MoCA 1.1 Specification for Device RF Characteristics

20140211

Table of Contents

1 MoCA 1.1 Specification - Introduction and Scope

1.1 *Scope*

This document summarizes several technical specifications for operation of Multimedia Over Coax Alliance (MoCA) devices ("nodes") using in-home coaxial wiring for transport of multimedia content. Section 1 describes the MoCA node protocol stack and physical network model, while section 2 describes MoCA specifications for Media Access Control (MAC) throughput, connector loss, transmit power, transmitter spectral mask, transmitter spurious output, and receiver sensitivity.

1.2 *Introduction*

The MoCA system network model creates a coax network which supports communications between a convergence layer in one MoCA node to the corresponding convergence layer in another MoCA node. The protocol stack of a MoCA node is shown in Figure 1-1. The MoCA specification does not include layers above the convergence layer.

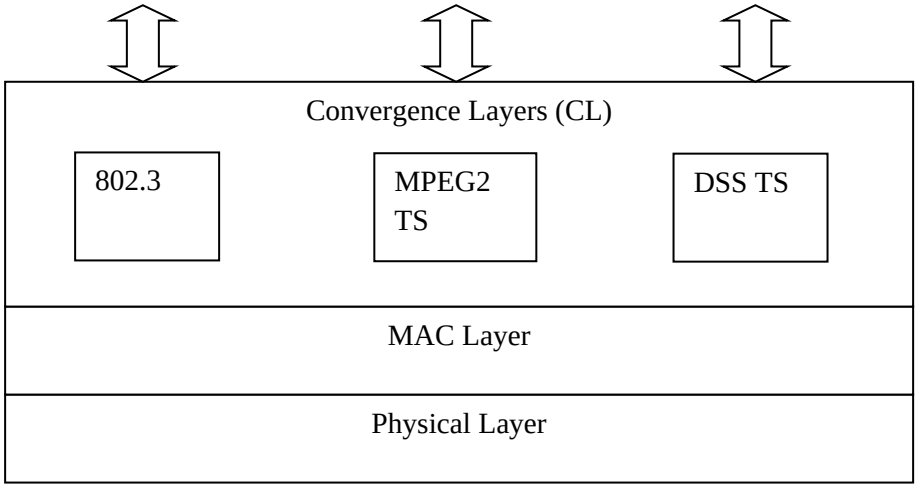

Figure 1-1: MoCA Node Protocol Stack

1.3 *Abbreviations*

Table 1-1. Table of Abbreviations

Term	Stands for
ACMT	Adaptive Constellation Multi-tone
APM	Added PHY Margin
CRC	Cyclic Redundancy Checksum
ECL	Ethernet Convergence Layer
FSK	Frequency Shift Keying
ISDB-T	Integrated Services Digital Broadcasting Terrestrial
LMO	Link Maintenance Operations
LNB	Low Noise Block down-converter

MAC	Media Access Control
MoCA	Multimedia over Coax Alliance
OSP	Operator-Service Provider
PHY	Physical Layer
RBW	Resolution Bandwidth
SWM	Single Wire Multi-switch
VBW	Video Bandwidth

1.4 *Definitions*

Flat Channel – A MoCA channel with power magnitude variation of less than 4.5 dB and group-delay variation of less than 2 ns across any MoCA channel with no added noise, interference, or multipath.

Intermediate Device – An Intermediate Device is a MoCA node that has as one of its primary functions bridging of user content between the MoCA Network and an external device over an industry standard interface such as Ethernet or USB.

Terminal Device – A Terminal Device is a MoCA node whose primary function is to source or sink user content over the MoCA Network. A set-top box is an example of a Terminal device.

1.5 *Physical Network Model*

Typical in-home coaxial networks are configured as a branching tree topology. The point of connection to the first splitter is called the Root Node. The MoCA nodes inside the home communicate with each other by having their signals traverse across one or more splitters. The signal path transmission between two MoCA nodes is the superposition of several individual paths. Each individual signal path may have a different magnitude and delay resulting in an aggregate signal path with frequency nulls, large attenuation, and significant delay spread. The MoCA Network will operate under these channel conditions.

