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Interface Practices Subcommittee

SCTE STANDARD

SCTE 199 2019

**Interface Specifications for an RF-Modulated Small
Form Factor Pluggable Optical Receiver Module
(SFP-RF-USRx)**

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1.0 REVISION HISTORY

Revision	Date	Description
R01	9/26//2012	Initial publication
R02	10/8/2012	Updates to the Electrical Interface section from F2F
R03	10/26/2012	Updates the Management Interface and Electrical Interface
R04	10/30/2012	Updates from the meeting, plus addition of appendix describing losses
R05	11/5/12	Made the updates to the following: • Section 7.2.2, Number 2 • Table 2, bytes 84 and 85 • Table 3, bytes 84 and 85 • Table 4 updates • Section 8.3.2
R06	11/7/12	Made updates to the following: • Table 2 • Table 3 • Table 4 • Section 8.3 • Section 9.3 • Appendix A
R07	11/13/12	Made the following updates: • Removed redundant fields from Table 70h • Updated descriptions of MOD_DESEL; assert and de-assert were backwards
R08	11/19/12	Made updates to the following: • Tables 2 and 3 • Added Table 4 • Added Table 5 • Updates to Table 7 • Updated the formula in section 8.3.2 • Added Table 10
R09	11/20/12	Reviewed and accepted changes during the 11/20/12 meeting. General clean up and definitions updates. Open issues still tracked/commented.
R10	11/28/12	Reviewed and accepted changes during the 11/28/12 meeting. This is the proposed final draft.
R11	12/4/12	Additional changes made during final review; changes are tracked
R12	12/11/12	Additional changes made during final review; changes are tracked
R13	12/13/12	Reverted the final sentence of the MOD_DESEL description back to what it was in the MSA.

Revision	Date	Description
R14	12/18/12	SCTE candidate

2.0 SCOPE

This document is identical to SCTE 199 2013 except for informative components which may have been updated such as the title page, NOTICE text, headers and footers. No normative changes have been made to this document.

The integration of optical interfaces into headend equipment offers cost and power savings to MSOs. However, implementing optical interfaces in these devices presents significant technical challenges, since the lack of standardization may result in too many combinations of interfaces to support effectively in a headend device.

Because of this challenge, it is proposed to create a standard that specifies the interfaces between an upstream laser receiver module and its host. The module is based on [XFP MSA], but is in an SFP form factor and will receive RF-modulated optical signals. This optical receiver module could be deployed in headend equipment, such as the Converged Cable Access Platform (CCAP) or HFC optoelectronics products, providing a standardized, interoperable solution. The optical receiver module will function as an upstream receiver for the output of return optical transmitters inside fiber optic nodes.

This standard focuses on the communication, electrical, and mechanical interfaces for the optical receiver module. Requirements held within this standard apply both to the receiver module and its host.

3.0 NORMATIVE REFERENCES

The following documents contain provisions, which, through reference in this text, constitute provisions of this specification. At the time of subcommittee approval, the editions indicated were valid. All standards and specifications are subject to revision, and parties to agreement based on this specification are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

Reference	Description
[IEC 61755-3-1]	IEC 61755-3-1:2006, ed. 1.0, July 1, 2006, Fibre optic connector optical interfaces – Part 3-1: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical full zirconia PC ferrule, single mode fibre. IEC Sub-committee 86B
[IEC 61755-3-2]	IEC 61755-3-2, ed. 1.0, July 12, 2006, Fibre optic connector optical interfaces - Part 3-2: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical full zirconia ferrules for 8 degrees angled-PC single mode fibres, IEC Sub-committee 86B

