



APPENDIX **B**

RF Specifications

Information in the following tables is from the DOCSIS and EuroDOCSIS Radio Frequency Interface Specification, and should be considered minimum recommended performance criteria for reliable data transmission on cable networks. The full specification may be found at the CableLabs website (<http://www.cablemodem.com>), and additional Euro-DOCSIS information may be found at tComLabs' Website (<http://www.tcomlabs.com>).

- NCTA—"NCTA Recommended Practices for Measurements on Cable Television Systems, 2nd Edition"- National Cable Television Association, Washington DC, revised October 1993
- CableLabs1—"Two-Way Cable Television System Characterization" - Cable Television Laboratories, Inc., April 12, 1995
- CableLabs2—Digital Transmission Characterization of Cable Television Systems, Cable Television Laboratories, Inc. November, 1999



Note

Raw data rate in Table B-1 and Table B-2 includes nominal data throughput plus overhead.

Table B-1 Downstream Channel Data Rates

Modulation Format	Channel Bandwidth, MHz	Symbol Rate, Msym/sec	Raw Data Rate, Mbps	Nominal Data Rate, Mbps
QAM-64	6	5.056941	30.34	~27
QAM-256	6	5.360537	42.88	~38
QAM-64	8	6.952	41.71	~37
QAM-256	8	6.952	55.62	~50

Table B-2 Upstream Channel Data Rates

Symbol Rate, ksym/sec	Channel Bandwidth, MHz	QPSK Raw Data Rate, Mbps	QPSK Nominal Data Rate, Mbps	QAM-16 Raw Data Rate, Mbps	QAM-16 Nominal Data Rate, Mbps
160	0.20	0.32	~0.3	0.64	~0.6
320	0.40	0.64	~0.6	1.28	~1.2
640	0.80	1.28	~1.2	2.56	~2.3

Table B-2 Upstream Channel Data Rates (continued)

Symbol Rate, ksym/sec	Channel Bandwidth, MHz	QPSK Raw Data Rate, Mbps	QPSK Nominal Data Rate, Mbps	QAM-16 Raw Data Rate, Mbps	QAM-16 Nominal Data Rate, Mbps
1280	1.60	2.56	~2.3	5.12	~4.6
2560	3.20	5.12	~4.6	10.24	~9.0

DOCSIS 1.0 Transmission Characteristics

The following tables provide information on the assumed downstream RF channel transmission characteristics for DOCSIS 1.0.

Downstream RF Channel Transmission Characteristics

Transmission is from the headend combiner to the cable modem input at the customer location. Measurement methods are defined in NCTA or CableLabs2 documentation.

Go to URL <http://www.ncta.com/>. Search on “transmission”.

Go to URL <http://www.cablelabs.com/>.

Table B-3 DOCSIS 1.0 Assumed Downstream RF Channel Transmission Characteristics

Parameter	Value
Frequency range ¹	Cable system normal downstream operating range is from 50 MHz to as high as 860 MHz. However, the values in this table apply only at frequencies \geq 88 MHz.
RF channel spacing (design bandwidth)	6 MHz
Transit delay from headend to most distant customer	\leq 0.800 msec (typically much less)
Carrier-to-noise ratio in a 6-MHz band (analog video level)	Not less than 35 dB ²
Carrier-to-interference ratio for total power (discrete and broadband ingress signals)	Not less than 35 dB within the design bandwidth
Composite triple beat distortion for analog modulated carriers	Not greater than -50 dBc within the design bandwidth
Composite second-order distortion for analog modulated carriers	Not greater than -50 dBc within the design bandwidth
Cross-modulation level	Not greater than -40 dBc within the design bandwidth
Amplitude ripple	0.5 dB within the design bandwidth
Group delay ripple in the spectrum occupied by the CMTS	75 ns within the design bandwidth
Micro-reflections bound for dominant echo	-10 dBc @ \leq 0.5 microsecond -15 dBc @ \leq 1.0 microsecond -20 dBc @ \leq 1.5 microsecond -30 dBc @ $>$ 1.5 microsecond
Carrier hum modulation ³	Not greater than -26 dBc (5%)
Burst noise	Not longer than 25 μ sec at a 10-Hz average rate
Signal level slope, 50-750 MHz	16 dB

Table B-3 DOCSIS 1.0 Assumed Downstream RF Channel Transmission Characteristics (continued)

Parameter	Value
Seasonal and diurnal signal level variation	8 dB
Maximum analog video carrier level at the cable modem input, inclusive of above signal level variation	17 dBmV
Lowest analog video carrier level at the cable modem input, inclusive of above signal level variation	-5 dBmV

1. For measurements above the normal operating frequency band (except hum), impairments are referenced to the highest-frequency NTSC carrier level.
2. This presumes that the digital carrier is operated at analog peak carrier level. When the digital carrier is operated below the analog peak carrier level, the carrier-to-noise ratio may be less.
3. For hum measurements above the normal downstream operating frequency band, a continuous-wave carrier is sent at the test frequency at the same level as the highest-frequency NTSC carrier.