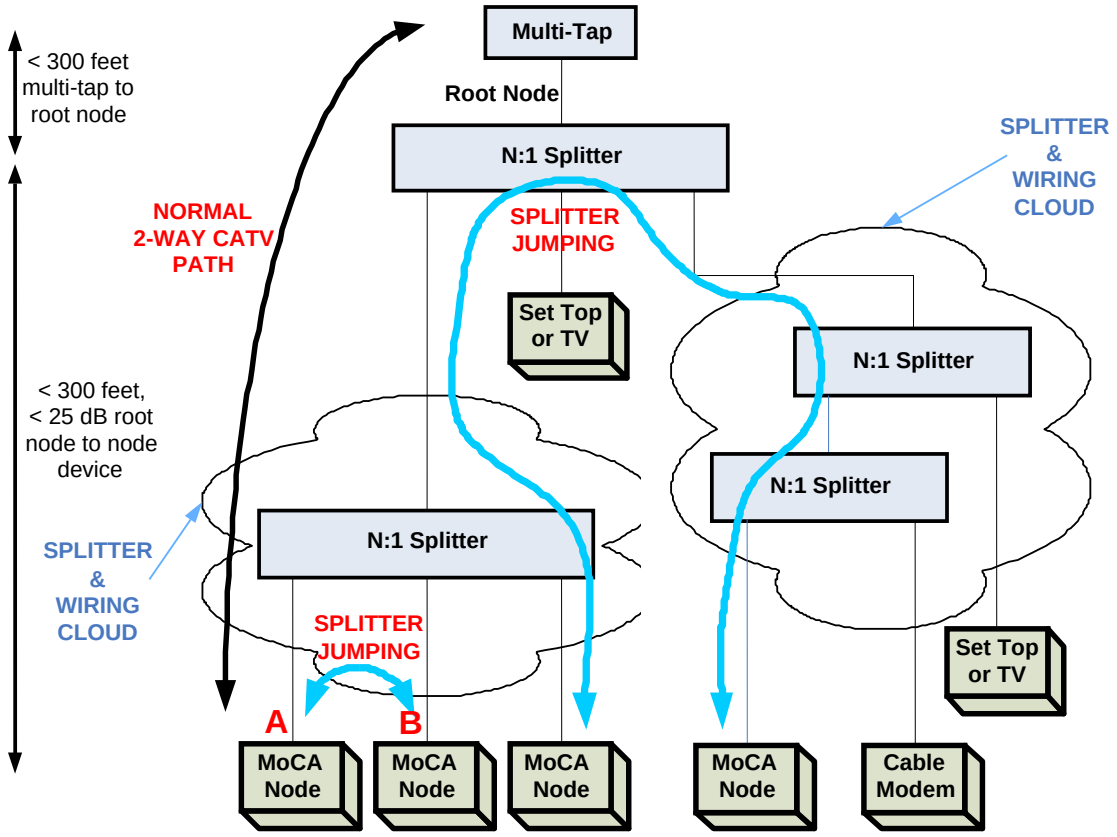

Figure 1-2: A Typical In-home MoCA Network

2 MoCA 1.1 Reference Specification

2.1 *MoCA Frequency Plan*

MoCA channel center frequencies are specified within several MoCA frequency bands between 500 and 1500 MHz (inclusive) at increments as listed in Table 2-1. The Multimedia Over Coax Alliance has procedures for establishing additional MoCA bands based on new markets and use cases.

Table 2-1. List of MoCA Bands and Channel Center Frequencies

MoCA Band	MoCA Channel Number	Channel Center Frequency [MHz]
A	A1	875
B	B1	900
C1	C1	925
C2	C2	950
C3	C3	975
C4	C4	1000
D	D1	1150
	D2	1200
	D3	1250
	D4	1300
	D5	1350
	D6	1400
	D7	1450
	D8	1500
E	E1	500
	E2	525
	E3	550
	E4	575
	E5	600
F	F1	675
	F2	700
	F3	725
	F4	750
	F5	775
	F6	800
	F7	825
	F8	850
G	G1	500
	G2	550
	G3	600
	G4	650
	G5	700
	G6	750
	G7	800
H	H1	975
	H2	1000
	H3	1025

2.2 *MAC Throughput*

For flat channels between any two Intermediate Devices with > 90 Mbps external interfaces (such as 100 Mbit Ethernet) in a MoCA Network, with 1518 byte packets coming into the ECL from outside the MoCA Network, MAC Rate at a PHY Rate MUST be greater than the corresponding Minimum MAC Rate value shown in Table 2-2.

Table 2-2. Minimum MAC Rate as a Function of PHY Rate

PHY Rate (Mbps)	Minimum MAC Rate (Mbps)
≥ 275	139.87
250	130.78
225	119.45
200	107.74
175	95.64
150	81.98
125	68.32
100	54.65
75	39.82

2.3 *Connector and Return Loss*

The RF input connector for a Node MUST be F-Type with a nominal impedance of 75 ohms. The return loss shall be ≥ 5 dB when operating in band A, B, C, or D, and ≥ 8 dB when operating in band E, F or H, measured over the frequency band of interest. (i.e., 45 MHz frequency band centered at the center of the tuned channel.)

2.4 *MoCA Transmit Power*

A Node MUST have a maximum output power between −4 dBm to +8 dBm when operating in band A, B, C, or D, or F, and between −1 dBm to +7 dBm when operating in band E or H, at every supported MoCA channel frequency, as measured at the RF connector at the output of any filter required by the Node for proper operation.

All transmit power is measured into a 75 ohm load.

