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Telecommunications
Engineers***

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**Operational Practice for the Coexistence of
DOCSIS 3.1 Signals and MoCA Signals
in the Home Environment**

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1. Scope

1.1. Executive Summary

DOCSIS® 3.1 signals and MoCA® signals can both exist at frequencies above 1 GHz. This operational practice explains how operators can use frequencies above 1 GHz for both types of services. MoCA versions 1.1 and 2.0 are included in the analysis. The three cases of how these signals may coexist are:

- Overlapping
- Adjacent
- Non-overlapping

This document provides many recommendations for operational best practices for the coexistence between DOCSIS 3.1 signals and MoCA signals. Each recommendation is preceded with the text “**Guideline**” and is numbered. The guidelines are summarized in Section 12.

This document demonstrates that the hybrid fiber coax (HFC) network performance impacts the calculations. The initial conclusions are conservative in light of the ability of DOCSIS 3.1 technology to adapt to real-world environments. Final calculations are based on the selection of optimal DOCSIS 3.1 bit loading, which allows adequate performance with less isolation.

This document explains the need for sufficient isolation and suggests the proper location and required performance of filters. Filters are necessary in most architectures to:

- Prevent MoCA signals from one residence from bridging to a nearby residence
- Prevent overload of DOCSIS receivers and MoCA receivers

Filter locations can be at the consumer premises equipment (CPE) and/or at the point of entry (PoE).

Finally, home-run vs. loop-through architectures are explained, with the final recommendation that non-overlapping channels and home-run architectures be used whenever possible.

1.2. Scope

This operational practice applies to any network that contains DOCSIS downstream signals at frequencies greater than 1 GHz and has MoCA signals in the premises. The calculations are valid for DOCSIS 3.1 and for MoCA 1.1 and 2.0 single channel operation.

1.3. Benefits

The recommendations in this document are designed to assure that the DOCSIS networks and MoCA networks perform with minimal impact on each other. If these recommendations are not followed, significant performance degradation could occur to either network and, in some scenarios, one or both networks could completely fail to operate.

1.4. Intended Audience

This operational practice is intended to be used by network designers, cable industry technical personnel, equipment designers and others who have an interest in coexistence of DOCSIS 3.1 signals and MoCA signals above 1 GHz to assure that proper frequencies are selected and that proper filters are specified to be installed.

1.5. Areas for Further Investigation or to be Added in Future Versions

Additional documents could:

- Analyze MoCA 2.5 signals
- Provide recommendations for filters in mid-split systems
- Coexistence of DOCSIS 3.1 technology with other home networking technologies such as G.hn, HomePlug, etc.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of the standard. At the time of Subcommittee approval, the editions indicated were valid. All standards are subject to revision; and while parties to any agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents may not be compatible with the referenced version.

2.1. SCTE References

- No normative references are applicable.

2.2. Standards from Other Organizations

- No normative references are applicable.

2.3. Published Materials

- [DOCSIS PHYv3.1] DOCSIS 3.1, Physical Layer Specification, CM-SP-PHYv3.1-I09-160602, June 2, 2016, Cable Television Laboratories, Inc.
- [MoCA 1.1] MoCA 1.1 Specification for Device RF Characteristics, MoCA_Specification_for_Device_RF_Characteristics, February 11, 2014, Multimedia over Coax Alliance, http://www.mocalliance.org/MoCA1/specification/MoCA_Specification_for_Device_RF_Characteristics.pdf
- [MoCA 2.0] MoCA 2.0 Specification for Device RF Characteristics, MoCA_2_Device_RF_Characteristics-150406d, February 11, 2014, Multimedia over Coax Alliance, http://www.mocalliance.org/MoCA2/specification/MoCA_2_Device_RF_Characteristics-150406d.pdf

3. Informative References

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

3.1. SCTE References

- [ANSI/SCTE 151] ANSI/SCTE 151 2015 Mechanical, Electrical, and Environmental Requirements for RF Traps and Filters (https://www.scte.org/documents/pdf/Standards/ANSI_SCTE%20151%202015.pdf).
- [ANSI/SCTE 79-1] ANSI SCTE 79-1 2009 DOCSIS 2.0 Part 1: Radio Frequency Interface

- [ANSI/SCTE 23-1] ANSI SCTE 23-1 2010 DOCSIS 1.1 Part 1: Radio Frequency Interface

3.2. Standards from Other Organizations

- No informative references are applicable.

