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SFP450/600 I²C Interface Programming Manual

1 Scope

This document describes in detail the I²C communication interface of the SFP450/600 series. (SFP450-, SFP600, ….) This includes the physical layer and the SW protocol.

2 SFP450/600 I²C Interface General Characteristic

SFP450/600 I²C interface	**slave**
I²C Device Addressing Format	**7bit**
Device Address Range	**AC_{Hex}...AF_{Hex}, $7F_{Hex}$,$7D_{Hex}$**
Max. SFP450/600 on one I²C Bus	**2**
Maximum I²C clock	**100kHz**
Maximum I²C clock without holding the SCL line down	**Serial EEPROM: 100kHz** **Status Port: 6.5kHz**
Pull-Up Voltage	**3.3…4V**
SDA/SCL internal series resistors	**100Ω**
Internal Pull-Up	**10kΩ**
Internal Pull-Up voltage	**3.3V**
Internal capacitance	**140pF**
Internal Pull-Up Address lines	**3.2kΩ**
Internal Pull-Up Address lines voltage	**3V**
Internal Pull-Up Write Protect	**4.7k**
Recommended external Pull-Up for SDA and SCL	**1.2kΩ …2kΩ**
Data Organization	**-Serial EEPROM (256 x 8bit)** **-Status Port with commands**

Figure 2-1 Characteristic

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4 SFP450/600 I²C features

4.1 Dynamic data

The SFP450/600 series supports following monitoring features:

-Measured Output 1 voltage [V]
-Measured Output 1 current [A]
-Power Supply seated/not seated
-Input Voltage in range/out of range
-All Output Voltage in range/out of range
-Output 1 over current occurred true/false
-Output 1 and 2 under voltage occurred true/false
-Output 1 over voltage occurred true/false
-Fan OK/failure
-Over Temperature true/false

4.2 Static data

In the EEPROM are following static data stored:

-Power Supply Model
-Serial Number
-Power-One Revision
-MFG Year
-MFG Month
-MFG Day
-MFG Name
-MFG Location Code
-Specified Output 1 Voltage
-Specified Output 2 Voltage
-Specified Output 1 Current
-Specified Output 2 Current
-Specified Output Power
-Minimum Specified Input Voltage
-Maximum Specified Input Voltage
-xx Bytes EEPROM for Customer use
-Spec Number
-Time Stamp
-Sequential Nr
-Checksum over static range

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General I²C HW configuration

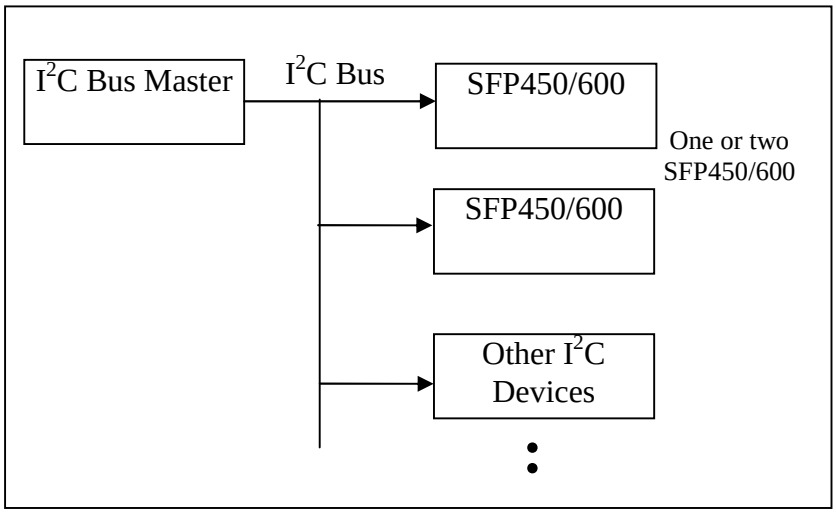

Figure 4-1 System Overview

4.3 Connecting the SFP450/600 to the I²C Bus

The following diagram shows how the SFP450/600 can be connected to the I²C Bus.

