SFF-8690

Specification for

Tunable SFP+ Memory Map

Rev 1.4.2 Apr 03, 2023

SECRETARIAT: SFF TA TWG

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ABSTRACT: This specification supplements SFF-8472 management interface and extends its definition to include management of tunable pluggable transceiver modules.

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Revision History

Rev.	Description	Date
1.1	First distributed version.	
1.2	Not distributed.	
1.3	Changes in response to ballot comments: - Deleted reference to new identifier code 0Dh in sections 1 and 4.1. - Added green to color code definition for zero chirp. - Added section on Timing Behavior	
1.4	Corrected table 4-4 and accompanying text. Reference to byte 152 changed to byte 151.	2013-01-23
1.4.1	Add registers to support Smart Tunables Self Tuning Specification - Added description for Self Tuning support in Page 02h. - Advertising bit 128.3 is defined to indicate if Self Tuning via Smart Tuning MSA is supported. - Control bit 151.1 is added to allow Self Tuning to be aborted, frozen or disabled or to restart Self Tuning. - Control bit 151.2 is added to allow a host to disable the Self Tuning RX LOS Timeout feature. - Current Status bit 168.7 is added to indicate the current live status of Self Tuning. - Current Latched Status bit 172.7 is added to indicate that the channel may have been acquired via Self Tuning. – Added Reference to SFF-8419 for modules with higher power classes. – Added Table 2 to summarize memory map.	2023-07-17
1.4.2	Updated per comment review. 2023-12-20 Clean up metadata	2024-04-03

CONTENTS

FIGURES

TABLES

1 Scope

This specification supplements SFF-8472 management interface to include management of tunable pluggable transceiver modules. Pluggable modules such as the SFP+, SFP28 and future SFP form factor that are compliant to SFF-8431, SFF-8419 and SFF-8472 may use this management interface; hereafter referred to as SFP+. Electrical, mechanical, and thermal interface details remain without change as specified in SFF-8431 and SFF-8419.

The scope of this SFF-8690 defines management interfaces for managing:
- Tunable transmitter
- Increased frequency resolution for wavelength reporting.
- Smart Tunable MSA defining optional Self Tuning between Transceivers.

This specification is applicable when A0h byte 65 bit 6 is set to 1 (as defined in SFF-8472) to indicate the availability of tunability in the pluggable module. A non-tunable module does not need to support registers defined in this specification.

2 References

2.1 Industry Documents

The following interface standards are relevant to this specification:

- SFF-8431	Enhanced Small Form Factor Pluggable Module SFP+
- SFF-8419	SFP+ Power and Low Speed Interface
- SFF-8472	Diagnostic Monitoring Interface for Optical Transceivers
- ITU-T G.694.1	Spectral grids for WDM applications: DWDM frequency grid
- ITU-T G.698.1	Multichannel DWDM applications with single-channel optical interfaces
- ITU-T G.698.2	Amplified multichannel DWDM applications with single channel optical interfaces
- ITU-T G.698.4	Series G: Transmission Systems and Media, Digital Systems and Networks
- OIF-ITLA-MSA-01.3	Integrable Tunable Laser Assembly Multi Source Agreement
- SelfTuning-01.0	Self-Tuning Optics Interoperability Specification

2.2 SFF Specifications

The complete list of SFF documents which have been published, are currently being worked on, or that have been expired by the SFF Committee can be found at http://www.snia.org/sff/specifications. Suggestions for improvement of this specification will be welcome, they should be submitted to http://www.snia.org/feedback.

Other standards may be obtained from the organizations listed below.

Standard	Organization	Website
IEEE	Institute of Electrical and Electronics Engineers	https://www.ieee.org
INCITS Fiber Channel	International Committee for Information Technology Standards	http://www.techstreet.com/incitsgate.tmpl
OIF/CMIS	Optical Internetworking Forum (OIF)	http://www.oiforum.com
Smart Tunable	SmartTunable Self Tunable Interoperability Specification	http://www.smarttunable-msa.org/

2.3 Sources

Those who join the SFF Committee as an Observer or Member receive electronic copies of the minutes and SFF specifications https://www.snia.org/sff.

2.4 Conventions

The ISO convention of numbering is used i.e., the thousands and higher multiples are separated by a space and a period is used as the decimal point. This is equivalent to the English/American convention of a comma and a period.

