

Sx-IP

IP67 versatile

Xenon Flash

MODBUS MANUAL

2.xx software revisions



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2 MODBUS INTERFACE:

Sx-IP device is fully configurable through a RS485 Modbus interface with following parameters:

- RTU mode
- 19200bps
- Even parity

For Modbus protocol details refer to:

- [MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3](#)
- [Modbus over serial line specification & implementation guide V1.02](#)

Up to 247 Sx-IP devices can be connected on a single RS485 link.

Modbus interface gives write access to configurable parameters like:

- Modbus address
- Energy level
- I/O configuration
- Device status, counters and statistics

Modbus interface also gives read access to many device parameters like:

- Device information (serial number; date code; hardware and software revisions...)
- Device status (flash energy; internal temperature; detailed status and errors...)
- Counters and statistics (Flash counts, min/max temperature, flash health...)

Design notes :

Endianness can be a little confusing:

- RS485 serial protocol is Little Endian (LSB first).
- Modbus protocol is Big Endian (MSB first).
- Sx-IP registers' implementation is Little Endian (MSB first)

Serial protocol	Modbus protocol	Sx-IP 32bits registers' implementation
bits order in serial frame	Byte order in 16bits words	16bits words orders in the Modbus frame
Little Endian	Big Endian	Little Endian

As a result, Sx-IP answer to a Modbus 32bits registers' read request will be as follow:

Address	Function	Nb of bytes	LSB of 32bit word		MSB of 32bit word		CRC		
			MSB	LSB	MSB	LSB	MSB	LSB	
0	7 0	7 0	7 8	15 0	7 24	31 16	23 8	15 0	7

2.1 REGISTERS

Register address		Register name	Register content	Access
Dec	Hex			
0	0x00	SERIAL_NUMBER	Device serial number	R
1	0x01	DATE_CODE	MSB = year, LSB = week	R
2	0x02	HARDWARE_REV	MSB = Major code (1->A), LSB = minor code, 0x0454 -> rev.D.54	R
3	0x03	PRODUCT_ID	Product ID	R
34	0x22	GLITCH_FILTER	Deglintch time before hardware trigger is accounted (10 to 255) (μs)	R/W
37	0x25	MISS_FLASH_WEIGHT	Weight of a missed flash for flash health supervision	R/W
38	0x26	FLASH_HEALTH_TH	Threshold for the flash health supervision to trigger a failure	R/W
39	0x27	RESET_ON_FAILURE	Time (s) from a failure detection to automatic device reset Value 0 disable automatic device reset in case of failure	R/W
40	0x28	ALT_HOLDING_TIME	Allow to automatically switch to alternate energy after a first flash at primary energy level. Alt holding time is specified in ms. Value 0 disable this feature.	R/W
48	0x30	MODBUS_ADDR_PRESET	Modbus address setting, 1 to 247, 0 for hardware selected address	R/W
49	0x31	ENERGY_LEVEL_PRESET_1	Energy level settings for the trigger 1 Levels from 0 to 15, 16 for hardware selected energy level 8bits LSB is primary energy level preset 8bits MSB is alternate energy level preset	R/W
50	0x32	ENERGY_LEVEL_PRESET_2	Energy level settings for the trigger 2	R/W
51	0x33	ENERGY_LEVEL_PRESET_3	Energy level settings for the trigger 3	R/W
52	0x34	ENERGY_LEVEL_PRESET_4	Energy level settings for the trigger 4	R/W
54	0x36	FLASH_DELAY	Delay from the flash request to the light pulse rising (μs)	R/W
55	0x37	SYNC_DELAY	Delay from the flash request to the synchronization signal activation (μs)	R/W
56	0x38	SYNC_WIDTH	Synchronization pulse width (μs)	R/W
62	0x3E	INPUTS_CONFIG	Select hardware inputs polarity and buffer	R/W
63	0x3F	OUTPUTS_CONFIG	Select hardware outputs polarity and function	R/W
64	0x40	ENERGY_HW_SEL	Set the combination of inputs generating the hardware selected energy level	R/W
65	0x41	ADDRESS_HW_SEL_L	Set the combination of inputs generating the hardware selected address	R/W
66	0x42	ADDRESS_HW_SEL_H		R/W
67	0x43	TRIGGERS_INPUT_SEL	Select an input for each of the four triggers	R/W
68	0x44	MISC_INPUT_SEL	Select an input for the alternate command	R/W
256	0x100	STATUS	Status flags	R
257	0x101	ERRORS	Error flags	R
258	0x102	FAILURES	Failure flags	R
259	0x103	COM_ERRORS (LSB) INTERNAL_ERRORS (MSB)	Communication error flags Internal error flags	R
260	0x104	CONFIG_ERRORS	Configuration error flags	R
262	0x106	IO_STATE	Actual state of hardware inputs and outputs	R
269	0x10D	RESET_SOURCE	Source of the last device's reset	R
270	0x10E	MODBUS_ADDRESS	Modbus address (1 to 247)	R
271	0x10F	ENERGY_LEVEL_T1 ENERGY_LEVEL_T2	Energy level (0 to 15) associated with trigger 1 Energy level (0 to 15) associated with trigger 2	R

Register address		Register name	Register content	Access
Dec	Hex			
272	0x110	ENERGY_LEVEL_T3 ENERGY_LEVEL_T4	Energy level (0 to 15) associated with trigger 3 Energy level (0 to 15) associated with trigger 4	R
273	0x111	INPUT_VOLTAGE	Input voltage (mV)	R
274	0x112	TEMPERATURE	Internal temperature (°C)	R
276	0x114	HT_VOLTAGE	Flash capacitor voltage (V/10)	R
279	0x117	FLASH_ENERGY	Last flash energy (J/100)	R
280	0x118	AVERAGE_POWER	Average device power (W) (8s average)	R
281	0x119	NOT_READY_COUNT	Count of flash requests that were not fulfilled because the flash was not ready	R
282	0x11A	FLASH_ERROR_COUNT	Flash error count since last reset	R
283	0x11B	HEALTH_INDICATOR	Flash health indicator (0 if no error)	R
285	0x11D	FAN_RPM	Fan speed (rpm)	A
286	0x11E	MIN_INPUT_VOLTAGE	Minimum voltage seen on input since last reset (mV)	R
287	0x11F	TARGET_ENERGY	Last flash target energy (J/100)	R
288	0x120	MAX_TEMP (LSB) MIN_TEMP (MSB)	Maximum recorded temperature Minimum recorded temperature	R
289	0x121	START_COUNT_L	Number of device power-up	R
290	0x122	START_COUNT_H		R
291	0x123	TIME_COUNT_L	Device up-time since last power-up (minutes)	R
292	0x124	TIME_COUNT_H		R
293	0x125	TOTAL_TIME_COUNT_L	Total device up-time (minutes)	R
294	0x126	TOTAL_TIME_COUNT_H		R
295	0x127	FLASH_COUNT_L	Flash count since last power-up	R
296	0x128	FLASH_COUNT_H		R
297	0x129	TOTAL_FLASH_COUNT_L	Total flash count	R
298	0x12A	TOTAL_FLASH_COUNT_H		R
301	0x12D	TUBE_COUNT_L	Flash count since last flash tube replacement	R
302	0x12E	TUBE_COUNT_H		R
304	0x130	GLITCH_COUNT	Count of glitches detected on triggers' inputs	R
305	0x131	FTIME_1	Flash time associated with trigger 1	R
306	0x132	FTIME_2	Flash time associated with trigger 2	R
307	0x133	FTIME_3	Flash time associated with trigger 3	R
308	0x134	FTIME_4	Flash time associated with trigger 4	R
309	0x135	HW_SEL_ENERGY (LSB) HW_SEL_ADDR (MSB)	Hardware selected energy value Hardware selected address value	R
310	0x136	ENERGY_1	Energy associated with trigger 1	R
311	0x137	ENERGY_2	Energy associated with trigger 2	R
312	0x138	ENERGY_3	Energy associated with trigger 3	R
313	0x139	ENERGY_4	Energy associated with trigger 4	R