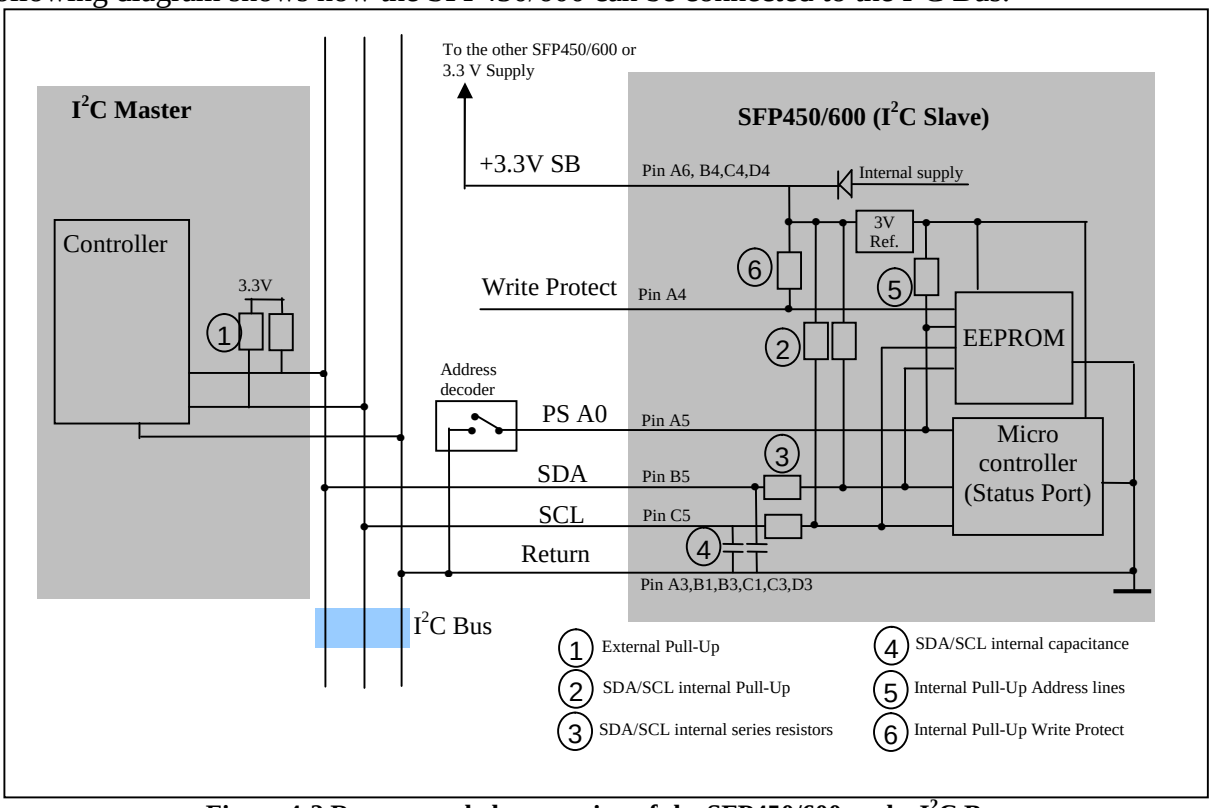

Figure 4-2 Recommended connecting of the SFP450/600 to the I²C Bus

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4.4 SFP450/600 I²C Supply (Slave)

The SFP450/600 Micro Controller/EEPROM is powered over the internal supply of the SFP450/600. For redundancy in case of DC failure or SFP450/600 internal failure the SFP450/600 Micro Controller/EEPROM can be powered over the "+3.3VSB" (Pin A6, B4,C4,D4 ;3.3V). If there is no power for the SFP450/600 Micro Controller the entire I²C Bus is blocked.

4.5 Device Address

The first byte after the START condition on the Bus is the device address sent out by the Bus Master to determine which device is being selected. The I²C Bus allows 7-bit or 10-bit addressing. The SFP450/600 Interface uses a 7-bit address mode as defined in the Philips I²C specification. The SFP450/600 contains an EEPROM and a STATUS (microcontroller) device and each device on the I2C Bus has to be assigned to a unique address.

As shown below in **Error! Reference source not found.**the address byte is built up from three parts:
- Bit 2...7: These bits are always the same independent of any address line.
- Bit 1: This bit depends how the Address line A0 is connected on the backplane on the address decoder. These are logic 1 if open and logic 0 if wired to 0V (Return).

-Bit 0: This bit is the read/write bit (R=1/W=0) and determines the direction of the data from or to the Master.

	MSB							LSB
Bit	7	6	5	4	3	2	1	0
SFP450/600-S102 EEPROM Device Address	1	0	1	0	1	1	PS A0	direc
	fix	fix	fix	fix	fix	fix	addr. line	R/W
SFP450/600-S102 STATUS Device Address	0	1	1	1	1	1	PS A0	direc
	fix	fix	fix	fix	fix	fix	addr. line	R/W

Figure 4-3 Device Address

	Address Line PS A0	Read/ Write	Device Address [Bin]	Device Address [Hex]	Device Address [Dec]
SFP450/600 EEPROM Device address	open	read	1010'1111	AF	175
SFP450/600 EEPROM Device address	open	write	1010'1110	AE	174
SFP450/600 STATUS Device address	open	Read	0111'1111	7F	127
SFP450/600 EEPROM Device address	0V	read	1010'1101	AD	173
SFP450/600 EEPROM Device address	0V	Write	1010'1100	AC	172
SFP450/600 STATUS Device address	0V	Read	0111'1101	7D	125

Figure 4-4 Device Address Table

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Example: On the backplane PS A0 is connected to 0V, you will have the following device address to read a byte from the SFP450/600 EEPROM:

	MSB							LSB
Bit	7	6	5	4	3	2	1	0
SFP450/600 EEPROM Device Address	**1**	**0**	**1**	**0**	**1**	**1**	**0**	**1**
	fix	fix	fix	fix	fix	fix	A0	R

->$1010'1101_{Bin}=AD_{Hex}=173_{Dec}$

4.6 I²C Bus Master and clock (SCL) speed

The I²C Bus Master controls communications between the Master and all I²C devices connected to the bus. If during an I²C communication cycle the SFP450/600 Status Port is interrupted by an internal service interrupt, the SFP450/600 will hold the SCL line low to force the master into a wait state. Data transfer will continue when the SFP450/600 releases the SCL line. Please note if the I²C bus is communicating with a clock frequency slower than 6.5kHz, the SCL line will not be held low. The SFP450/600 EERPOM is an ATMEL AT24C02 compatible device and is not holding down the SCL line.