American	French	ISO
0.6	0,6	0.6
1,000	1 000	1 000
1,323,462.9	1 323 462,9	1 323 462.9

3 Keywords, Acronyms, and Definitions

3.1 Keywords

May: Indicates flexibility of choice with no implied preference.

May or may not: Indicates flexibility of choice with no implied preference.

Obsolete: Indicates that an item was defined in prior specifications but has been removed from this specification.

Optional: Describes features which are not required by the SFF specification. However, if any feature defined by the SFF specification is implemented, it shall be done in the same way as defined by the specification. Describing a feature as optional in the text is done to assist the reader.

Prohibited: Describes a feature, function, or coded value that is defined in a referenced specification to which this SFF specification makes a reference, where the use of said feature, function, or coded value is not allowed for implementations of this specification.

Reserved: Defines the signal on a connector contact. Its actual function is set aside for future standardization. It is not available for vendor specific use. Where this term is used for bits, bytes, fields, and code values; the bits, bytes, fields, and code values are set aside for future standardization. The default value shall be zero. The originator is required to define a Reserved field or bit as zero, but the receiver should not check Reserved fields or bits for zero.

Restricted: Refers to features, bits, bytes, words, and fields that are set aside for other standardization purposes. If the context of the specification applies the restricted designation, then the restricted bit, byte, word, or field shall be treated as a value whose definition is not in scope of this document, and is not interpreted by this specification.

Shall: Indicates a mandatory requirement. Designers are required to implement all such mandatory requirements to ensure interoperability with other products that conform to this specification.

Should: Indicates flexibility of choice with a strongly preferred alternative.

Vendor specific: Indicates something (e.g., a bit, field, code value) that is not defined by this specification. Specification of the referenced item is determined by the manufacturer and may be used differently in various implementations.

3.2 Acronyms and Abbreviations

COR: Clear On Read
TEC: Thermal Electric Cooler

3.3 Definitions

Nothing new defined.

4 General Description

SFF-8431 defines the 10 Gigabit Small Formfactor Pluggable SFP+ Module including electrical, mechanical, and thermal requirements. 2-wire management interface details are defined in SFF-8472. (The range of pluggable modules types applicable to this SFF standards are discussed Scope Section 1)

In the SFF-8472 specification, an Optical Variant Transceiver (A0h Byte 8 bits 3-2 are 0s) advertises the transmitter wavelength in 1 nanometer resolution at A0h bytes 60 and 61. In addition byte 62 may be used to report wavelength in 0.01 nm (value 0 to 99). Since A0h low memory bytes are intended to be read-only EEPROM, the recommended behavior is that A0h bytes 60-62 all reporting 0's for tunable transceivers, as A0h byte 63 is the EEPROM checksum. However, historically after the initial release of SFF-8690, custom specification had arisen to define A0h bytes 60-62 report the current wavelength, after a channel switch. This behavior will remain undefined by SFF-8690.

Many applications for a tunable SFP+ must conform to an ITU frequency grid of 50 GHz (approximately 400 picometers). DWDM specifications also demand spectral excursion limits that can be as tight as ±2.5 GHz under normal operating conditions. Thus 1 nanometer wavelength step size defined in SFF-8472 does not adequately define the wavelength of a tunable SFP+.

To avoid possible conflict with legacy tuning systems designed to SFF-8472, the frequency grid tuning commands of SFF-8690 supplement rather than supplant the wavelength definitions of SFF-8472. These frequency grid tuning commands are detailed in Section 5.

5 Tuning Management Interface for DWDM Applications

5.1 Memory Map Changes to A0h and A2h

Tunable SFP+ implements A0h and A2h as in SFF-8472 with the modification herein.

A0h byte 65 bit 6, shall indicate transmitter technology. If the value of bit 6 is 0 the transmitter is not tunable. If the value of bit 6 is 1 the transmitter technology is tunable.

Tunable SFP+ Control/Status, consisting of addressable locations A2h at bytes 128 and 132 to 173 are accessible when the Page Select Byte is set to page 02h. Register definitions in the bytes described in the remainder of this section is based on the Page Select Byte set to 02h. All undefined registers in the byte ranged described are reserved and are set to 00h.