3.3. Published Materials

- [CTA-542] CTA-542-D: CTA Standard, Cable Television Channel Identification Plan, June 2013. (Formerly CEA-542-D. Recently renamed CTA-542-D, but the contents have not changed.)
- [DOCSIS PHYv3.0] DOCSIS 3.0, Physical Layer Specification, CM-SP-PHYv3.0-I12-150305, March 5, 2015, Cable Television Laboratories, Inc. (<http://www.cablelabs.com/wp-content/uploads/specdocs/CM-SP-PHYv3.0-I12-150305.pdf>)
- [COUNTING] “Counting Channels,” <http://www.scte.org/TechnicalColumns/08-12-01%20counting%20channels.pdf>, December 2008 issue, *Communications Technology*

4. Compliance Notation

<i>shall</i>	This word or the adjective “ <i>required</i> ” means that the item is an absolute requirement of this specification.
<i>shall not</i>	This phrase means that the item is an absolute prohibition of this specification.
<i>forbidden</i>	This word means the value specified shall never be used.
<i>should</i>	This word or the adjective “ <i>recommended</i> ” 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 weighted before choosing a different course.
<i>should not</i>	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.
<i>may</i>	This word or the adjective “ <i>optional</i> ” 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.
<i>deprecated</i>	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of the standard. Implementations should avoid use of deprecated features.

5. Abbreviations and Definitions

5.1. Abbreviations

ACI	adjacent channel interference
ACI/N	ACI emissions-to-noise ratio
AWGN	additive white Gaussian noise
BW	bandwidth

bps/Hz	bits per second per hertz
CEA	Consumer Electronics Association (now Consumer Technology Association)
CM	cable modem
CMTS	cable modem termination system
CNR	carrier-to-noise ratio
CNIR	carrier-to-noise-plus-interference ratio
CPE	customer premises equipment
CTA	Consumer Technology Association (formerly Consumer Electronics Association)
dB	decibel
dBm	decibel milliwatt
dBmV	decibel millivolt
dBr	decibel reference (or decibel relative)
DVR	digital video recorder
DOCSIS	Data-Over-Cable Service Interface Specifications
DTA	digital transport adapter (or digital terminal adapter)
eMTA	embedded multimedia terminal adapter
ETSI	European Telecommunications Standards Institute
ExD	extended band D
FEC	forward error correction
FTTP	fiber to the premises
GHz	gigahertz
GW	gateway
HPF	high-pass filter
Hz	hertz
i.e.	that is (<i>id est</i>)
kbps	kilobits per second
kHz	kilohertz
LAN	local area network
LDPC	low density parity check
log	logarithm
MAC	media access control (or medium access control)
MATV	master antenna television
Mbps	megabits per second
MDU	multiple dwelling unit
MHz	megahertz
MoCA	Multimedia over Coax Alliance
MULPI	MAC and upper layer protocols interface
NF	noise figure
ODU	outdoor unit
OFDM	orthogonal frequency division multiplexing
OFDMA	orthogonal frequency division multiple access
ONT	optical network terminal
OP2OP	output port-to-output port
OSP	outside plant
OSSI	operation(s) support system interface
PHY	physical layer
PoE	point of entry

QAM	quadrature amplitude modulation
QoS	quality of service
QPSK	quadrature phase shift keying
RF	radio frequency
RX	receiver (or receive)
S-CDMA	synchronous code division multiple access
SC-QAM	single carrier quadrature amplitude modulation
SCTE	Society of Cable Telecommunications Engineers
SIK	self-installation kit
SMATV	satellite master antenna television
SNR	signal-to-noise ratio
STB	set-top box
TCM	trellis coded modulation
TPC	transmit power control
TV	television

5.2. Definitions

ACI susceptibility	The degree to which the performance of a desired signal is degraded by out-of-band or out-of-channel emissions from an adjacent signal. See also <i>adjacent channel interference</i> .
adjacent	An operating condition in which the bandwidth of the guard band between a DOCSIS 3.1 downstream signal and a MoCA 1.1 <i>Band D</i> signal is ≥ 5 MHz but ≤ 25 MHz, or the bandwidth of the guard band between a DOCSIS 3.1 downstream signal and a MoCA 2.0 <i>Band D</i> signal is ≥ 5 MHz but ≤ 75 MHz.
adjacent channel interference (ACI)	Out-of-band or out-of-channel emissions from one signal that degrade the performance of another signal occupying a channel or frequency next to the first signal.
diplexer	A passive device or circuit comprising a combination of low pass and high pass filters, used to combine or separate signals in two frequency ranges. Two of the device's ports or connections (e.g., low frequency or "L" and high frequency or "H") are multiplexed onto a third port or connection (e.g., common or "C").
downstream	1) The direction of RF signal transmission from headend or hub site to subscriber. Also called forward. In North American cable networks, the downstream or forward spectrum may occupy frequencies from just below 54 MHz to as high as 1002 MHz or more. 2) The DOCSIS 3.1 downstream spectrum is 258 MHz (optional 108 MHz) to 1218 MHz (optional 1794 MHz).
filter mask	A graph of a filter's desired magnitude (or other characteristic)-versus-frequency response limits, which may be overlaid on the filter's measured frequency response plot to provide a quick visual indication of whether the measured response meets specification. The graph can show minimum and/or maximum performance limits, typical performance limits, or other performance metrics of interest. See also <i>filter response</i> .
filter response	Magnitude-versus-frequency and phase-versus-frequency characteristics of a filter, including such parameters as half-power