4.7 Maximum and minimum values for Pull-Up resisters

For I²C-bus systems, the values of the Pull-Up resistors depend on the following parameters:
- Supply voltage
- Bus capacitance
- Number of connected devices (input current + leakage current).

The supply voltage limits the minimum value of the Pull-Up resistor due to the specified minimum sink current of 3mA. On a 3.3V supply, this makes $\mathbf{R_{min}=3.3V/3mA=1.1k\Omega}$.
The bus capacitance is the total capacitance of wire, connections and pins. This capacitance limits the maximum value of the Pull-Up resister due to the specified rise time. For a System with 380pF capacitance (two SFP450/600 and a wire capacitance of 100pf) $\mathbf{R_{max}=2.1k\Omega}$.

For further information concerning the Pull-Up resister, refer to:
I²C Bus specification, 16.1 Maximum and minimum values of resistors Rp and Rs for Standard-mode I2C-bus devices.

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5 SW Protocol

The static data are stored in a serial I^2C EEPROM and the dynamic data can be requested over the Status Port with three commands.

5.1 Static serial EEPROM data

Therefore each EEPROM address has defined data; this definition is documented in the file: 104718_xxx.pdf, 104788_xxx.pdf

	Dez		Hex
Address	0	static data	0
	1	static data	1
	251	static data	FB
	252	checksum	FC
	253	checksum	FD
	254	checksum	FE
	255	checksum	FF

Figure 5-1: Data Organization

There are three different message formats for the SFP450/600 Serial EEPROM:
-Read an EEPROM byte
-Read an EEPROM block
-Write an EEPROM byte

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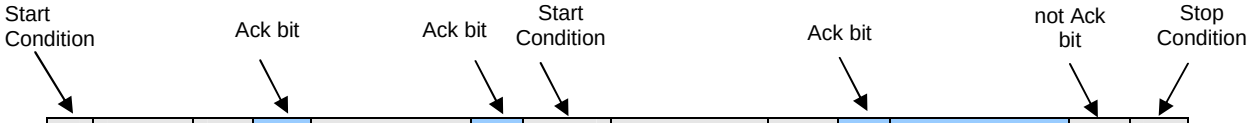
5.1.1 How to Read an EEPROM byte

1) "Start condition" from Master
2) Master sends "Device address" with "write attribute"
3) "Acknowledge" from Slave device (SFP450/600)
4) Master sends "EEPROM address"
5) "Acknowledge" from Slave device (SFP450/600)
6) "Repeated start" from Master (Sr/S)
7) Master sends "Device address" with "read attribute"
8) "Acknowledge" from Slave device (SFP450/600)
9) Slave sends "Data byte"
10) "Not Acknowledge" from Master (power management system)
11) "Stop condition" from Master



S	Slave Adr.	W	A	EEPROM Adr.	A	Sr/S	Slave Adr.	R	A	Data Byte	/A	P
	8bit			8 bit			8bit			8 bit		

Master
Slave (SFP450/600 EEPROM)

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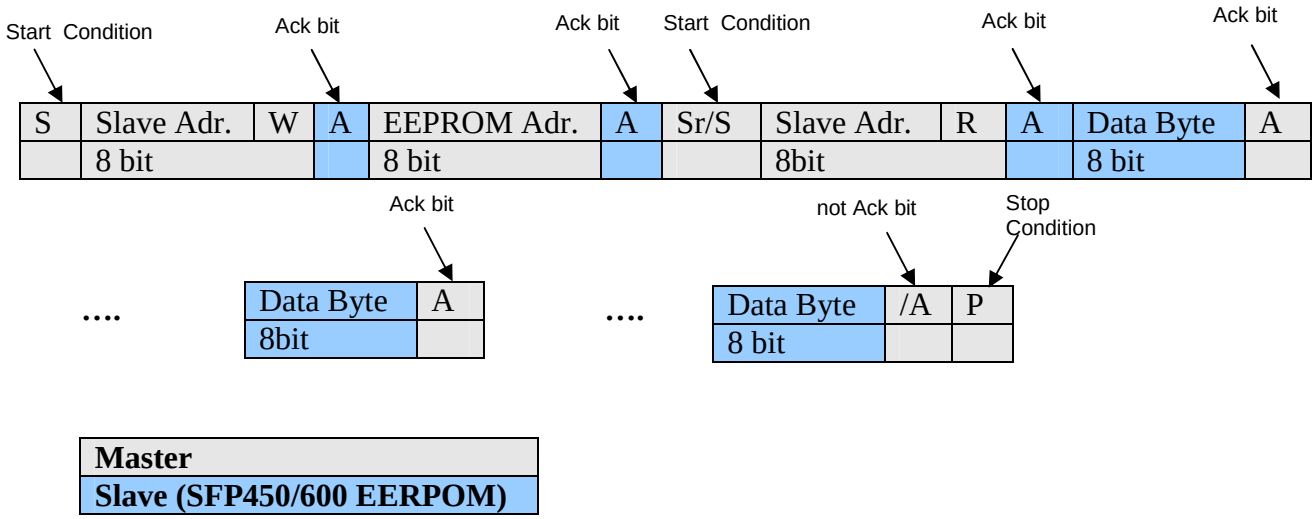
5.1.2 How to read an EEPROM data block

