Data-Over-Cable Service Interface Specifications
FARMSIS™

DOCSIS® Fixed Wireless for Rural Broadband PHY Specification

CM-SP-FARMSIS-I01-211216

ISSUED

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Document Status Sheet

Document Control Number:	CM-SP-FARMSIS-I01-211216			
Document Title:	DOCSIS® Fixed Wireless for Rural Broadband PHY Specification			
Revision History:	D01 – Released 8/26/2021 D02 – Released 10/20/2021 I01 – Released 12/16/2021			
Date:	December 16, 2021			
Status:	~~Work in Progress~~	~~Draft~~	**Issued**	~~Closed~~
Distribution Restrictions:	~~Author Only~~	~~CL/Member~~	~~CL/Member/ Vendor~~	**Public**

Key to Document Status Codes

Work in Progress An incomplete document, designed to guide discussion and generate feedback that may include several alternative requirements for consideration.

Draft A document in specification format that is considered largely complete, but lacking review by Members and vendors. Drafts are susceptible to substantial change during the review process.

Issued A generally public document that has undergone rigorous Member and Technology Supplier review, cross-vendor interoperability, and is suitable for certification/qualification testing if applicable. Issued Specifications are subject to the Engineering Change Process.

Closed A static document, reviewed, tested, validated, and closed to further engineering change requests to the specification through CableLabs.

Trademarks

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1 SCOPE

1.1 Introduction

Delivery of Internet services is critical for connecting individuals and communities in rural areas. Bridging the digital divide is not just about bringing streaming video to rural subscribers. It also brings education, "smart" solutions, and a necessary pipeline of local, national, and international awareness. Among the existing fixed wireless access (FWA) solutions, the three most popular spectrum choices include 3.5 GHz, ISM bands (e.g., 2.4 and 5 GHz), and television white space (TVWS). These spectrum choices span multiple solutions, such as proprietary 802.11 baseband and CBRS, an LTE-based solution requiring a 3GPP Evolved Packet Core (EPC), a Spectrum Access System (SAS), and eNodeB (eNB) devices.

In all these scenarios, the solution usually involves the installation of a directional antenna on a tower transmitting toward a rural area and the placement of a home receiving antenna, usually on a tower or tall building near the home. Hardware within the home is unique to the deployment solution and sometimes requires additional devices for in-home Wi-Fi. The installation is expensive and requires a truck roll to nearly every home. The rural nature of these deployments only adds to the expense of the solution.

FARMSIS—Fixed Wireless for Rural Broadband—leverages the existing cable infrastructure, supply chain, and cable modem hardware to significantly reduce the cost of installation and number of truck rolls to rural homes. It defines wireless adapters to connect to a fiber node to deliver cable connectivity to a cable modem with a wireless adapter connected to the F-Type connector. It effectively extends the cable network wirelessly to deliver services to homes and communities where a hybrid fiber-coax (HFC) network is not possible or is cost prohibitive. In addition to delivering rural broadband, this solution could also deliver services such as voice and video.

1.2 Scope and Organization of Document

This document will specify all aspects of the wireless enablement of both the cable modem and the fiber node.

The document also will define the wireless solutions as separate components to both the cable modem and the fiber node, but a vendor could integrate the functionality into either respective device.

1.3 Not in Scope

This document will not add or change any requirements to the DOCSIS specifications in any way, nor will it define the electrical properties of the wireless components.

Government bodies regulate the maximum EIRP (effective isotropic radiated power) for wireless transmissions related to the TVWS and ISM bands. This information is available via respective government websites and is out of the scope of this document.

Antennas for both forward and return paths are also out of the scope of this document. Operators can choose the appropriate antennas for their deployment environments.

1.4 Assumptions

This document assumes these devices will be attached to a DOCSIS cable infrastructure. It assumes the use of fiber to extend the network to a point where extending the network further using fiber or coax is no longer a cost-effective option. Therefore, the cost-effective option is to wirelessly extend the network to deliver services to additional subscribers. At this point, a fiber node is used to provide the wireless connectivity an interface to the fiber backhaul. This document also assumes a cable modem is the termination device at the subscriber's home or business.

1.5 Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized.

"MUST"	This word means that the item is an absolute requirement of this specification.
"MUST NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word 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 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.

2 REFERENCES

2.1 Normative References

In order to claim compliance with this specification, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references.

All references 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.

[EN/IEC 61169-24]	EN IEC 61169-24:2019, Radio-Frequency Connectors—Part 24: Sectional Specification—Radio Frequency Coaxial Connectors with Screw Coupling, Typically for Use in 75 Ω Cable Networks (Type F), September 19, 2019, https://standards.iteh.ai/catalog/standards/clc/85745b8a-712a-41d6-94d0-26ab08b1a22c/en-iec-61169-24-2019
[SCTE 02]	ANSI/SCTE 02 2021, Specification for "F" Port, Female, Indoor, February 2021, https://www.scte.org/standards-development/library/standards-catalog/specification-for-f-port-female-indoor/
[PHYv3.0]	DOCSIS 3.0 Physical Layer Specification, CM-SP-PHYv3.0-C01-171207, December 7, 2017, https://www.cablelabs.com/specifications/CM-SP-PHYv3.0
[PHYv3.1]	DOCSIS 3.1 Physical Layer Specification, CM-SP-PHYv3.1-I19-211110, November 10, 2021, https://www.cablelabs.com/specifications/CM-SP-PHYv3.1
[PHYv4.0]	DOCSIS 4.0 Physical Layer Specification, CM-SP-PHYv4.0-I04-210826, August 26, 2021, https://www.cablelabs.com/specifications/CM-SP-PHYv4.0
[47 C.F.R. §§ 15.711–712]	Radio Frequency Devices—White Space Devices, 47 C.F.R. §§ 15.711–15.712 (as of May 21, 2021), https://www.ecfr.gov/cgi-bin/text-idx?SID=e33a97ebf37933de2857c53c96d03fec&mc=true&node=%0Bpt47.1.15&rgn=div5#se47.1.15_1711
[RFC 7545]	Protocol to Access White-Space (PAWS) Databases, IETF RFC 7545, May 2015, https://www.rfc-editor.org/rfc/rfc7545.html

2.2 Informative References

This specification uses the following informative references.

