Project Documentation mc_foc_sl_fip_dspic33ck_mclv2

July 28, 2020

Contents

Part I

X2C Model

1 Version Information

1.1 X2C

- X2C: Version 6.2.1993

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

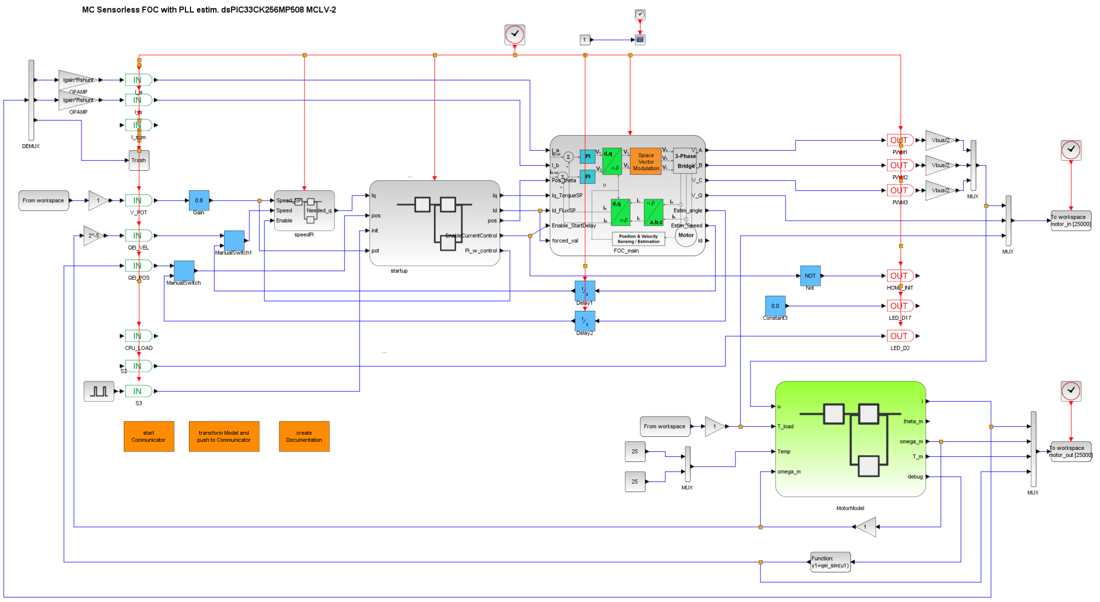

Figure 1: mc_foc_sl_fip_dspic33ck_mclv2

2.2 Subsystems

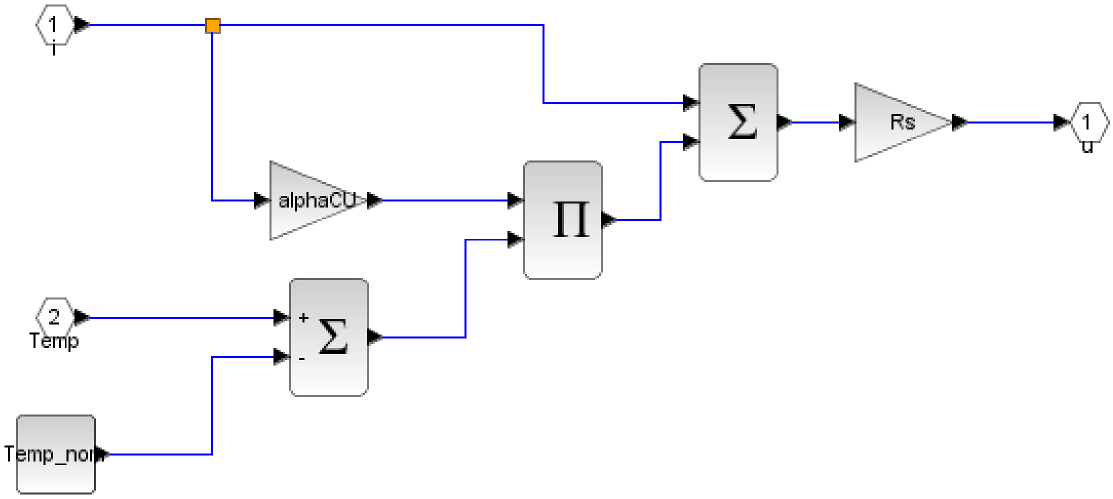

Figure 2: mc_foc_sl_fip_dspic33ck_mclv2_startup

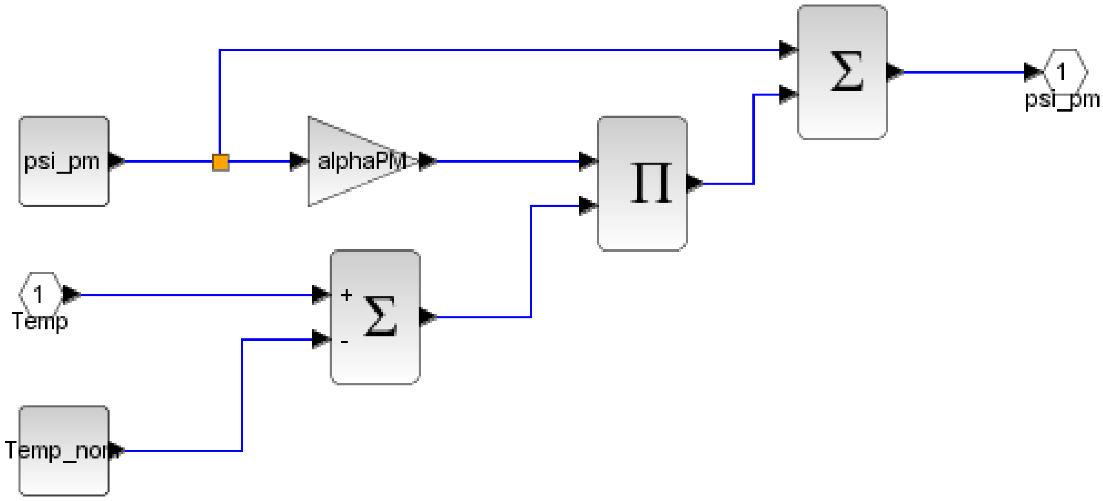

Figure 3: mc_foc_sl_fip_dspic33ck_mclv2_speedPI

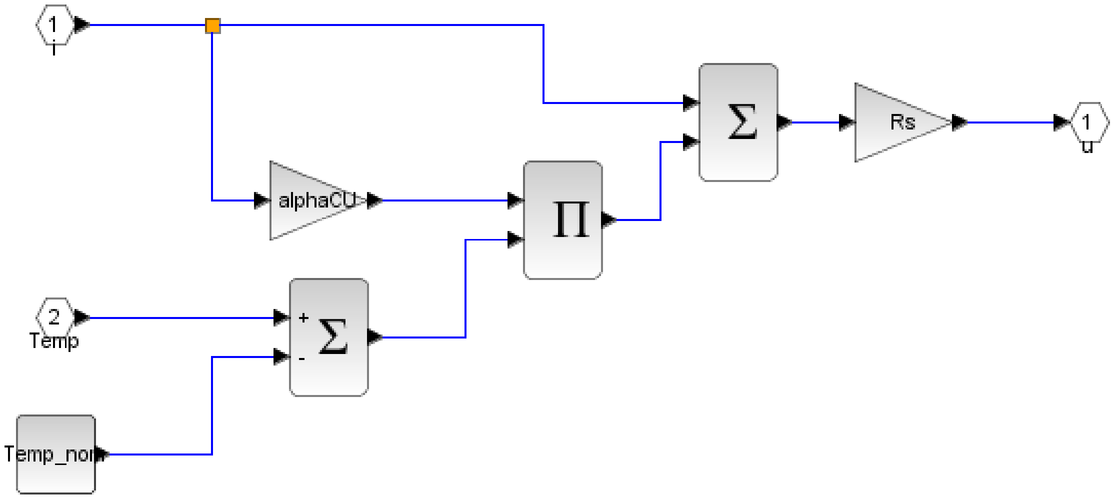