1) "Start condition" from Master
2) Master sends "Device address" with "write attribute"
3) "Acknowledge" from Slave device (SFP450/600-S102)
4) Master sends "EEPROM address"
5) "Acknowledge" from Slave device (SFP450/600-S102)
6) "Repeated start" from Master (Sr/S)
7) Master sends "Slave address" with "read attribute"
8) "Acknowledge" from Slave device (SFP450/600-S102)
9) Slave sends "Data byte"
10) "Acknowledge" from Master (power management system)

n-time repetition of step 9) and 10)

11) Slave sends "Data byte"
12) "Not Acknowledge" from Master (power management system)
13) "Stop condition" from Master



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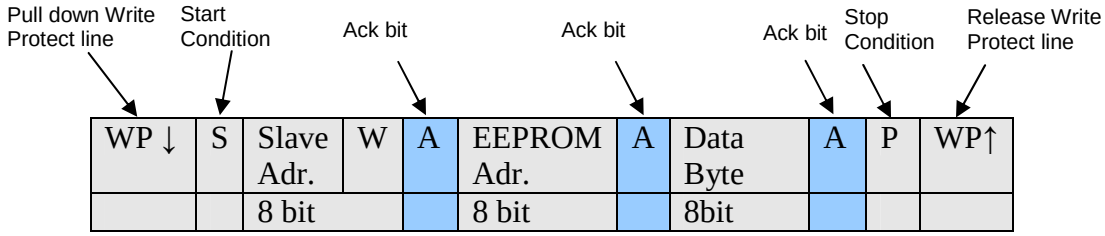
5.1.3 How to write an EEPROM byte

1) Pull down the Write Protect line (Pin A4)
2) "Start condition" from Master
3) Master sends "Slave address" with "write attribute"
4) "Acknowledge" from Slave device (SFP450/600)
5) Master sends "EEPROM address"
6) "Acknowledge" from Slave device (SFP450/600)
7) Master sends "Data byte"
8) "Acknowledge" from Slave device (SFP450/600)
9) "Stop condition" from Master
10) Release the Write Protect line (Pin A4)
11) Wait 5ms for the next EEPROM communication (EEPROM write time)



Master
Slave (SFP450/600 EEPROM)

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5.1.4 Power One EEPROM Definitions

5.1.4.1 Timestamp

The UNIX timestamp is a 32-bit big-endian integer that represents the number of seconds since January 1, 1970 at 00:00:00 UTC (GMT).

Byte 220								
Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Value of the bit	2^{31}	2^{30}	2^{29}	2^{28}	2^{27}	2^{26}	2^{25}	2^{24}
Seconds Value	x	x	x	x	x	x	x	x
Byte 221								
Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Value of the bit	2^{23}	2^{22}	2^{21}	2^{20}	2^{19}	2^{18}	2^{17}	2^{16}
Seconds Value	x	x	x	x	x	x	x	x
Byte 222								
Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Value of the bit	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}
Seconds Value	x	x	x	x	x	x	x	x
Byte 223								
Bits	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Value of the bit	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}
Seconds Value	x	x	x	x	x	x	x	x

Figure 2 Table for Time stamp

5.1.4.2 Checksum32

Checksum 32 is calculated from field 220 to 251.

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5.2 Dynamic Status Port Data

The I^2C Master can read from the status port the status of the PS, the measured voltage and current. There exist three commands.
0x01: read status byte
0x02: read measured voltage
0x03: read measured current

