Keywords: rf, rfic, catv, docsis, upstream, amplifier, qpsk, cable ic, cable modem, set top box, qam, rfics, amplifiers, rf ics

Performance of Maxim's Cable Upstream Amplifier Meets DOCSIS 2.0 Requirements

Mar 25, 2003

Abstract: This application note presents the measured performance of the MAX3514/MAX3516 cable upstream amplifier. The measured data include 2nd Harmonics, 3rd Harmonics, output power vs. frequency, and ACPR. Tests are conducted using DOCSIS 2.0 as the standard, and the amplifiers are found to meet all requirements.

Summary

The upstream CATV amplifiers MAX3514/MAX3516 were tested for compliance to DOCSIS 2.0 PHY Requirements. The test results show that these ICs meet the DOCSIS 2.0 standards.

DOCSIS 2.0

DOCSIS (Data-Over-Cable Service Interface Specification) are RF interface specifications for high-speed data-over-cable systems.

Click here for an overview of the wireless components used in a typical radio transceiver.

DOCSIS 2.0 is the third generation of the DOCSIS specification. The terms DOCSIS 2.0, DOCSIS 1.1, and DOCSIS 1.0 refer to three different specifications.

The DOCSIS 2.0 specification primarily aims at enhancing the limited upstream physical layer performance of a DOCSIS 1.0- or 1.1-based cable access system. Two new MAC (medium access controller) Management Message Types have been defined, and several new parameter encodings have been defined in the existing MAC messages. A DOCSIS 2.0 CMTS (cable modem termination system) is capable of supporting a higher upstream throughput for a given channel bandwidth as well as increased tolerance to noise experienced in the upstream. DOCSIS 2.0 CMTS is backward compatible with DOCSIS 1.0 and DOCSIS 1.1.

The MAX3514/MAX3516 are a family of programmable-gain upstream amplifiers designed for use in CATV upstream applications. They operate over a frequency range of 5MHz to 65MHz and drives up to +64dBmV QPSK (MAX3516). Since both input and output ports are differential, an external balun at the output port is required. The variable gain feature provides greater than 56dB of dynamic range (MAX3514/MAX3516) and is controlled by a SPI 3-wire interface. Gain control is available in 0.5dB steps (MAX3514/MAX3516) or 1dB step (MAX3510).

Measurements

- All tests at room temperature.
- V_{CC} = 5.0V
- P_{IN} = -13dBm (+34dBmV in 50Ω system, channel power)
- Input signal:
    - QPSK modulation with 20b PRBS, root cosine filter, α= 0.25
    - 16 QAM modulation with 20b PRBS, root cosine filter, α= 0.25
    - 64 QAM modulation with 20b PRBS, root cosine filter, α= 0.25
- High Power Mode
- Input ACPR -66dBc
- 160kHz measurement bandwidth (200kHz channel spacing)
- 320kHz measurement bandwidth (400kHz channel spacing)
- 640kHz measurement bandwidth (800kHz channel spacing)
- 1280kHz measurement bandwidth (1600kHz channel spacing)
- 2560kHz measurement bandwidth (3200kHz channel spacing)
- 5120kHz measurement bandwidth (6400kHz channel spacing)

Corrections and Unit Conversion

- In 50Ω system, $P_{IN/OUT}$ (dBmV) = $P_{IN/OUT}$ (dBm) + 47dB
- In 75Ω system, $P_{IN/OUT}$(dBmV) = $P_{IN/OUT}$ (dBm) + 49dB
- MAX3514/MAX3516EVKit boards have 7.5dB minimum loss pad at the output, so P_{OUT} (dBmV) = P_{OUT} (dBm) + 47dB + 7.5dB + cable loss