	point(s), and pass-band and stop-band bandwidth, flatness, attenuation, and ripple.
isolation	1) The difference, in decibels, between the power of a desired signal or signal component and the power of an undesired signal or signal component. 2) The amount of attenuation or signal loss, in decibels, between two ports or connections of a passive or active device or circuit.
MoCA Band D	A frequency range above 1 GHz used for transmission of Multimedia over Coax Alliance signals. <i>Band D</i> comprises eight 50 MHz-wide channels in the 1125 MHz to 1525 MHz range. <i>Extended Band D</i> is 550 MHz wide and comprises 100 MHz-wide single channels, 225 MHz-wide bonded-pair channels, and two sub-bands (D-Low and D-High) in the 1125 MHz to 1675 MHz range.
noise figure (NF)	A measure, in decibels, of the difference between input and output SNR (or CNR) in a component, circuit, or device. Also an expression of a device's noise factor (F) in decibels. Both NF and F are often stated at a standard temperature of 290 K. Mathematically, $NF = SNR_{input(dB)} - SNR_{output(dB)}$ or $NF = 10\log_{10}(F)$ or where NF is noise figure in decibels, F is noise factor, $SNR_{input(dB)}$ is the input signal-to-noise ratio in decibels due to thermal (or Johnson-Nyquist) noise, and $SNR_{output(dB)}$ is the output signal-to-noise ratio in decibels
non-overlapping	An operating condition in which the bandwidth of the guard band between a DOCSIS 3.1 signal and a MoCA signal is > 25 MHz for MoCA 1.1 and > 75 MHz for MoCA 2.0.
overlapping	An operating condition in which a DOCSIS 3.1 downstream signal and a MoCA signal occupy some or all of the same range of frequencies.
S-parameter (S_{xy})	The ratio of the voltage appearing at port x of a device to the applied voltage at port y of a device. For example, if a device has two ports, 1 and 2, where port 1 is the input and port 2 is the output, the S-parameter, or scattering parameter, S_{21} is the ratio of the voltage appearing at port 2 to the applied voltage at port 1. In this example, S_{21} is equivalent to the voltage gain. Similarly, S_{11} is the ratio of any reflected voltage at port 1 to the applied voltage at port 1. S-parameters are in general complex values. However, it is often useful to deal with the magnitude of S-parameters, as indicated by the vertical bars on either side (i.e., $ S_{21} $). The magnitude of an S-parameter is typically expressed in decibels.
triplexer	A passive device or circuit comprising a combination of three filters, used to combine or separate signals in three frequency ranges. Three of the device's ports or connections (e.g., low frequency, mid-frequency, and high frequency) are multiplexed onto a common fourth port or connection.
upstream	1) The direction of RF signal transmission from subscriber to headend or hub site. Also called return or reverse. In most North American cable networks, the legacy upstream spectrum occupies frequencies from 5 MHz to as high as 42 MHz. 2) The DOCSIS 3.1 upstream spectrum is 5 MHz to 204 MHz, with support for 5 MHz to 42 MHz, 5 MHz to 65 MHz, 5 MHz to 85 MHz, and 5 MHz to 117 MHz.

6. Coexistence of DOCSIS 3.1 Signals and MoCA Signals Overview

In the Data-Over-Cable Service Interface Specifications (DOCSIS®) version 3.1, the radio frequency (RF) spectrum was expanded to beyond 1 gigahertz (GHz), either to 1.2 GHz or even to 1.8 GHz. Unfortunately, this means DOCSIS 3.1 signals and Multimedia over Coax Alliance (MoCA) signals now share common frequencies above 1 GHz. Plus, the vastly different signal levels expected in the home coax network for DOCSIS 3.1 signals and MoCA signals means achieving the required isolation between them will be challenging. In this document, operational practices for the coexistence of DOCSIS 3.1 signals and MoCA signals on the same coax network in the customer premises will be given, with the goal of ensuring the maximum performance of both networks when they must coexist on the same physical medium.