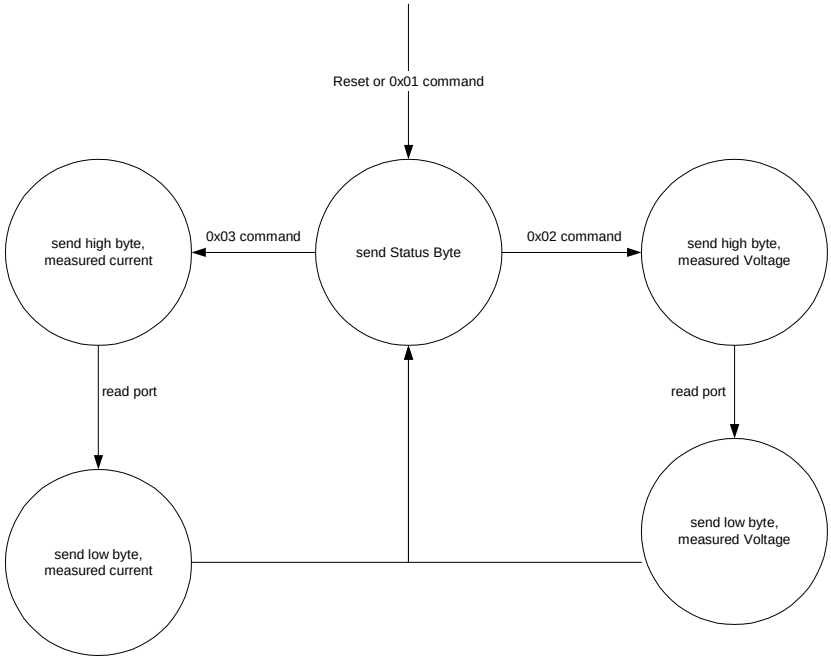

Figure 3 Software states for the Status port

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5.2.1 Status Byte definition

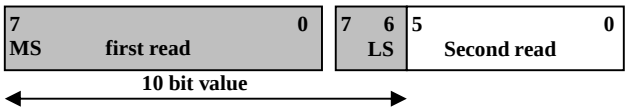
			Explanation
Bit 0	PS present = 0 (True)	False = 1	This Signal indicates that the PS is present.
Bit 1	PW OK = 1 (PS OK)	Fault = 0	Output Power Good, signalized that all outputs are valid.
Bit 2	AC OK = 0 (OK)	Fault = 1	AC in specified range.
Bit 3	OC +12V = 1 (PS OK)	Fault = 0	+12 V Over Current goes low when it exceeds the current rating. The output will be latched.*
Bit 4	UV+12V,UV+3V3SBY = 1 (PS OK)	Fault = 0	+12V Under Voltage goes low, when +12V dips under the specified voltage and shuts down the Unit. The Output will be latched.* Or the 3.3VSBY has an Under Voltage.
Bit 5	OV +12V = 1 (PS OK)	Fault = 0	+12V Over Voltage goes low, when +12V trips over the specified voltage and shuts down the unit. The Output will be latched. *
Bit 6	ALERT = 1 (PS OK)	Fault = 0	The Alert signal goes high, if one of the fans falls below a threshold speed value or an OTP occurs.
Bit 7	OTP = 1(PS OK)	Fault=0	The Over Temperature Protection circuit has shut down the unit.

Table for status information

*Latched states can only be cleared by recycling AC mains or toggling PS_ON.

5.2.2 Voltage/current data interpretation

The voltage and current monitor can be accessed with the commands 0x02 and 0x03. The values are returned in an unsigned 10bit number which is left justified. For the voltage measuring the resolution is



20mV/bit and for the current resolution is 50mA/bit.
Example of a voltage measuring:

Bit 7							Bit 0	Bit 7							Bit 0
1	0	0	1	0	1	1	0	0	0	x	x	x			x
First byte 1								Second byte							

This gives the value: $10'0101'1000_{BIN} = 258_{HEX} = 600_{DEZ}$
The measured voltage is 600_{DEZ} *20mV/bit=**12000 mV**

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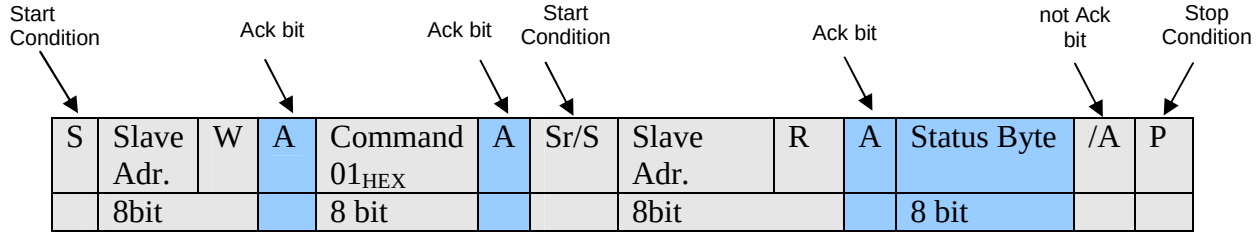
5.2.3 How to read the status byte from Status Port

To read the status byte, is like reading from a serial EEPROM at address 0x01.