[FCC 20-156]	Unlicensed White Space Device Operations in the Television Bands—Report and Order and Further Notice of Proposed Rulemaking, FCC-20-156, October 28, 2020, https://www.fcc.gov/document/fcc-increases-unlicensed-wireless-operations-tv-white-spaces-0
[PNMP-V03]	PNM Best Practices: HFC Networks (DOCSIS 3.0), CM-GL-PNMP-V03-160725, July 25, 2016, https://www.cablelabs.com/specifications/proactive-network-maintenance-using-pre-equalization
[CM-OSSIv3.1]	Cable Modem Operations Support System Interface Specification, CM-SP-CM-OSSIv3.1-I21-211022, October 22, 2021, https://www.cablelabs.com/specifications/CM-SP-CM-OSSIv3.1

2.3 Reference Acquisition

- Cable Television Laboratories, Inc.; 858 Coal Creek Circle, Louisville, CO 80027; Phone: +1-303-661-9100; Fax: +1-303-661-9199; http://www.cablelabs.com
- SCTE•ISBE, Society of Cable Telecommunications Engineers Inc.; 140 Philips Road, Exton, PA 19341; Phone: +1-610-363-6888 / 1-800-542-5040; Fax: +1-610-363-5898; http://www.scte.org/

3 TERMS, DEFINITIONS, SHAPES, AND SYMBOLS

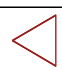
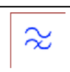
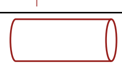
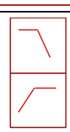
3.1 Terms and Definitions

This specification uses the following terms.

Diplexer	A three-port passive device that allows two different devices to share a common communication channel. It consists of two filters (low pass, high pass, or band pass) at different frequencies connected to a single antenna.
F-Type Connector	A two-wire (signal and ground) coaxial cable connector used to connect antennas and set-top boxes to televisions, VCRs, and DVD players. F-Type connector cables typically carry analog NTSC television signals, and the plug's socket is easily identified by its threads. Plugs come threaded and unthreaded, both of which fit the threaded socket.
Impedance Matching	In electronics, the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from the load.
Narrow Band Pass Filter / Wide Band Pass Filter	A filter that allows only the signal of a certain band of frequency or signal components of a certain range of frequency. This range of frequency is termed the "pass band." A narrow band pass filter is a band pass filter with a very narrow or very small pass band.
Variable Attenuator	A circuit that decreases the strength of the input signal either continuously or step by step without appreciable signal distortion while substantially maintaining a constant impedance match.
Narrowband	The frequency band that includes all wireless frequency bands supported by the FARMSIS system.

3.2 Shapes

This specification uses the following shapes in drawings throughout the document.

	antenna
	power amplifier
	high pass filter
	low pass filter
	impedance matching
	diplexer

4 ABBREVIATIONS

This specification uses the following abbreviations.

3GPP	3rd Generation Partnership Project
AGC	automatic gain control
CBRS	Citizens Broadband Radio Service
CEPT	European Conference of Postal and Telecommunications Administrations
CM	cable modem
CMTS	cable modem termination system
CNR	carrier-to-noise ratio
DOCSIS	Data-Over-Cable Service Interface Specifications
DTA	digital terminal adapter
EIRP	effective isotropic radiated power
eNB	eNodeB
EPC	3GPP Evolved Packet Core
FARMSIS	DOCSIS Fixed Wireless for Rural Broadband
FCC	Federal Communications Commission
FWA	fixed wireless access
HFC	hybrid fiber-coax
IF	intermediate frequency
IP3	third-order intercept point
ISM	industrial, scientific, and medical
LO	local oscillator
LTE	long-term evolution
MER	modulation error ratio
NTSC	National Television Standards Committee
Ofcom	Office of Communications (United Kingdom)
PSD	power spectral density
QPSK	quadrature phase shift keying
RF	radio frequency
RFoG	radio frequency over glass
SAS	Spectrum Access System
STB	set-top box
TVWS	television white space

5 OVERVIEW

The goal of FARMSIS is to have its components utilize the wireless spectrum for return and forward path transport from the network to a wirelessly enabled cable modem at a distance of up to 2 km. FARMSIS extends the cable plant PHY (physical) layer to rural subscribers at a low cost to operators.

The 2-km range was selected to reduce the cost of the adapters. The WINNER II model was used to determine the path loss of a strand-mounted fiber node wireless transmission to a wireless-enabled cable modem 2 km away. The model took into consideration some obstacles in the path, such as trees. The choice of range was meant to accomplish three goals:

1. reduce the complexity and cost of the adapters,
2. leverage the return path dynamic range of the cable modem as managed by the cable modem termination system (CMTS), and
3. ensure the availability of enough link budget to potentially support a self-install.

Though a 2-km range will cover a large percentage of homes, it will not provide a broadband solution for all rural subscribers. Support for further distances could potentially be achieved in the future, depending on factors including frequency band, amplification, antenna type, and antenna placement.

The components for FARMSIS include a wireless fiber node adapter with external antennas for wireless transmissions and a cable modem wireless adapter as the receiving end of these transmissions.

The significant advantage of this system is that it provides wireless connectivity directly to the communities and homes needed. Unlike cabling to rural homes, it does not require transmitting radio frequency (RF) over long distances, dealing with propagation challenges, installing towers, and investing in long-distance trenching or pole attachments.

5.1 Fiber Node Wireless Adapter

The fiber node wireless adapter is different from a standard fiber node in that it requires much less expensive components. The amplifier is much smaller and only requires support for a narrow band. No equalizer is necessary because of the narrow bandwidth. The return and forward dedicated for this wireless application are farther apart in frequency, so they require only a low-complexity diplexer; there is no need for a diplexer with a sharp roll-off. The fiber node can be fully integrated or wirelessly enabled through an external adapter. Requirements in this document focus on an external adapter implementation. The adapter could be added to different sizes of fiber nodes ranging from radio frequency over glass (RFoG) to medium and large fiber nodes. The operator can deploy on any fiber connection that traverses multiple towns and passes rural homes and communities, or the operator can deploy the wireless solution in urban environments. The limitation is simply the reach of available fiber or wavelengths and the available spectrum. Figure 1 illustrates the scope of the fiber node wireless adapter.

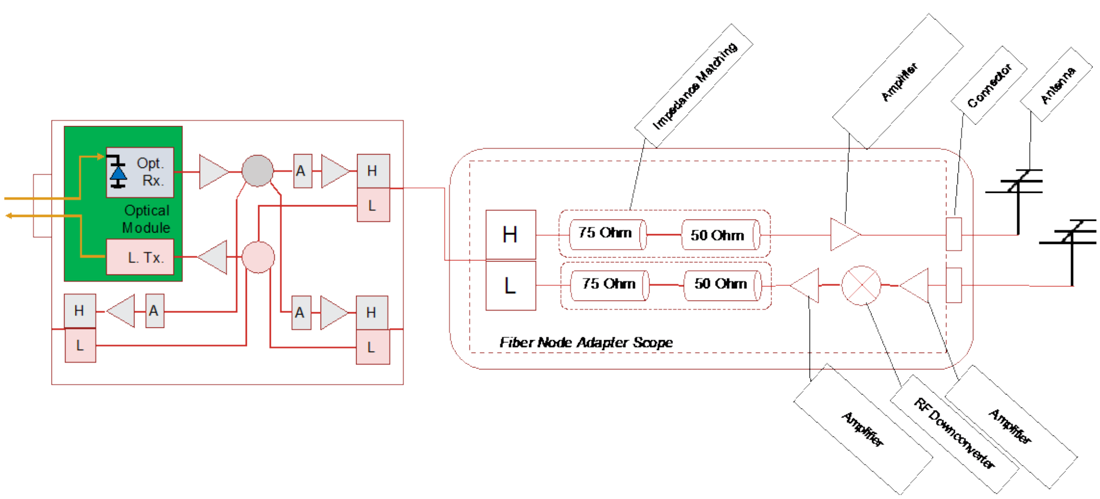


Figure 1 - Fiber Node Wireless Adapter Scope

The items within the shaded area of Figure 1 include the following.