[INF-8074]	INF-8074i, Revision 1.0, May 12, 2001, Specification for SFP (Small Formfactor Pluggable) Transceiver, SFF Committee, http://www.sffcommittee.com/
[FINISH]	IEC 61300-3-35, ed. 1.0, November 20, 2009, Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-35: Examinations and measurements - Fibre optic connector endface visual and automated inspection, IEC Sub-committee 86B
[SFF-8083]	SFF-8083, Revision 2.5, January 19, 2010, 0.8mm Card Edge Connector for 8/10 Gb/s Applications, SFF Committee, http://www.sffcommittee.com/
[SFF-8432]	SFF-8432, Revision 5.0, July 16, 2007, Improved Pluggable Formfactor, SFF Committee, http://www.sffcommittee.com/
[SFF-8433]	SFF-8433, Revision 0.7, June 5, 2009, Improved Pluggable Formfactor (IPF) for SFP+ Ganged Cages, SFF Committee, http://www.sffcommittee.com/
[XFP MSA]	INF-8077i, Revision 4.5, August 31, 2005, 10 Gigabit Small Form Factor Pluggable Module, SFF Committee, http://www.sffcommittee.com/

4.0 INFORMATIVE REFERENCES

The following documents may provide valuable information to the reader but are not required when complying with this specification.

Reference	Description
[UM10204]	UM10204, Version 4.0, February 13 2012, The I2C-Bus specification and user manual, NXP Semiconductors

5.0 COMPLIANCE NOTATION

“SHALL”	This word or the adjective “REQUIRED” means that the item is an absolute requirement of this specification.
“SHALL NOT”	This phrase means that the item is an absolute prohibition of this specification.
“SHOULD”	This word or the adjective “RECOMMENDED” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.
“SHOULD NOT”	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
“MAY”	This word or the adjective “OPTIONAL” means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the

	product, for example; another vendor may omit the same item.
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6.0 DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

Term	Definition
AGC	Automatic Gain Control
APC	Angled Physical Contact
APD	Avalanche Photodiode
CCAP	Converged Cable Access Platform
CDR	Clock Data Recovery
CLEI	Common Language Equipment Identification
CMTS	Cable Modem Termination System
DC	Direct Current <i>or</i> Directional Coupler
DSA	Digital Step Attenuator
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMI	Electromagnetic Interference
HFC	Hybrid Fiber-Coax
host	The device into which the optical module is integrated.
I/O	Input/Output
I ² C	Inter-Integrated Circuit, a 2-wire communication interface
LOS	Loss of Signal
NVRAM	Non-Volatile Random-Access Memory
OMI	Optical Modulation Index
PD	Photodiode
R/W	Read/Write
RF	Radio Frequency
RFoG	RF over Glass
RX	Receive
SCL	Serial Clock
SDA	Serial Data
SFP	Small Formfactor Pluggable
TEC	Thermo-Electric Cooler
TX	Transmit
UPC	Ultra Physical Contact
USRx	Upstream Receiver
XFP	10 Gigabit Small Form Factor Pluggable; a standard for an optical transceiver. See [XFP MSA].

7.0 MANAGEMENT INTERFACE

2-Wire Communications (I²C) for the SFP-RF-USRx module are based upon [XFP MSA]. I²C is an implementation of the NXP (formerly Philips) I²C [UM10204] specification with mapped memory address locations (also known as “well-known addresses”) for diagnostics and operations. The SFF Committee specifies the I²C common memory mapping in [XFP MSA] for SFP and XFP, as well as additional physical layer requirements. This specification uses the same well-known memory map locations (addresses)

for functions that are the same or substantially similar. Because the SFP-RF-USRx is a dual receiver (and not a transceiver), there is a need for additional and different functions that the SFF specifications do not require.

The SFP-RF-USRx module shall implement the I²C requirements specified in [XFP MSA], except where specified differently in the following sections.

7.1 Summary of 2-Wire Communications Requirements

In [XFP MSA] 2-wire communication requirements are spread across several sections, including section 4.2 and Table 26, section 2.6 and Table 3. The following bullets summarize these requirements; refer to [XFP MSA] for complete details.

- I²C communications may not be available for up to 300 ms after power up or reset
- The MOD_DESEL pin functions as defined in section 4.2 of [XFP MSA]. Note, if the I²C interface bus is not shared, the MOD_DESEL pin may be pulled *low* permanently.
- There must be at least 20 μ s between the STOP signal and the next START signal for a particular module.
- The clock rate can be as high as 400 kHz (I²C fast mode).
- Up to two START signals per command are allowed (the second START is also known as a RESTART signal).
- Only one STOP signal is allowed per command.
- Multiple master systems are not supported.
- Host boards shall accommodate SFP-RF-USRx modules that hold the SCL line *low* (clock stretching) for up to a maximum of 500 μ s during an I²C read or write operation.
- After a write from the host to the module, the module may not respond to further I²C commands for up to 40 ms (typically this would be for writing non-volatile values). The phrase “not respond” means that the device address given immediately after the START signal from the host is not acknowledged by the module.
- I²C packet error checking protocol is optional as defined in the [XFP MSA].