6.1. DOCSIS Physical Layer Characteristics

6.1.1. Overview of DOCSIS Technology and Specifications

The first version, DOCSIS 1.0, was introduced in the late 1990s, and gave the cable industry standards-based interoperability. The latter means “certified” cable modems from any vendor will work with a “qualified” cable modem termination systems (CMTS) from any vendor. The second version, DOCSIS 1.1, added a number of features, including quality of service (QoS), more robust scheduling, packet classification, and other enhancements that facilitated voice and non-best effort data services.

DOCSIS 1.0 and 1.1 technology and specifications – collectively known as DOCSIS 1.x – supported per-channel downstream raw data rates (includes forward error correction (FEC) coding and framing overhead) of 30.34 megabits per second (Mbps) using 64-QAM (64-state quadrature amplitude modulation) and 42.88 Mbps using 256-QAM in a 6 megahertz (MHz) channel bandwidth. DOCSIS 1.x technology and specifications supported several upstream raw data rates (includes FEC coding and framing overhead), ranging from a low of 320 kilobits per second (kbps) to a high of 10.24 Mbps. It also supported two upstream modulation formats – quadrature phase shift keying (QPSK) and 16-QAM – as well as five upstream radio frequency (RF) channel bandwidths from 200 kilohertz (kHz) to 3.2 MHz. DOCSIS 1.1 technology and specifications added some enhancement to upstream transmission robustness, using 8-tap adaptive pre-equalization. Figure 1 shows the frequency usage by DOCSIS 1.x equipment. The upstream was 5 MHz to 42 MHz, and the downstream 88 MHz to 860 MHz.¹

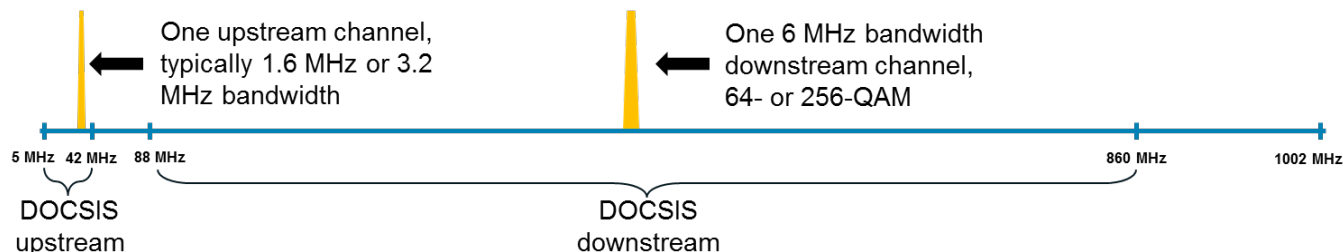


Figure 1 - DOCSIS 1.x Equipment Frequency Usage

Downstream data rates and the downstream channel bandwidth in the next version, DOCSIS 2.0, remained unchanged from DOCSIS 1.x, but supported higher upstream raw data rate per RF channel, up

¹ A downstream upper frequency limit of 860 MHz does not align with the upper channel boundary of any CTA cable channel as defined in [CTA-542]. Depending on channel capacity, the highest upper CTA channel boundary frequencies that match a nominal 860 MHz are 858 MHz, 864 MHz, or 870 MHz. For more on this, see [COUNTING].

to 30.72 Mbps in a 6.4 MHz channel bandwidth. DOCSIS 2.0 technology and specifications supported 8-QAM, 32-QAM, and 64-QAM – and optionally 128-QAM trellis coded modulation (TCM) encoded modulations for synchronous code division multiple access (S-CDMA) channels. To facilitate more robust upstream data transmission, DOCSIS 2.0 technology introduced advanced physical layer (PHY), including features such as a 24-tap pre-equalizer, improved upstream FEC and interleaving, ingress cancellation, and direct sampled RF in the CMTS's upstream burst receiver. Figure 2 shows DOCSIS 2.0 frequency usage, which remained the same as DOCSIS 1.x. frequency usage