2.2 IMPLEMENTED STANDARD FUNCTIONS

2.2.1 FUNCTION 03: READ HOLDING REGISTERS

Example of serial number (0x0000) register read operation:

Request	8 bytes		Answer	7 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x03	Function code	1 byte	0x03
Starting address	2 bytes	0x0000	Number of bytes	1 byte	0x02
Quantity of registers	2 bytes	0x0001	Register content	2 bytes	0x0001
CRC	2 bytes	0x840A	CRC	2 bytes	0x7984

Example of out of range (0x0320) register read operation:

Request	8 bytes		Answer	5 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x03	Error code	1 byte	0x83
Starting address	2 bytes	0x0320	Exception code	1 byte	0x02
Quantity of registers	2 bytes	0x0001	CRC	2 bytes	0xC0F1
CRC	2 bytes	0x8584			

Example of multiple register read (0x0005 to 0x0008) operation:

Request	8 bytes		Answer	7 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x03	Function code	1 byte	0x03
Starting address	2 bytes	0x0000	Number of bytes	1 byte	0x06
Quantity of registers	2 bytes	0x0003	Register content	6 bytes	0x0001 170E 0200
CRC	2 bytes	0x05CB	CRC	2 bytes	0x79A2

2.2.2 FUNCTION 06: PRESET SINGLE REGISTER

Example of energy level preset (0x0031) register write operation:

Request	8 bytes		Answer	7 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x06	Function code	1 byte	0x06
Register address	2 bytes	0x0031	Register address	2 bytes	0x0031
Value to write	2 bytes	0x0005	Value to be write	2 bytes	0x0005
CRC	2 bytes	0x1806	CRC	2 bytes	0x1806

Example of out of range (serial number = 0x0000) register write operation:

Request	8 bytes		Answer	5 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x03	Error code	1 byte	0x86
Register address	2 bytes	0x0000	Exception code	1 byte	0x02
Value to write	2 bytes	0x0001	CRC	2 bytes	0xC3A1
CRC	2 bytes	0x480A			

2.2.3 FUNCTION 05: WRITE SINGLE COIL

Write single coil function is used to send specific commands to the Sx-IP.

Command code		Command name	Purpose	Execution time
Dec	Hex			
1	0x01	RESET	Sx-IP software reset request	<10ms
2	0x02	INIT_DONE	Set the INIT_DONE flag	<10ms
3	0x03	CLEAR	Clear errors and fault counters	<10ms
4	0x04	FLASH	Software flash request	<10ms
5	0x05	SAVE_SETTINGS	Save setting registers' content	Up to 2s
6	0x06	CLR_TUBE_COUNT	Clear flash tube count (at flash tube replacement)	Up to 200ms

Example of clear command (0x0003):

Request	8 bytes		Answer	7 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x05	Function code	1 byte	0x05
Coil address	2 bytes	0x0003	Coil address	2 bytes	0x0003
Value to be write	2 bytes	0xFF00	Value to be write	2 bytes	0xFF00
CRC	2 bytes	0x7C3A	CRC	2 bytes	0x7C3A

Example of unauthorized command (0x0011):

Request	8 bytes		Answer	5 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x05	Error code	1 byte	0x85
Coil address	2 bytes	0x000B	Exception code	1 byte	0x03
Value to be write	2 bytes	0x0000	CRC	2 bytes	0x0291
CRC	2 bytes	0x3DCA			

Design notes:

The Sx-IP will answer a request only after completion of the process (after the execution delay).

For long processes like «Save setting», a suitable response timeout shall be set at client side.

2.2.4 SERIAL LINE DIAGNOSTIC COUNTERS

Serial line diagnostic counters are available as defined by the Modbus organization.

Example of Bus message counter read:

Request	8 bytes		Answer	7 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x08	Function code	1 byte	0x08
Sub function code	2 bytes	0x000B	Sub function code	2 bytes	0x000B
Value to write	2 bytes	0x0000	Value to be write	2 bytes	0x24B2
CRC	2 bytes	0x91C9	CRC	2 bytes	0x0ABC

2.2.5 READ DEVICE IDENTIFICATION

Basic device identification is available as defined by the Modbus organization.

Example of Read Modbus ID request:

Request	7 bytes		Answer	7 bytes	
Device address	1 byte	0x01	Device address	1 byte	0x01
Function code	1 byte	0x2B	Function code	1 byte	0x2B
MEI type	1 byte	0x0E	MEI type	1 byte	0x0E
Read Dev Id code	1 byte	0x02	Read Dev Id code	1 byte	0x02
Object Id	1 byte	0x00	Conformity level	1 byte	0x82
CRC	2 bytes	0x7087	More follows	1 byte	0x00
			Next object Id	1 byte	0x00
			Nb of objects	1 byte	0x05
			Object Id	1 byte	0x00
			Object length	1 byte	0x07
			Object value	7 bytes	"PHOXENE"
			Object Id	1 byte	0x01
			Object length	1 byte	0x05
			Object value	4 bytes	"0953U"
			Object Id	1 byte	0x02
			Object length	1 byte	0x04
			Object value	4 bytes	"C.00"
			Object Id	1 byte	0x03
			Object length	1 byte	0x0B
			Object value	11 bytes	"phoxene.com"
			Object Id	1 byte	0x04
			Object length	1 byte	0x04
			Object value	4 bytes	"Sx-IP"
			CRC	2 bytes	0x4C10

Modbus identification information is then:

Vendor name	PHOXENE
Product code	0953U
Revision	C00
Vendor Url	phoxene.com
Product name	Sx-IP

3 SX-IP CONFIGURATION

3.1 SX-IP OVERVIEW

3.1.1 OPERATING MODES

Sx-IP operating mode is configurable. Two modes are available:

- Energy regulation: The Sx-IP adjust the flash time to the expected flash energy according to the last flash energy. This mode is intended to be used when the flashes are requested at constant frequency.
- Burst mode: The Sx-IP use reference tables to adapt the flash time to the capacitors' voltage. It allows to chain flashes of constant energy in high frequency bursts without recharging.