Test Equipment List

(See **Figure 1** for typical test setup)
- Signal Generator capable of generating 64 QAM signals (RODHE & SCHWARZ SMIQ 06B)
- Spectrum Analyzer (RODHE & SCHWARZ FSEB)
- Power Meter (HP437B)
- Power Sensor (HP8482A)
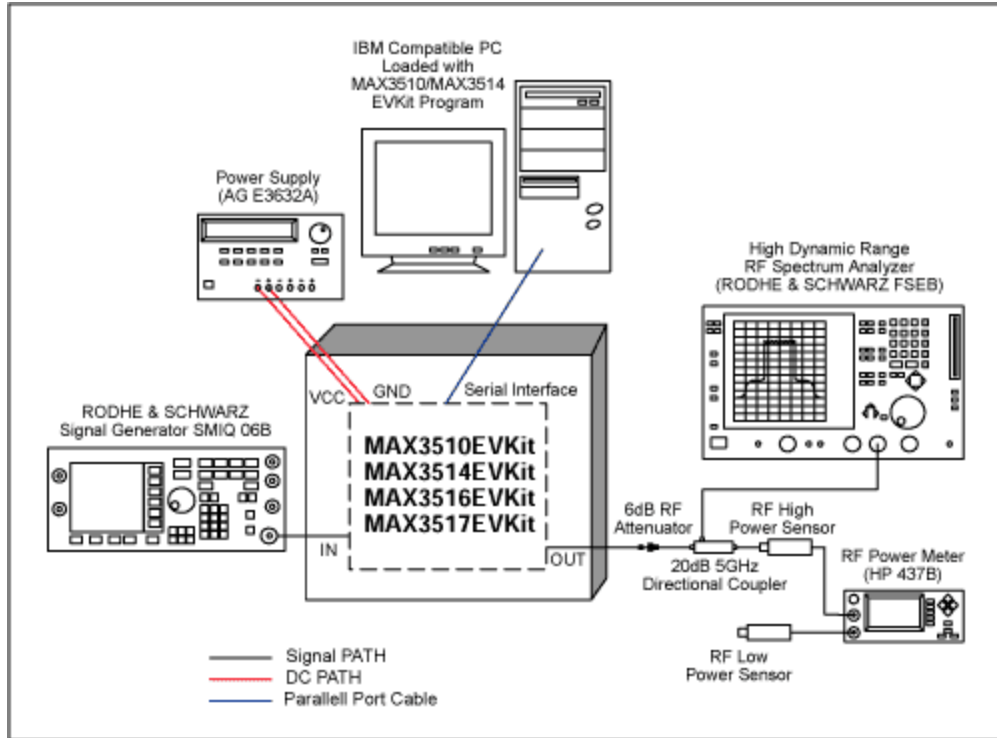- Power Supply (Agilent E3632A)
- DMM (HPE3631A)

Figure 1. Test equipment set up.

Results

Test Signal:

Modulation = 64
QAM Alpha = 0.25
Modulation Signal Center
Frequency = 22MHz Symbol Rates: 160ksps, 320ksps, 640ksps, 1280ksps, 2560ksps, 5120ksps

Table 1. The MAX3514 2nd and 3rd Harmonic vs. Output Power and Frequency : (+54dBmV to +58dBmV)

	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	108	6.8	53.8	-61.7	-60.0
22MHz (160ksps)	-13	110	7.8	54.8	-61.8	-60.0
	-13	112	8.8	55.8	-61.9	-59.8
	-13	114	9.8	56.8	-62.1	-59.4
	-13	116	10.8	57.8	-62.3	-59.0
	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	108	6.9	53.9	-61.0	-59.8
22MHz (320ksps)	-13	110	7.9	54.9	-61.3	-59.7
	-13	112	8.9	55.9	-61.4	-59.5
	-13	114	9.9	56.9	-61.6	-59.2