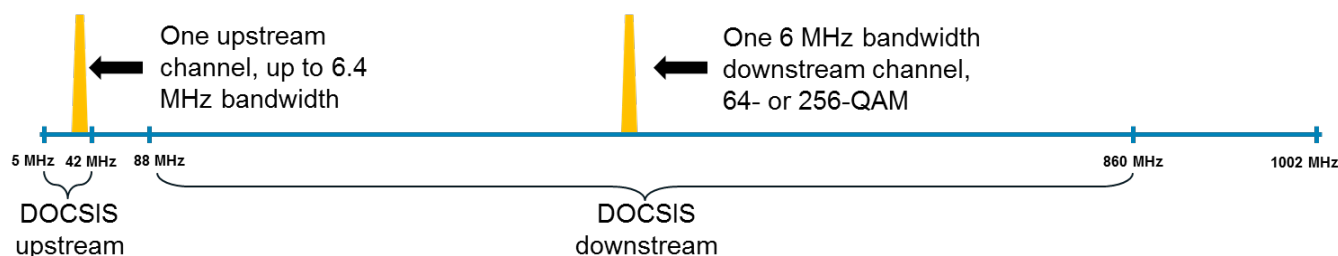


Figure 2 - DOCSIS 2.0 Equipment Frequency Usage

DOCSIS 3.0 technology and specifications retained a downstream channel bandwidth of 6 MHz, and upstream channel bandwidths up to 6.4 MHz. The DOCSIS 3.0 specification introduced channel bonding, in which logical bonding of multiple channels increases data throughput. For example, bonding four downstream 256-QAM 6 MHz-wide channels gives a raw data rate of $42.88 \text{ Mbps} \times 4 = 171.52 \text{ Mbps}$. The downstream lower frequency limit changed from DOCSIS 1.x and 2.0's 88 MHz to 108 MHz, and the upper frequency limit increased from 860 MHz to 1002 MHz. The upstream upper frequency limit increased to as high as 85 MHz (optional); see Figure 3. DOCSIS 1.x / 2.0 cable modems can reside on same system as DOCSIS 3.0 modems.

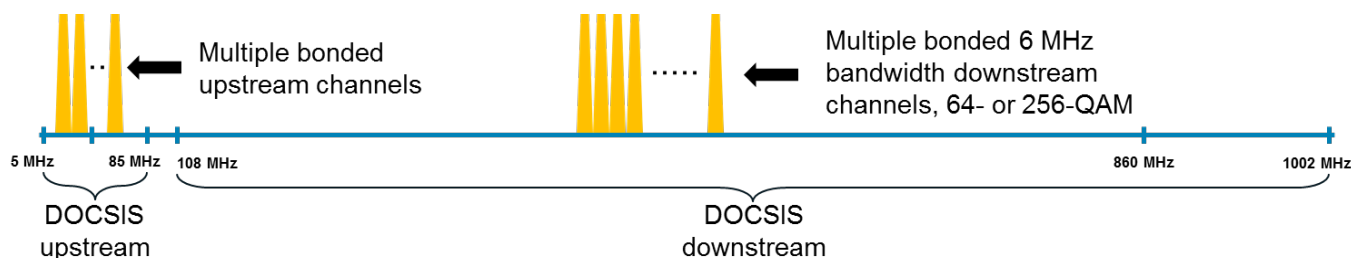


Figure 3 - DOCSIS 3.0 Equipment Frequency Usage

6.1.2. DOCSIS 3.1 Technology and Specifications Overview

DOCSIS 3.1 is the latest set of CableLabs' DOCSIS Specifications. CableLabs® released version I01 of the new 3.1 spec in late October, 2013. The latest version is I09, released June, 2016. All DOCSIS 3.1 specifications including *MAC and Upper Layer Protocols Interface Specification (MULPI)*, *Cable Modem Operations Support System Interface Specification (OSS)*, *Physical Layer Specification (PHY)*, *CCAP™ Operations Support System Interface Specification*, and *Security Specification* have been publicly released. DOCSIS 3.1 specifications became an international standard in early December 2014 (ETSI TS 103 311).

Why not just continue with DOCSIS 3.0 technology? After all, DOCSIS 3.0 devices can scale to gigabit-class speeds. However, DOCSIS 3.1 technology will scale better, and is more spectrally efficient than single carrier quadrature amplitude modulation (SC-QAM) technology. Among the goals of the DOCSIS 3.1 specification are achieving 10+ gigabits per second (Gbps) in the downstream and 1+ Gbps in the

upstream; backwards compatibility with DOCSIS 3.0, 2.0, & 1.1 equipment; and the previously mentioned better spectral efficiency – that is, more bits per second per hertz (bps/Hz) through the use of higher modulation orders.

DOCSIS 3.1 operation takes advantage of technology that is new for the cable industry: orthogonal frequency division multiplexing (OFDM) in the downstream, orthogonal frequency division multiple access (OFDMA) in the upstream, and low density parity check (LDPC) FEC. Also supported are higher modulation orders than earlier versions of DOCSIS equipment: Up to 4096-QAM in the downstream and upstream, optional to 16384-QAM in the downstream.