Design notes:

Operating mode is a Factory setting.

3.1.1 SX-IP FLASH SEQUENCE OVERVIEW

Sx-IP flash sequence is initiated with an unactive to active edge on one of the trigger's inputs.

Sequence starts with a deglitch time that can be configured from 10µs to 255µs (refer to §3.6).

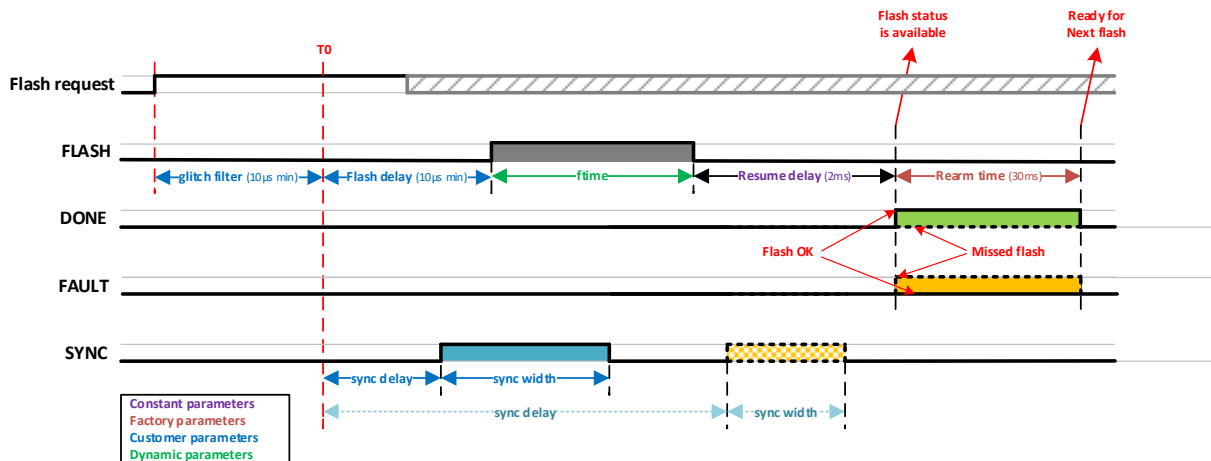
The end of the deglitch time is referenced as T0.

The light emission does not start at T0 but after a minimum 10µs delay. This delay is referenced as "flash delay" and can be configured from 10µs to 60ms (refer to §3.7).

The flash duration is referenced as "ftime". The ftime parameter is computed accordingly to the requested flash energy and the operating mode.

Flash status (energy, errors...) is available after a 2ms resume delay.

The Sx-IP is ready for the next flash after observing a recovery time that is a factory setting (usually 30ms).



Flash status signals (DONE and FAULT) are available for reading after the resume delay has elapsed and until the recovery time has elapsed.

Sx-IP is also able to generate a synchronization signal with configurable delay and pulse with (refer to §3.8).

3.1.2 SX-IP TRIGGER MANAGEMENT OVERVIEW

Sx-IP include **four logical triggers**. Each of this logical trigger is associated with:

- **A primary and alternate energy level** that is selected from the corresponding *ENERGY_LEVEL_PRESET* register
- **A physical trigger source** (input) that is selected from the *TRIGGER_INPUT_SEL* register

Each logical trigger is armed with energy (*ENERGY[1:4]*) and flash time (*FTIME[1:4]*) values that are read from tables according to:

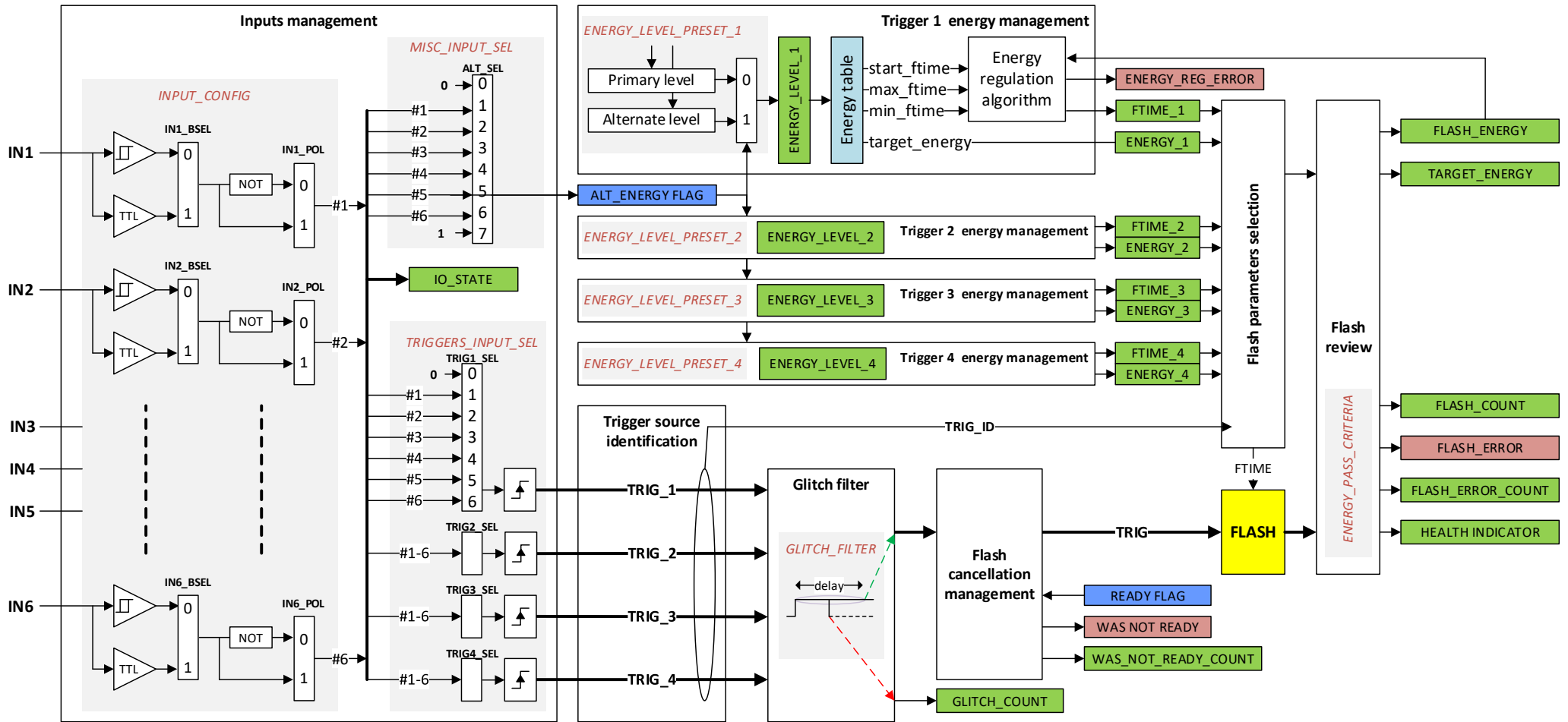
- The operating mode
- The alternate energy flag that can be associated to an input state using the *MISC_INPUT_SEL* register
- The energy storage voltage