2.5 *MoCA Transmitter Spectral Mask*

The spectral mask requirements apply for each MoCA band of operation in the frequency ranges specified in Table 2-3. The spectrum at the RF connector from the MoCA transmitter MUST conform to the mask specified in Table 2-4. The spectral mask from Fc−50 MHz to Fc+50 MHz should be measured with the spectrum analyzer set to RBW = 300 kHz, VBW = 3 kHz, Sweep Mode = Continuous, Sweep Time = 300 msec, Video Averaging = On (100 traces), Span = 75 MHz. The measured peak power of any 300 kHz band within Fc ± 21.5 MHz (except for the range Fc−0.931 MHz to Fc+0.931 MHz) is the 0 dBr value. For farther out spectral mask measurements, set the spectrum analyzer to:

- Start freq = the low edge of the frequency range in Table 2-3, stop freq = Fc – 50 MHz
- Start freq = Fc + 50 MHz, stop freq = the high edge of the frequency range in Table 2-3

Table 2-3. Transmitter Spectral Mask Frequency Ranges

MoCA Band	Frequency Range
A, B, C, D	775 MHz < f < 1525 MHz
E	400 MHz < f ≤ 800 MHz
F	600 MHz < f < 925 MHz
H	850 MHz < f < 1160 MHz

Table 2-4. Transmitter Spectral Mask

Frequency Range	Output
Fc – 21.5 MHz ≤ f < Fc – 0.931 MHz	–3 dBr to 0 dBr/300 kHz
Fc + 0.931 MHz < f ≤ Fc + 21.5 MHz	–3 dBr to 0 dBr/300 kHz
Fc – 30 MHz ≤ f < Fc – 25 MHz	< -20 dBr/300 kHz
Fc + 25 MHz < f ≤ Fc + 30 MHz	< -20 dBr/300 kHz
Fc – 50 MHz ≤ f < Fc – 30 MHz	< -40 dBr/300 kHz
Fc + 30 MHz < f ≤ Fc + 50 MHz	< -40 dBr/300 kHz
f < Fc – 50 MHz	< -45 dBr/2 MHz
Fc + 50 MHz < f	< -45 dBr/2 MHz

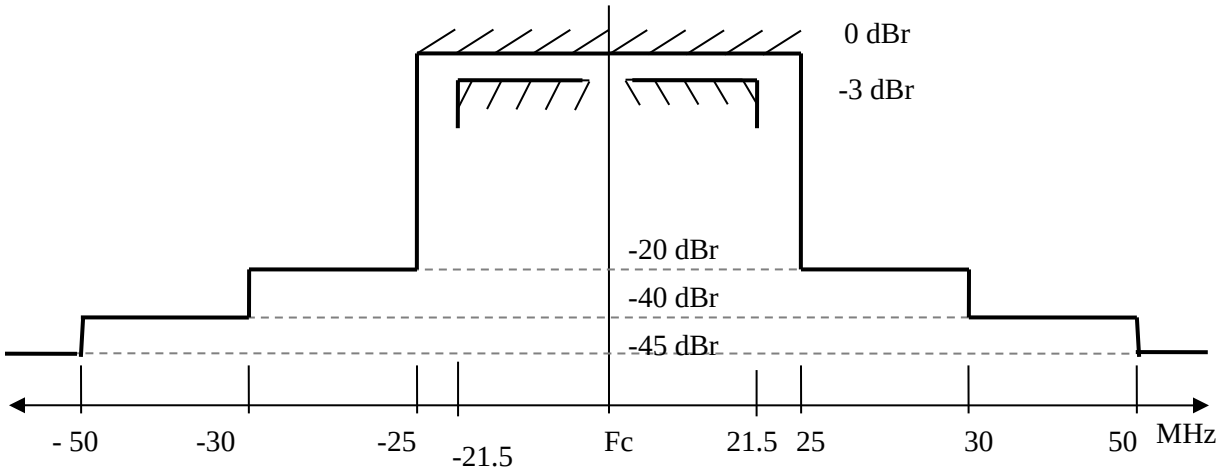

Figure 2-1. Transmitter Spectral Mask

The MoCA transmitter MUST NOT be turned on during symbol transmissions of adjacent packets from other MoCA nodes. When a MoCA transmitter is turned on and no packets are being transmitted, the transmitted output power MUST be less than –39 dBc relative to the transmitted power when the ACMT carriers are turned-on excluding the following two allowed spurious:

- A single spurious at Fc with relative power of less than -23 dBc
- A single spurious at either Fc+25MHz or Fc-25MHz with relative power of less than -39 dBc appearing not earlier than 4.0 µs before the first sample of its PHY frame preamble is output at the F-connector, and with relative power of less than -35 dBc not earlier than 1.5 µs before the first sample of its PHY frame preamble is output at the F-connector.