1) "Start condition" from Master
2) Master sends "Status Port Device address" with "write attribute"
3) "Acknowledge" from Slave device (SFP450/600 Status Port)
4) Master sends "Status Port command address 01"
5) "Acknowledge" from Slave device (SFP450/600 Status Port)
6) "Repeated start" from Master (Sr/S)
7) Master sends "Status Port device address" with "read attribute"
8) "Acknowledge" from Slave device (SFP450/600 Status Port)
9) Slave sends "Status byte"
10) "Not Acknowledge" from Master (power management system)
11) "Stop condition" from Master



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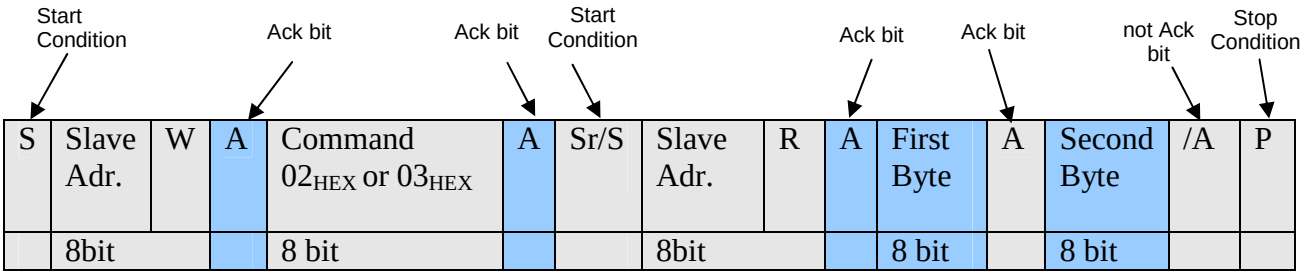
5.2.4 How to read the measured output Voltage/Current

1) "Start condition" from Master
2) Master sends "Status Port Device address" with "write attribute"
3) "Acknowledge" from Slave device (SFP450/600 Status Port)
4) Master sends "Command 02 (Voltage) or 03(Current)"
5) "Acknowledge" from Slave device (SFP450/600 Status Port)
6) "Repeated start" from Master (Sr/S)
7) Master sends "Status Port Device address" with "read attribute"
8) "Acknowledge" from Slave device (SFP450/600 Status Port)
9) Slave sends "first data Byte"
8) "Acknowledge" from Master (power management system)
9) Slave sends "second data Byte"
10) "Not Acknowledge" from Master (power management system)
11) "Stop condition" from Master



Master
Slave (SFP450/600 Status Port)

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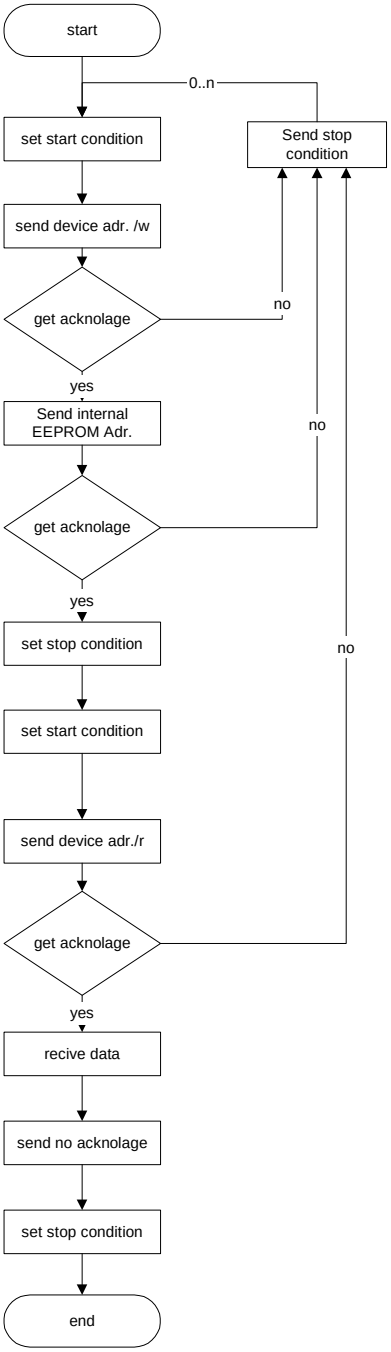
5.3 Error Handling

Errors in the communication can occur. The following flowchart shows how the Bus Master can handle such errors.

5.3.1 Read Byte



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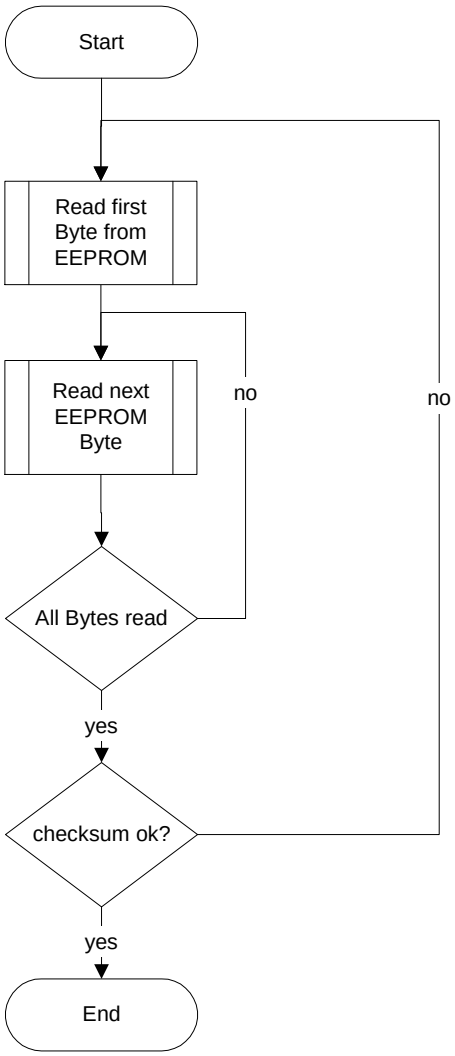
5.3.2 Read Static serial EEPROM