When one of the inputs configured as trigger source is activated:

- The input is identified to select the flash parameters (energy and flash time) armed in the logical trigger associated with the input
- During the glitch filter time, the triggered source input is supervised to detect state changes. If the active state is not hold for the glitch filter time, the flash request is aborted and *GLTICH_COUNT* is incremented.
- The system check that the device is ready to flash. If not, the flash is aborted, the *WAS_NOT_READY* flag is set and *WAS_NOT_READY_COUNT* is incremented
- The flash is triggered

After the flash:

- *FLASH_ENERGY* is computed and compared to the *TARGET_ENERGY* energy using *ENERGY_PASS_CRITERIAS*.
- If the *FLASH_ENERGY* is correct, *FLASH_COUNT* is incremented
- If the *FLASH_ENERGY* is not correct, *FLASH_ERROR* flag is set, *FLASH_ERROR_COUNT* and *HEALTH_INDICATOR* registers are incremented
- In energy regulation mode, the flash time associated with the triggered logical trigger is adjusted according to the *FLASH_ENERGY*. If regulation limits are reached *ENERGY_REG_ERROR* flag is set.



3.2 MODBUS ADDRESS SELECTION

Modbus address can be selected from 1 to 247 by *MODBUS_ADDRESS_PRESET* register setting.

Alternatively; by writing 0 in the *MODBUS_ADDRESS_PRESET* register; the Modbus address is the hardware selected address (*HW_SEL_ADDR*), refer to §3.13.

MODBUS_ADDRESS_PRESET (0x30) (R/W)

15	-	-	-	8	7	-	-	-	0
-					Modbus address preset				

Value	Description
0	Modbus address is the hardware selected address, refer to §3.13
1 to 247	Modbus address is set to the value
>247	Return exception. Modbus address is set to 1

Design notes:

Factory default Modbus address is '1'

3.3 ENERGY LEVEL SELECTION

For each of the four logical triggers, *ENERGY_LEVEL_PRESET_x* registers allow to select two energy levels from 0 to 15.

PRIMARY_ENERGY_LEVEL_PRESET is the default energy level preset assigned to the logical trigger.

ALTERNATE_ENERGY_LEVEL_PRESET is the alternate energy level preset assigned to the logical trigger.

If the active energy preset value is “16”, the energy level is the hardware selected energy level (*HW_SEL_ENERGY*), refer to §3.12.

ENERGY_LEVEL_PRESET_1 (0x31) (R/W)

ENERGY_LEVEL_PRESET_2 (0x32) (R/W)

ENERGY_LEVEL_PRESET_3 (0x33) (R/W)

ENERGY_LEVEL_PRESET_4 (0x34) (R/W)

15	-	-	-	8	7	-	-	-	0
Alternate energy level preset					Primary energy level preset				

Bits 7-0: Primary energy level preset

Value	Description
0 to 15	Primary energy level affected to logical trigger is the value
16	Primary energy level affected to logical trigger is the hardware selected energy level, refer to §3.12
>16	Return illegal value exception.

Bits 15-8: Alternate energy level preset

Value	Description
0 to 15	Alternate energy level affected to logical trigger is the value
16	Alternate energy level affected to logical trigger is the hardware selected energy level, refer to §3.12
>16	Return illegal value exception.

Design notes:

Alternate energy levels allow to switch between energy levels (for example day/night) using a discrete signal.

3.4 INPUTS POLARITY AND BUFFERS

Inputs polarity and buffer type can be configured using *INPUT_CONFIG* register.

INPUT_CONFIG (0x3E) (R/W)

15	14	13	12	11	10	9	8
-	-	IN6_BSEL	IN5_BSEL	IN4_BSEL	IN3_BSEL	IN2_BSEL	IN1_BSEL
7	6	5	4	3	2	1	0
		IN6_POL	IN5_POL	IN4_POL	IN3_POL	IN2_POL	IN1_POL

POL bits: Polarity selection

Value	Description
0	The input is active low / trig on falling edges
1	The input is active high / trig on rising edges

IN1, IN2, IN3 and IN4 BSEL bits: Buffer selection

Value	Description
0	Input buffer is optimized for 5V levels (levels are 1.0V and 4.0V with Schmitt trigger)
1	Input buffer is TTL 3.3V compatible (levels are 0.8V and 2.0V) ⁽¹⁾

IN5 and IN6 BSEL bits: Buffer selection

Value	Description
0	Input buffer is optimized for 12V levels (levels are 2.0V and 8.0V with Schmitt trigger)
1	Input buffer is TTL 5V compatible (levels are 1.6V and 4.0V) ⁽¹⁾

Design notes:

⁽¹⁾ TTL buffers are not windowed, they have lower immunity to perturbations than Schmitt trigger buffers. When possible, Schmitt triggers shall be preferred.

3.5 TRIGGERS INPUT SELECTION

For each of the four logical triggers, an input can be configured using *TRIGGERS_INPUT_SEL* register.

TRIGGERS_INPUT_SEL (0x43) (R/W)

15	-	-	12	11	-	-	8	7	-	-	4	3	-	-	0
TRIG4_SEL				TRIG3_SEL				TRIG2_SEL				TRIG1_SEL			

TRIGx_SEL

Value	Description
0	The logical trigger is not used
1 to 6	The logical trigger is associated with corresponding input (IN1 to IN6)
7	Not implemented (the logical trigger is not used)

ALTERNATE ENERGY LEVEL INPUT SELECTION

Alternate energy levels input can be configured using *MISC_INPUT_SEL* register.

MISC_INPUT_SEL (0x44) (R/W)

15	-	-	12	11	-	-	8	7	-	-	4	3	-	-	0
												ALT_ENERGY_SEL			

ALT_ENERGY_SEL

Value	Description
0	No input is associated to energy level selection. Primary energy levels are used.
1 to 6	Alternate energy level selection is associated to corresponding input (IN1 to IN6) Primary energy levels are used if the associated input is unactive Alternate energy levels are used if the associated input is active
7	No input is associated to energy level selection. Alternate energy levels are used.

3.6 GLITCH FILTER AND DEBOUNCING

Glitch filtering and debouncing of trigger inputs sources is available by configuring the *GLITCH_FILTER* register.