	Input (dBm)	GCW	Output(dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	116	10.9	57.9	-61.7	-58.8
22MHz (640ksps)	-13	108	6.8	53.8	-59.8	-58.6
	-13	110	7.8	54.8	-60.0	-58.6
	-13	112	8.8	55.8	-60.2	-58.7
	-13	114	9.8	56.8	-60.4	-58.6
	-13	116	10.8	57.8	-60.6	-58.8
22MHz (1280ksps)	-13	109	7.1	54.1	-58.4	-58.0
	-13	111	8.1	55.1	-58.8	-58.1
	-13	113	9.1	56.1	-59.1	-58.1
	-13	115	10.1	57.1	-59.2	-57.7
	-13	117	11.0	58.0	-59.4	-57.4
22MHz (2560ksps)	-13	109	7.0	54.0	-56.1	-56.5
	-13	111	8.0	55.0	-56.3	-56.9
	-13	113	9.0	56.0	-56.6	-57.2
	-13	115	10.0	57.0	-57.0	-57.3
	-13	117	11.0	58.0	-57.2	-56.7
22MHz (5120ksps)	-13	109	7.1	54.1	-53.5	-54.6
	-13	111	8.1	55.1	-54.1	-55.0
	-13	113	9.1	56.1	-54.6	-55.1
	-13	115	10.1	57.1	-54.9	-55.1
	-13	117	11.1	58.1	-55.4	-55.3

Table 2. DOCSIS 2.0 Specifications on 2nd and 3rd Order Harmonics (57dBmV output)

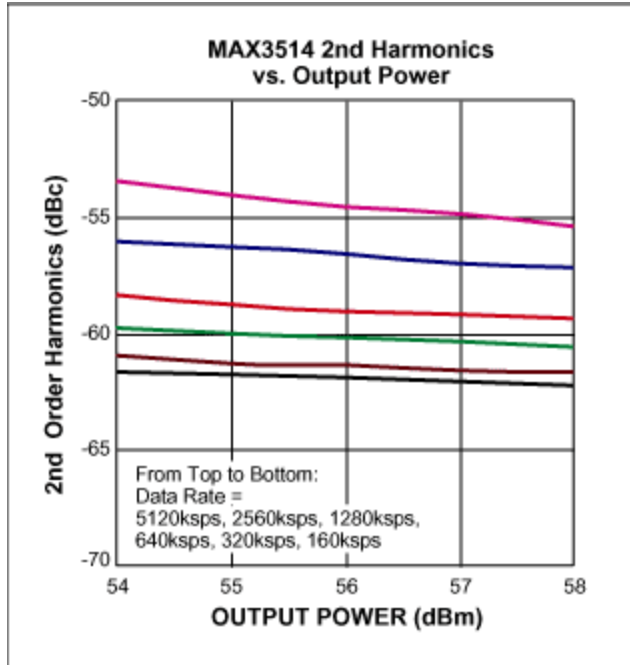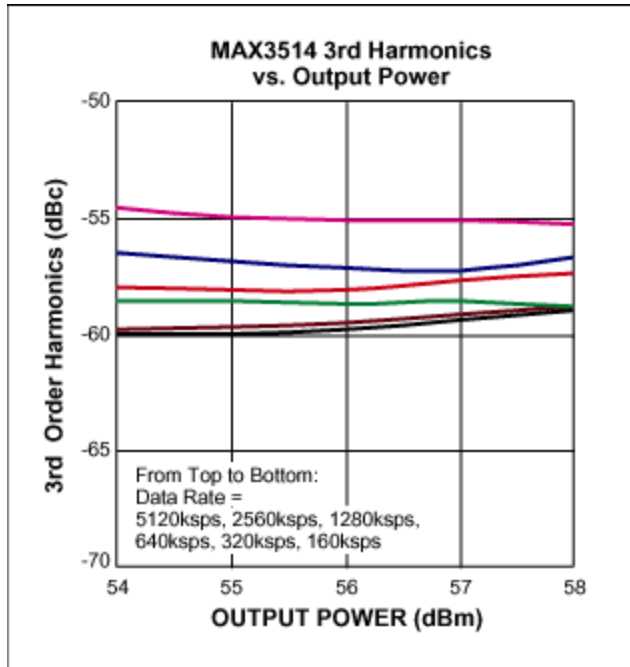| Modulation Rate (ksps)	160	320	640	1280	2560	5120
2nd order harmonics DOCSIS 2.0 Spec. (dBc)	-47	-50	-50	-50	-50	-50
3rd order harmonics DOCSIS 2.0 Spec. (dBc)	-47	-50	-50	-50	-50	-50

Figure 2.