- diplexer functionality for splitting the forward (H) and return (L) paths
- impedance matching for changing 75 ohm to 50 ohm
- narrowband low-noise amplifier for the return path
- RF downconverter to convert the DOCSIS signal on the wireless frequency to the coax cable frequency
- narrowband power amplifier for the forward path
- connectors for use with different types of antennas
- passive cooling
- enclosure environmental requirements

Separate forward and return path antenna ports avoid the need for an additional diplexer. A single antenna adapter would reduce the flexibility to select from the available wireless frequency channels for forward and return path because the return frequency upper range cannot be determined in advance. The return frequency could be anywhere in the TVWS (television white space) or ISM (industrial, scientific, and medical) bands.

This document describes the wireless adapter as being external to the fiber node, but it could also be integrated with a fiber node. This implementation would make a lightweight, inexpensive wireless fiber node that the operator could deploy in rural locations along fiber connectivity. Deployment of the FARMSIS fiber nodes along a fiber run needs to be considered relative to energy budgets. They would need to be adjusted to optimize power based on the range and number of fiber nodes deployed on a fiber strand. The operator can do so by adjusting the coupling ratio (e.g., 90/10 or 80/20) at each fiber node deployment.

If multiple communities surround a fiber node, then the operator can use multiple wireless sectors, limited only by the physical capacity of the fiber node.

5.2 Cable Modem Wireless Adapter

The approach to the wireless adapter design shown in Figure 2 allows the operator to attach it to an existing cable modem, digital transport adapter (DTA), set-top box (STB), or similar cable component. The adapter contains the components necessary to align impedance with the device and provide all necessary amplification, filtering, and splitting of the wireless signal as necessary. This setup allows the operator to use existing preferred devices and a simple modular wireless adapter to provide subscribers with the preferred service or services. Figure 2 shows the scope of the cable modem wireless adapter.

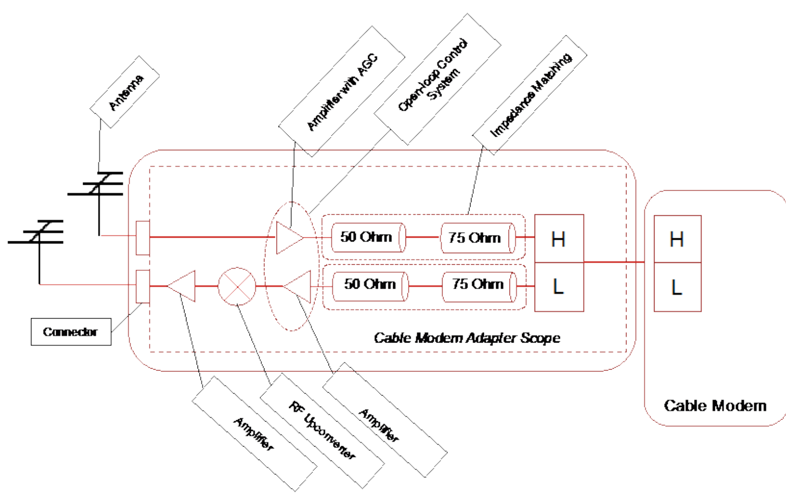


Figure 2 - Cable Modem Wireless Adapter Scope

The items within the shaded area of Figure 2 include the following.

- interface between cable modem and adapter
- diplexer functionality for splitting the forward (H) and return (L) paths
- impedance matching for changing 75 ohm to 50 ohm
- narrowband low-noise amplifier with automatic gain control (AGC) for the forward path
- open-loop control system to adapt return power levels
- narrowband amplifier on the return path at the input of the RF upconverter
- RF upconverter to convert the DOCSIS signal on the coax cable to the desired over-the-air frequency
- narrowband power amplifier for the return path
- connectors for use with different types of antennas
- enclosure environmental requirements

AGC is necessary on the forward path (1) to compensate for variability in the path loss caused by distance, clutter, and factors that influence the wireless signal received at the cable modem and (2) to correctly scale the signal level within the range accepted by the cable modem receiver.

Similar to the fiber node wireless adapter, separate forward and return antenna ports avoid the need for an additional diplexer. An additional diplexer would reduce the flexibility to select from the available wireless frequency channels for forward and return because the return frequency upper range cannot be determined in advance. The return frequency could be anywhere in the TVWS or ISM bands.

Note that outputs can be 50 or 75 ohm depending on the type of RF antenna (or transceiver) connected to the port. If using a 75 ohm output, the antenna ports will likely be an F-Type connector rather than an SMA connector. The objective of the hardware changes is to make an adapter for which a technician can easily change a cable component, such as a cable modem, from coax-connected to wireless for easy deployment to rural subscribers.

For a self-install, the subscriber needs to be able to screw this adapter to an F-Type connector, attach antennas, and plug the adapter into a common AC outlet within the home. The manufacturer may choose to integrate the wireless capability into the cable modem to further simplify home installation.

5.3 Spectrum

For the forward path, this specification requires support for the TVWS and sub-gigahertz ISM frequency bands. In the United States, TVWS provides up to 176 MHz of available spectrum, especially in rural areas. In Europe and the United Kingdom, TVWS provides up to 224 MHz of available spectrum. There is no limit to the number of available channels that can be used.

- TVWS bands in the United States: 470–614 MHz, 6 MHz per channel
- TVWS bands in the Europe and the United Kingdom and: 470–694 MHz, 8 MHz per channel

In North America, the sub-gigahertz ISM band covers 902–928 MHz, providing 26 MHz of spectrum that can be used alone or in conjunction with the available TVWS spectrum. Channels available in TVWS and ISM do not need to be contiguous to be used together.

These bands are within the forward range of the DOCSIS PHY specifications ([PHYv3.0], [PHYv3.1], [PHYv4.0]). Use of these bands is intentional to reduce the complexity of the adapter and its overall cost, which is accomplished by removing the IF-IF conversion on the forward path.

For the return path, this specification requires support for the following ISM bands.

- ISM bands in North America: 902–928 MHz
- ISM bands the Europe and the United Kingdom: 863–870 MHz
- other required ISM bands: 2400–2500 MHz, 5725–5875 MHz

In North America, an additional 6 MHz of spectrum is also available in the 900 MHz band, 897.5–900.5 MHz and 936.6–939.5 Mhz. Though this seems like a small amount of spectrum, it can be used on the return path for small quadrature phase shift keying (QPSK) channels such as 1.6 MHz. Coupled with a 6- or 8-MHz channel, it provides additional resiliency for the connection.

FARMSIS adapters are not limited to operating in only these bands. Any available frequency band, whether licensed or unlicensed, could be used with minor changes to the wireless adapters.