GLITCH_FILTER (0x22) (R/W)

15	-	-	-	8	7	-	-	-	0						
0x00								Glitch filter time							

Value	Description
0 to 9	Return illegal value exception
10 to 255	Set the glitch filter time to 10 to 255µs
>255	Return illegal value exception

Design notes:

Factory default glitch filter time is 10µs that is the minimum value

3.7 FLASH DELAY (0X36) (R/W)

The delay from the flash request to the occurrence of the flash can be configured from 10 μ s to 60ms by writing the *FLASH_DELAY* register.

Value	Description
< 10 μ s	Return an illegal data exception
10 to 60000	Flash delay (μ s) from the end of the deglitch time to the start of the flash
> 60000	May return an illegal data exception

3.8 SYNCHRONIZATION SIGNAL

The flash can generate a synchronization signal. By playing with the *FLASH_DELAY* and *SYNC_DELAY* settings, it is possible to shift the synchronization from 60ms before, to 60ms after the flash.

3.8.1 SYNC_DELAY (0X37) (R/W)

The delay from the flash request to sync signal activation can be configured from 0 μ s to 60ms by writing the *SYNC_DELAY* register.

Value	Description
0 to 60000	Delay (μ s) from the end of the deglitch time to the sync signal activation
> 60000	Return an illegal data exception

3.8.2 SYNC_PULSE_WIDTH (0X38) (R/W)

The synchronization signal pulse width is configurable from 0 μ s to 5ms by writing the *SYNC_WIDTH* register.

Value	Description
0 to 5000	Synchronization signal pulse width (μ s)
> 5000	Return an illegal data exception

3.9 RESET ON FAILURE (0X27)

Reset on failure function can be adjusted by writing *RESET_ON_FAILURE* register.

Value	Description
0	Reset on failure is unactive
1 to 65535	Timeout from failure apparition to automatic device reset (seconds)

3.10 ALT. HOLDING TIME (0X28)

After a first flash done at primary energy, the flash can automatically turn to alternate energy for an adjustable amount of time by writing the *ALT_HOLDING_TIME* register.

This function is primarily designed to capture two consecutive images at different lighting levels without the need for communication or multiple trigger handling.

Value	Description
0	Alt. holding function is unactive
1 to 65535	Time during which the energy level is switched to alternate level after a first flash at primary level (ms).

3.11 OUTPUTS POLARITY AND FUNCTION SELECTION

Outputs polarity and function selection can be configured using *OUTPUT_CONFIG* register.

OUTPUT_CONFIG (0x3F) (R/W)

15	14	13	12	11	10	9	8
OUT8_FSEL		OUT8_POL		OUT7_FSEL		OUT7_POL	
7	6	5	4	3	2	1	0
OUT5_FSEL		OUT5_POL		OUT1_FSEL		OUT1_POL	

POL bits: Polarity selection

Value	Description
0	The output is active low (closed)
1	The input is active high (released)

FSEL bits: Mode selection

Value	Description
0	The output is released (polarity bit don't care)
1	The output is low (polarity bit don't care)
2	The output is synchronization signal
3	The output is DONE signal
4	The output is READY signal
5	The output is FAULT signal
6, 7	Not implemented (output is released)

3.12 ENERGY LEVEL HARDWARE SELECTION

ENERGY_HARD_SELECT registers set the combination of inputs that will generate the hardware selected energy level (*HW_SEL_ENERGY*).

ENERGY_HARD_SELEC (R/W)

15	-	-	12	11	-	-	8	7	-	-	4	3	-	-	0
ENERGY_HSEL_3				ENERGY_HSEL_2				ENERGY_HSEL_1				ENERGY_HSEL_0			

For each HSEL bit:

Value	Description
0	HSEL bit is read as 0
1 to 6	HSEL bit is according to input 1 to 6
7	Not implemented (HSEL bit is read à 0)
8 to 11	HSEL bit is according to selector bits 0 to 3
12 to 14	Not implemented (HSEL bit is read à 0)
15	HSEL bit is read as 1

3.12.1 SELECTION EXEMPLES

Energy level hardware selection is from the coder (default configuration)

Parameter	ENERGY_HSEL_3	ENERGY_HSEL_2	ENERGY_HSEL_1	ENERGY_HSEL_0
Value	11	10	9	8
Bit linked to	Coder bit 3	Coder bit 2	Coder bit 1	Coder bit 0

Energy level hardware selection is from inputs 1 to 4 state

Parameter	ENERGY_HSEL_3	ENERGY_HSEL_2	ENERGY_HSEL_1	ENERGY_HSEL_0
Value	4	3	2	1
Bit linked to	Input 4	Input 3	Input 2	Input 1

Energy level hardware selection is from inputs 1 to 3 state (only even values can be selected)

Parameter	ENERGY_HSEL_3	ENERGY_HSEL_2	ENERGY_HSEL_1	ENERGY_HSEL_0
Value	3	2	1	0
Bit linked to	Input 3	Input 2	Input 1	0

Energy level hardware selection can be 4, 8, 12 and 16 selected from inputs 5 to 6.

Parameter	ENERGY_HSEL_3	ENERGY_HSEL_2	ENERGY_HSEL_1	ENERGY_HSEL_0
Value	6	5	0	0
Bit linked to	Input 6	Input 5	0	0

3.13 MODBUS ADDRESS HARDWARE SELECTION

ADDR_HARD_SELECT registers set the combination of inputs that will generate the hardware selected Modbus address (*HW_SEL_ADDR*).

ADDR_HARD_SELEC_0 (0x41) (R/W)

15	-	-	12	11	-	-	8	7	-	-	4	3	-	-	0
ADDR_HSEL_3				ADDR_HSEL_2				ADDR_HSEL_1				ADDR_HSEL_0			

ADDR_HARD_SELEC_1 (0x42) (R/W)

15	-	-	12	11	-	-	8	7	-	-	4	3	-	-	0
ADDR_HSEL_7				ADDR_HSEL_6				ADDR_HSEL_5				ADDR_HSEL_4			

For each HSEL bit:

Value	Description
0	HSEL bit is read as 0
1 to 6	HSEL bit is according to input 1 to 6
7	Not implemented (HSEL bit is read à 0)
8 to 11	HSEL bit is according to selector bits 0 to 3
12 to 14	Not implemented (HSEL bit is read à 0)
15	HSEL bit is read as 1

3.13.1 SELECTION EXEMPLES

Address hardware selection is 0 to 15 from the coder (default configuration)

Parameter	HSEL_7	HSEL_6	HSEL_5	HSEL_4	HSEL_3	HSEL_2	HSEL_1	HSEL_0
Value	0	0	0	0	11	10	9	8
Bit linked to	0	0	0	0	Coder b3	Coder b2	Coder b1	Coder b0

Address hardware selection is 32 x Input 2 + 16 x Input 1 + 0 to 15 from the coder

Parameter	HSEL_7	HSEL_6	HSEL_5	HSEL_4	HSEL_3	HSEL_2	HSEL_1	HSEL_0
Value	0	0	2	1	11	10	9	8
Bit linked to	0	0	Input 2	Input 1	Coder b3	Coder b2	Coder b1	Coder b0

Design notes:

Modbus address 0 is reserved for broadcast. If the hardware address selection is 0 it will be shifted to 1.