Figure 4: mc_foc_sl_fip_dspic33ck_mclv2_MotorModel

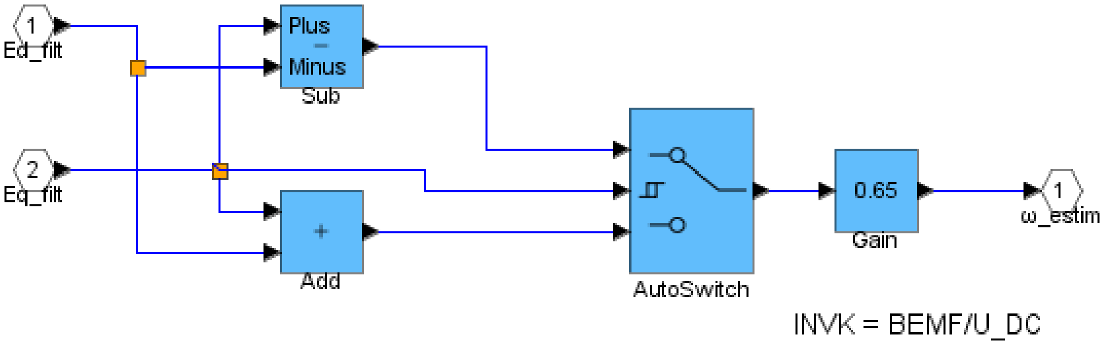

Figure 5: mc_foc_sl_fip_dspic33ck_mclv2_FOC_main

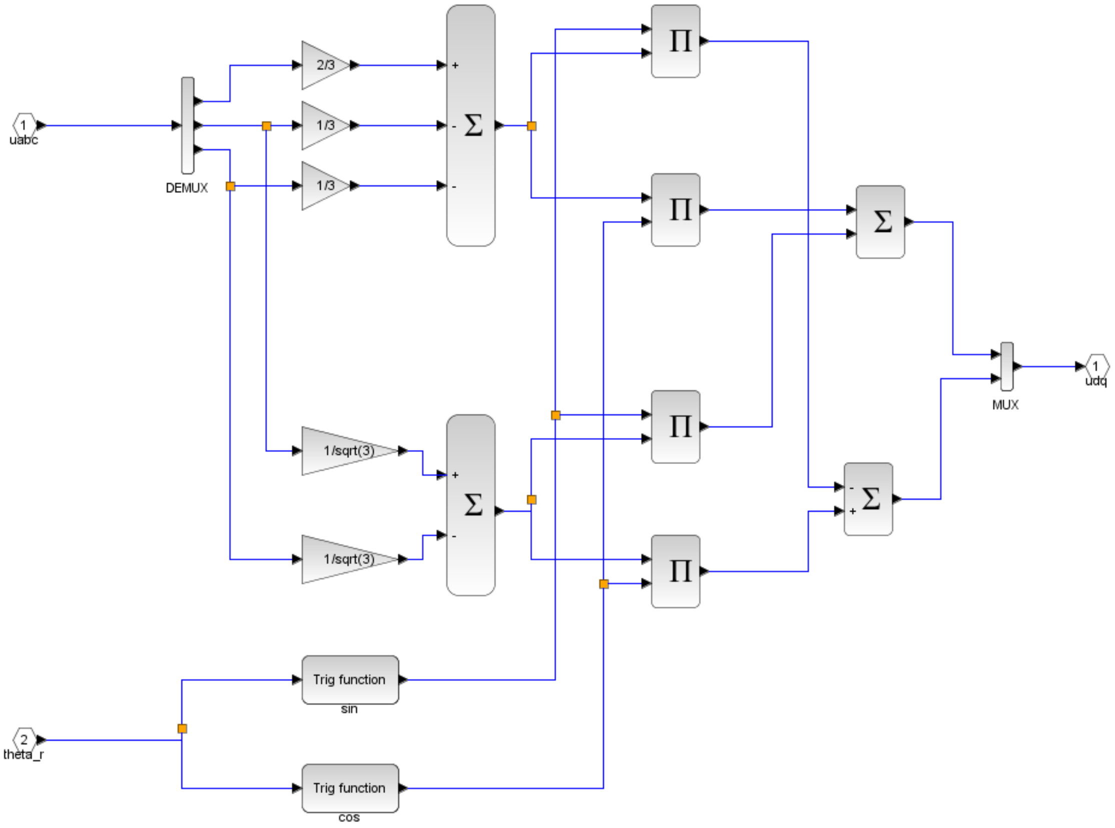

Figure 6: mc_foc_sl_fip_dspic33ck_mclv2_4

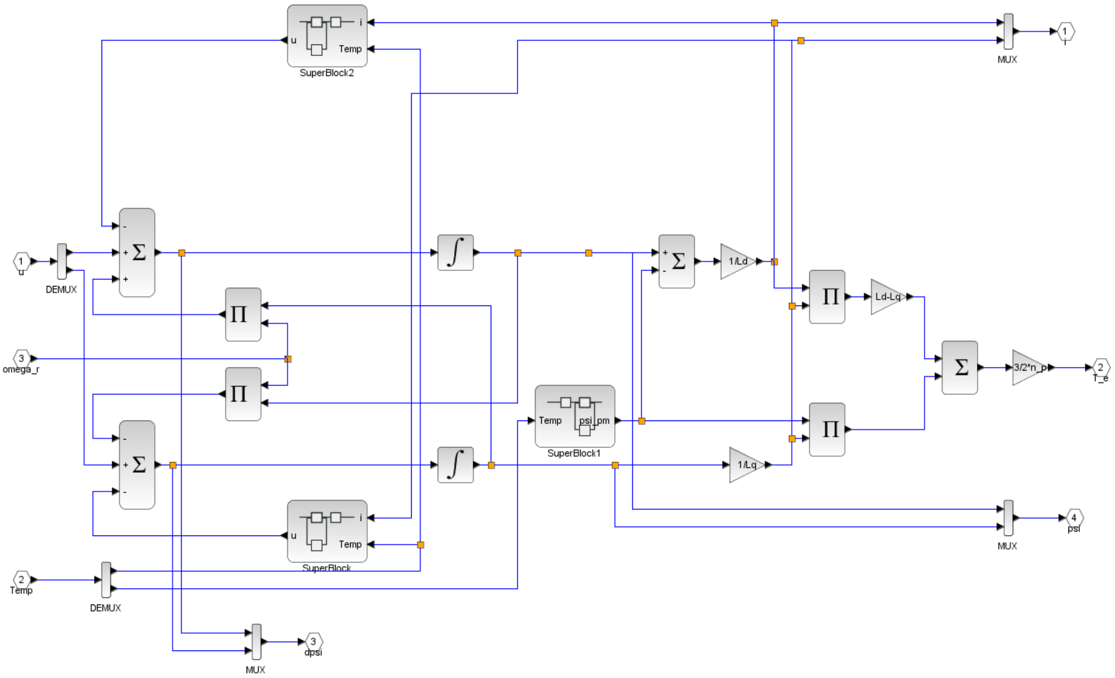

Figure 7: mc_foc_sl_fip_dspic33ck_mclv2_3

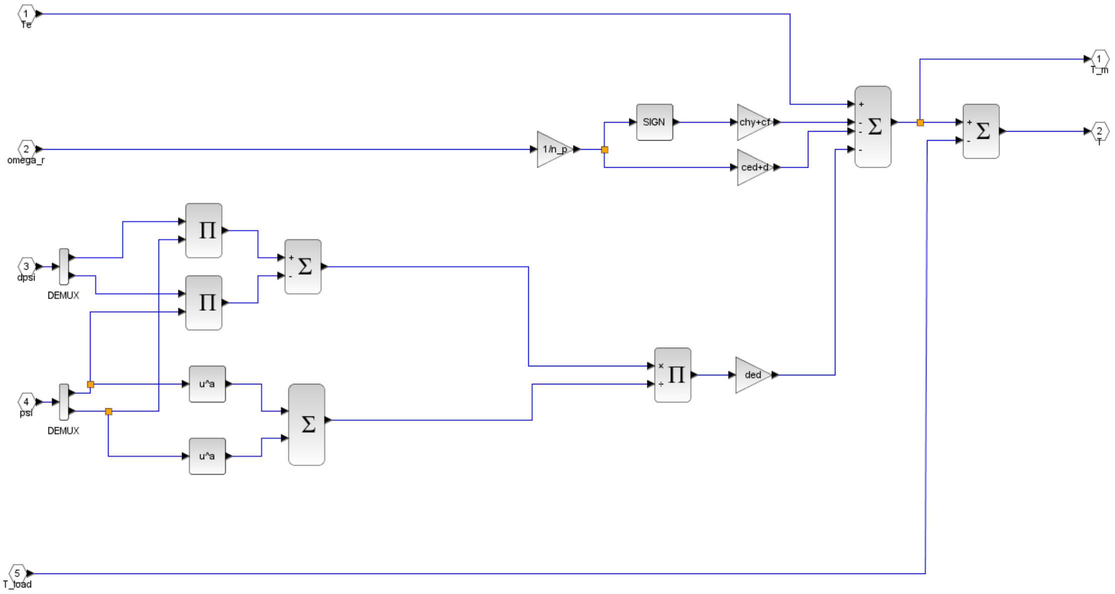

Figure 8: mc_foc_sl_fip_dspic33ck_mclv2_2

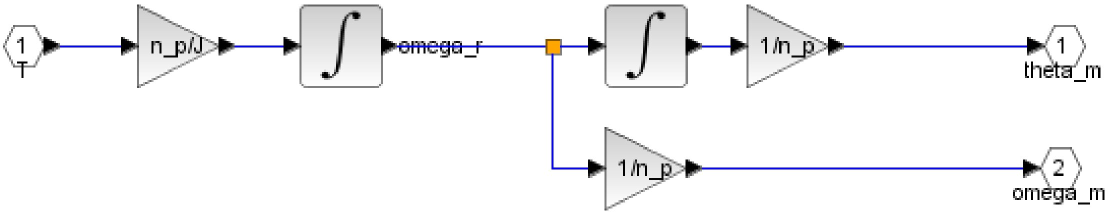

Figure 9: mc_foc_sl_fip_dspic33ck_mclv2_1

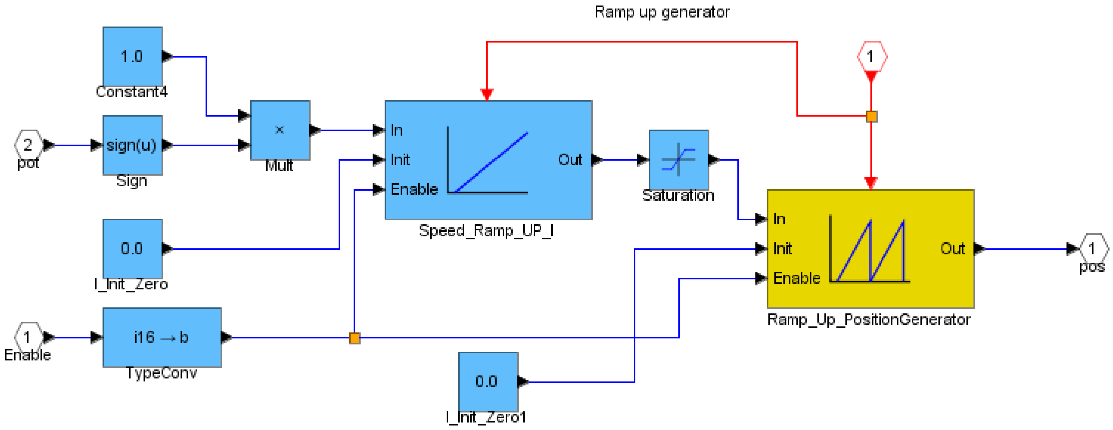

Figure 10: mc_foc_sl_fip_dspic33ck_mclv2_0

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 =50E-6;

// CODE GENERATION PARAMETERS

// Speed PI
SpeedKi = 1;
SpeedKi = 0.5;

// Current PI
PIFluxKp = 0.8;
PIFluxKi = 0.5;

PITorqueKp = 0.8;
PITorqueKi = 0.5;

// PLL parameters
MotorLs = 0.41;
MotorRs = 0.35;
U_DCLINK = 24;
I_MAX = 3.95;
BEMF_D_UDC = 0.65;
PLL_INT = 800;









// POWERSTAGE DATA
Vbus = 24;
Rshunt = 0.025;
Igain = -15;

// MOTORDATEN
Nm_ozin = 7.061552e-3;
KRPM_rads = 0.060/2/%pi;

Rs = 4.03;
Ld = 4.60e-3;
Lq = 4.60e-3;
Kell = 7.24;
n_p = 5;        // number of polepairs


