Connecting the Cisco uBR7225VXR Router to the Cable Headend

This chapter describes how to connect the Cisco uBR7225VXR universal broadband router to a cable headend and contains the following sections:

- Two-Way Data Headend Architecture, page 4-2
- One-Way Data Headend Architecture, page 4-3
- RF and Digital Data Overview, page 4-3
- Connecting and Configuring the Downstream, page 4-4
- Measuring the Downstream RF Signal, page 4-4
- Connecting and Configuring the Upstream, page 4-18
- Measuring the Upstream RF Signal, page 4-22
- Measuring the RF Signal at the Forward Test Point on a Laser Transmitter, page 4-37
- Configuring the Digital Signal, page 4-40

Note: Before installing your Cisco uBR7225VXR router, analyze the radio frequency (RF) setup at your headend and configure the analog RF signals for interaction with digital data. This chapter guides you through the process of configuring the RF and digital data at the headend for optimal performance.
Two-Way Data Headend Architecture

Figure 4-1 shows a typical headend configuration configured for two-way data, including digitized voice and fax.

Figure 4-1  Typical Cable Headend Configuration for Two-Way Data
One-Way Data Headend Architecture

Figure 4-2 shows a typical headend configuration configured for one-way (downstream) data in a telco return cable system.

Figure 4-2  Typical Cable Headend Configuration for One-Way (Telco Return) Data

RF and Digital Data Overview

This section describes the interaction of digital and analog RF data as both signals are carried on the hybrid fiber-coaxial (HFC) network.

Two-way digital data signals are more susceptible than one-way signals to stresses in the condition of the HFC network. Degradation in video signal quality might not be noticed, but when two-way digital signals share the network with video signals, digital signals might be hampered by the following types of network impairments:

- **Impulse and electrical noise**—Impulse and electrical noise, usually forms of ingress, can enter the network from sources within a home, such as hair dryers, light switches, and thermostats; or from high-voltage lines that run near CATV cabling in the network. Areas of signal ingress may be located and repaired by implementing a comprehensive signal leakage maintenance program.
- **Amplifier thermal noise**—Amplifiers add noise to the HFC network that usually goes unnoticed in video signals, assuming a properly designed and operated network. Improperly configured amplifiers will degrade digital data signals. The larger the network, the higher the probability of amplifier thermal noise affecting the signals.
- **Ingress noise**—Ingress noise includes electrical sources (see “Impulse and electrical noise” above); amateur radio transmissions; citizens band radios; or high-power shortwave broadcast signals, which can interfere with frequencies anywhere between 3 and 65 MHz. These often are picked up by cabling and equipment in the network.

### Note

Some HFC upstream equipment passes interfering signals below 5 MHz, which may overload the reverse path.
- Noise funneling—The upstream data path to the headend is susceptible to picking up noise and interference from anywhere in the network, and all upstream noise ultimately ends up at the headend. This effect is known as *noise funneling* because of the cumulative nature of the noise from one or more locations in the network that becomes concentrated at the headend. As a network serviced by a single upstream receiver increases in size, the probability of noise funneling also increases.

- Variable transmit levels—Signal loss over coaxial cable is affected by temperature. This can cause variations of 6 to 10 dB per year.

- Clipping—The lasers in fiber-optic transmitters can stop transmitting light (clipping) when input levels are excessive. Excessive input levels may cause bit errors and reduced data throughput in both the upstream and downstream transmissions. If a laser is overdriven as briefly as a fraction of a second, clipping can occur.

### Connecting and Configuring the Downstream

After you install the Cisco uBR7225VXR universal broadband router in your headend site, you must connect the Cisco uBR7225VXR router to the HFC network and configure the network. The following sections describe how to connect to and configure the downstream.

### Installing and Configuring the Upconverter

The Cisco uBR-MC16U/E-16U and Cisco uBR-MC28U/E-28U cable interface line cards have an onboard integrated upconverter that generates an RF signal suitable for connection to a combiner and transmission on the coaxial cable network, without the need for any external upconverters.

**Note**

For more information, refer to the *Cisco uBR7200 Series Cable Interface Line Card Hardware Installation Guide* at the following URL:


### Measuring the Downstream RF Signal

The configuration of the downstream digitally modulated carrier at the headend is critical to the performance of the Cisco uBR7225VXR universal broadband router and cable modems. The following guidelines are provided to assist you in configuring the RF signal to the necessary specifications. There are two options you can use to measure the RF signal with a spectrum analyzer. These options are described in the following sections:

- **Measuring the Downstream RF Signal Using the Channel Power Option on a Spectrum Analyzer**, page 4-5
- **Measuring the Downstream RF Signal Using CATV Mode on a Spectrum Analyzer**, page 4-11 (equipped with digital channel power mode)
These two sections describe the procedures necessary to use a spectrum analyzer. You may also use a signal level meter that has the ability to measure the average power level of digitally modulated carriers, as well as a QAM analyzer. Some instruments to perform these measurements include:

- