
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:

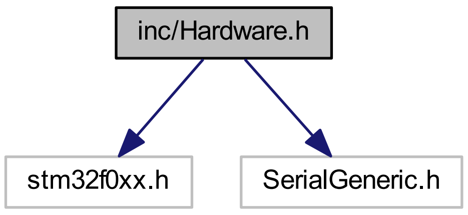
6 File Documentation

6.1 inc/Hardware.h File Reference

Hardware initialization.

```
#include <stm32f0xx.h>
#include "SerialGeneric.h"
```

Include dependency graph for Hardware.h:



Functions

- void initHardware (void)

  Initialization of hardware peripherials.
- void initClock (void)

  Initialization of system clock.
- void initSerial (tSerial ∗serialSTM32F0)

  Initialization of serial interface.
- void ADC1_COMP_IRQHandler (void)

  Interrupt service routine for ADC end of conversion interrupt.

6.1.1 Detailed Description

Hardware initialization.

6.1.2 Function Documentation

6.1.2.1 void initClock (void)

Initialization of system clock.
Configuration:

- Internal high speed clock with PLL
- 48 MHz system clock

6.1.2.2 void initSerial (tSerial ∗ *serialSTM32F0*)

Initialization of serial interface.

- enable port A clock
- setup pins A2 & A3 as USART2 pins
- setup USART Rx- & Tx pins
- enable USART2 clock
- setup baudrate, parity, data bits, stop bits, and flow control
- hook serial functions

6.2 inc/Main.h File Reference

Main application.

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

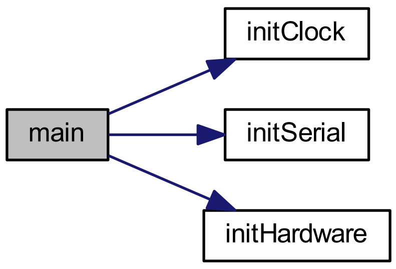
The main function will never return due to the never ending loop.

- initialize system clock
- initialize "integrated monitor":
  - configuration of LNet protocol:
    - Node-ID: 1

        * Buffer size: 255

- initialize serial interface
    - configuration of USART2:
    - Baudrate: 115.2kB/s
    - Data bits: 8
    - Parity: none
    - Stop bits: 1
- initialize X2C
- initialize hardware
- 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

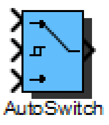
Part III

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

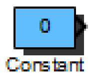
64 Bit Floating Point Implementation

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: Gain

Inports	
In	Input

Outports	
Out	Amplified input

Mask Parameters	
Gain	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

Name	FiP8
ID	16
Revision	1.0
C filename	Gain_FiP8.c
H filename	Gain_FiP8.h

8 Bit Fixed Point Implementation

Controller Parameters	
V	Gain factor
sfr	Shift factor

Data Structure:

```
typedef struct {
        uint16          ID;
        int8            *In;
```

```
     int8           Out;
     int8           V;
     int8           sfr;
} GAIN_FIP8;
```

Implementation: FiP16

Name	FiP16
ID	17
Revision	1.0
C filename	Gain_FiP16.c
H filename	Gain_FiP16.h

16 Bit Fixed Point Implementation

Controller Parameters	
V	Gain factor
sfr	Shift factor

Data Structure:

```
typedef struct {
     uint16         ID;
     int16          *In;
     int16          Out;
     int16          V;
     int8           sfr;
} GAIN_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	18
Revision	1.0
C filename	Gain_FiP32.c
H filename	Gain_FiP32.h

32 Bit Fixed Point Implementation

Controller Parameters	
V	Gain factor
sfr	Shift factor

Data Structure:

```
typedef struct {
     uint16         ID;
     int32          *In;
```

```
    int32       Out;
    int32       V;
    int8        sfr;
} GAIN_FIP32;
```

Implementation: Float32

Name	Float32
ID	19
Revision	0.1
C filename	Gain_Float32.c
H filename	Gain_Float32.h

32 Bit Floating Point Implementation

Controller Parameters	
V	Gain factor

Data Structure:

```
typedef struct {
    uint16      ID;
    float32     *In;
    float32     Out;
    float32     V;
} GAIN_FLOAT32;
```

Implementation: Float64

Name	Float64
ID	20
Revision	0.1
C filename	Gain_Float64.c
H filename	Gain_Float64.h

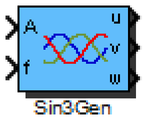
64 Bit Floating Point Implementation

Controller Parameters	
V	Gain factor

Data Structure:

```
typedef struct {
    uint16      ID;
    float64     *In;
    float64     Out;
    float64     V;
} GAIN_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

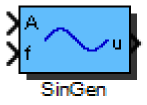
Controller Parameters	
delta_phi	Angle increment
offset	Amplitude offset
phi	Current angle

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:

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

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;
```