Upstream RF Channel Transmission Characteristics

Transmission is from the cable modem output at the customer location to the headend. Measurement methods are defined in NCTA or CableLabs2 documentation.

Table B-4 DOCSIS 1.0 Assumed Upstream RF Channel Transmission Characteristics

Parameter	Value
Frequency range	5 to 42 MHz edge to edge
Transit delay from the most distant cable modem to the nearest cable modem or CMTS	≤ 0.800 msec (typically much less)
Carrier-to-noise ratio	Not less than 25 dB
Carrier-to-ingress power (the sum of discrete and broadband ingress signals) ratio	Not less than 25 dB ¹
Carrier-to-interference (the sum of noise, distortion, common-path distortion, and cross-modulation) ratio	Not less than 25 dB
Carrier hum modulation	Not greater than -23 dBc (7%)
Burst noise	Not longer than 10 μsec at a 1-kHz average rate for most cases ^{2, 3}
Amplitude ripple	5 to 42 MHz: 0.5 dB/MHz
Group delay ripple	5 to 42 MHz: 200 ns/MHz
Micro-reflections—single echo	-10 dBc @ ≤ 0.5 microsecond -20 dBc @ ≤ 1.0 microsecond -30 dBc @ > 1.0 microsecond
Seasonal and diurnal signal level variation	Not greater than 8 dB min to max

1. Ingress avoidance or tolerance techniques may be used to ensure operation in the presence of time varying discrete ingress signals that could be as high as 0 dBc.(CableLabs1)
2. Amplitude and frequency characteristics sufficiently strong to partially or wholly mask the data carrier.
3. Impulse noise levels more prevalent at lower frequencies (<15 MHz).

DOCSIS 1.1 Transmission Characteristics

The following tables provide information on the assumed downstream RF channel transmission characteristics for DOCSIS 1.1.

Downstream RF Channel Transmission Characteristics

Transmission is from the headend combiner to the cable modem input at the customer location. Measurement methods are defined in NCTA or CableLabs2 documentation.

Go to URL <http://www.ncta.com/>. Search on “transmission”.

Go to URL <http://www.cablelabs.com/>.

Table B-5 DOCSIS 1.1 Assumed Downstream RF Channel Transmission Characteristics

Parameter	Value
Frequency range	Cable system normal downstream operating range is from 50 MHz to as high as 860 MHz. However, the values in this table apply only at frequencies \geq 88 MHz.
RF channel spacing (design bandwidth)	6 MHz
Transit delay from headend to most distant customer	\leq 0.800 msec (typically much less)
Carrier-to-noise ratio in a 6-MHz band	Not less than 35 dB ¹
Carrier-to-composite triple beat distortion ratio	Not less than 41 dB ¹
Carrier-to-composite second order distortion ratio	Not less than 41 dB ¹
Carrier-to-cross-modulation ratio	Not less than 41 dB ¹
Carrier-to-any other discrete interference (ingress)	Not less than 41 dB ¹
Amplitude ripple	3 dB within the design bandwidth
Group delay ripple in the spectrum occupied by the CMTS	75 ns within the design bandwidth
Micro-reflections bound for dominant echo	-10 dBc @ \leq 0.5 microsecond -15 dBc @ \leq 1.0 microsecond -20 dBc @ \leq 1.5 microsecond -30 dBc @ $>$ 1.5 microsecond
Carrier hum modulation	Not greater than -26 dBc (5%)
Burst noise	Not longer than 25microseconds at a 10-Hz average rate
Maximum analog video carrier level at the cable modem input	17 dBmV
Maximum number of analog carriers	121

1. Measured relative to a QAM signal that is equal to the nominal video level in the plant.

Upstream RF Channel Transmission Characteristics

Transmission is from the cable modem output at the customer location to the headend. Measurement methods are defined in NCTA or CableLabs2 documentation.