A MoCA transmitter SHOULD be turned on less than 7.4 µs before the first symbol has reached 90% of its final value and SHOULD be turned off less than 1 µs after the last transmitted symbol.

2.6 *RF Mode Transmitter Spurious Output*

The spurious signals at the output of the MoCA RF connector MUST conform to the Table 2-5 when operating in band A, B, C, or D, to Table 2-6 when operating in band E, to Table 2-7 when operating in Band F, and to Table 2-8 when operating in band H, where the dBc value is measured relative to total transmitted signal power.

Table 2-5. Transmitter Spurious Output When Operating in Band A, B, C, or D

Parameter	Value	Notes
Spurious at Fc	< -23 dBc	
Inband spurious and noise excluding at Fc	< -39 dBc	Measured in 45 MHz band
54 – 806 MHz spurious and noise when using A, C1, or C2 band channels	< -45dBmV	Measured in 4 MHz BW including discretes
54 – 864 MHz spurious and noise when using B, C3, C4, or D-band channels	< -45dBmV	Measured in 4 MHz BW including discretes
54 – 806 MHz discrete tones only when using A, C1, or C2 band channels	< -50 dBmV	
54 – 864 MHz discrete tones only when using B, C3, C4 or D-band channels	< -50 dBmV	
Single tone ≥ 2000 MHz	< - 3 dBmV	
950 MHz to 2150 MHz spurious and noise when using A or B band channels	< – 1 dBmV	Measured in 20 MHz BW including discretes. This requirement protects L-band signals when using A or B band channels.

Table 2-6. Transmitter Spurious Output When Operating in Band E

Parameter	Value	Notes
Spurious at Fc	-23 dBc	
Inband Spurious and Noise excluding at Fc	-39 dBc	Measured in 45 MHz band
0.5 MHz to ≤ 2.1 MHz	-50 dBm/152 kHz	Reduce home networking OOB emissions to protect FSK transmissions
2.1 MHz to ≤ 2.5 MHz	-78 dBm/152 kHz	Reduce home networking OOB emissions to protect FSK transmissions
>2.5 MHz to ≤ 3 MHz	< -40 dBm	Integrated power over the band
> 3 MHz to ≤ 4 MHz	≤ -20 dBm	Integrated power over the band
> 800 MHz to < 950 MHz	< -55 dBm/20 MHz	
≥ 950 – 2500 MHz	< -94 dBm/20 MHz	Reduce home networking OOB emissions to protect Satellite signals
> 2500 to 3000 MHz	-80 dBm/20 MHz	Reduce home networking OOB emissions to protect Satellite signals

Table 2-7: Transmitter Spurious Output When Operating in Band F

Parameter	Maximum Value	Notes
Spurious at Fc	-23dBc	
Inband Spurious and Noise, excluding at Fc	-39dBc	Measured in a 45MHz band
>10kHz to ≤ 1MHz	25mV p-p at 12 ohm	
>1MHz to < 500MHz	< -58dBm/50MHz	
≥500MHz to ≤575MHz	< -83dBm/50MHz	
>575MHz to < 600MHz	<-52dBm	
>925MHz to <950MHz	<-52dBm	
≥950MHz to 3000MHz	< -94dBm/27MHz	

Table 2-8. Transmitter Spurious Output When Operating in Band H

Parameter	Value	Notes
Spurious at Fc	-23 dBc	
Inband Spurious and Noise excluding at Fc	-39 dBc	Measured in 45 MHz band
0.5 MHz to ≤ 2.1 MHz	-50 dBm/152 kHz	Reduce home networking OOB emissions to protect FSK transmissions
2.1 MHz to ≤ 2.5 MHz	-78 dBm/152 kHz	Reduce home networking OOB emissions to protect FSK transmissions
>2.5 MHz to ≤ 3 MHz	< -40 dBm	Integrated power over the band
> 3 MHz to ≤ 4 MHz	< -20 dBm	Integrated power over the band
>4 MHz to <50 MHz	-54.2 dBm/2 MHz	Spurious and noise
50 MHz to <174 MHz	-89 dBm/6 MHz	For protection of low VHF band devices
174 MHz to 216 MHz	-101 dBm/6 MHz	Protect ISDB-T Rx
>216 MHz to <470 MHz	-53 dBm/6 MHz	Protect ISDB-T Rx from spurious and noise
470 MHz to 806 MHz	-101 dBm/6 MHz	Protect ISDB-T Rx
>806 MHz to 850 MHz	-53 dBm/6 MHz	Protect ISDB-T Rx
>1160 MHz to < 1257 MHz	< -55 dBm/20 MHz	Protect satellite Rx adjacent channel response
>1257 MHz to 2500 MHz	< -94 dBm/20 MHz	Protect SWM channel frequencies and Satellite Rx signals
> 2500 to 3000 MHz	-80 dBm/20 MHz	Protect OOB satellite Rx spurious