TABLE 5-1 PAGE SELECT

A2h Address	Bit	Description
Byte 127	All	Page Select Byte Entry. For Tunable SFP+ Control/Status = 02h

TABLE 5-2 REGISTER GROUPS FOR PAGE 02

A2h Address Bytes	SFF	Read/Write	Description
128	8690	RO	Feature Advertisement for Tunability
129	8472	RO	See SFF-8472.
130-131	8472	-na-	See SFF-8472.
132-141	8690	RO	Advertisement of Module Capabilities.
142-143	8690	-	Reserved for 8690
144-147	8690	RW	Channel Tuning, Frequency and wavelength controls.
144-150	8690	-	Reserved for 8690
151	8690	RW	Module, Module TX control
152-155	8690	RO	Diagnostics Frequency or Wavelength Error
156-167	8690	-	Reserved for Tunable
168	8690	RO	Current Status
169-171	8690	-	Reserved for Additional Status
172	8690	RO	Latched Status
173	8690	-	Reserved for Additional Latched Status
174-175	8472	-	See SFF-8472
176-191	8472	-	See SFF-8472
192-255	8472	-	See SFF-8472

5.2 Byte Definitions

The Tunable SFP+ module may be tuned by several methods which shall be advertised in A2h Byte 128. Table 5-3 bits 0,1,3 and 4 defines 4 methods.

The Tunable SFP+ module may support "Tx Dither" for the suppression of Stimulated Brillouin Scattering (SBS). Support for Tx dithering is indicated by A2h byte 128 bit 2.

TABLE 5-3 FEATURES ADVERTISEMENT FOR TUNABILITY

A2h Address	Bit	Description of Transceiver
Byte 128	5-7	Reserved
Byte 128	4	Vendor defined, including tunability or self tunability via proprietary methods or via other messaging channels identical or similar to G.698.4. (G.metro)
Byte 128	3	Self Tuning via Smart Tunable MSA Supported
Byte 128	2	Tx Dither Supported
Byte 128	1	Tunable DWDM (selection by channel number; bytes 144-145)
Byte 128	0	Tunable DWDM (selection in 50pm steps; bytes 146-147)

Module capabilities are defined in A2h, bytes 132-141.

TABLE 5-4 MODULE CAPABILITIES

A2h Address	Size	Name	Description
Bytes 132 (MSB) & 133 (LSB)	2 bytes	LFL1	Laser's First Frequency (THz)
Bytes 134 (MSB) & 135 (LSB)	2 bytes	LFL2	Laser's First Frequency (GHz*10), in units of 0.1 GHz
Bytes 136 (MSB) & 137 (LSB)	2 bytes	LFH1	Laser's Last Frequency (THz)
Bytes 138 (MSB) & 139 (LSB)	2 bytes	LFH2	Laser's Last Frequency (GHz*10), in units of 0.1 GHz
Bytes 140 (MSB) & 141 (LSB)	2 bytes	LGrid	Laser's minimum supported grid spacing (GHz*10), i.e., in units of 0.1 GHz NOTE: LGrid can be a positive or negative number.

A desired frequency channel can be commanded by the user by writing into A2h bytes 144 (MSB) and 145 (LSB).

The channel number is derived from the following equation using parameters found in Module capabilities as listed in A2h bytes 132-141:

Channel number = 1 + (Desired Frequency - First Frequency) / Grid Spacing

Alternatively, a desired wavelength on the ITU grid can be commanded by the user by writing into A2h bytes 146 (MSB) and 147 (LSB). Thus for instance a target wavelength of 1556.55 nm would correspond to 79h (MSB) written to A2h byte 146 and 9Bh (LSB) written to A2h byte 147.

The behavior of writing bytes 144-145 and 146-147, and the precedence in how and which frequency the module tunes is not defined in the specification especially if there is a mismatch in frequencies commanded by the host in a TWI write to 144-145 and 146-147. It is assumed that the host should use a 2 byte TWI transaction.

If Self-Tuning is enabled and cycling through the channels, the module shall update the channel number bytes 144-145 and the wavelength bytes 146-147 with the current active channel under test as the module is cycling through the channels. A host reading through the register will know that the module is self tuning. A write to these registers during self tuning should be ignored.

A2h byte 151 bit 0 can be used to enable and disable TX Dithering, if Byte 128 bit 2 indicates that Tx Dither is supported.

Frequency and wavelength control commands are detailed in Table 5-5.