Table B-6 DOCSIS 1.1 Assumed Upstream RF Channel Transmission Characteristics

Parameter	Value
Frequency range	5 to 42 MHz edge to edge
Transit delay from the most distant cable modem to the nearest cable modem or CMTS	≤ 0.800 msec (typically much less)
Carrier-to-interference plus ingress (the sum of noise, distortion, common-path distortion, and cross-modulation and the sum of discrete and broadband ingress signals, impulse noise excluded) ratio	Not less than 25 dB ¹
Carrier hum modulation	Not greater than -23 dBc (7%)
Burst noise	Not longer than 10 microseconds at a 1-kHz average rate for most cases ^{2, 3}
Amplitude ripple	5 – 42 MHz: 0.5 dB/MHz
Group delay ripple	5 – 42 MHz: 200 ns/MHz
Micro-reflections—single echo	-10 dBc @ ≤ 0.5 microsecond -20 dBc @ ≤ 1.0 microsecond -30 dBc @ > 1.0 microsecond
Seasonal and diurnal reverse gain (loss) variation	Not greater than 14 dB min to max

1. Ingress avoidance or tolerance techniques may be used to ensure operation in the presence of time varying discrete ingress signals that could be as high as 10 dBc. Ratios are guaranteed only within the digital carrier channels.
2. Amplitude and frequency characteristics sufficiently strong to partially or wholly mask the data carrier.
3. Impulse noise levels more prevalent at lower frequencies (<15 MHz).

EuroDOCSIS Transmission Characteristics

The following tables provide information on the assumed RF channel transmission characteristics for EuroDOCSIS.

Downstream RF Channel Transmission Characteristics

Transmission is from the headend combiner to the cable modem input at the customer location. Measurement methods are defined in CENELEC 50083-7 documentation.

Table B-7 EuroDOCSIS Assumed Downstream RF Channel Transmission Characteristics for Analog TV and Sound Signals

Parameter	Value
Frequency range ¹	Cable system normal downstream operating range is from 47 MHz to as high as 862 MHz. However, the operating range for data communication is from 108 to 862 MHz. The use of frequencies between 108 and 136 MHz may be forbidden due to national regulation with regard to interference with aeronautical navigation frequencies.
RF channel spacing (design bandwidth)	7/8 MHz, 8 MHz channels are used for data communication
Transit delay from headend to most distant customer	≤ 0.800 msec (typically much less)
Carrier-to-noise ratio in a 8-MHz band (analog video level)	Not less than 44 dB ²
Carrier-to-interference ratio for total power (discrete and broadband ingress signals)	Not less than 52 dB within the design bandwidth
Composite triple beat distortion for analog modulated carriers	PAL—Not greater than –57 dBc within the design bandwidth SECAM—Not greater than –52 dBc within the design bandwidth.
Composite second order distortion for analog modulated carriers	PAL—Not greater than –57 dBc within the design bandwidth. SECAM—Not greater than –52 dBc within the design bandwidth.
Cross-modulation level	Under consideration
Amplitude ripple	2.5 dB in 8 MHz
Group delay ripple in the spectrum occupied by the CMTS	100 ns over frequency range 0.5 – 4.43 MHz
Micro-reflections bound for dominant echo	–10 dBc @ ≤ 0.5 microsecond –15 dBc @ ≤ 1.0 microsecond –20 dBc @ ≤ 1.5 microsecond –30 dBc @ > 1.5 microsecond
Carrier hum modulation ³	Not greater than –46 dBc (5%)
Burst noise	Not longer than 25 microseconds at a 10-Hz average rate
Signal level slope, 85–862 MHz	12 dB
Seasonal and diurnal signal level variation	8 dB
Maximum analog video carrier level at the system outlet, inclusive of above signal level variation	PAL: 77 dBmicroV SECAM: 74 dBmicroV
Lowest analog video carrier level at the system outlet, inclusive of above signal level variation	PAL: 60 dBmicroV SECAM: 57 dBmicroV

1. For measurements shown, the normal downstream operating frequency band (except hum), impairments are referenced to the highest-frequency PAL/SECAM carrier level.
2. This presumes that the digital carrier is operated at analog peak carrier level. When the digital carrier is operated below the analog peak carrier level, the carrier-to-noise ratio may be less.
3. For hum measurements above the normal downstream operating frequency band, a continuous-wave carrier is sent to the test frequency at the same level as the highest-frequency PAL/SECAM carrier.