6 WIRELESS ADAPTER REQUIREMENTS

NOTE: In the following section, FARMSIS adapter applies to both the fiber node wireless adapter and cable modem wireless adapter. If a requirement applies only to the fiber node wireless adapter or the cable modem wireless adapter, the requirement will be specific to the fiber node wireless adapter or the cable modem wireless adapter.

6.1 Spectrum

Table 1 provides a list of the forward frequency bands that are used in the FARMSIS adapters.

Table 2 represents the return frequencies used in the FARMSIS adapters. A single table could be used for both directions, but avoiding TVWS for the return path relieves the cable modem wireless adapter from needing to report its location to the TVWS database (based on regional rules).

1. The FARMSIS adapters MUST support the frequency bands specified in Table 1 - FARMSIS Forward Path (Downstream) Spectrum for the forward path.
2. The FARMSIS adapters MAY support the frequency bands specified in Table 2 - FARMSIS Return Path (Upstream) Spectrum for the forward path.
3. The FARMSIS adapters MUST support the frequency bands specified in Table 2 - FARMSIS Return Path (Upstream) Spectrum for the return path.
4. The FARMSIS adapters MAY support the frequency bands specified in Table 1 - FARMSIS Forward Path (Downstream) Spectrum for the return path.
5. In the FARMSIS system, the FARMSIS adapters MUST ensure that the frequency used in the forward path (downstream) does not collide with the frequency used in the return path (upstream).

Table 1 - FARMSIS Forward Path (Downstream) Spectrum

Region	TVWS	
	Start	**End**
United States	470 MHz	614 MHz
Europe/U.K.	470 MHz	694 MHz
Region	**ISM**	
	Start	**End**
North America	902 MHz	928 MHz

Table 2 - FARMSIS Return Path (Upstream) Spectrum

Region	ISM	
	Start	**End**
North America	897.5 MHz	900.5 MHz
North America	936.6 MHz	939.5 MHz
North America	902 MHz	928 MHz
North America	2400 MHz 5725 MHz	2500 MHz 5875 MHz
Europe/U.K.	863 MHz	870 MHz
Europe/U.K.	2400 MHz 5725 MHz	2500 MHz 5875 MHz

When [PHYv4.0] becomes available for use with FARMSIS, the TVWS bands can also be used for the return path up to 684 MHz. However, using TVWS for the return path will introduce the requirement for the cable modem wireless adapter to report its location to the TVWS database (based on regional rules).

These frequency bands correlate to the official documents published by the regulatory body governing the specific geographical region where the FARMSIS system is deployed (e.g., the FCC in the United States, Ofcom in the United Kingdom, and CEPT in Europe).

6.2 DOCSIS Version

1. The FARMSIS adapters MUST interface with DOCSIS 3.0 system [PHYv3.0].
2. The FARMSIS adapters MUST interface with DOCSIS 3.1 system [PHYv3.1].
3. The FARMSIS adapters SHOULD interface with DOCSIS 4.0 system [PHYv4.0].

6.3 FARMSIS Adapters Coax Interface

1. The FARMSIS adapter coax interface MUST be 75 ohm.
2. The FARMSIS adapter coax interface MUST use an F-Type connector.

NOTE: The maximum length of the coax cable needs to meet the maximum path loss such that the signal power and carrier-to-noise ratio (CNR) meet the requirements. This length can vary based on the distance of the farthest cable modem from the fiber node that the operator wants to reach and the length of cabling between the cable modem and the cable modem wireless adapter.

6.4 Fiber Node Wireless Adapter

6.4.1 Fiber Node Wireless Adapter Antenna Interfaces

1. The fiber node wireless adapter MUST support two antenna interfaces—one for forward and one for return.
2. Each fiber node wireless adapter MUST have an antenna interface that supports 50 ohm impedance match at the connector.
3. The fiber node wireless adapter SHOULD have an antenna interface that supports an N-Type connector interface.

6.4.2 Fiber Node Wireless Adapter RF Amplifiers

6.4.2.1 Fiber Node Wireless Adapter Forward Path Amplifier

1. The fiber node wireless adapter MUST be capable of receiving an input signal level greater than 40 dBmV.
2. The fiber node wireless adapter MUST use a minimum 36-dB RF amplifier. This amplifier is used to increase the signal level towards the antenna interface.
3. The fiber node wireless adapter MUST provide the maximum conducted power limit for the forward path sent to the antenna interface based on regional rules. For example, the FCC allows a maximum of 30 dBm. Table 3, taken from [FCC 20-156], describes how conducted power relates to EIRP for TVWS.

Table 3 - Example of FCC Conducted Power Limits for TVWS

EIRP (6 MHz)		Conducted Power Limit (6 MHz)		Conducted PSD Limit (100 kHz)	Conducted Adjacent Channel Emission Limit (100 kHz)
16 dBm	(40 mW)	10 dBm	(10 mW)	-7.4 dBm	-62.8 dBm
20 dBm	(100 mW)	14 dBm	(25 mW)	-3.4 dBm	-58.8 dBm
24 dBm	(250 mW)	18 dBm	(63 mW)	0.6 dBm	-54.8 dBm
28 dBm	(625 mW)	22 dBm	(158 mW)	4.6 dBm	-50.8 dBm
32 dBm	(1600 mW)	26 dBm	(400 mW)	8.6 dBm	-46.8 dBm

EIRP (6 MHz)		Conducted Power Limit (6 MHz)		Conducted PSD Limit (100 kHz)	Conducted Adjacent Channel Emission Limit (100 kHz)
36 dBm	(4000 mW)	30 dBm	(1000 mW)	12.6 dBm	-42.8 dBm
40 dBm	(10000 mW)	30 dBm	(1000 mW)	12.6 dBm	-42.8 dBm
42 dBm	(16000 mW)	30 dBm	(1000 mW)	12.6 dBm	-42.8 dBm

6.4.2.2 Fiber Node Wireless Adapter Return Path Amplifier

1. The fiber node wireless adapter MUST use a minimum 36-dB amplifier for the return signal.

6.4.2.3 Fiber Node Wireless Adapter Downstream Electrical Characteristics

The information in Table 4 applies to each channel used by FARMSIS for the forward signaling path, and it assumes that the adapter is external to the fiber node. If the wireless adapter is integrated, some optimizations could be used to simplify the design, such as using 50 ohm impedance through the adapter.