In the case where 16 different addresses shall be selected from the hardware selector, the address range can be shifted by forcing HSEL_4 to 1. The hardware selector will thus select addresses from 16 to 31.

3.14 SAVING SETTINGS:

Registers' modifications change current setting but are not retained after a device reset.

In order to save current settings, the Modbus client shall issue a SAVE_SETTINGS command. Refer to §4.5.

4 SX-IP COMMANDS

Command requests are sent using Modbus write single coil instructions (refer to § 0).

4.1 RESET (0X01):

Request a software reset of the device.

4.2 INIT_DONE (0X02):

Set the INIT_DONE flag of the status register. INIT_DONE flag is cleared on reset.

This flag is intended to be set by the Modbus client after start-up then periodically read to check that the device has not been reset since last INIT_DONE command.

4.3 CLEAR (0X03):

Clear errors flags, failure flags and flash health value.

4.4 FLASH (0X04):

Software flash command.

4.5 SAVE_SETTINGS (0X05):

Save flash settings in a non-volatile memory. This operation can take up to 2s to complete. A suitable timeout shall be implemented on client side.

4.6 CLR_TUBE_COUNT (0X06):

Reset the flash tube counter. This command shall be sent after a flash tube replacement. This operation can take up to 200ms to complete. A suitable timeout shall be implemented on client side.

5 SX-IP READ ONLY REGISTERS

5.1 CURRENT REGISTERS:

5.1.1 IO STATE (0X106) (R):

Device inputs and outputs state is available from the *IO_STATE* register. This register is mainly for debug purpose, in order to test that the Sx-IP is correctly interfaced.

IO_STATE (R)

15	14	13	12	11	10	9	8
OUT8	OUT7	OUT5	OUT1	SEL3	SEL2	SEL1	SEL0
7	6	5	4	3	2	1	0
-	-	IN6	IN5	IN4	IN3	IN2	IN1

IN bits: Input state

Value	Description
0	Input is unactive state (released or low according to the polarity bit)
1	Input is active state (low or released according to the polarity bit)

OUT bits: Output state

Value	Description
0	Output is unactive (released or low according to the polarity bit)
1	Output is active (low or released according to the polarity bit)

5.1.2 MODBUS ADDRESS (0X10E) (R):

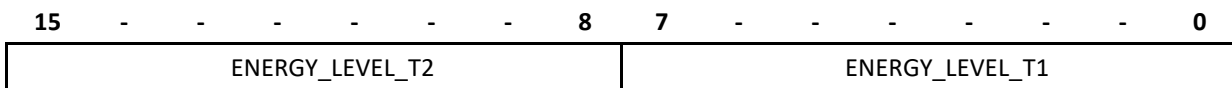
Modbus address is available from the *MODBUS_ADDRESS* register.

Value	Description
1 to 247	Current Modbus address

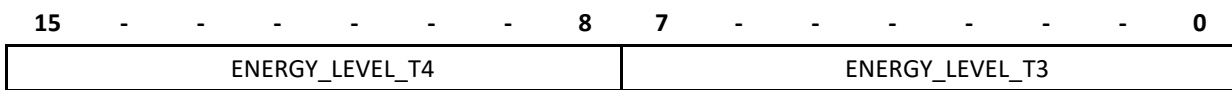
5.1.3 ENERGY LEVEL (0X10F & 0X110) (R):

For each of the four logical triggers, associated energy level is available from the *ENERGY_LEVEL_T* registers.

0x10F (R/W)



0x110 (R/W)



ENERGY_LEVEL

Value	Description
0 to 15	Energy level associated with the logical trigger

5.1.4 FLASH TIME ASSOCIATED WITH TRIGGERS (0X131 TO 0X134):

Flash time associated with logical triggers are available from the *FTIME_x* registers.

0x131 - *FTIME_1* (R)

0x132 - *FTIME_2* (R)

0x133 - *FTIME_3* (R)

0x134 - *FTIME_4* (R)

Value	Description
0 to 65536	Flash time associated with the logical trigger (µs)

5.1.5 ENERGY ASSOCIATED WITH TRIGGERS (0X136 TO 0X139):

Flash time associated with logical triggers are available from the *FTIME_x* registers.

0x136 - *ENERGY_1* (R)

0x137 - *ENERGY_2* (R)

0x138 - *ENERGY_3* (R)

0x139 - *ENERGY_4* (R)

Value	Description
0 to 65536	Energy associated with the logical trigger (hundredths of Joules)

5.1.6 INPUT VOLTAGE (0X111) (R):

Input voltage is available from the *INPUT_VOLTAGE* register.

Value	Description
0 to 3500	Input voltage in hundredths of volts

5.1.7 TEMPERATURE (0X112) (R)

Internal temperature is available from the *TEMPERATURE* register.

Value	Description
-50 to 120	Temperature in °C

5.1.8 HT VOLTAGE (0X114 (R):

Flash voltage is available from the *HT_VOLTAGE* register.

Value	Description
0 to 3100	Input voltage in tenths of volts

5.1.9 FLASH ENERGY (0X117) (R):

Last flash energy is available from the *FLASH_ENERGY* register.

Value	Description
0 to 50000	Last flash energy in hundredths of Joules

5.1.10 AVERAGE POWER (0X118) (R):

Average output power calculated on an 8s sliding period is available from the *AVERAGE_POWER* register.

Value	Description
0 to 100	Average power in Watts

5.1.11 FLASH ERROR COUNT (0X11A) (R):

Count of missed flashes since last reset is available from the *FLASH_ERROR_COUNT* register.

Value	Description
0 to 65536	Number of missed flashes

FLASH_ERROR_COUNT register is cleared on reset.

5.1.12 NOT READY COUNT (0X119) (R):

Count of flashes requests that occurs while the flash was not ready is available from the *NOT_READY_COUNT* register.

Value	Description
0 to 65536	Count of flash requests that were not fulfilled because the flash was not ready

NOT_READY_COUNT register is cleared on reset.

5.1.13 GLITCH COUNT (0X130) (R):

Count of glitches detected on trigger source inputs since last reset is available from the *GLITCH_COUNT* register.

Value	Description
0 to 65536	Count of glitches detected on trigger source inputs

GLITCH_COUNT register is cleared on reset.

5.1.14 FLASH HEALTH (0X11B) (R):

HEALTH_INDICATOR register is a flash fault rate indicator. It is mainly designed for flash tube health supervision.

This indicator is increased by *MISSED_FLASH_WEIGHT* on a missed flash, decreased by 1 on a successful flash.

A flash failure occurs if the value reach *HEALTH_THRESHOLD*.

Value	Description
0 to 65536	Flash fault rate

HEALTH_INDICATOR register is cleared on reset.