J = 0.000628 * Nm_ozin;   // inertia
cf = 0;
chy = 0;
d = 0;
ced = 0;
```

```
ded = 0;

alphaCU = 0;
alphaPM = 0;
Temp_nom = 25;
omega_m0 = 0;
theta_m0 = -0.5;
psi_pm = Kell/sqrt(3)*60/(2*%pi*1000)/n_p;
theta_r0 = theta_m0*2*%pi*n_p;
omega_r0 = omega_m0/60*2*%pi*n_p;










// Umrechnen auf Rechnenwerte fuer Modell
Ld = Ld/2;
Lq = Lq/2;
Rs = Rs/2;




// initalize input for simulation
exec("./gen_inputs.sci");
exec("./qei_sim.sce");
exec("./qei_sim2.sce");
```

Listing 1: ModelParameter.sce

4 Mask Parameter

Constant: Constant3	
Value	0.0
Used Implementation	Bool

Delay: Delay1	
ts_fact	1.0
Used Implementation	FiP16

Delay: Delay2	
ts_fact	1.0
Used Implementation	FiP16

Clarke_Park_MCHP: Clarke_Park_MCHP	
Used Implementation	FiP16

Constant: Constant	
Value	0.2
Used Implementation	FiP16

Constant: Constant1	
Value	1.0
Used Implementation	FiP16

Gain: Gain	
Gain	0.5
Used Implementation	FiP16

Gain: Gain1	
Gain	0.98
Used Implementation	FiP16

Gain: Gain2	
Gain	0.98
Used Implementation	FiP16

ManualSwitch: ManualSwitch	
Toggle	1.0
Used Implementation	FiP16

ManualSwitch: ManualSwitch1	
Toggle	1.0
Used Implementation	FiP16

ManualSwitch: ManualSwitch2	
Toggle	1.0
Used Implementation	FiP16

ManualSwitch: ManualSwitch3	
Toggle	1.0
Used Implementation	FiP16

ManualSwitch: ManualSwitch4	
Toggle	1.0
Used Implementation	FiP16

Not: Not	
Used Implementation	Bool

Constant: OpenLoop_Vd	
Value	0.0
Used Implementation	FiP16

Constant: OpenLoop_Vq	
Value	0.3
Used Implementation	FiP16

PI: PI_flux	
Kp	0.8
Ki	0.5
ts_fact	1.0
Used Implementation	FiP16

PI: PI_torque	
Kp	0.8
Ki	5.0
ts_fact	1.0
Used Implementation	FiP16

BEMF_MCHP: BEMF_MCHP	
Ls	0.1
Rs	0.1
U0	24.0
I0	1.0
ts_fact	1.0
CurrentSampleFactor	1.0
Used Implementation	FiP16

Constant: Constant1	
Value	0.0
Used Implementation	FiP16

Delay: Delay1	
ts_fact	1.0
Used Implementation	FiP16

PT1: Edfilter	
V	1.0
fc	400.0
ts_fact	1.0
method	zoh
Used Implementation	FiP16

PT1: Eqfilter	
V	1.0
fc	400.0
ts_fact	1.0
method	zoh
Used Implementation	FiP16

Park_MCHP: Park_MCHP	
Used Implementation	FiP16

Add: Add	
Used Implementation	FiP16

AutoSwitch: AutoSwitch	
Thresh_up	0.0
Thresh_down	0.0
Used Implementation	FiP16

Gain: Gain	
Gain	0.65
Used Implementation	FiP16

Sub: Sub	
Used Implementation	FiP16

uI: uI	
Ki	800.0
ts_fact	1.0
Used Implementation	FiP16

Park_Clarke_inv_SVM_MCHP: Park_Clarke_inv_SVM_MCHP	
Used Implementation	FiP16

Saturation: Saturation	
max	0.98
min	-0.98
Used Implementation	FiP16

Saturation: Saturation1	
max	0.98
min	-0.98
Used Implementation	FiP16

Sin3Gen: Sin3Gen	
fmax	100.0
Offset	0.0
ts_fact	1.0
Used Implementation	FiP16

Sub: Sub_flux	
Used Implementation	FiP16

Sub: Sub_torque	
Used Implementation	FiP16

Gain: Gain	
Gain	0.8
Used Implementation	FiP16

ManualSwitch: ManualSwitch	
Toggle	1.0
Used Implementation	FiP16

ManualSwitch: ManualSwitch1	
Toggle	1.0
Used Implementation	FiP16

Not: Not	
Used Implementation	Bool

Constant: Constant	
Value	0.05
Used Implementation	FiP16

Constant: Constant1	
Value	0.0
Used Implementation	FiP16

ManualSwitch: ManualSwitch	
Toggle	0.0
Used Implementation	FiP16

PI: PI_speed	
Kp	1.0
Ki	0.5
ts_fact	10.0
Used Implementation	FiP16

RateLimiter: RateLimiter	
Tr	0.0010
Tf	0.0010
ts_fact	10.0
Used Implementation	FiP16

Constant: Speed_Init	
Value	1.0
Used Implementation	Bool

Constant: Speed_Init1	
Value	0.0
Used Implementation	FiP16

Sub: Speed_error	
Used Implementation	FiP16

Add: Add	
Used Implementation	FiP16

AutoSwitch: AutoSwitch	
Thresh_up	0.0
Thresh_down	0.0
Used Implementation	FiP16

Constant: Constant	
Value	1.0
Used Implementation	FiP16

Constant: Constant1	
Value	0.01
Used Implementation	FiP16

Constant: Constant2	
Value	1.0
Used Implementation	Bool

Constant: Constant3	
Value	0.0
Used Implementation	FiP16

Gain: Gain	
Gain	-1.0
Used Implementation	FiP16

RateLimiter: RateLimiter	
Tr	0.0
Tf	0.0
ts_fact	10.0
Used Implementation	FiP16

SinGen: SinGen	
fmax	100.0
Offset	0.0
Phase	0.0
ts_fact	10.0
Used Implementation	FiP16

Constant: Constant1	
Value	0.0
Used Implementation	FiP16

Constant: Constant2	
Value	0.0
Used Implementation	FiP16

Constant: Constant5	
Value	1.0
Used Implementation	Bool

AutoSwitch: Flux_select	
Thresh_up	0.5
Thresh_down	0.5
Used Implementation	FiP16

AutoSwitch: Flux_select1	
Thresh_up	0.5
Thresh_down	0.5
Used Implementation	FiP16

RateLimiter: IdRateLimiter	
Tr	0.5
Tf	3.0
ts_fact	1.0
Used Implementation	FiP16

AutoSwitch: Iq_select	
Thresh_up	0.5
Thresh_down	0.5
Used Implementation	FiP16

PI: PI	
Kp	0.05
Ki	0.0050
ts_fact	1.0
Used Implementation	FiP16

uSub: PosError	
Used Implementation	FiP16

AutoSwitch: PosSwitch	
Thresh_up	0.5
Thresh_down	0.5
Used Implementation	FiP16

Constant: Ramp_Up_Current	
Value	0.3
Used Implementation	FiP16

Constant: Constant4	
Value	1.0
Used Implementation	FiP16

Constant: I_Init_Zero	
Value	0.0
Used Implementation	FiP16

Constant: I_Init_Zero1	
Value	0.0
Used Implementation	FiP16

Mult: Mult	
Used Implementation	FiP16

uI: Ramp_Up_PositionGenerator	
Ki	100.0
ts_fact	1.0
Used Implementation	FiP16

Saturation: Saturation	
max	2.0
min	-2.0
Used Implementation	FiP16

Sign: Sign	
Used Implementation	FiP16

I: Speed_Ramp_UP_I	
Ki	1.0
ts_fact	1.0
Used Implementation	FiP16

TypeConv: TypeConv	
Used Implementation	FiP16_Bool

Sequencer: Sequencer	
Delay1	0.2
Delay2	1.0
Delay3	2.2
Delay4	3.0
ts_fact	1.0
Used Implementation	FiP16

TypeConv: TypeConv	
Used Implementation	FiP16_Bool

TypeConv: TypeConv1	
Used Implementation	FiP16_Bool

TypeConv: TypeConv2	
Used Implementation	FiP16_Bool

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

TMR1 Generated Driver API Source File
@Company Microchip Technology Inc.
@File Name tmr1.c
@Summary This is the generated source file for the TMR1 driver using PIC24 / dsPIC33 / PIC32MM MCUs
@Description This source file provides APIs for driver for TMR1. Generation Information : Product Revision : PIC24 / dsPIC33 / PIC32MM MCUs - 1.167.0 Device : dsPIC33CK256MP508 The generated drivers are tested against the following: Compiler : XC16 v1.50 MPLAB : MPLAB X v5.35Section: Included FilesSection: File specific functionsSection: 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:/LCM/X2C/_WorkApplications/mc_foc_sl_fip_dspic33ck_mclv2/mcc_generated_files/re

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:/LCM/X2C/_WorkApplications/mc_foc_sl_fip_dspic33ck_mclv2/mcc_generated_files/sy

Initializes the CPU core control register.

`SYSTEM_CORCONInitialize();`