TABLE 5-5 MODULE CAPABILITIES

A2h Address	Bit	Name	Description
Bytes 144 (MSB) & 145 (LSB)	All	Channel Number Set	User input of wavelength channel # integer 1 to N (N=Number of channels)
Bytes 146 (MSB) & 147 (LSB)	All	Wavelength Set	User input of Wavelength setpoint. (Units of 0.05 nm)
Bytes 148-150	All	Reserved	Reserved
Byte 151	7-3	Reserved	Reserved
Byte 151	2	Disable Self Tuning Restart on LOS Timer Timeout	This bit is applicable when Self Tuning feature Byte 128.3 is set to 1. This bit defines the behavior of the Self Tuning feature when LOS timer expires. If bit is 0, when the RxLOS duration has exceeded the Self Tuning Timer T3 the module shall restart the self tuning algorithm. If bit is 1, when the RxLOS duration has exceeded the Self Tuning Timer T3 then module shall not take any action. The expected behavior is for the Host via the management interface to restart the self tuning. This bit is evaluated when LOS timer T3 expires. Behavior of module if this bit is changed after the LOS expires to 0 is undefined. See Byte 151.1 to restart Self Tuning.
Byte 151	1	Enable Self Tuning	This bit is applicable when Self Tuning feature Byte 128.3 is set to 1, as well as the behavior of this bit depends on the self tuning state. If this bit is set to 0, then the module behaves like a standard tunable module. Tuning can be performed by writing to Bytes 144-145 or 146-147 consistent to module advertisement. If this bit is set to 1, then the module may be either "Self Tuning In Progress" or "Self Tune Has Locked to Channel". Changing this bit to 0 if Self Tune has locked will leaves the TX channel enabled. Changing this bit to 0 if the module is in Self Tuning is "In Progress" results in indeterminate behavior. The host is expected to manage the channel once the bit is set to 0. Writing this bit to 1 if this bit is already 1 shall have no impact in behavior. Writing this bit to 1 if this bit was previously 0 will restart self tuning.
Byte 151	0	Tx Dither	Logic 1 disables Dither, 0 enables Dither.

Digital Diagnostics and Alarms

A2 bytes 152-155, 168, and 172 contain digital diagnostic monitoring and alarms.

The frequency error in bytes 152-153 and wavelength error in bytes 154-155 are 16 bit signed 2's complement value in units of 0.1 GHz and 0.005 nm respectively. Both these error reporting registers should be implemented by the module. NOTE: Frequency and wavelength error is expected to be "actual measured value" – "target value". This error was not defined in prior releases. If frequency error is positive, then the corresponding wavelength error should be negative.

TABLE 5-6 FREQUENCY AND WAVELENGTH ERRORS

A2h Address	Bit	Name	Description
Bytes 152 (MSB)& 153 (LSB)	All	Frequency Error	Frequency error reported in 16 bit signed integer with LSB=0.1 GHz
Bytes 154 (MSB) & 155 (LSB)	All	Wavelength Error	Wavelength error reported in 16 bit signed integer with LSB=0.005 nm

A2h byte 168 is the current status register containing unlatched status bits for Temperature Controller (TC) Fault, Wavelength Unlock, and TxTune status (i.e., tuning operation is in process and is not yet completed).

TABLE 5-7 CURRENT STATUS

A2h Address	Bit	Name	Description
Byte 168	7	Self Tuning	0: Idle or Locked. 1: In Progress. This describes the current status of self tuning. If bit is 1, Self Tuning is in progress which mean that the transceiver is scanning through all the channels. If bit is 0, Self Tuning has locked onto a channel or it is under manual control.
Byte 168	6	TC (Temperature Control) Fault	If A0h Byte 64 bit 2 in SFF-8472 indicate that the module is cooled, then this fault bit shall be used to indicate a fault in the Temperature Controller. A TC (Temperature Controller) may be implemented using a TEC (Thermal Electric Cooler) device.
Byte 168	5	Wavelength Unlocked	Wavelength Unlocked Condition
Byte 168	4	TxTune	Identifies Tx is not ready due to tuning
Byte 168	3-0	Reserved	Reserved

A2h byte 172 is the latched status register. The latched indicators for TEC Fault and Wavelength Unlock are located here. Bit 4, Bad Channel, indicates a bad channel number request (i.e., a channel number outside of the supported range). Bit 3, New Channel, indicates that a channel change operation has completed. Bit 2 indicates that Tx Dither has been requested in a module that does not support dithering.