5.1.15 MINI INPUT VOLTAGE (0X11E) (R):

MIN_INPUT_VOLTAGE register records the minimum input voltage seen since last reset.

Value	Description
0 to 45055	Minimum input voltage in mV

5.1.16 TARGET ENERGY (0X11F) (R):

TARGET_ENERGY register indicates the last flash target energy.

Value	Description
0 to 65536	Last flash target flash energy in in hundredths of Joules

5.1.17 MIN & MAX TEMPERATURE (0X64) (R):

Sx-IP records minimal and maximal temperatures. These values are available from the *MIN_MAX_TEMP* register.

15	-	-	-	8	7	-	-	-	0
Minimum temperature					Maximum temperature				

MAX_TEMP (0x64 LSB) (R)

7	-	-	-	-	-	-	-	-	0
Maximum temperature									

Value	Description
-50 to 120	Maximum temperature in °C

MIN_TEMP (0x64 MSB) (R)

7	-	-	-	-	-	-	-	-	0
Minimum temperature									

Value	Description
-50 to 120	Minimum temperature in °C

5.1.18 START COUNTER (0X69, 0X6A) (R):

Sx-IP records the number of device power-up events (software reset are not accounted) This 32bits counter available from the *START_COUNT_L* and *START_COUNT_H* registers.

31	-	-	-	16	15	-	-	-	0
Start count H (0x6A)					Start count L (0x69)				
Start count									

Value	Description
0 to 2 ³²	Number of device power-up (over device life)

5.1.19 TIME COUNTER (0X6B, 0X6C) (R):

The power-up time (since last power-up) is available from *TIME_COUNT_L* and *TIME_COUNT_H* registers.

31	-	-	-	16	15	-	-	-	0
Time count H (0x6C)					Time count L (0x6B)				
Time count									

Value	Description
0 to 2 ³²	Power-up time in minutes since last power-up

5.1.20 TOTAL TIME COUNTER (0X6D, 0X6E) (R):

Sx-IP records the total power-up time (over device life). This 32bits counter is available from *TOTAL_TIME_COUNT_L* and *TOTAL_TIME_COUNT_H* registers.

31	-	-	-	16	15	-	-	-	0
Total time count H (0x6E)				Total time count L (0x6D)					
Total time count									

Value	Description
0 to 2³²	Total power-up time in minutes since last (over device life)

5.1.21 FLASH COUNTER (0X6F, 0X70) (R):

Flash count (since last power-up) is available from *FLASH_COUNT_L* and *FLASH_COUNT_H* registers.

31	-	-	-	16	15	-	-	-	0
Flash count H (0x70)				Flash count L (0x6F)					
Flashes count									

Value	Description
0 to 2³²	Flash count last (since last power-up)

5.1.22 TOTAL FLASH COUNTER (0X71, 0X72) (R):

Sx-IP records the total flash count (over device life). This 32bits counter is available from *TOTAL_FLASH_COUNT_L* and *TOTAL_FLASH_COUNT_H* registers.

31	-	-	-	16	15	-	-	-	0
Total flash count H (0x72)				Total flash count L (0x71)					
Flashes count									

Value	Description
0 to 2³²	Total flash count last (over device life)

5.1.23 FLASH TUBE COUNTER (0X75, 0X76) (R):

Flash tube count record the total flash count of the flash tube. This 32bits counter is available from *FT_COUNT_L* and *FT_COUNT_H* registers.

31	-	-	-	16	15	-	-	-	0
Flash tube count H (0x76)				Flash tube count L (0x75)					
Flash tube count									

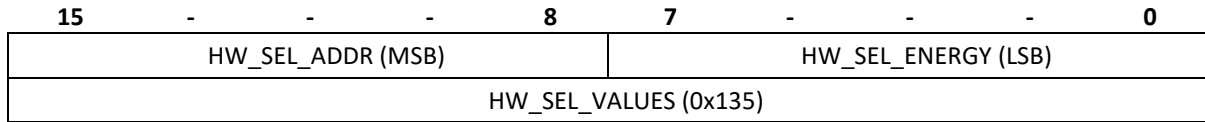
Value	Description
0 to 2³²	Flash tube count (since last Flash tube count clear)

Flash tube count can be cleared after flash tube replacement by sending a CLR_FT_COUNT command (refer to §4.6).

5.1.24 HARDWARE SELECTED VALUES (0X135) (R):

Computed values for energy level and address hardware selection.

Values are resulting from hardware inputs multiplexed according to *ENERGY_HW_SEL* and *ADDRESS_HW_SEL* registers' rules.



HW_SEL_ENERGY

Value	Description
0 to 15	Hardware selected energy level

HW_SEL_ADDR

Value	Description
1 to 247	Hardware selected Modbus address

5.2 STATUS REGISTER:

STATUS register provides most important device information concerning the device.

STATUS (0x100) (R)

Bit	Flag name	Description
1	INITIALIZED	Set using INIT_DONE command
2	READY	Sx-IP is ready to flash (internal 100ms refresh rate)
3	COM_ERROR	An error occurs on the Modbus link (details available from <i>COM_ERRORS</i> register)
4	ERROR	Global error flag
5	FAILURE	Global failure flag
8	ALT_ENERGY_LEVEL	Alternate energy level is selected (night mode)

5.3 ERRORS AND FAILURES FLAGS REGISTERS:

ERRORS, *FAILURES*, *INT_ERRORS* and *COM_ERRORS* register provides detailed error information.

5.3.1 ERRORS (0X101) (R)

Bit	Flag name	Description
0	VIN_OUT_OF_RANGE	Input voltage is not in the required range
2	WAS_NOT_READY	A flash request occurs while the device was not ready (cleared on next flash)
4	ENERGY_REG_ERROR	The energy regulation algorithm reaches one of its flash time limits
5	FLASH_ERROR	Last flash was missed or out of expected energy range
6	FAN_ERROR	Internal fan is not spinning at expected speed
7	OVERTEMP	Internal temperature exceed 80°C (2°C hysteresis)
8	INTERNAL_ERROR	An internal error occurs (details available from <i>INT_ERRORS</i> register)
9	CONFIG_ERROR	Some value in settings is not supported
10	OVERLOAD	The average output power overpass the limit

5.3.2 FAILURES (0X102) (R)

Bit	Flag name	Description
5	FLASH_FAILURE	Flash error occurrences exceed defined health parameters
6	FAN_FAILURE	Internal fan was in error for 10s
7	DCDC_ERROR	An over-voltage condition occurs on the internal high voltage supply
8	IDLE_CURRENT_ERROR	Unexpected current in the flash tube during idle state

5.3.3 COM_ERRORS AND INTERNAL ERRORS (0X103) (R)

15	-	-	-	8	7	-	-	-	0
INTERNAL_ERRORS (MSB)					COM_ERRORS (LSB)				

COM_ERRORS (0x103 LSB) (R)

Bit	Flag name	Description
0	RS485_FRAMING_ERROR	A received frame was not correct (uart frame level)
1	RS485_PARITY_ERROR	A received frame comes with bad parity
2	RS485_FIFO_OVERFLOW	More characters were received that the FIFO can hold
3	RS485_BUFFER_OVERFLOW	A character was received before last frame was processed
5	MODBUS_FRAME_ERROR	A frame was received with unexpected size
6	MODBUS_CRC_ERROR	A frame was received with a bad CRC.