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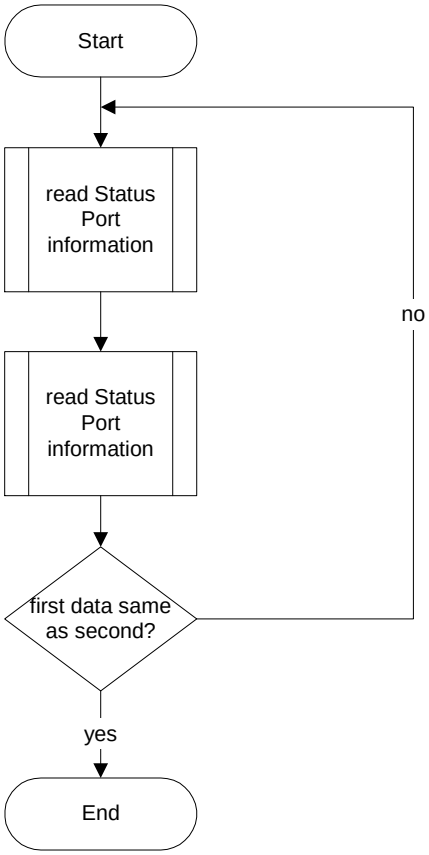
5.3.3 Read Status Port

To be sure that there are no corrupt data, you have to read the data twice.



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6 Power-One I²C Interface tool

The Power-One I²C – Management Software (HZZ02002SW, www.power-one.com) demonstrates all the I²C interface features of the SFP450/600.

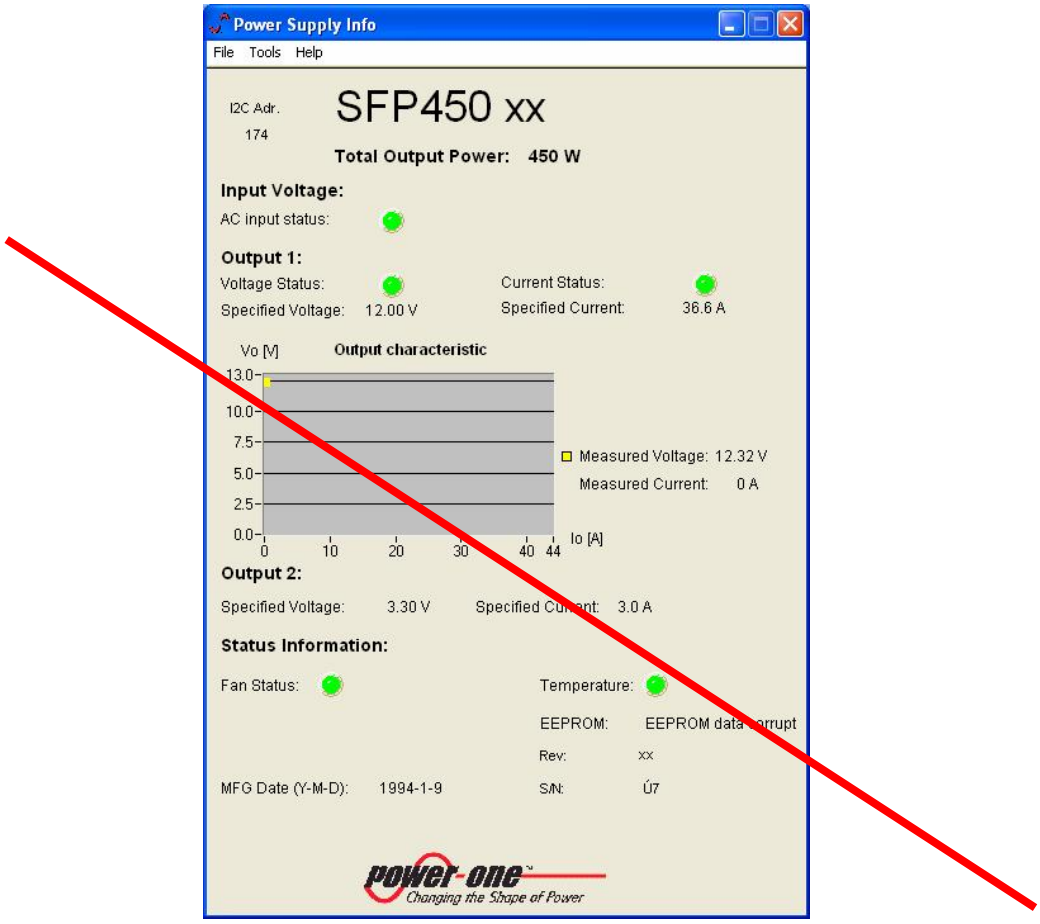
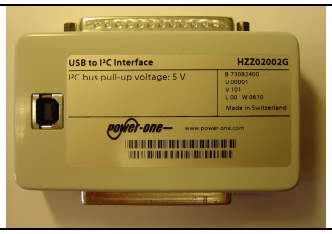