2.7 *MoCA Receiver Minimum Sensitivity*

The minimum receiver power at the MoCA RF input connector to reach a specified PHY Rate MUST NOT exceed that shown in Figure 2-2 and Table 2-9 when operating in band A, B, C, or D, and in Figure 2-3 and Table 2-10 when operating in band E, F or H with TPC disabled, and as shown in Figure 2-4 and Table 2-11 when operating in band F with TPC enabled, under the following conditions:

- Flat Channel
- In the presence of the following signals appearing at the input to the Node:
    - When operating in bands C or D: a CATV signal as shown in Table 2-12
    - When operating in band E: Simultaneously:
        - An OSP Satellite transponder signal shown in Table 2-13
        - An FSK control signal as show in Table 2-14
        - Maximum intermittent power levels as specified in Table 2-15

- When operating in band F: Simultaneously:
  - OSP Satellite Transponder Signal Level as shown in Table 2-16
  - DiSEqC signal as show in

        - Table 2-17
        - Maximum intermittent power levels as specified in Table 2-18
        - UHF Analog video signal as shown in Table 2-19
    - When operating in band H: Simultaneously:
        - An ISDB-T signal shown in Table 2-20
        - An OSP Satellite transponder signal shown in Table 2-21
        - An FSK control signal as show in Table 2-14
        - Maximum intermittent power levels as specified in Table 2-22
- No other External Interference

A MoCA receiver operating in a Flat Channel MUST be able to detect beacons at a received power level of at least −76 dBm.

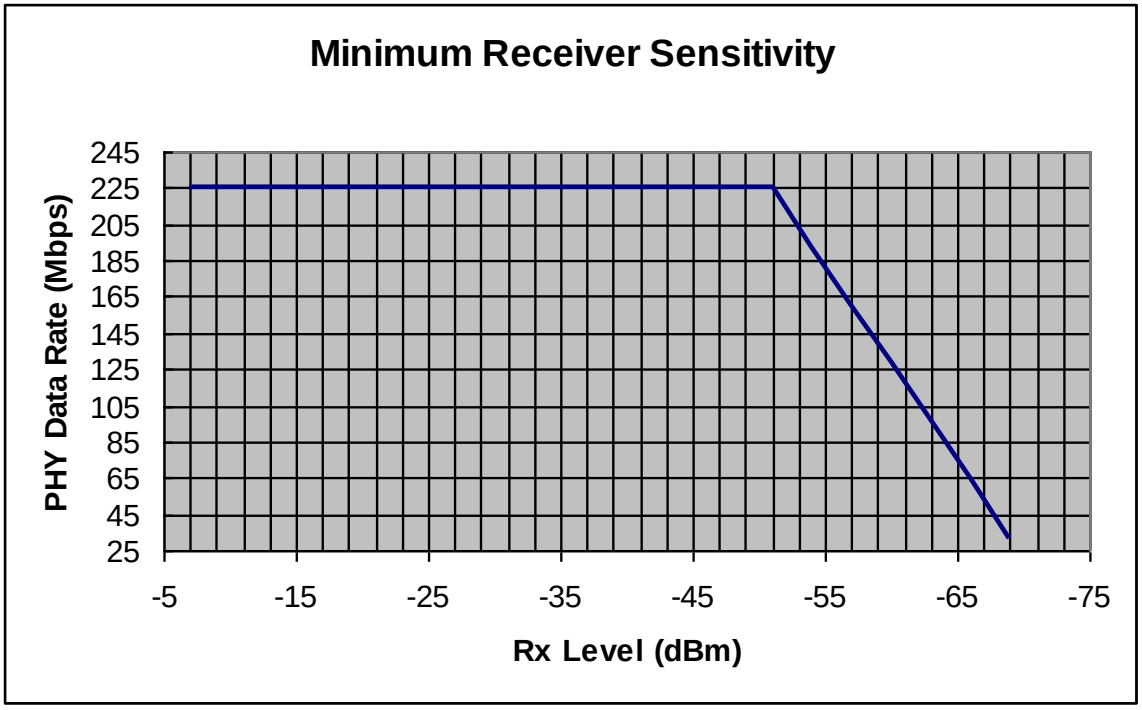

Figure 2-2. Minimum Receiver Sensitivity When Operating in Band A, B, C, or D

Table 2-9. Receiver Sensitivity When Operating in Band A, B, C, or D

Min PHY Rate (Mbps)	Receive Level
57	-66.7 dBm (-17.95 dBmV)
64.3	-66 dBm (-17.25 dBmV)
96.4	-63 dBm (-14.25 dBmV)
128.6	-60 dBm (-11.25 dBmV)
160.7	-57 dBm (- 8.25dBmV)
192.9	-54 dBm (-5.25 dBmV)
225	-7 dBm (41.75 dBmV) to -51 dBm (-2.25 dBmV)