Of interest to coexistence with MoCA, the DOCSIS 3.1 specification supports expanded downstream and upstream spectrum usage (see Figure 4). The mandatory supported downstream spectrum is 258 MHz to 1218 MHz, optional to 1794 MHz (and optionally starting at 108 MHz on the lower end of the downstream spectrum). The upstream spectrum is from 5 MHz to as high as 204 MHz. The maximum downstream OFDM channel bandwidth is 192 MHz, and the minimum is 24 MHz. The maximum upstream OFDMA channel bandwidth is 96 MHz, and the minimum occupied bandwidth (equal to the encompassed spectrum minus exclusions) is either 6.4 MHz (25 kHz subcarrier spacing) or 10 MHz (50 kHz subcarrier spacing).



Figure 4 – Allowable DOCSIS 3.1 Downstream Frequency Usage

Figure 5 shows that DOCSIS 3.1 signals and MoCA signals are both allowed to occupy frequencies between 1125 MHz and 1675 MHz



Figure 5 - DOCSIS 3.1 and MoCA Signals Could Share the Same Frequencies

6.2. MoCA

MoCA develops home networking media access control (MAC) and PHY specifications and certification programs for its members. MoCA has provided RF characteristics summaries for both MoCA 1.1 and MoCA 2.0 specifications to the public via its website. See [MoCA 1.1] and [MoCA 2.0] for details.

MoCA technology is capable of establishing communications links that have frequency nulls, large attenuation, and significant delay spread. MoCA has been designed to communicate over components where communication may not have been originally intended. Some examples of the RF challenges MoCA can overcome include:

- Communicating across home splitter or amplifier output ports
- Communicating through devices that may have spectral nulls above 1 GHz

- Communicating through high coaxial cable attenuation above 1 GHz

Figure 6 illustrates a typical in-home MoCA network from [MoCA 2.0], where communication between nodes could involve, at a minimum, communication across splitter output ports (sometimes called “splitter jumping”). Splitter jumping is illustrated in Figure 6 as the communication path between point A and point B. Many legacy splitters were designed with the intention to not allow signals to pass across their output ports, hence the specification output port-to-output port (OP2OP) isolation. A common value of OP2OP isolation is 25 decibels (dB) minimum up to 1 GHz. Also frequency nulls (high attenuation over a relatively narrow bandwidth) may exist above 1 GHz, a region of spectrum historically not specified on legacy splitters or home amplifiers. Since MoCA has been in use since 2010, it has been designed to coexist with these RF challenges. A detailed description of the advantages and usage of PoE filters is provided in section 11, “Existence/Location of PoE and Protection Filters.”