Figure 6-1 Screenshot SFP450/600

Power-One I²C – Management Software supports two I²C converters:

iPort MIIC-201 (Micro Computer Control)	HZZ02002G from Power-One
	

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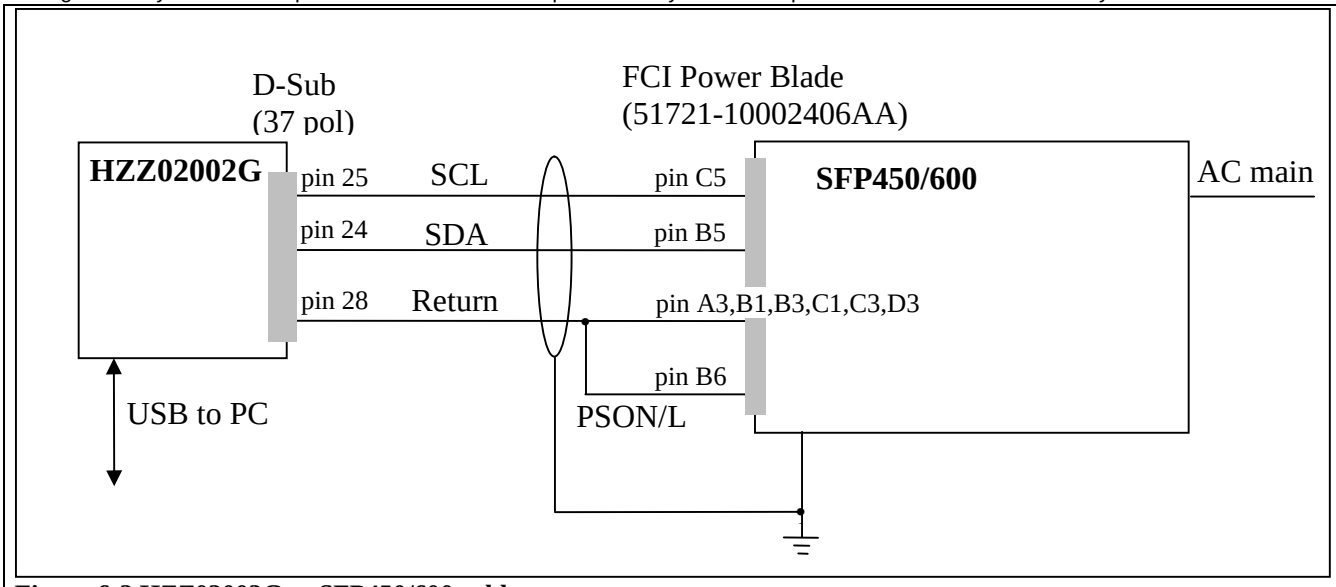

Figure 6-2 HZZ02002G to SFP450/600 cable

The HZZ02002G has the Pull-Up resisters connected to 5V and 3.3V compatible inputs. The SFP450/600 has an internal clamp circuit to 4V. Connect “SDA”(pin B5), “SCL”(pin C5) and “Return” (pin A3,B1,B3,C1,C3,D3) to the I^2C to USB converter. Connect “PSON/L” to “Return” to enable the SFP450/600 and plug the SFP450/600 to the mains.

The I^2C EEPROM device address: 175_{Dez} (read)
The I2C Status Port device address: 127_{Dez} (read).

In your final application the I^2C master will be a Micro Computer or an FPGA with an I^2C interface. That makes it easy and inexpensive to use the interface.

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7 Bibliography

-Philips Semiconductors, The I 2C-BUS Specification, V.2.1, Document order number: 9398 393 40011
www.semiconductors.**philips**.com/ acrobat/literature/9398/39340011.pdf

-Philips SemiconductorsI2C Handbook
www.semiconductors.**philips**.com/ acrobat/various/**philips_i2c**_handbook.pdf

-Power-One, SFP450/600 Data-Sheet
-Power-One, SFP450/600 I2C Table

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9 Glossary

µC	Micro Controller
Bin	Value in binary number system
Dec	Value in decimal number system
EEPROM	Electrically Erasable Programmable Read Only Memory
Hex	Value in hexadecimal number system
I^2C Bus	Inter-Integrated Circuit Bus
kHz	SI unit of frequency: Hertz(1/s) * 10^3
LSB	Least significant bit
MFG	Manufacturing
MSB	Most significant bit
pF	SI unit of Capacitance: farad($kg^{-1}\cdot m^{-2}\cdot A^2\cdot s4$) * 10^{-12}
SCL	serial clock line
SDA	serial data line