7.2 Theory of Operation

Using Chapter 5: Management Interface of [XFP MSA] as reference, the following sections define the operation of the SFP-RF-USRx module I²C interface that is used for serial ID, digital diagnostics and other control/monitoring functions.

7.2.1 SFP-RF-USRx Module Boot Up Sequence

When a SFP-RF-USRx module is plugged in, the host needs to perform a number of initialization steps in a particular order with a particular timing. Some of these involve the SFP-RF-USRx module pins, and some involve I²C communications. As most of these are documented in the [XFP MSA] or are implied by stated dependencies, a reference to the location(s) in that document will accompany each step in the following sequence descriptions.

Before the boot up sequence can be discussed, communications and host requirements need to be understood.

7.2.1.1 I²C Communications Requirements

Once I²C is operational, the host shall adhere to the following timing and pin requirements (see [XFP MSA] section 4.2, Table 26):

- The host shall pull MOD_DESEL *low* for a minimum of 2 ms before issuing the START signal (Host_select_setup).
- While MOD_DESEL is *low*, the host shall wait at least 20 μs after the previous STOP signal before issuing a new START signal (t_{BUF}).

If the SFP-RF-USRx module is not sharing the I²C interface bus with other SFP-RF-USRx modules, the MOD_DESEL pin may be left *low* indefinitely. Otherwise, it shall be pulled *high* for at least 2 ms before another command is executed on the shared bus (presumably to a different SFP-RF-USRx module).

Write operations may cause the SFP-RF-USRx module to not respond to further I²C signals or messages for up to 40 ms (t_{WR} in section 4.3, Table 27, and section 4.5.7 of [XFP MSA]). The specification does not restrict this to EEPROM writes. This applies for writes from one to four bytes (the limit for a write is four bytes).

The SFP-RF-USRx module may perform a clock stretch of up to 500 μ s during read or write operations ($T_{\text{clock_hold}}$, [XFP MSA] section 4.3, Table 27). This is distinct from unresponsiveness after a write operation (t_{WR}).

7.2.1.2 Pin State Prior to SFP-RF-USRx Module Boot Up

Before a SFP-RF-USRx module can begin boot up, the host shall meet the following pin requirements.

The voltages listed for pins 15 (VCC3_DIGITAL) and 16 (VCC5_ANALOG) in Table 9 shall be available.

The value of pin 7 (P_DOWN/RST) should be set to *low* to allow the SFP-RF-USRx module to run in full power (power level II or III), although a setting of *high* may be used to limit the SFP-RF-USRx module to low power consumption (≤ 1.0 watts). Refer to section 2.4.7.3, Module Behavior During Power Down and Reset of [XFP MSA] for further details.

Pin 8 ($\overline{\text{INTERRUPT}}$) shall be pulled *high* by the host. If an unmasked error, alarm or warning condition is encountered during operation, the SFP-RF-USRx module shall pull this value *low*.

7.2.1.3 Initial SFP-RF-USRx Module Boot Sequence

Once the SFP-RF-USRx module is inserted, it goes through its initialization sequence, as shown in the following flow chart.