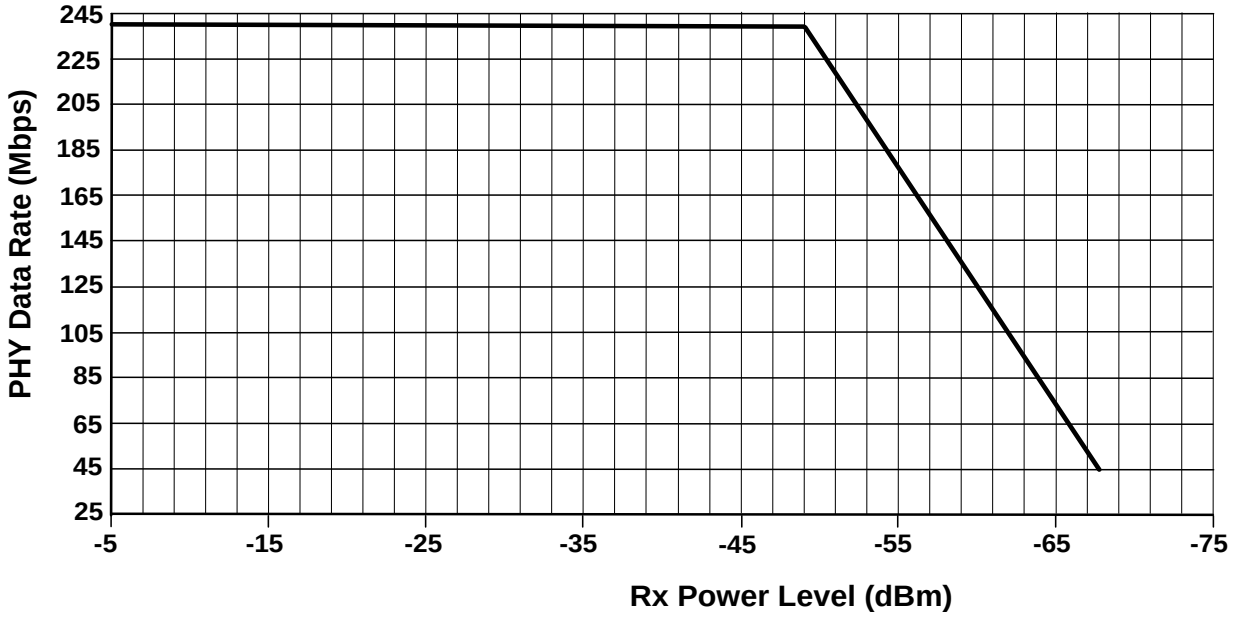

Figure 2-3. Minimum Receiver Sensitivity When Operating in Band E and F with TPC Disabled

Table 2-10. Receiver Sensitivity When Operating in Band E and F with TPC Disabled

Min PHY Rate (Mbps)	Receive Level
57	-66.1 dBm (-17.35 dBmV)
90.2	-63 dBm (-14.25 dBmV)
122.3	-60 dBm (-11.25 dBmV)
154.4	-57 dBm (- 8.25dBmV)
186.5	-54 dBm (-5.25 dBmV)
225	-50.4 dBm (-1.65 dBmV)
240	-6 dBm (42.75 dBmV) to -49 dBm (-0.25 dBmV)