```
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*/
#ifndef _XTAL_FREQ
#define _XTAL_FREQ  200000000UL
#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:/LCM/X2C/_WorkApplications/mc_foc_sl_fip_dspic33ck_mclv2/mcc_generated_files/wa

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

```
WATCHDOG_TimerSoftwareEnable();
```

```
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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 */
```

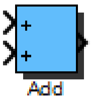
Part III

Used X2C-Blocks

8 Project Specific Blocks

9 Internal Library Blocks

Block: Add



Inports	
In1	Addend 1
In2	Addend 2

Outports	
Out	Sum

Description:

Addition of input 1 and input 2.

Calculation:

$$\mathrm{Out} = \mathrm{In}_1 + \mathrm{In}_2$$

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	
In1	int8
In2	int8

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In1	int16
In2	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In1	int32
In2	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In1	float32
In2	float32

Outports Data Type	
Out	float32

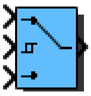
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In1	float64
In2	float64

Outports Data Type	
Out	float64

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

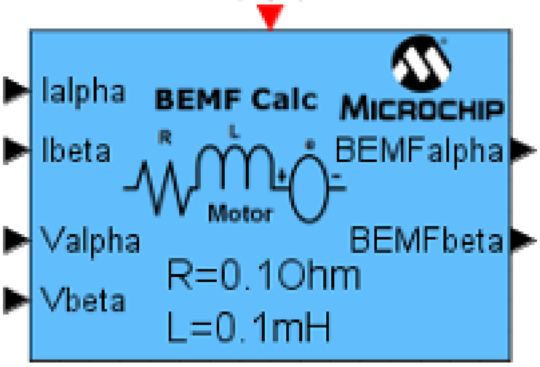
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In1	float64
Switch	float64
In3	float64

Outports Data Type	
Out	float64

Block: BEMF_calc



Inports	
Ialpha	Clarke transformed A phase current
Ibeta	Clarke transformed B phase current
Valpha	Clarke transformed Output A phase voltage
Vbeta	Clarke transformed Output B phase voltage

Outports	
BEMFalpha	back electromotive force alpha voltage
BEMFbeta	back electromotive force beta voltage

Mask Parameters	
Ls	Motor phase inductance for Y connection (MilliHenry)
Rs	Motor phase resistance for Y connection (Ohm)
U0	U0: DC link voltage (Only in Fip implementation)
I0	The maximum peak current per phase (Only in Fip implementation)
ts_fact	Multiplication factor of base sampling time (in integer format)
CurrentSampleFactor	Division factor for current sample. (in integer format) Current sample = ModelSampleTime/CurrentSampleFactor

Description:

BEMFalpha=Va-Rs0*Ia-Ls0*deltaIa
BEMFbeta=Vb-Rs0*Ib-Ls0*deltaIb
FIP:
Rs0 = Rs*(I0/U0)
Ls0 = Ls*(I0/U0)
Float:

Rs0 = Rs
Ls0 = Ls

Implementations:

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

Implementation: FiP16

Name	FiP16
ID	20992
Revision	0.2
C filename	BEMF_calc_FiP16.c
H filename	BEMF_calc_FiP16.h

16 Bit Fixed Point Implementation

Controller Parameters	
Ls	Motor phase inductance. Scales by I0/U0
Rs	Motor phase resistance. Scales by I0/U0
sfrLs	Shift factor for Ls
sfrRs	Shift factor for Rs
Ib_old	Input value from previous cycle. Sample time divided by CurrentSampleFactor
Ia_old	Input value from previous cycle. Sample time divided by CurrentSampleFactor
CurrentSampleFactor	Division factor for current sample. Current sample: ModelSampleTime/CurrentSampleFactor
V_Ls_alpha	Voltage of inductance. (Save data for next calculation)
V_Ls_beta	Voltage of inductance (Save data for next calculation)
FactCounter	Current Sample Factor loop counter

Data Structure:

```
typedef struct {
          uint16          ID;
          int16           *Ialpha;
          int16           *Ibeta;
          int16           *Valpha;
          int16           *Vbeta;
          int16           BEMFalpha;
          int16           BEMFbeta;
          int16           Ls;
```

```
    int16          Rs;
    int8           sfrLs;
    int8           sfrRs;
    int16          Ib_old;
    int16          Ia_old;
    uint8          CurrentSampleFactor;
    int16          V_Ls_alpha;
    int16          V_Ls_beta;
    uint8          FactCounter;
} BEMF_CALC_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	20993
Revision	0.2
C filename	BEMF_calc_FiP32.c
H filename	BEMF_calc_FiP32.h

32 Bit Fixed Point Implementation

Controller Parameters	
Ls	Motor phase inductance. Scales by I0/U0
Rs	Motor phase resistance Scales by I0/U0
sfrLs	Shift factor for Ls
sfrRs	Shift factor for Rs
Ia_old	Input value from previous cycle. Sample time divided by CurrentSampleFactor
Ib_old	Input value from previous cycle. Sample time divided by CurrentSampleFactor
CurrentSampleFactor	Division factor for current sample. Current sample: ModelSampleTime/CurrentSampleFactor
V_Ls_alpha	Voltage of inductance. (Save data for next calculation)
V_Ls_beta	Voltage of inductance. (Save data for next calculation)
FactCounter	Current Sample Factor loop counter

Data Structure:

```
typedef struct {
    uint16         ID;
    int32          *Ialpha;
    int32          *Ibeta;
    int32          *Valpha;
    int32          *Vbeta;
    int32          BEMFalpha;
```

```
        int32           BEMFbeta;
        int32           Ls;
        int32           Rs;
        int8            sfrLs;
        int8            sfrRs;
        int32           Ia_old;
        int32           Ib_old;
        uint8           CurrentSampleFactor;
        int32           V_Ls_alpha;
        int32           V_Ls_beta;
        uint8           FactCounter;
} BEMF_CALC_FIP32;
```

Implementation: Float32

Name	Float32
ID	20994
Revision	0.2
C filename	BEMF_calc_Float32.c
H filename	BEMF_calc_Float32.h

32 Bit Floating Point Implementation

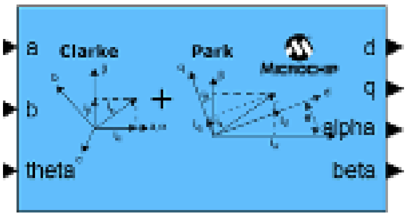
Controller Parameters	
Ls	Motor phase inductance
Rs	Motor phase resistance
Ia_old	Input value from previous cycle. Sample time divided by CurrentSampleFactor
Ib_old	Input value from previous cycle. Sample time divided by CurrentSampleFactor
CurrentSampleFactor	Division factor for current sample. Current sample: ModelSampleTime/CurrentSampleFactor
V_Ls_alpha	Voltage of inductance. (Save data for next calculation)
V_Ls_beta	Voltage of inductance. (Save data for next calculation)
FactCounter	Current Sample Factor loop counter

Data Structure:

```
typedef struct {
        uint16          ID;
        float32         *Ialpha;
        float32         *Ibeta;
        float32         *Valpha;
        float32         *Vbeta;
        float32         BEMFalpha;
        float32         BEMFbeta;
        float32         Ls;
        float32         Rs;
        float32         Ia_old;
```

```
    float32         Ib_old;
    uint8           CurrentSampleFactor;
    float32         V_Ls_alpha;
    float32         V_Ls_beta;
    uint8           FactCounter;
} BEMF_CALC_FLOAT32;
```

Block: Clark_Park



Inports	
a	A phase current
b	B phase current
theta	Rotating position

Outports	
d	d steady axis (typically flux)
q	q steady axis (typically torque)
alpha	Shifted A phase current
beta	Shifted B phase current

Description:

Merged Clark and park transform.
d=a*cos(theta)+((a*2b)*1.732)*sin(theta)
q=-a*sin(theta)+((a*2b)*1.732)*cos(theta)
Moves a three-axis, two-dimensional
coordinate system, referenced to the stator, onto a
two-axis system, keeping the same reference.
The two-axis orthogonal system with the axis called
alpha-beta transform into another two-axis
system that is rotating with the rotor flux.
Two-axis rotating coordinate system is
called the d-q axis.
Theta represents the rotor angle.

Implementations:

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

Implementation: FiP16

Name	FiP16
ID	20960
Revision	0.1
C filename	Clark_Park_FiP16.c
H filename	Clark_Park_FiP16.h

16 Bit Fixed Point Implementation

Data Structure:

```
typedef struct {
     uint16         ID;
     int16          *a;
     int16          *b;
     int16          *theta;
     int16          d;
     int16          q;
     int16          alpha;
     int16          beta;
} CLARK_PARK_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	20961
Revision	0.1
C filename	Clark_Park_FiP32.c
H filename	Clark_Park_FiP32.h

32 Bit Fixed Point Implementation

Data Structure:

```
typedef struct {
     uint16         ID;
     int32          *a;
     int32          *b;
     int32          *theta;
     int32          d;
     int32          q;
     int32          alpha;
     int32          beta;
} CLARK_PARK_FIP32;
```

Implementation: Float32

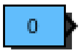
Name	Float32
ID	20962
Revision	0.1
C filename	Clark_Park_Float32.c
H filename	Clark_Park_Float32.h

32 Bit Floating Point Implementation

Data Structure:

```
typedef struct {
     uint16         ID;
     float32        *a;
     float32        *b;
     float32        *theta;
     float32        d;
     float32        q;
     float32        alpha;
     float32        beta;
} CLARK_PARK_FLOAT32;
```

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

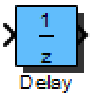
Outports Data Type	
Out	float32

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

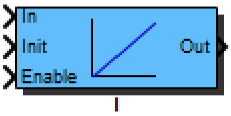
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: I



Inports	
In	Control error input
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

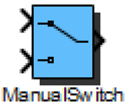
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64
Init	float64
Enable	bool

Outports Data Type	
Out	float64

Block: ManualSwitch



Inports	
In1	Input #1
In2	Input #2

Outports	
Out	

Mask Parameters		
Name	**ID**	**Description**
Toggle	1	Toggle

Description:

Toggling between inputs by double-clicking on block.

Doubleclicking of the *ManualSwitch* block changes the routing of the input signals and doesn't open the *Function Block Parameters* dialog. So if changing the implementation is required, one has to open the dialog via *Mask Parameters* command of the context menu.

9.0.0.1 Developer note:

To get the double-click feature the callback function of *OpenFnc* in *Block Properties* is manually altered to

```
if get_param(gcb,'Toggle') == '0'
    set_param(gcb,'Toggle', '1');
else
    set_param(gcb,'Toggle', '0');
end
setBlockData(gcs, gcb);
initSFunction(gcb);
```

Implementations:

Bool	Boolean 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

Inports Data Type	
In1	bool
In2	bool

Outports Data Type	
Out	bool

Implementation: FiP8

8 Bit Fixed Point Implementation

Inports Data Type	
In1	int8
In2	int8

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In1	int16
In2	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In1	int32
In2	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In1	float32
In2	float32

Outports Data Type	
Out	float32

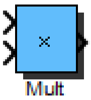
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In1	float64
In2	float64

Outports Data Type	
Out	float64

Block: Mult



Inports	
In1	Multiplicand 1
In2	Multiplicand 2

Outports	
Out	Product

Description:

Multiplication of input 1 with input 2.

Calculation:

$$\mathrm{Out} = \mathrm{In}_1 \cdot \mathrm{In}_2$$

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	
In1	int8
In2	int8

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
In1	int16
In2	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In1	int32
In2	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
In1	float32
In2	float32

Outports Data Type	
Out	float32

Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In1	float64
In2	float64

Outports Data Type	
Out	float64

Block: Not

Inports	
In	

Outports	
Out	

Description:

Logical inverter block.