INTERNAL_ERRORS (0x103 MSB) (R)

Bit	Flag name	Description
0	INTERNAL_VCC_ERROR	Internal VCC supply out of range error
1	MEMORY_ERROR	Memory is corrupted or contains unexpected value(s)
2	INT_COM_ERROR	Internal communication error
3	EXECUTION_ERROR	Something unexpected occurs
4	INTERNAL_12V_ERROR	Internal 12V supply out of range error

5.3.4 CONFIG_ERRORS (0X104) (R)

Bit	Flag name	Description
0	IDENTITY_ERROR	Device's identity registers' content is not valid
1	HARD_PARAM_ERROR	Hardware parameters registers' content is not valid
2	OP_PARAM_ERRORS	Operational parameters are not valid
3	SETTINGS_ERROR	Settings are not valid
4	IO_SETTINGS_ERROR	Inputs / outputs settings are not valid
5	FLASH_SEQUENCE_ERROR	Parameters do not allow to build a flash sequence
6	SYNC_SEQUENCE_ERROR	Parameters do not allow to build a synchronization signal sequence
7	FTIME_TABLE_ERROR	Ftime table content is not valid
8	ENERGY_TABLE_ERROR	Energy table content is not valid
9	CONFIG_CRC_ERROR	Configuration registers' check sum is not valid

6 ADVANCED FUNCTIONALITIES

6.1 HEALTH MONITORING

Sx-IP device has a build in configurable health monitoring function.

It allows to detect when a device regularly miss flashes, that is relevant of a flash tube end of life.

6.1.1 HEALTH MONITORING ALGORITHM

The algorithm is:

- Each missed flash *HEALTH_INDICATOR* register is incremented by *MISS_FLASH_WEIGHT*.
- Each succeeded flash *HEALTH_INDICATOR* register is decremented by 1 (if not zero).
- If *HEALTH_INDICATOR* reach *FLASH_HEALTH_TH*, a flash failure is triggered

Design notes:

Setting *FLASH_HEALTH_TH* to zero inhibits triggering a flash failure.

Flash health evolution laws and failure thresholds are factory configured. It can be adapted to client needs.

Default values are 1000 for *MISSED_FLASH_WEIGHT* and 1000 for *HEALTH_THRESHOLD*. It allows 10 missed flashes every 10 000 flashes.

6.1.2 HEALTH MONITORING SET-UP

Health monitoring algorithm allows to adjust the health monitoring based on two parameters:

- The maximum allowed consecutive missed flashes; subsequently called **CMF**
- The maximum allowed missed flash rate; subsequently called **MFR**

Health monitoring registers' value can be calculated using following equations:

$$MISS_FLASH_WEIGHT = 1 / MFR$$

$$FLASH_HEALTH_TH = (CMF + 1) * MISS_FLASH_WEIGHT$$

Calculation example:

Let's assume that we want the flash failure to trigger if the missed flash rate rise above 1% or if more than two consecutive flashes are missed:

- Expected CMF = 2 consecutive flashes
- Expected MFR = 1%

$$MISS_FLASH_WEIGHT = 1 / 1\% = 100$$

$$FLASH_HEALTH_TH = (2 + 1) * 100 = 300$$

7 TROUBLESHOOTING

7.1 FAILURES MANAGEMENT

Failures make Sx-IP unable to operate.

In case of failure, Sx-IP will try to resume by a software reset every 5s (configurable refer to §3.9).

7.2 ERRORS MANAGEMENT

Errors are usually not critical.

Most errors (fan error, internal errors, communication errors) are for information. These errors do not cause degradation of the device performances.

Configuration errors make the device unable to flash. Most of time, configuration errors result of inappropriate settings values that need to be corrected.

Over-temp error makes the device unable to flash until the temperature drop two degrees below the over-temp threshold.

Overload error makes the device unable to flash for a few seconds, until compute average power drop below 90% of the maximum allowed average power.

Fan error will cause a failure if it lasts for 10s.

Vin out of range error is maintained for 10s every time the input voltage is detected out of range.

If the input voltage remains out of range for more than several milliseconds, it may cause multiple errors and failures due to internal supplies fall.

7.3 ERRORS AND FAILURES WORKAROUND

Error flag	Causes	Workaround
Vin out of range	Input voltage has been detected out of range during the last 10s.	Check power supply voltage, current capacity and voltage drop in cables Supervise the <i>MIN_VOLTAGE</i> register
HT out of reg	The device fails in reaching the energy storage regulation point	Contact Phoxene
Was not ready	A flash request occurs while the device was not ready.	Check that the delay between two flash requests is compatible with the flash configuration
Energy reg error	The energy regulation algorithm reaches a limit	Check / replace the lamp Contact Phoxene
Flash error	Last flash was missed or out of expected energy range	Nothing to do.
Fan error	Internal fan has been detected low	Nothing to do.
Over-temp	Internal temperature exceeds over-temperature threshold	Reduce average power (flash energy and/or cadence) Reduce ambient temperature. Protect the flash housing from direct sunlight. Increase air-flow around the flash housing
Config error	Some settings are not supported	Fix settings Reload factory settings Contact Phoxene
Overload	The average output power overpass the limit.	Reduce average power (flash energy and/or cadence)
COM error	An error occurs on the Modbus link	Detailed error flags are available in <i>COM_ERROR</i> register
RS485 Framing error	Received frame is not correct	Check serial parameters (baud rate, nb bits, stop bits) Check RS485 link quality (common mode voltage...)
RS485 parity error	Received frame parity is not correct	Check serial parameters (baud rate, nb bits, stop bits) Check RS485 link quality (common mode voltage...)
RS485 FIFO overflow	More characters were received that the FIFO can hold	Check frame length Check frame cadence (was the last frame answered ?)
RS485 buffer overflow	A character was received before last frame was processed	Check frame cadence (was the last frame answered ?)
Modbus Frame error	Frame length is not as expected	Check Modbus client frame construction
Modbus CRC error	The frame CRC is not valid	Check Modbus client CRC algorithm Check Modbus client frame construction
Internal error	An internal error occurs	Contact Phoxene
Flash failure	Device fails to flash and/or flash energy is not in expected range.	Check / replace the flash tube Contact Phoxene
Fan failure	Internal fan failure	Contact Phoxene
DC/DC error	An over-voltage condition occurs on the internal high voltage supply	Contact Phoxene
Idle current error	Unexpected current in the flash tube in idle state	Contact Phoxene