Figure 3.

Table 3. The MAX3516 2nd Harmonic vs. Output Power and Frequency (+57dBmV to +61dBmV)

	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	108	10.0	57.0	-66.0	-60.7
22MHz (160ksps)	-13	110	11.0	58.8	-66.5	-60.7

	-13	112	12.0	59.0	-67.0	-59.7
	-13	114	13.0	60.0	-67.7	-58.4
	-13	116	14.0	61.0	-68.5	-56.5

22MHz (320ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	108	10.0	57.0	-64.8	-60.3
	-13	110	11.0	58.0	-65.1	-60.0
	-13	112	12.0	59.0	-65.6	-59.1
	-13	114	13.0	60.0	-66.3	-58.0
	-13	116	14.0	61.0	-67.0	-56.4

22MHz (640ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	108	10.0	57.0	-63.1	-59.8
	-13	108	11.0	58.0	-63.4	-59.8
	-13	110	12.0	59.0	-63.7	-59.1
	-13	112	13.0	60.0	-64.4	-58.4
	-13	114	14.0	61.0	-65.0	-56.6

22MHz (1280ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	108	10.0	57.0	-61.2	-59.1
	-13	110	11.0	58.0	-61.3	-59.0
	-13	112	12.0	59.0	-61.8	-58.5
	-13	114	13.0	60.0	-62.2	-57.5
	-13	116	14.0	61.0	-62.7	-56.0

22MHz (2560ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	108	9.8	56.8	-58.0	-57.7
	-13	110	10.8	57.8	-58.5	-57.7
	-13	112	11.8	58.8	-59.0	-57.4
	-13	114	12.8	59.8	-59.5	-56.7
	-13	116	13.8	60.8	-59.8	-55.6

22MHz (5120ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	2nd Harm (dBc)	3rd Harm (dBc)
	-13	108	9.8	56.8	-55.3	-55.7
	-13	110	10.8	57.8	-55.7	-55.8
	-13	112	11.8	58.8	-56.0	-55.8
	-13	114	12.8	59.8	-56.3	-55.4
	-13	116	13.8	60.8	-56.7	-54.6

Table 4. DOCSIS 2.0 Specifications on 2nd and 3rd Order Harmonics (60dBmV output)

Modulation Rate (ksps)	160	320	640	1280	2560	5120

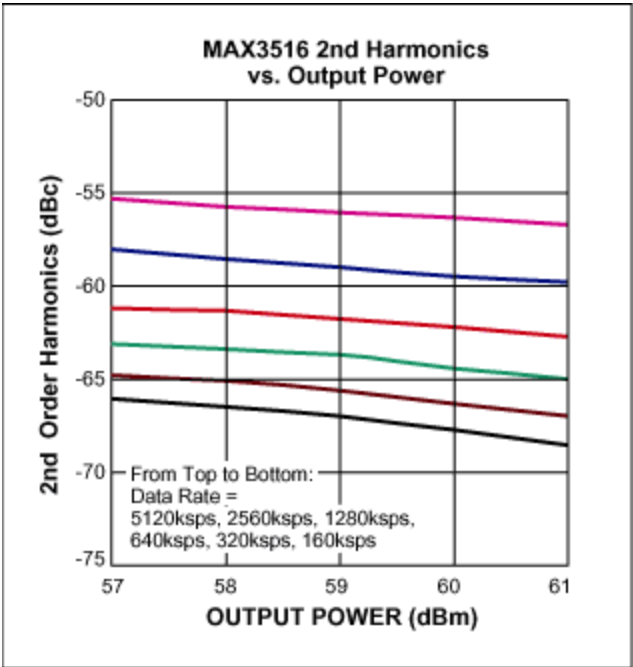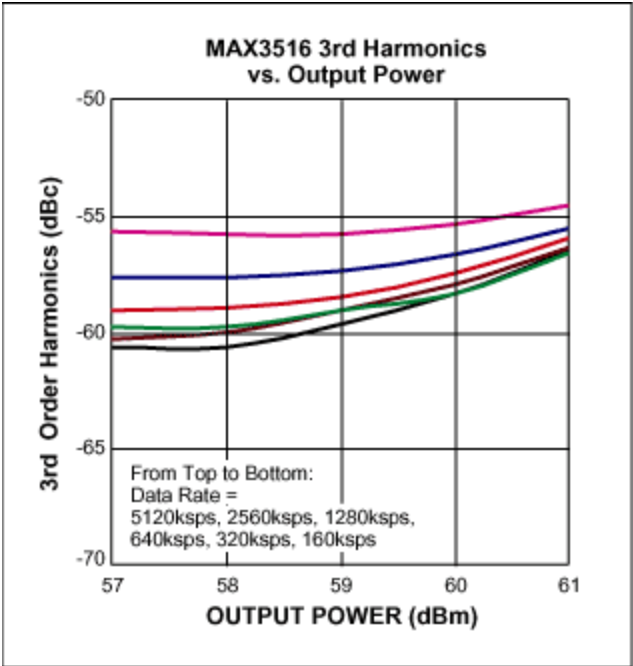|						
2nd order harmonics DOCSIS 2.0 Spec. (dBc)	-47	-50	-50	-50	-50	-50
3rd order harmonics DOCSIS 2.0 Spec. (dBc)	-47	-50	-50	-50	-50	-50