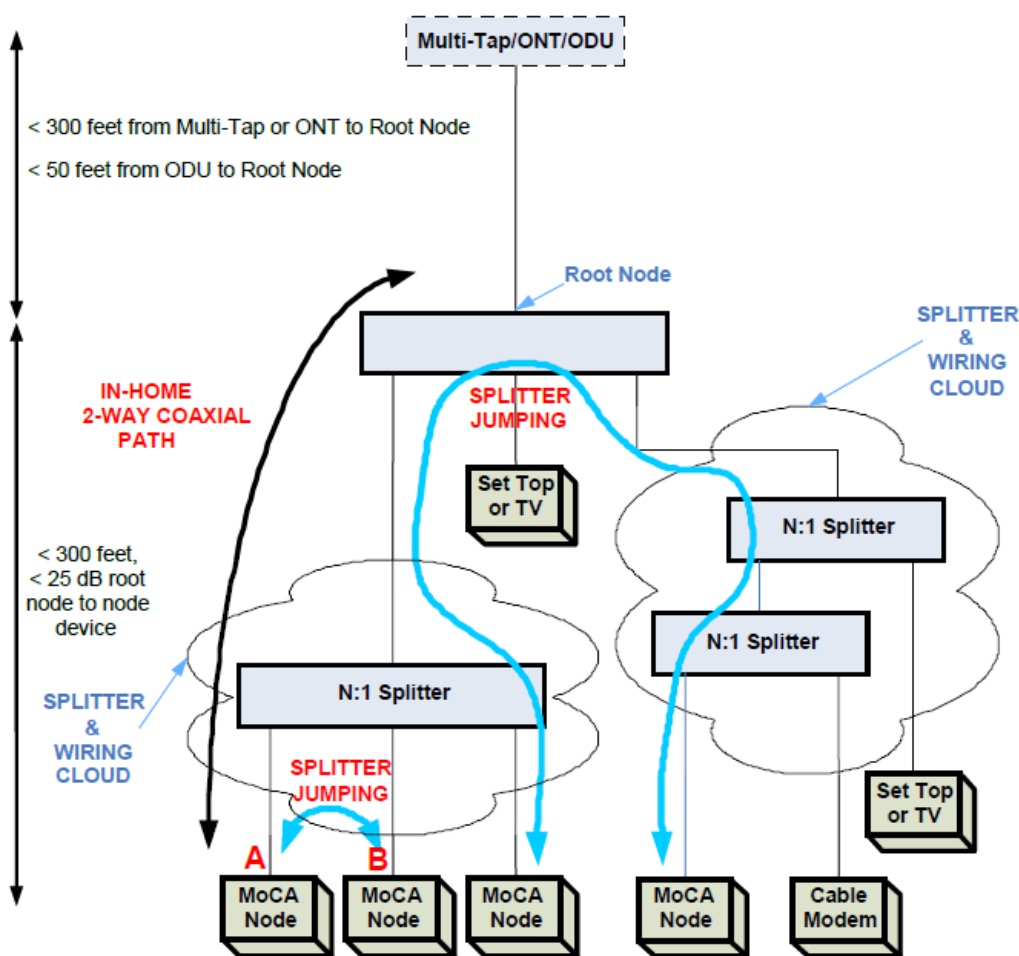


Figure 6 - A Typical In-home MoCA Network

MoCA band D has a frequency range above 1 GHz used for transmission of Multimedia over Coax Alliance signals. Band D comprises eight 50 MHz-wide channels in the 1125 MHz to 1525 MHz range. Extended Band D, introduced in MoCA 2.0, is 550 MHz wide and comprises 100 MHz-wide single channels, 225 MHz-wide bonded-pair channels, and two sub-bands (D-Low and D-High) in the 1125 MHz to 1675 MHz range.

MoCA 2.0 primary channels (100 MHz bandwidth (BW)) in ExD are centered on a 25 MHz grid and their maximum total output power can be between -1 decibel milliwatt (dBm) and +7 dBm per 100 MHz. The spectral mask for MoCA 2.0 has been provided in Figure 7 and is the basis for the MoCA 2.0 Out of channel emissions discussed in Section 9.2 Fidelity Requirements for MoCA.

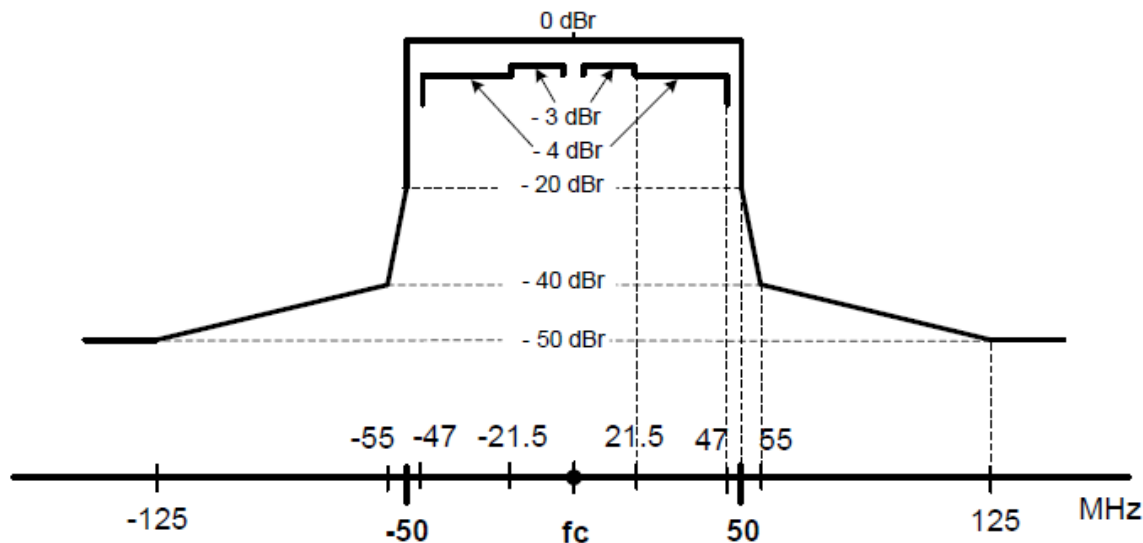


Figure 7 - MoCA 2 Transmit Spectral Mask (for TPC Settings of -12 to 20)

The spectral mask for MoCA 1.1 has been provided in Figure 8 and is the basis for MoCA 1.1 Out of channel emissions discussed in Section 9.2 Fidelity Requirements for MoCA. The spectral mask attributes of MoCA and DOCSIS signals are critical in understanding the isolation requirements for coexistence, which are described in more detail, later in this document.