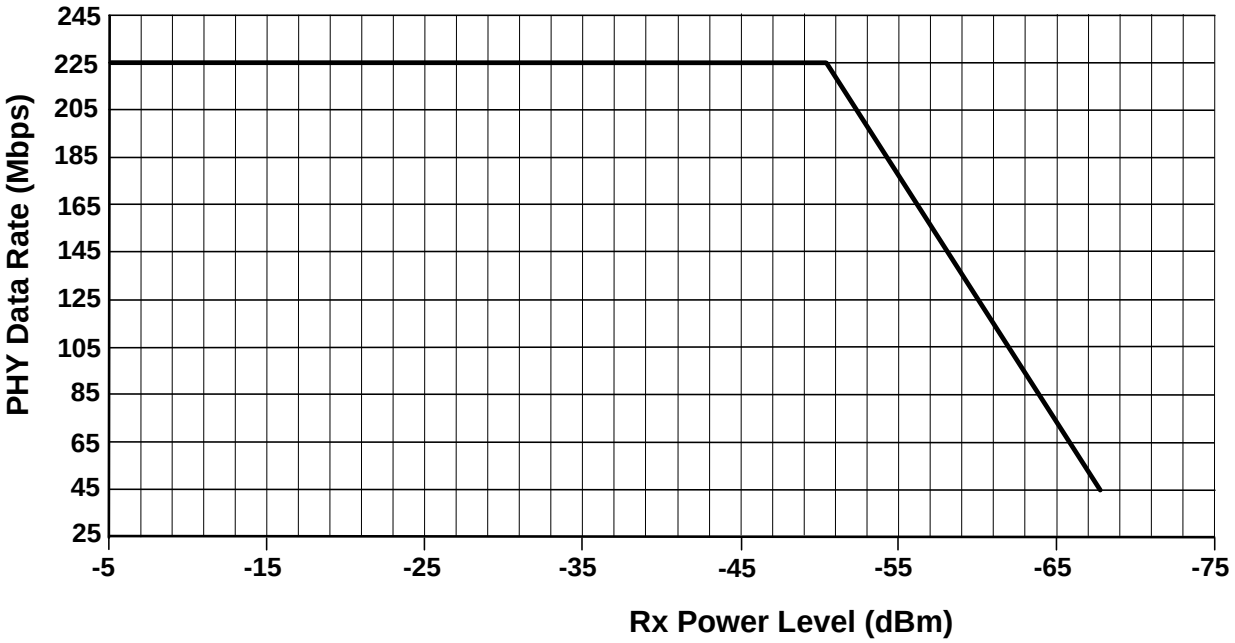

Figure 2-4: Minimum Receiver Sensitivity in Band F with TPC Enabled

Table 2-11: Minimum Receiver Sensitivity in Band F with TPC Enabled

Min PHY Rate (Mbps)	Receive Level
57	-66.1 dBm (-17.35 dBmV)
90.2	-63 dBm (-14.25 dBmV)
122.3	-60 dBm (-11.25 dBmV)
154.4	-57 dBm (- 8.25dBmV)
186.5	-54 dBm (-5.25 dBmV)
225	-6 dBm (42.75 dBmV) to -50.4 dBm (-1.65 dBmV)

Table 2-12. CATV Signal Level

Parameter	Value
Input Frequency range	54-864 MHz
RF channel spacing	6 MHz
Analog video carrier level (per channel)	-15 dBmV to +15 dBmV (peak envelop power in 6 MHz channel BW)
Digital carrier level (per channel)	-15 dBmV to +10 dBmV (average power in 6 MHz channel BW)
Maximum number of analog carriers	121
Total Power from 54-864 MHz	< 30 dBmV

Table 2-13. OSP Satellite Transponder Signal Level

Parameter	Value
Input Frequency range	950-2150 MHz
Signal level (in any 24 MHz bandwidth in the Input Frequency range)	Up to -20 dBm (average power per carrier)
Total aggregated power level (measured at the Terminal Device)	-10 dBm

Table 2-14. FSK Control Signal

Parameter	Value
Tx Carrier Frequency	2.3 MHz ± 10 kHz
Tx Frequency shift	± 40 kHz +10/-5 kHz
Asynchronous Serial Bit Rate	39 kbaud ±0.5%
Tx Carrier maximum Power	-1 dBm (75 ohms)

Table 2-15. Maximum Intermittent Power Levels at the Input to the Node when Operating in Band E

Frequency	Power Level*
0.2 MHz to 0.6 MHz	Increasing linearly from -31dBm/200kHz to -28dBm/200kHz
> 0.6 MHz to 1 MHz	Increasing linearly from -28dBm/200kHz to -25dBm/200kHz
> 1 MHz to 1.8 MHz	Increasing linearly from -25dBm/200kHz to -16dBm/200kHz
> 1.8 MHz to 2 MHz	Increasing linearly from -16dBm/200kHz to -9dBm/200kHz
> 2.0 MHz to 2.1 MHz	Increasing linearly from -9dBm/200kHz to -1dBm/200kHz
> 2.1 MHz to 2.5 MHz	-1 dBm/200 kHz
> 2.5 MHz to 100 MHz	Decreasing linearly from -1 dBm to -30 dBm/200 kHz
> 100 MHz to 200 MHz	-35 dBm/200 kHz; -30 dBm Aggregate
> 200 MHz to 300 MHz	-45 dBm/200 kHz; -40 dBm Aggregate
> 300 MHz to 450 MHz	-55 dBm/200 kHz; -50 dBm Aggregate
> 450 MHz to 470 MHz	-65 dBm/200 kHz; -60 dBm Aggregate
> 470 MHz to 475 MHz	-96 dBm/200 kHz
> 475 MHz to 625 MHz	-116 dBm/200 kHz
> 625 MHz to 630 MHz	-96 dBm/200 kHz
> 630 MHz to 650 MHz	-65 dBm/200 kHz; -60 dBm Aggregate
> 650 MHz to 800 MHz	-55 dBm/200 kHz; -50 dBm Aggregate
> 800 MHz to 950 MHz	-55 dBm/20 MHz

* The power level is the measured peak power level over any 5 μs time interval.