TABLE 5-8 LATCHED STATUS

A2h Address	Bit	Name	Description
Byte 172	7	L-Self Tune	Latched Self Tuning flag. If configured for self tuning, and this flag is 1, then self tuning is in progress. It will remain set until Self Tuning is completed. If 0 then self tuning is completed (locked) or laser is

			under manual control.
Byte 172	6	L-TEC Fault	Latched TEC Fault
Byte 172	5	L-Wavelength Unlocked	Latched Wavelength Unlocked Condition
Byte 172	4	L-Bad Channel	Latched Bad Channel Requested
Byte 172	3	L-New Channel	Latched New Channel Acquired
Byte 172	2	L-Unsupported TX Dither	Latched Unsupported TX Dither Request
Byte 172	1-0	Reserved	Reserved

6 Color Coding and Labeling of Tunable SFP+ Transceiver

The bail latch, which is an exposed feature of the tunable SFP+ transceiver (a feature or surface extending outside of the bezel) has been traditionally color coded. Historically, the current color coding of the bail latch, shall be color coded as follows:

- Green for negative chirp tunable SFP+.
- Yellow or green for zero chirp tunable SFP+.

In future, this SFF-8690 specification will not specify mechanical nor color coding scheme beyond what is previously specified. Hence the above text is left as it is in this revision of the specification, and new color codes will not be specified in this document.

7 Timing Behavior

The SFF committee decided to leave these figures un-annotated in this 1.4.2 release.