Upstream RF Channel Transmission Characteristics

Transmission is from the cable modem output at the customer location to the headend.

Table B-8 EuroDOCSIS Assumed Upstream RF Channel Transmission Characteristics

Parameter	Value
Frequency range	5 up to 65 MHz to edge
Transit delay from the most distant cable modem to the nearest cable modem or cable modem termination system	≤ 0.800 msec (typically much less)
Carrier-to-noise ratio in active channel	Not less than 22 dB
Carrier-to-ingress power (the sum of discrete and broadband ingress signals) ratio in active channel	Not less than 22 dB ¹
Carrier-to-interference (the sum of noise, distortion, common-path distortion, and cross-modulation) ratio in active channel	Not less than 22 dB
Carrier hum modulation	Not greater than -23 dBc (7%)
Burst noise	Not longer than 10 microsecond at a 1 kHz average rate for most cases ^{2, 3}
Amplitude ripple	5 to 65 MHz: 2.5 dB in 2 MHz
Group delay ripple	5 to 65 MHz: 300 ns in 2 MHz
Micro-reflections—single echo	-10 dBc @ ≤ 0.5 microsecond -20 dBc @ ≤ 1.0 microsecond -30 dBc @ > 1.0 microsecond
Seasonal and diurnal signal level variation	Not greater than 12 dB min to max

1. Ingress avoidance or tolerance techniques MAY be used to ensure operation in the presence of time varying discrete ingress signals that could be as high as 0 dBc.
2. Amplitude and frequency characteristics sufficiently strong to partially or wholly mask the data carrier.
3. Impulse noise levels more prevalent at lower frequencies (<15 MHz).

Electrical Input and Output

The information in [Table B-9](#) and [Table B-10](#) relates to both DOCSIS and EuroDOCSIS specifications.

Table B-9 Electrical Input to the Cable Modem

Parameter	Value
Center frequency	<ul style="list-style-type: none"> • DOCSIS: 91 to 857 MHz ±30 kHz • EuroDOCSIS: 112 to 858 MHz ±30 kHz
Level range (one channel)	<ul style="list-style-type: none"> • DOCSIS: -15 dBmV to +15 dBmV • EuroDOCSIS: 43 to 73 dBmicroV for QAM-64 47 to 77 dBmicroV for QAM-256
Modulation type	QAM-64 and QAM-256

Table B-9 *Electrical Input to the Cable Modem (continued)*

Parameter	Value
Symbol rate (nominal)	<ul style="list-style-type: none"> • DOCSIS: 5.056941 Msym/sec (QAM-64) and 5.360537 Msym/sec (QAM-256) • EuroDOCSIS: 6.952 Msym/sec for QAM-64 and QAM-256
Bandwidth	<ul style="list-style-type: none"> • DOCSIS: 6 MHz <ul style="list-style-type: none"> – 18% square root raised cosine shaping for QAM-64 – 12% square root raised cosine shaping for QAM-256 • EuroDOCSIS: 8 MHz <ul style="list-style-type: none"> – 15% square root raised cosine shaping for both QAM-64 and QAM-256
Total input power (40 - 900 MHz)	< 30 dBmV (90 dBmicroV)
Input (load) impedance	75 ohms
Input return loss	<ul style="list-style-type: none"> • DOCSIS: > 6 dB (88–860 MHz) • EuroDOCSIS: > 6 dB (85–862 MHz)
Connector	F connector per ISO-169-24 (common with the output)

Table B-10 *Upstream Electrical Output from the Cable Modem*

Parameters	Value
Frequency	<ul style="list-style-type: none"> • DOCSIS: 5 to 42 MHz edge to edge • EuroDOCSIS: 5 to 65 MHz edge to edge
Level range (one channel)	<ul style="list-style-type: none"> • QAM-16: +8 to +55 dBmV (+68 to +115 dBmicroV) • QPSK: +8 to +58 dBmV (+68 to +118 dBmicroV)
Modulation type	QPSK and QAM-16
Symbol rate (nominal)	160 ksym/sec 320 ksym/sec 640 ksym/sec 1280 ksym/sec 2560 ksym/sec
Bandwidth	200 kHz 400 kHz 800 kHz 1600 kHz 3200 kHz
Output impedance	75 ohms
Output return loss	<ul style="list-style-type: none"> • DOCSIS: >6 dB (5–42 MHz) • EuroDOCSIS: >6 dB (5–65 MHz)
Connector	F connector per ISO-169-24 (common with the input)