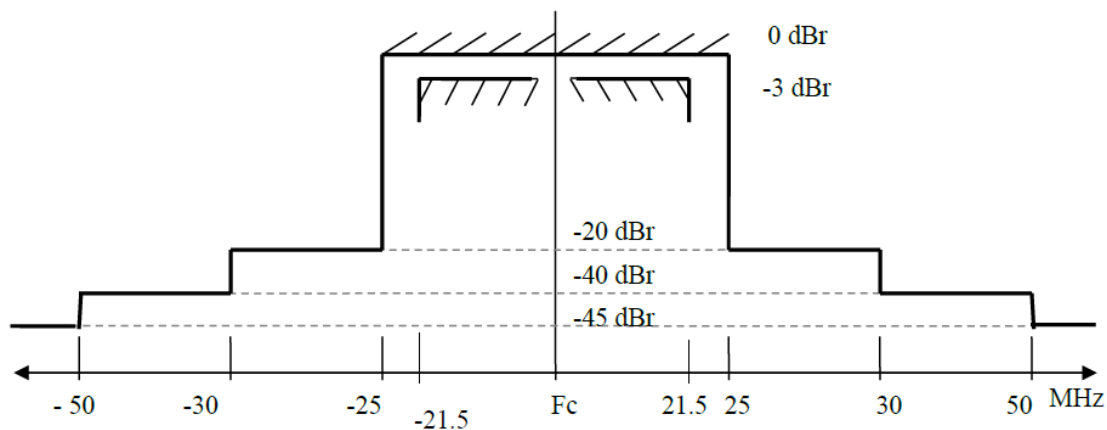


Figure 8 – MoCA 1.1 Transmit Spectral Mask

7. Home Environment and Topology

Cable operators have used two architectures for residential and multiple dwelling unit (MDU) installations. One is loop-through, and the other is home-run. Figure 9 illustrates a high-level view of the two architectures.

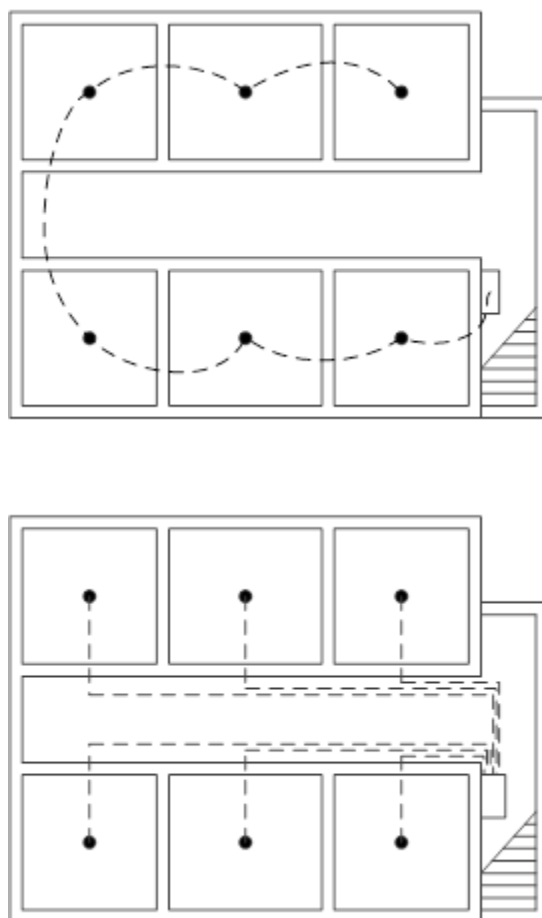


Figure 9 - Loop-through (top) and Home-run (bottom) Subscriber Drop Architectures

A home-run architecture is similar to a hub-and-spoke architecture, in which each room or unit is fed by a dedicated run of coaxial cable from the root device or signal distribution point. Home-run wiring is commonly used in residential installations, and in most MDUs.

A loop-through architecture is series-wired from a root device or signal distribution point to the rooms or units in the building (or floor). One port of a splitter or directional coupler in the first room taps off signal for that room, and the other port feeds subsequent rooms or units. Loop-through architectures were at one time widely used for master antenna television (MATV) and satellite master antenna television (SMATV) signal distribution in MDUs, and also were used for distribution of cable signals in MDUs and in some single-family residences. Though no longer in widespread use, some buildings still have loop-through cabling. Some single family residences have a hybrid of both home-run and loop-through topology.

7.1. Home-run

A detailed home-run topology is depicted in Figure 10. An important characteristic of a home-run topology is a single cable between a root device or distribution point and each customer premises equipment (CPE) location. In one variation, one output of a two-way splitter feeds the cable modem, and the other output is connected to a second splitter that in turn feeds the remaining CPE. In another variation (shown in Figure 10), splitters are not cascaded.

Guideline 1: A home-run topology should be used to control losses and RF levels more uniformly across the home CPE.