Table 4 - Fiber Node Wireless Adapter Downstream Signal Characteristics

Parameter	Value
Frequency: Input	Table 1
Frequency: Output	Table 1, Table 2
Channel Bandwidth	North America: 6 MHz minimum Europe/U.K.: 8 MHz minimum
Input Level	North America: 70 dBmV per 6 MHz peak power Europe/U.K.: 70 dBmV per 8 MHz peak power
Input Impedance	75 ohm
Input Return Loss	16 dB minimum
Input Connector	F-Type connector per [EN/IEC 61169-24] or [SCTE 02]
Output Impedance	50/75 ohm
Output Connector	50/75 ohm: N-Type
Output Return Loss	16 dB minimum
Output Level	Maximum conducted power based on regional rules

1. The fiber node wireless adapter MUST support 470- to 694-MHz input frequency on the forward path.
2. The fiber node wireless adapter MUST support 902- to 928-MHz input frequency on the forward path.
3. The fiber node wireless adapter MUST support 470- to 614-MHz output frequency on the forward path for the United States.
4. The fiber node wireless adapter MUST support 470- to 694-MHz output frequency on the forward path for Europe/United Kingdom.
5. The fiber node wireless adapter MUST support 902- to 928-MHz output frequency on the forward path for North America.
6. The fiber node wireless adapter MAY support 2400- to 2500-MHz output frequency on the forward path.
7. The fiber node wireless adapter MAY support 5725- to 5875-MHz output frequency on the forward path.
8. The fiber node wireless adapter MUST support a minimum bandwidth of 6 MHz on the forward path for North America.
9. The fiber node wireless adapter MUST support a minimum bandwidth of 8 MHz on the forward path for Europe/United Kingdom.

10. The fiber node wireless adapter MUST support a peak input power level of 70 dBmV per 6 MHz on the forward path for North America.
11. The fiber node wireless adapter MUST support a peak input power level of 70 dBmV per 8 MHz on the forward path for Europe/United Kingdom.
12. When not integrated, the fiber node wireless adapter MUST support input impedance of 75 ohm on the forward path.
13. The fiber node wireless adapter MUST support a minimum of 16-dB input return loss on the forward path.
14. The fiber node wireless adapter MUST support an F-Type input connector per [EN/IEC 61169-24] or [SCTE 02] on the forward path.
15. The fiber node wireless adapter MUST support an output impedance at the diplexer function of 50 ohm on the forward path.
16. The fiber node wireless adapter MAY support an output impedance at the diplexer function of 75 ohm on the forward path.
17. The fiber node wireless adapter MUST support a 50 ohm N-Type output connector on the forward path.
18. The fiber node wireless adapter MAY support a 75 ohm N-Type output connector on the forward path.
19. The fiber node wireless adapter MUST support minimum output return loss of 16 dB on the forward path.
20. The fiber node wireless adapter MUST support the maximum conducted power based on the regional rules.

For additional FARMSIS adapter transmission characteristics for Europe, please reference Annex B of the [PHYv3.0] specification.

6.4.2.4 Fiber Node Wireless Adapter Upstream Electrical Characteristics

The information in Table 5 applies to each channel used by FARMSIS for the return signaling path, and it assumes the adapter is external to the fiber node. If the fiber node wireless adapter is integrated, some optimizations could be used to simplify the design, such as using 50 ohm impedance through the adapter.

Table 5 - Fiber Node Wireless Adapter Upstream Signal Characteristics

Parameter	Value
Frequency: Input	Table 2, Table 1
Frequency: Output	5–204 MHz
Channel Bandwidth	1.6 MHz minimum
Input Level	-29 to -73 dBm per 6.4 MHz -29 to -73 dBm per 3.2 MHz -29 to -73 dBm per 1.6 MHz
Input Impedance	50/75 ohm
Input Return Loss	16 dB minimum
Input Connector	50/75 ohm: N-Type
Inband Noise Figure	3 dB
Output Impedance	75 ohm
Output Connector	F-Type connector per [EN/IEC 61169-24] or [SCTE 02]
Output Return Loss	16 dB minimum
Output Level	10–20 dBmV per 1.6 MHz 10–20 dBmV per 3.2 MHz 10–20 dBmV per 6.4 MHz

1. The fiber node wireless adapter MUST support 902- to 928-MHz input frequency on the return path for North America.

2. The fiber node wireless adapter MUST support 897.5- to 900.5-MHz input frequency on the return path for North America.
3. The fiber node wireless adapter MUST support 936.6- to 939.5-MHz input frequency on the return path for North America.
4. The fiber node wireless adapter MUST support 863- to 870-MHz input frequency on the return path for Europe/United Kingdom adapters.
5. The fiber node wireless adapter MUST support 2400- to 2500-MHz input frequency on the return path.
6. The fiber node wireless adapter MUST support 5725- to 5875-MHz input frequency on the return path.
7. The fiber node wireless adapter MAY support 470- to 614-MHz input frequency on the return path in the United States.
8. The fiber node wireless adapter MAY support 470- to 694-MHz input frequency on the return path in Europe/United Kingdom.
9. The fiber node wireless adapter MUST support an output frequency of 5 to 204 MHz on the return path.
10. The fiber node wireless adapter MUST support a minimum bandwidth of 1.6 MHz on the return path.
11. The fiber node wireless adapter MUST support an input power level of -29 to -73 dBm/6.4 MHz on the return path.
12. The fiber node wireless adapter MUST support an input power level of -29 to -73 dBm/3.2 MHz on the return path.
13. The fiber node wireless adapter MUST support an input power level of -29 to -73 dBm/1.6 MHz on the return path.
14. The fiber node wireless adapter MUST support an input impedance of 50 ohm on the return path.
15. The fiber node wireless adapter MUST support a minimum of 16-dB input return loss on the return path.
16. The fiber node wireless adapter MUST support a 50 ohm N-Type input connector on the return path.
17. The fiber node wireless adapter MAY support a 75 ohm N-Type input connector on the return path.
18. The fiber node wireless adapter MUST support an inband noise figure of 3 dB on the return path.
19. The fiber node wireless adapter MUST support an output impedance of 75 ohm on the return path.
20. The fiber node wireless adapter MUST support an F-Type output connector per [EN/IEC 61169-24] or [SCTE 02] on the return path.
21. The fiber node wireless adapter MUST support minimum output return loss of 16 dB on the return path.
22. The fiber node wireless adapter MUST support an output level in the range of 10 dBmV per 1.6 MHz to 20 dBmV per 1.6 MHz on the return path.
23. The fiber node wireless adapter MUST support an output level in the range of 10 dBmV per 3.2 MHz to 20 dBmV per 3.2 MHz on the return path.
24. The fiber node wireless adapter MUST support an output level in the range of 10 dBmV per 6.4 MHz to 20 dBmV per 6.4 MHz on the return path.

For additional FARMSIS adapter transmission characteristics for Europe, please reference Annex B of the [PHYv3.0] specification.

6.4.3 Fiber Node Wireless Adapter RF Upconverter

1. If the selected forward wireless carrier frequency is different from the selected forward cable carrier frequency on the HFC plant, the fiber node wireless adapter MUST use an RF upconverter to shift the frequency of the forward signal from the selected forward cable carrier frequency to the selected forward wireless carrier frequency.