Figure 4.

Figure 5.

Table 5. The MAX3514 ACPR vs. Output Power and Frequency

	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)

	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
39MHz (160ksps)	-13	109	7.0	54.0	-55.5
	-13	111	8.0	55.0	-54.4
	-13	113	9.0	56.0	-53.2
	-13	115	10.0	57.0	-52.0
	-13	117	11.0	58.0	-50.9
39MHz (320ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
	-13	109	7.0	54.0	-54.8
	-13	111	8.0	55.0	-54.2
	-13	113	9.0	56.0	-53.3
	-13	115	10.0	57.0	-52.2
	-13	117	11.0	58.0	-51.0
39MHz (640ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
	-13	109	7.0	54.0	-53.9
	-13	111	8.0	55.0	-53.3
	-13	113	9.0	56.0	-52.1
	-13	115	10.0	57.0	-51.4
	-13	117	11.0	58.0	-50.2
39MHz (1280ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
	-13	109	6.8	53.8	-52.2
	-13	111	7.8	54.8	-51.6
	-13	113	8.8	55.8	-50.8
	-13	115	9.8	56.8	-50.0
	-13	117	10.8	57.8	-48.6
39MHz (2560ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
	-13	109	7.0	54.0	-49.3
	-13	111	8.0	55.0	-48.4
	-13	113	9.0	56.0	-48.0
	-13	115	10.0	57.0	-47.1
	-13	117	11.0	58.0	-46.3
39MHz (5120ksps)	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
	-13	109	6.8	53.8	-46.2
	-13	111	7.8	54.8	-45.6
	-13	113	8.8	55.8	-45.1
	-13	115	9.8	56.8	-44.3
	-13	117	10.8	57.8	-43.5

Table 6. Adjacent Channel Power Ratio DOCSIS 2.0 Specifications

Modulation Rate (ksps)	160	320	640	1280	2560	5120
ACPR DOCSIS 2.0 SPec. (dBc)	-47	-47	-46	-45	-44	-42