Implementations:

Bool	Boolean Implementation

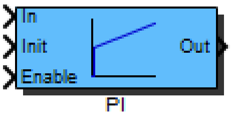
Implementation: Bool

Boolean Implementation

Inports Data Type	
In	bool

Outports Data Type	
Out	bool

Block: PI



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	

Mask Parameters		
Name	**ID**	**Description**
Kp	1	Proportional Factor
Ki	2	Integral Factor
ts_fact	3	Multiplication factor of base sampling time (in integer format)

Description:

PI controller:
G(s) = Kp + Ki/s

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

Transfer function (zero-order hold discretization method):

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

9.0.0.2 Developer note:

For the fixed point implementations the source code of block **??** 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
Init	int8
Enable	int8

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

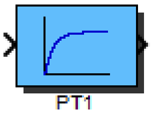
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64
Init	float64
Enable	bool

Outports Data Type	
Out	float64

Block: 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.

9.0.0.3 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

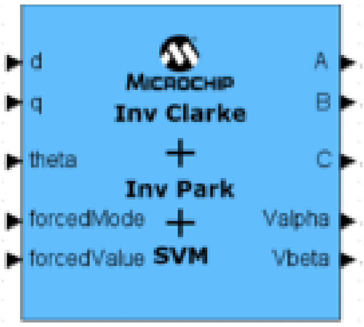
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: Park_Clark_inv



Inports	
d	d voltage axis in rotating system
q	q voltage axis in rotating system
theta	Rotating position
forcedMode	Force Motor to base position. 0 -> No force. Normal mode. 1 -> Force the motor to base position
forcedValue	The forced voltage value

Outports	
A	Phase A out
B	Phase B out
C	Phase C out
Valpha	Inverse Park Voltage output
Vbeta	Inverse Park Voltage output

Description:

Merged Inverse Park, Iverse Clark and Space Vector Modulation
Park_inv:
alpha = d*cos(theta) - q*sin(theta)
beta = d*sin(theta) + q*cos(theta)
Clark_inv:
a = beta
b = (-beta + 1.732*alpha)/2
c = (-beta - 1.732*alpha)/2
SVM:
Optimize output for PWM
Description:
Transform from the two-axis rotating d-q frame
to the two-axis stationary frame ?-?.
Transform from the stationary two-axis ?-? frame
to the stationary three-axis, 3-phase reference frame.
Optimize output for PWM

Implementations:

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

Implementation: FiP16

Name	FiP16
ID	20976
Revision	0.1
C filename	Park_Clark_inv_FiP16.c
H filename	Park_Clark_inv_FiP16.h

16 Bit Fixed Point Implementation

Data Structure:

```
typedef struct {
     uint16            ID;
     int16             *d;
     int16             *q;
     int16             *theta;
     int8              *forcedMode;
     int16             *forcedValue;
     int16             A;
     int16             B;
     int16             C;
     int16             Valpha;
     int16             Vbeta;
} PARK_CLARK_INV_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	20977
Revision	0.1
C filename	Park_Clark_inv_FiP32.c
H filename	Park_Clark_inv_FiP32.h

32 Bit Fixed Point Implementation

Data Structure:

```
typedef struct {
     uint16            ID;
     int32             *d;
     int32             *q;
     int32             *theta;
     int8              *forcedMode;
     int32             *forcedValue;
     int32             A;
```

```
    int32          B;
    int32          C;
    int32          Valpha;
    int32          Vbeta;
} PARK_CLARK_INV_FIP32;
```

Implementation: Float32

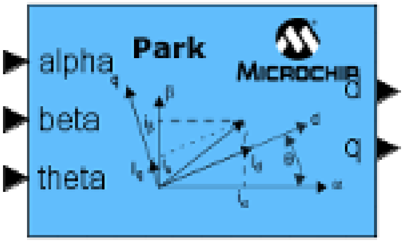
Name	Float32
ID	20978
Revision	0.1
C filename	Park_Clark_inv_Float32.c
H filename	Park_Clark_inv_Float32.h

32 Bit Floating Point Implementation

Data Structure:

```
typedef struct {
    uint16         ID;
    float32        *d;
    float32        *q;
    float32        *theta;
    int8           *forcedMode;
    float32        *forcedValue;
    float32        A;
    float32        B;
    float32        C;
    float32        Valpha;
    float32        Vbeta;
} PARK_CLARK_INV_FLOAT32;
```

Block: Park



Inports	
alpha	
beta	
theta	

Outports	
d	
q	

Description:

The two-axis orthogonal system with the axis called
alpha-beta transform into another two-axis
system that is rotating with the rotor flux.
Two-axis rotating coordinate system is
called the d-q axis.
Theta represents the rotor angle.

Implementations:

FiP16	16 Bit Fixed Point Implementation (uses MCHP dsp if possible)
FiP32	32 Bit Fixed Point Implementation
Float32	32 Bit Floating Point Implementation

Implementation: FiP16

Name	FiP16
ID	20880
Revision	0.2
C filename	Park_FiP16.c
H filename	Park_FiP16.h

16 Bit Fixed Point Implementation (uses MCHP dsp if possible)

Data Structure:

```c
typedef struct {
    uint16      ID;
    int16       *alpha;
    int16       *beta;
    int16       *theta;
    int16       d;
    int16       q;
} PARK_FIP16;
```

Implementation: FiP32

Name	FiP32
ID	20881
Revision	0.1
C filename	Park_FiP32.c
H filename	Park_FiP32.h

32 Bit Fixed Point Implementation

Data Structure:

```c
typedef struct {
    uint16      ID;
    int32       *alpha;
    int32       *beta;
    int32       *theta;
    int32       d;
    int32       q;
} PARK_FIP32;
```

Implementation: Float32

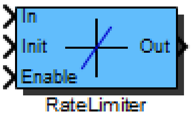
Name	Float32
ID	20882
Revision	0.1
C filename	Park_Float32.c
H filename	Park_Float32.h

32 Bit Floating Point Implementation

Data Structure:

```c
typedef struct {
    uint16      ID;
    float32     *alpha;
    float32     *beta;
    float32     *theta;
    float32     d;
    float32     q;
} PARK_FLOAT32;
```

Block: RateLimiter



Inports	
In	
Init	Value which is loaded at rising flanke of enable signal
Enable	Enable == 0: Deactivation of block; Out is set to In. Enable != 0: Activation of block; Out is rate limited. Enable 0->1: Preloading of output; Out is set to value of Init input

Outports	
Out	

Mask Parameters		
Name	**ID**	**Description**
Tr	1	Rising time in seconds. Slew rate will be 1/Tr
Tf	2	Falling time in seconds. Slew rate will be 1/Tf
ts_fact	3	Multiplication factor of base sampling time (in integer format)

Description:

Limitation of rising and falling rate.
Function of Enable:
0: rate limiting disabled, signal is passed through
1: rate limiting enabled, signal is rate limited
0->1: preload of output with value from init input

Rising and falling time refer to a step from 0 to 1. Entries for *Tr: Rising time* and *Tf: Falling time* smaller than the actual sample time will be limited to the sample time internally.
The 16- and 32-Bit fixed point implementations are based on an internal 32-Bit wide slew-rate variable while the 8-Bit fixed point implementation uses a 16-Bit wide slew-rate variable.

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
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: Saturation

Inports	
In	Input

Outports	
Out	Limited output

Mask Parameters		
Name	**ID**	**Description**
max	1	Upper Limit
min	2	Lower Limit

Description:

Saturation of output to adjustable upper and lower limit.

If the entry for *Upper Limit* is lower than the entry for *Lower Limit* then the limits will be swapped internally.

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

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

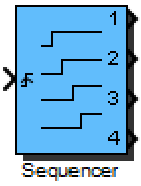
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64

Outports Data Type	
Out	float64

Block: Sequencer



Inports	
Start	Start signal. Rising flank triggers sequence

Outports	
Out1	Output #1
Out2	Output #2
Out3	Output #3
Out4	Output #4

Mask Parameters		
Name	**ID**	**Description**
Delay1	1	Time delay for output 1
Delay2	2	Time delay for output 2
Delay3	3	Time delay for output 3
Delay4	4	Time delay for output 4
ts_fact	5	Multiplication factor of base sampling time (in integer format)

Description:

Generation of time delayed (enable) sequence.

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	
Start	int8

Outports Data Type	
Out1	int8
Out2	int8
Out3	int8
Out4	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
Start	int16

Outports Data Type	
Out1	int16
Out2	int16
Out3	int16
Out4	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
Start	int32

Outports Data Type	
Out1	int32
Out2	int32
Out3	int32
Out4	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
Start	float32

Outports Data Type	
Out1	float32
Out2	float32
Out3	float32
Out4	float32

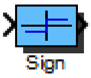
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
Start	float64

Outports Data Type	
Out1	float64
Out2	float64
Out3	float64
Out4	float64

Block: Sign



Inports	
In	Input u

Outports	
Out	Value corresponding to sign of u

Description:

Signum function.

Calculation:

$$\mathrm{Out} = \operatorname{sgn}(\mathrm{In}) = \begin{cases} 1 & \mathrm{In} \geq 0 \\ -1 & \mathrm{In} < 0 \end{cases}$$

Implementations:

FiP8	8 Bit Fixed Point Implementation
FiP16	16 Bit Fixed Point Implementation
FiP32	32 Bit Fixed 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

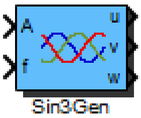
Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
In	int32

Outports Data Type	
Out	int32

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

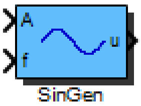
Implementation: Float64

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

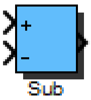
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
A	float64
f	float64

Outports Data Type	
u	float64

Block: Sub



Inports	
Plus	Minuend
Minus	Subtrahend

Outports	
Out	Difference

Description:

Subtraction of input Minus from input Plus.

Calculation:

$$\mathrm{Out} = \mathrm{Plus} - \mathrm{Minus}$$

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	
Plus	int8
Minus	int8

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
Plus	int16
Minus	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
Plus	int32
Minus	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
Plus	float32
Minus	float32

Outports Data Type	
Out	float32

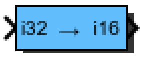
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
Plus	float64
Minus	float64

Outports Data Type	
Out	float64

Block: TypeConv



Inports	
In	

Outports	
Out	

Description:

Data Type Conversion

Implementations:

FiP8_16	8 to 16 Bit Fixed Point Implementation
FiP8_32	8 to 32 Bit Fixed Point Implementation
FiP16_8	16 to 8 Bit Fixed Point Implementation
FiP16_32	16 to 32 Bit Fixed Point Implementation
FiP32_8	32 to 8 Bit Fixed Point Implementation
FiP32_16	32 to 16 Bit Fixed Point Implementation
Bool_FiP16	Boolean to 16 Bit Fixed Point Implementation
Bool_FiP32	Boolean to 32 Bit Fixed Point Implementation
FiP16_Bool	16 Bit Fixed Point to Boolean Implementation
FiP32_Bool	32 Bit Fixed Point to Boolean Implementation

Implementation: FiP8_16

8 to 16 Bit Fixed Point Implementation

Inports Data Type	
In	int8

Outports Data Type	
Out	int16

Implementation: FiP8_32

8 to 32 Bit Fixed Point Implementation

Inports Data Type	
In	int8

Outports Data Type	
Out	int32

Implementation: FiP16_8

16 to 8 Bit Fixed Point Implementation

Inports Data Type	
In	int16

Outports Data Type	
Out	int8

Implementation: FiP16_32

16 to 32 Bit Fixed Point Implementation

Inports Data Type	
In	int16

Outports Data Type	
Out	int32

Implementation: FiP32_8

32 to 8 Bit Fixed Point Implementation

Inports Data Type	
In	int32

Outports Data Type	
Out	int8

Implementation: FiP32_16

32 to 16 Bit Fixed Point Implementation

Inports Data Type	
In	int32

Outports Data Type	
Out	int16

Implementation: Bool_FiP16

Boolean to 16 Bit Fixed Point Implementation

Inports Data Type	
In	bool

Outports Data Type	
Out	int16

Implementation: Bool_FiP32

Boolean to 32 Bit Fixed Point Implementation

Inports Data Type	
In	bool

Outports Data Type	
Out	int32

Implementation: FiP16_Bool

16 Bit Fixed Point to Boolean Implementation

Inports Data Type	
In	int16

Outports Data Type	
Out	bool

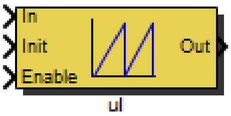
Implementation: FiP32_Bool

32 Bit Fixed Point to Boolean Implementation

Inports Data Type	
In	int32

Outports Data Type	
Out	bool

Block: uI



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

Outports	
Out	Integrator output

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

Description:

Integrator for angle signals:
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

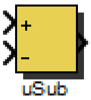
Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
In	float64
Init	float64
Enable	bool

Outports Data Type	
Out	float64

Block: uSub



Inports	
Plus	Minuend
Minus	Subtrahend

Outports	
Out	Difference

Description:

Subtraction of input Minus from input Plus with output wrapping.

Calculation:

$$\mathrm{Out} = \mathrm{Plus} - \mathrm{Minus}$$

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	
Plus	int8
Minus	int8

Outports Data Type	
Out	int8

Implementation: FiP16

16 Bit Fixed Point Implementation

Inports Data Type	
Plus	int16
Minus	int16

Outports Data Type	
Out	int16

Implementation: FiP32

32 Bit Fixed Point Implementation

Inports Data Type	
Plus	int32
Minus	int32

Outports Data Type	
Out	int32

Implementation: Float32

32 Bit Floating Point Implementation

Inports Data Type	
Plus	float32
Minus	float32

Outports Data Type	
Out	float32

Implementation: Float64

64 Bit Floating Point Implementation

Inports Data Type	
Plus	float64
Minus	float64

Outports Data Type	
Out	float64