2. The fiber node wireless adapter MUST have an RF upconverter functionality that results in a net 0-dB gain.
3. The fiber node wireless adapter MUST use an RF upconverter input frequency range that supports DOCSIS 3.0 return spectrum bands.
4. The fiber node wireless adapter MUST use an RF upconverter input frequency range that supports DOCSIS 3.1 return spectrum bands.
5. The fiber node wireless adapter SHOULD use an RF upconverter input frequency range that supports DOCSIS 4.0 return spectrum bands.
6. The fiber node wireless adapter MUST have an RF upconverter that supports the output frequency bands defined in Table 1 - FARMSIS Forward Path (Downstream) Spectrum and Table 2 - FARMSIS Return Path (Upstream) Spectrum, with a minimum of 6 MHz for North America and 8 MHz for Europe/United Kingdom.
7. The fiber node wireless adapter MUST filter any output signals other than the intended signal for cable modem input. These signals could include the LO frequency and the resulting "low" output frequency.

Table 6 - Fiber Node Wireless Adapter RF Upconverter Signal Characteristics

Parameter	Value
Frequency: Input	Table 1
Frequency: Output	Table 1, Table 2
LO Conversion Step Size	1–3 MHz
Input IP3	20 dBm minimum
RF/IF Input Peak Power	15 dBm
Input and Output Impedance	50 ohm

6.4.4 Fiber Node Wireless Adapter RF Downconverter

1. If the selected return wireless carrier frequency is different from the selected return cable carrier frequency on the HFC plant, the fiber node wireless adapter MUST use an RF downconverter to shift the frequency of the return signal from the selected return wireless carrier frequency to the selected return cable carrier frequency.
2. The fiber node wireless adapter MUST have an RF downconverter functionality that results in a net 0-dB gain.
3. The fiber node wireless adapter MUST support 902- to 928-MHz RF downconverter input frequency range.
4. The fiber node wireless adapter MUST support 897.5- to 900.5-MHz RF downconverter input frequency range.
5. The fiber node wireless adapter MUST support 936.6- to 939.5-MHz RF downconverter input frequency range.
6. The fiber node wireless adapter MUST support 863- to 870-MHz RF downconverter input frequency range for Europe/United Kingdom adapters.
7. The fiber node wireless adapter MUST support 2400- to 2500-MHz input frequency RF downconverter input frequency range.
8. The fiber node wireless adapter MUST support 5725- to 5875-MHz RF downconverter input frequency range.
9. The fiber node wireless adapter MAY support 470- to 614-MHz RF downconverter input frequency range in the United States.
10. The fiber node wireless adapter MAY support 470- to 694-MHz RF downconverter input frequency range in Europe/United Kingdom.

11. The fiber node wireless adapter MUST use an RF downconverter output frequency range that supports DOCSIS 3.0 return spectrum bands.
12. The fiber node wireless adapter MUST use an RF downconverter output frequency range that supports DOCSIS 3.1 return spectrum bands.
13. The fiber node wireless adapter SHOULD use an RF downconverter output frequency range that supports DOCSIS 4.0 return spectrum bands.
14. The fiber node wireless adapter MUST filter any output signals other than the intended signal for fiber node input. These signals could include the LO frequency and the resulting "high" output frequency.

Table 7 - Fiber Node Wireless Adapter RF Downconverter Signal Characteristics

Parameter	Value
Frequency: Input	Table 1, Table 2
Frequency: Output	5–684 MHz
LO Conversion Step Size	1–3 MHz
Input IP3	20 dBm minimum
RF/IF Input Peak Power	15 dBm
Input and Output Impedance	50 ohm

6.4.5 Fiber Node Wireless Adapter Modulation Error Ratio

1. The fiber node wireless adapter MUST NOT change the end-to-end (CMTS to CM) MER requirements or deviate outside of the DOCSIS PHY specifications ([PHYv3.0], [PHYv3.1], [PHYv4.0]), as this would result in changing the underlying DOCSIS PHY requirements.

6.4.6 Fiber Node Wireless Adapter Diplexer Functionality

1. The fiber node wireless adapter MUST use at least one diplexer.

6.4.7 Fiber Node Wireless Adapter Impedance Matching

If the fiber node wireless adapter does not maintain a 75 ohm impedance through the wireless adapter, including support for 75 ohm antennas, then impedance matching is necessary.

1. The fiber node wireless adapter MUST use a 75 to 50 ohm impedance matching component.
2. The fiber node wireless adapter MUST have an impedance matching component that connects to the power amplifier on the forward path, to the low-noise amplifier on the return path, and to the diplexer on the other side.

6.4.8 Fiber Node Wireless Adapter TVWS Database Interface

1. The fiber node wireless adapter MUST comply with [47 C.F.R. §§ 15.711–712] for database check-in and interference avoidance methods.
2. The fiber node wireless adapter MUST use the [RFC 7545] interface for the TVWS check in.

6.5 Cable Modem Wireless Adapter

6.5.1 Cable Modem Wireless Adapter Antenna Interfaces

1. The cable modem wireless adapter MUST support two antenna interfaces—one for forward and one for return.
2. Each cable modem wireless adapter interface MUST support 50 ohm impedance match at the connector.
3. The cable modem wireless adapter interface SHOULD support an SMA interface.

4. The cable modem wireless adapter interface MAY support an N-Type interface.

The forward antenna will connect to the forward amplifier, and the return antenna will connect to the return amplifier.

6.5.2 Cable Modem Wireless Adapter RF Amplifiers

6.5.2.1 Cable Modem Wireless Adapter Return Path Amplifier

Signal input level from the cable modem into the cable modem wireless adapter needs to be greater than 40 dBmV. This level allows the cable modem wireless adapter to amplify the signal to cover the 2-km distance for the farthest cable modem from the fiber node.

1. The cable modem wireless adapter MUST use a minimum 36-dB RF amplifier.
2. The cable modem wireless adapter MUST provide the maximum conducted power limit for the forward path sent to the antenna interface based on regional rules. For example, the FCC allows a maximum of 30 dBm. Table 8, taken from [FCC 20-156], describes how this relates to EIRP for TVWS.

Table 8 - Example of FCC Conducted Power Limits

EIRP (6 MHz)		Conducted Power Limit (6 MHz)		Conducted PSD Limit (100 kHz)	Conducted Adjacent Channel Emission Limit (100 kHz)
16 dBm	(40 mW)	10 dBm	(10 mW)	-7.4 dBm	-62.8 dBm
20 dBm	(100 mW)	14 dBm	(25 mW)	-3.4 dBm	-58.8 dBm
24 dBm	(250 mW)	18 dBm	(63 mW)	0.6 dBm	-54.8 dBm
28 dBm	(625 mW)	22 dBm	(158 mW)	4.6 dBm	-50.8 dBm
32 dBm	(1600 mW)	26 dBm	(400 mW)	8.6 dBm	-46.8 dBm
36 dBm	(4000 mW)	30 dBm	(1000 mW)	12.6 dBm	-42.8 dBm
40 dBm	(10000 mW)	30 dBm	(1000 mW)	12.6 dBm	-42.8 dBm
42 dBm	(16000 mW)	30 dBm	(1000 mW)	12.6 dBm	-42.8 dBm

6.5.2.2 Cable Modem Wireless Adapter Forward Path Amplifier

1. The cable modem wireless adapter MUST use a minimum 36-dB low-noise amplifier with AGC for the forward signal.
2. The cable modem wireless adapter MUST conform the forward signal for the cable modem to a signal compatible with the DOCSIS version the cable modem is running.