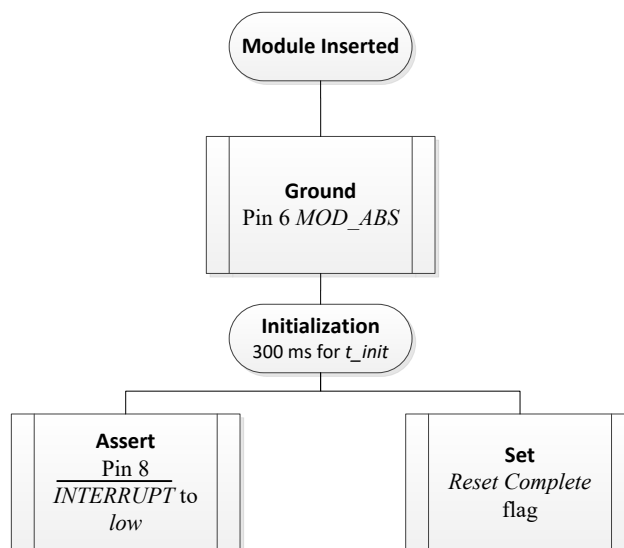


Figure 1 – SFP-RF-USRx Module Boot Sequence

This series of actions is described here.

1. The SFP-RF-USRx module shall indicate its presence to the host by grounding pin 6 (MOD_ABS) upon insertion.
2. After 300 ms, SFP-RF-USRx module initialization (aka *Reset Complete*, described in Table 39 of [XFP MSA]) shall be finished (t_{init} , [XFP MSA] section 2.6, Table 3).
3. The SFP-RF-USRx module shall assert pin 8 (INTERRUPT) to *low* and set corresponding *Reset Complete* flag ([XFP MSA] section 2.4.7.3, Table 39). *Reset Complete* can be detected by the host via an INTERRUPT signal (pin 8 pulled *low*) with a corresponding *Reset Complete* flag being set.

Note that until the boot sequence is complete, signals on the RF output pins may not be valid and the SFP-RF-USRx module shall not assert the INTERRUPT pin spuriously, as detailed in section 2.4.7.3 of [XFP MSA].

The *Reset Complete* flag also does not imply that registers are valid; the module sets the *Data_Not_Ready* flag (from

Table 42 in [XFP MSA]) to *low* to indicate that register contents are valid and can be read. When the module is ready to function, the MOD_NR pin is pulled *low*.

7.2.2 Host Initialization of the SFP-RF-USRx Module

After the module has pulled MOD_NR *low*, the host shall initialize the module, including interrupt masks, control, and miscellaneous parameters, as detailed in the following flow chart.

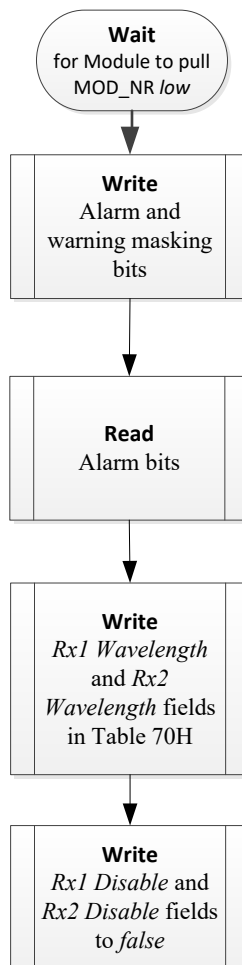


Figure 2 – Host SFP-RF-USRx Module Initialization

This series of actions is described here.

1. The host can set alarm and warning masks for any events of interest. These can be found in Table 40

in section 5.11.1 of [XFP MSA] with the exception of those alarms and warnings listed in section 7.4.2, Lower Memory Map (Common Table). By default none of these is masked. In particular, the *Reset Complete* status bit (and its corresponding INTERRUPT) is not masked. At a minimum, the host should set the masking bits for:

- TX_NR
 - Laser Fault
 - TX CDR Loss of Lock
 - TEC Fault
 - Vee5 High
 - Vee5 Low
 - Vcc2 High
 - Vcc2 Low
 - APD Supply (if it is not supported)
 - Wavelength Unlocked
 - TX Bias Low
 - TX Power Low
2. The host can clear any existing latched alarms by reading those alarm bits (the alarm bits are listed in Table 39 in section 5.11.1 of [XFP MSA]). As these flags are latched, their initial presence does not necessarily indicate a continuing fault. For example, the presence of the *Reset Complete* flag upon insertion of the module is not a fault. Among the existing latched alarms that can be reasonably expected are:
- Reset Complete
 - Rx1(2) CDR Loss of Lock (if used)