Table 7. The MAX3516 ACPR vs. Output Power and Frequency

	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
39MHz (160ksps)	-13	109	10.2	57.2	-52.0
	-13	111	11.2	58.2	-50.9
	-13	113	12.2	59.2	-49.4
	-13	115	13.2	60.2	-47.8
	-13	117	14.2	61.2	-46.0
	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
39MHz (320ksps)	-13	108	9.9	56.9	-52.2
	-13	110	10.8	57.8	-50.9
	-13	112	11.8	58.8	-49.8
	-13	114	12.8	59.8	-48.4
	-13	116	13.8	60.8	-46.9
	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
39MHz (640ksps)	-13	109	10.3	57.3	-50.7
	-13	111	11.2	58.2	-49.8
	-13	113	12.2	59.2	-48.7
	-13	115	13.2	60.2	-47.3
	-13	117	14.2	61.2	-45.7
	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
39MHz (1280ksps)	-13	109	10.1	57.1	-49.6
	-13	111	11.0	58.0	-48.7
	-13	113	12.1	59.1	-47.6
	-13	115	13.0	60.0	-46.5
	-13	117	14.0	61.0	-44.9
	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
39MHz (2560ksps)	-13	109	10.2	57.2	-46.7
	-13	111	11.1	58.1	-46.0
	-13	113	12.1	59.1	-45.0
	-13	115	13.1	60.1	-43.8
	-13	117	14.1	61.1	-42.6
	Input (dBm)	GCW	Output (dBm)	Output (dBmv)	ACPR (dBc)
39MHz (5120ksps)	-13	109	10.2	57.2	-43.8
	-13	111	11.2	58.2	-43.1
	-13	113	12.2	59.2	-42.2
	-13	115	13.2	60.2	-41.4
	-13	117	14.2	61.2	-40.3

Table 8. Adjacent Channel Power Ratio DOCSIS 2.0 Specifications

Modulation Rate (ksps)	160	320	640	1280	2560	5120

ACPR DOCSIS 2.0 SPec. (dBc)	-47	-47	-46	-45	-44	-42

MAX3514 ACPR vs. Output Power

From Top to Bottom:
Data Rate =
5120ksps, 2560ksps, 1280ksps,
640ksps, 320ksps, 160ksps

Figure 6.

MAX3516 ACPR vs. Output Power

From Top to Bottom:
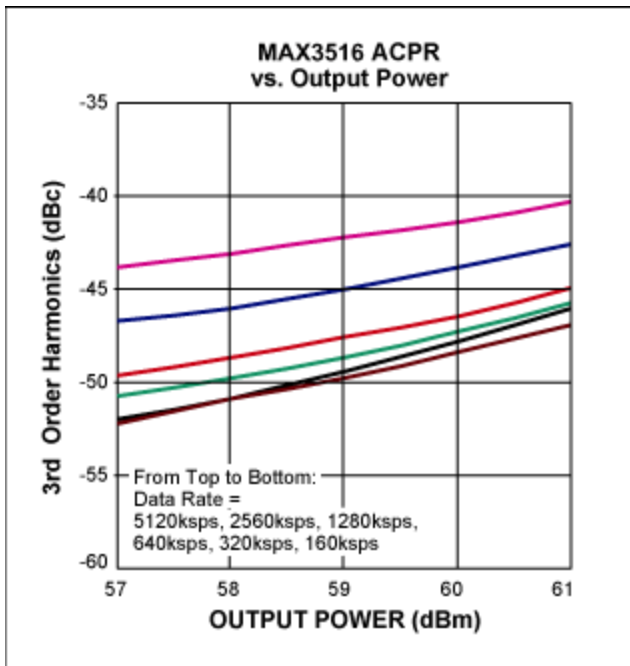Data Rate =
5120ksps, 2560ksps, 1280ksps,
640ksps, 320ksps, 160ksps

Figure 7.

Conclusion

The test results in Table 1, 3, 5, 7 show that MAX3514/MAX3516 meet the DOCSIS 2.0 standards.

Related Parts	
MAX3510	Upstream CATV Amplifier
MAX3514	Upstream CATV Amplifiers
MAX3516	Upstream CATV Amplifiers

More Information
For Technical Support: http://www.maximintegrated.com/support
For Samples: http://www.maximintegrated.com/samples
Other Questions and Comments: http://www.maximintegrated.com/contact

Application Note 1945: http://www.maximintegrated.com/an1945
APPLICATION NOTE 1945, AN1945, AN 1945, APP1945, Appnote1945, Appnote 1945
Copyright © by Maxim Integrated Products
Additional Legal Notices: http://www.maximintegrated.com/legal