6.5.3 Cable Modem Wireless Adapter Return Signal Power Control System

The purpose of this continuous open-loop control system is to avoid overdriving the fiber node adapter receiver and compensate for fast-fading events occurring between DOCSIS ranging processes. The amplification level is varied based on the path loss between the fiber node and the cable modem wireless adapters, which is estimated in the cable modem wireless adapter.

NOTE: Overdriving the fiber node wireless adapter receiver will cause all return traffic received from all associated cable modem wireless adapters to become distorted.

1. The cable modem wireless adapter MUST allow a configurable parameter for the associated fiber node wireless adapter EIRP.
2. The cable modem wireless adapter MUST allow a configurable parameter for the adapter's antenna gain.
3. The cable modem wireless adapter MUST estimate the RF signal path loss between the associated fiber node wireless adapter and the cable modem wireless adapter.

4. The cable modem wireless adapter MUST use the estimated path loss to adjust the return signal amplification output level.

6.5.3.1 Cable Modem Wireless Adapter Downstream Electrical Characteristics

Table 9 - Cable Modem Wireless Adapter Downstream Signal Characteristics

Parameter	Value
Frequency: Input	Table 1, Table 2
Frequency: Output	Table 1
Bandwidth	North America: 6 MHz minimum Europe/U.K.: 8 MHz minimum
Input Level	North America: -29 to -73 dBm per 6 MHz power Europe/U.K.: -29 to -73 dBm per 8 MHz power
Input Impedance	50 ohm
Input Return Loss	16 dB minimum
Input Connector	50 ohm N-Type/SMA
Inband Noise Figure	3 dB
Link Loss Level Indicator	Accuracy ±5 dB Skew 20 dB per 500 ms
Output Impedance	75 ohm
Output Connector	F-Type Connector per [EN/IEC 61169-24] or [SCTE 02]
Output Return Loss	16 dB minimum
Output Level	-15 to +15 dBmV per 6 MHz

1. The cable modem wireless adapter MUST support 470- to 614-MHz input frequency on the forward path for the United States.
2. The cable modem wireless adapter MUST support 470- to 694-MHz input frequency on the forward path for Europe/United Kingdom.
3. The cable modem wireless adapter MUST support 902- to 928-MHz input frequency on the forward path for North America.
4. The cable modem wireless adapter MAY support 2400- to 2500-MHz input frequency on the forward path.
5. The cable modem wireless adapter MAY support 5725- to 5875-MHz input frequency on the forward path.
6. The cable modem wireless adapter MUST support 470- to 614-MHz output frequency on the forward path for the United States.
7. The cable modem wireless adapter MUST support 470- to 694-MHz output frequency on the forward path for Europe/United Kingdom.
8. The cable modem wireless adapter MUST support 902- to 928-MHz output frequency on the forward path for North America.
9. The cable modem wireless adapter MUST support a minimum bandwidth of 6 MHz on the forward path for North America.
10. The cable modem wireless adapter MUST support a minimum bandwidth of 8 MHz on the forward path for Europe/United Kingdom.
11. The cable modem wireless adapter MUST support input power level of -29 to -73 dBm per 6 MHz on the forward path for North America.
12. The cable modem wireless adapter MUST support input power level of -29 to -73 dBm per 8 MHz on the forward path for Europe/United Kingdom.

13. The cable modem wireless adapter MUST support input impedance of 50 ohm in the forward path.
14. The cable modem wireless adapter MUST support a minimum of 16-dB input return loss in the forward path.
15. The cable modem wireless adapter MUST support a 50 ohm N-Type input connector in the forward path.
16. The cable modem wireless adapter SHOULD support a 50 ohm SMA input connector in the forward path.
17. The cable modem wireless adapter MUST support an in band noise figure of 3 dB in the forward path.
18. The cable modem wireless adapter MUST have a forward receiver that provides an indication of the wireless path loss to the return path transmitter.
19. The cable modem wireless adapter MUST have a path loss indication that is accurate to within ±5 dB.
20. The cable modem wireless adapter MUST have a path loss indication that supports a skew of 20 dB per 500 ms.
21. The cable modem wireless adapter MUST support an output impedance of 75 ohm in the forward path.
22. The cable modem wireless adapter MUST support an F-Type output connector at the diplexer function per [EN/IEC 61169-24] or [SCTE 02] in the forward path.
23. The cable modem wireless adapter MUST support minimum output return loss of 16 dB in the forward path.
24. The cable modem wireless adapter MUST support an average output level of -15 to +15 dBmV per 6 MHz in the forward path.

For additional FARMSIS adapter transmission characteristics for Europe, please reference Annex B of the [PHYv3.0] specification.

6.5.3.2 Cable Modem Wireless Adapter Upstream Electrical Characteristics

Table 10 - Cable Modem Wireless Adapter Upstream Signal Characteristics

Parameter	Value
Frequency: Input	5–204 MHz
Frequency: Output	Table 1, Table 2
Bandwidth	1.6 MHz minimum
Input Level	65 dBmV per 6.4 MHz maximum
Input Impedance	75 ohm
Input Return Loss	16 dB minimum
Input Connector	F-Type connector per [EN/IEC 61169-24] or [SCTE 02]
Output Impedance	50 ohm
Output Connector	50 ohm N-Type/SMA
Output Return Loss	16 dB minimum
Output Level	Maximum conducted power based on regional rules
Output Level Control	1-dB steps over 30-dB range

1. The cable modem wireless adapter MUST support an input frequency of 5 to 204 MHz on the return path.
2. The cable modem wireless adapter MUST support 902- to 928-MHz output frequency on the return path for North America.
3. The cable modem wireless adapter MUST support 897.5- to 900.5-MHz output frequency on the return path for North America.
4. The cable modem wireless adapter MUST support 936.6- to 939.5-MHz output frequency on the return path for North America.

5. The cable modem wireless adapter MUST support 863- to 870-MHz output frequency on the return path for Europe/United Kingdom.
6. The cable modem wireless adapter MUST support 2400- to 2500-MHz output frequency on the return path.
7. The cable modem wireless adapter MUST support 5725- to 5875-MHz output frequency on the return path.
8. The cable modem wireless adapter MAY support 470- to 614-MHz output frequency on the return path for the United States.
9. The cable modem wireless adapter MAY support 470- to 694-MHz output frequency on the return path for Europe/United Kingdom.
10. The cable modem wireless adapter MUST support a minimum bandwidth of 1.6 MHz on the return path.
11. The cable modem wireless adapter MUST support a maximum average input power level of 65 dBmV per 6.4 MHz on the return path.
12. The cable modem wireless adapter MUST support input impedance of 75 ohm on the return path.
13. The cable modem wireless adapter MUST support a minimum of 16-dB input return loss on the return path.
14. The cable modem wireless adapter MUST support a 75 ohm F-Type input connector per [EN/IEC 61169-24] or [SCTE 02] on the return path.
15. The cable modem wireless adapter MUST have a return path transmitter that receives an indication of the wireless path loss from the forward receiver.
16. The cable modem wireless adapter MUST support an output impedance of 50 ohm on the return path.
17. The cable modem wireless adapter MUST support a 50 ohm N-Type output connector on the return path.
18. The cable modem wireless adapter SHOULD support a 50 ohm SMA output connector on the return path.
19. The cable modem wireless adapter MUST support minimum output return loss of 16 dB on the return path.
20. The cable modem wireless adapter MUST support the maximum conducted power based on the regional rules.
21. The cable modem wireless adapter SHOULD support the output level control in 1-dB steps over a 30-dB range on the return path.