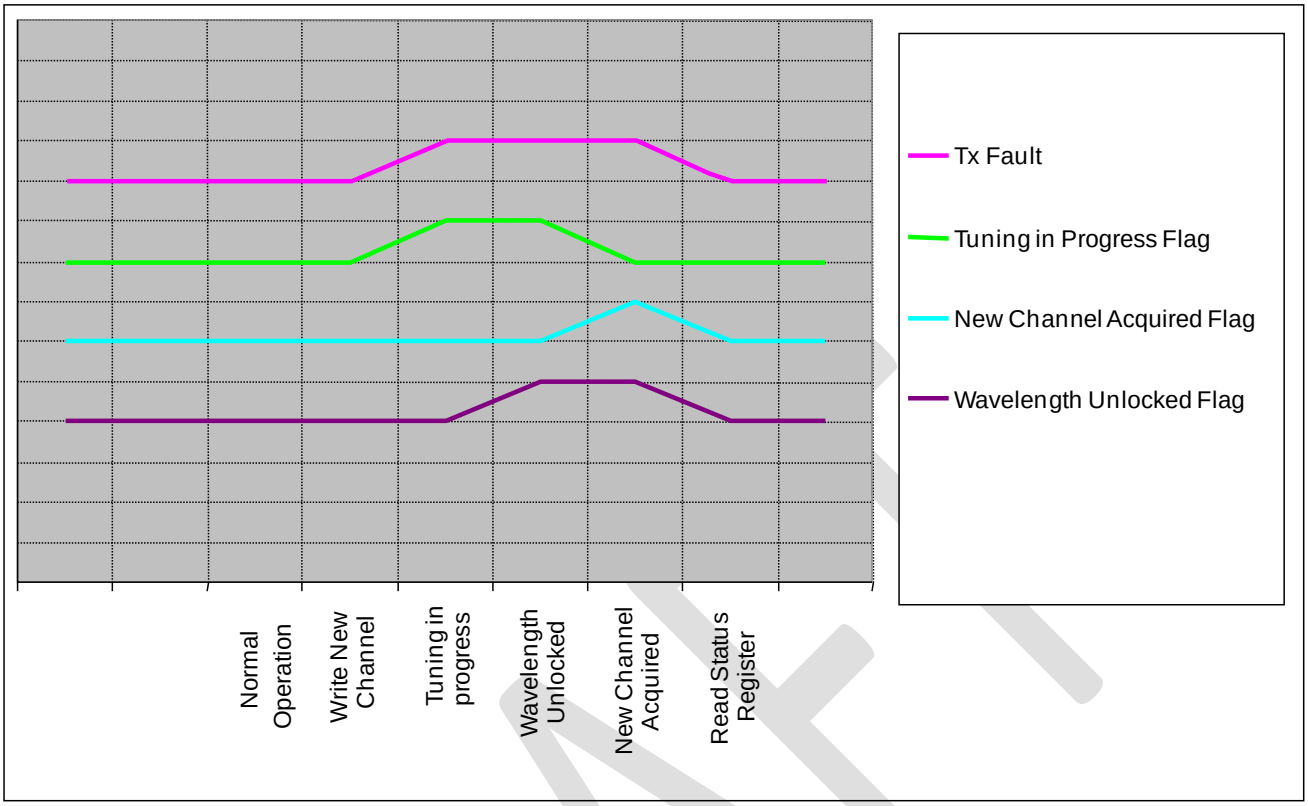

FIGURE 7-1 CHANNEL TO CHANNEL SWITCHING

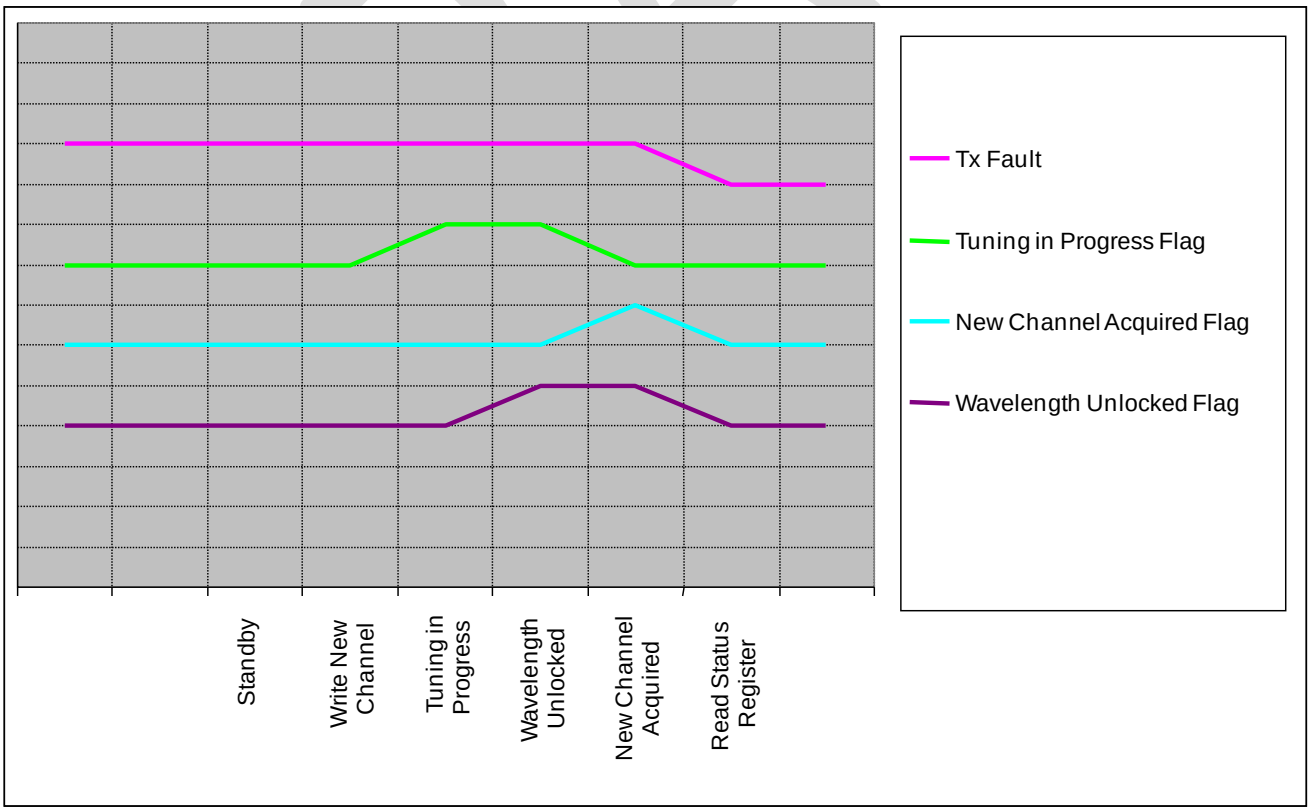

FIGURE 7-2 STANDBY TO CHANNEL SWITCHING