Table 2-16. OSP Satellite Transponder Signal Level at Node Input in Band F

Parameter	Value	Notes
Input Frequency range	950-3000 MHz	
Signal level	-25 dBm	Per 27MHz transponder
Total aggregated power level	-7 dBm	

Table 2-17. DiSEqC Control Signal at Node Input in Band F

Parameter	Value	Notes
Tx Carrier Frequency	17.6 kHz - 26.4 kHz	
Signal level	200 mVp-p – 1Vp-p	
DiSEqC Impedance (DiSEqC™ Bus Specification Version 4.2 (February 25, 1998))	12 – 18 ohm	Rx mode

Table 2-18. Maximum Intermittent Power Levels at Node Input in Band F

Frequency	Power Level*
1 MHz < f ≤ 10MHz	-30dBm/200KHz, -13dBm aggregate
10 MHz < f ≤ 300MHz	-35dBm/200KHz, -30dBm aggregate
300 MHz < f ≤ 450MHz	-45dBm/200KHz, -40dBm aggregate
450 MHz < f ≤ 625MHz	-55dBm/200KHz, -50dBm aggregate
625 MHz < f ≤ 645MHz	-65dBm/200KHz, -60dBm aggregate
645 MHz < f ≤ 650MHz	-96dBm/200KHz
650 MHz < f ≤ 875 MHz	-116 dBm/200 kHz
875 MHz < f ≤ 880 MHz	-96dBm/200KHz
880 MHz < f ≤ 900MHz	-65dBm/200KHz, -60dBm aggregate
900 MHz < f ≤ 950MHz	-55dBm/200KHz, -50dBm aggregate

* The power level is the measured peak power level over any 5 μs time interval.

Table 2-19. UHF Analog Signal Level at Node Input in Band F

Parameter	Value	Notes
Input frequency range	500 - 575MHz	
Maximum signal power level (per channel)	-27dBm	Peak NTSC picture carrier level in 6MHz bandwidth
Maximum number of carriers	2	
Maximum aggregate power level	-24dBm	

Table 2-20. ISDB-T Signal Level

Parameter	Value
Input Frequency range	174-216 MHz and 470-806 MHz
RF channel spacing	6 MHz
Digital carrier level (per channel)	-14.8 dBm (maximum power in 6 MHz)
Maximum number of digital carriers	30
Total Power from 174-216 MHz and 470-806 MHz	0 dBm

Table 2-21. OSP Satellite Transponder Signal Level for Band H

Parameter	Value
Input Frequency range	1257-2150 MHz
Signal level (in any 24 MHz bandwidth in the Input Frequency range)	Up to -16 dBm (average power per carrier)
Total aggregated power level (over the full band measured at the SWM LNB output)	-6.5 dBm

Table 2-22. Maximum Intermittent Power Levels at the Input to the Node When Operating in Band H

Frequency	Power Level*
0.2 MHz to 0.6 MHz	Increasing linearly from -31dBm/200kHz to -28dBm/200kHz
> 0.6 MHz to 1 MHz	Increasing linearly from -28dBm/200kHz to -25dBm/200kHz
> 1 MHz to 1.8 MHz	Increasing linearly from -25dBm/200kHz to -16dBm/200kHz
> 1.8 MHz to 2 MHz	Increasing linearly from -16dBm/200kHz to -9dBm/200kHz
> 2.0 MHz to 2.1 MHz	Increasing linearly from -9dBm/200kHz to -1dBm/200kHz
> 2.1 MHz to 2.5 MHz	-1 dBm/200 kHz
> 2.5 MHz to <30 MHz	Decreasing linearly from -1 dBm to -21 dBm/200 kHz
> 30 MHz to <45 MHz	Decreasing linearly from -21 dBm to -60 dBm/200 kHz
> 45 MHz to <50 MHz	-60 dBm/200 kHz
50 MHz to < 174 MHz	-89 dBm/6 MHz
174 MHz to 216 MHz	-99 dBm/6 MHz
> 216 MHz to 470 MHz	-60 dBm/200 kHz; -55 dBm Aggregate over the full band
> 470 MHz to 806 MHz	-99 dBm/6 MHz
> 806 MHz to 925 MHz	-55 dBm/200 kHz; -50 dBm Aggregate over the full band
> 925 MHz to 945 MHz	-65 dBm/200 kHz; -60 dBm Aggregate over the full band
> 945 MHz to 950 MHz	-96 dBm/200 kHz
> 950 MHz to 1050 MHz	-116 dBm/200 kHz
> 1050 MHz to 1080 MHz	-96 dBm/200 kHz
>1080 MHz to 1100 MHz	-65 dBm/200 kHz; -60 dBm Aggregate over the full band
>1100 MHz to 1175 MHz	-55 dBm/200 kHz; -50 dBm Aggregate over the full band
>1175 MHz to 1257 MHz	-55 dBm/20 MHz
>1257 MHz to 2150 MHz	-94 dBm/20 MHz
>2150 MHz to 2500 MHz	-94 dBm/20 MHz
>2500 MHz to 3000 MHz	-80 dBm/20 MHz

* The power level is the measured peak power level over any 5μs time interval.