For additional FARMSIS adapter transmission characteristics for Europe, please reference Annex B of the [PHYv3.0] specification.

6.5.4 Cable Modem Wireless Adapter RF Downconverter

1. If the selected forward wireless carrier frequency is different from the selected forward cable carrier frequency on the HFC plant, the cable modem wireless adapter MUST use an RF downconverter to shift the frequency of the forward signal from the selected forward wireless carrier frequency to the selected forward cable carrier frequency.
2. The cable modem wireless adapter MUST have an RF downconverter functionality that results in a net 0-dB gain.
3. The cable modem wireless adapter MUST have an RF downconverter that supports input frequency bands defined in Table 1 - FARMSIS Forward Path (Downstream) Spectrum and Table 2 - FARMSIS Return Path (Upstream) Spectrum, with a minimum of 6 MHz for North America and 8 MHz for Europe/United Kingdom.
4. The cable modem wireless adapter MUST use an RF downconverter output frequency range that supports DOCSIS 3.0 return spectrum bands.
5. The cable modem wireless adapter MUST use an RF downconverter output frequency range that supports DOCSIS 3.1 return spectrum bands.

6. The cable modem wireless adapter SHOULD use an RF downconverter output frequency range that supports DOCSIS 4.0 return spectrum bands.
7. The cable modem wireless adapter MUST filter any output signals other than the intended signal for fiber node adapter receive. These signals could include the LO frequency and the resulting "high" output frequency.

Table 11 - Cable Modem Wireless Adapter RF Downconverter Signal Characteristics

Parameter	Value
Frequency: Input	Table 1, Table 2
Frequency: Output	Table 1
LO Conversion Step Size	1–3 MHz
Input IP3	20 dBm minimum
RF/IF Input Peak Power	15 dBm
Input and Output Impedance	50 ohm

6.5.5 Cable Modem Wireless Adapter RF Upconverter

1. If the selected return wireless carrier frequency is different from the selected return cable carrier frequency on the HFC plant, the cable modem wireless adapter MUST use an RF upconverter to shift the frequency of the return signal from the selected return wireless carrier frequency to the selected return cable carrier frequency.
2. The cable modem wireless adapter MUST have an RF upconverter functionality that results in a net 0-dB gain.
3. The cable modem wireless adapter MUST use an RF upconverter input frequency range that supports DOCSIS 3.0 return spectrum bands.
4. The cable modem wireless adapter MUST use an RF upconverter input frequency range that supports DOCSIS 3.1 return spectrum bands.
5. The cable modem wireless adapter SHOULD use an RF upconverter input frequency range that supports DOCSIS 4.0 return spectrum bands.
6. The cable modem wireless adapter MUST support 902- to 928-MHz RF upconverter output frequency range for North America.
7. The cable modem wireless adapter MUST support 897.5- to 900.5-MHz RF upconverter output frequency range for North America.
8. The cable modem wireless adapter MUST support 936.6- to 939.5-MHz RF upconverter output frequency range for North America.
9. The cable modem wireless adapter MUST support 863- to 870-MHz RF upconverter output frequency range for Europe/United Kingdom.
10. The cable modem wireless adapter MUST support 2400- to 2500-MHz RF upconverter output frequency range.
11. The cable modem wireless adapter MUST support 5725- to 5875-MHz RF upconverter output frequency range.
12. The cable modem wireless adapter MAY support 470- to 614-MHz RF upconverter output frequency range for the United States.
13. The cable modem wireless adapter MAY support 470- to 694-MHz RF upconverter output frequency range for Europe/United Kingdom.

14. The cable modem wireless adapter MUST filter any output signals other than the intended signal for fiber node adapter receive. These signals could include the LO frequency and the resulting "low" output frequency.

Table 12 - Cable Modem Wireless Adapter RF Upconverter Signal Characteristics

Parameter	Value
Frequency: Input	5–204 MHz
Frequency: Output	Table 2, Table 1
LO Conversion Step Size	1–3 MHz
Input IP3	20 dBm minimum
RF/IF Input Peak Power	15 dBm
Input and Output Impedance	50 ohm

6.5.6 Cable Modem Wireless Adapter Modulation Error Ratio

1. The cable modem wireless adapter MUST not change the end-to-end (CMTS to CM) MER requirements or deviate outside of the DOCSIS PHY specifications ([PHYv3.0], [PHYv3.1], [PHYv4.0]), as this would result in changing the underlying DOCSIS PHY requirements.

6.5.7 Cable Modem Wireless Adapter Diplexer Functionality

1. The cable modem wireless adapter MUST use at least one diplexer or diplexer functionality.

6.5.8 Cable Modem Wireless Adapter Impedance Matching

If the cable modem wireless adapter does not maintain a 75 ohm impedance through the wireless adapter, including support for 75 ohm antennas, then impedance matching is necessary.

1. The cable modem wireless adapter MUST use a 75 to 50 ohm impedance matching component.

6.5.9 CM Spectrum Analysis

Because Proactive Network Maintenance (PNM) uses CM spectrum analysis ([PNMP-V03], [CM-OSSIv3.1]), it will allow operators to monitor the spectrum received by the cable modem and make determinations as to how clean the spectrum is relative to other bands available for FARMSIS.

6.5.10 Cable Modem Wireless Adapter Physical Enclosure

1. If the cable modem wireless adapter is placed outside the home, the adapter SHOULD be placed inside a minimum IP65-rated box.

Appendix I Frequency Management for FARMSIS Adapters

If the cable modem wireless adapter supports the frequency bands in Table 1, then the fiber node wireless adapter needs the ability to communicate to the cable modem wireless adapter regarding frequency band changes. One option is for the fiber node wireless adapter to support remote configuration for frequency band changes. The fiber node wireless adapter could transmit frequency band changes continuously to all associated cable modem wireless adapters. For security, the fiber node wireless adapter could use and store a minimum 128-bit pre-shared key for encrypting the frequency band before transmitting.

When the cable modem wireless adapter first comes up, it would start listening to the fiber node wireless adapter on a pre-configured frequency to receive the return path frequency it should use. The cable modem wireless adapter could then periodically or continuously listen on the frequency for any frequency changes needed for the return path.

* * *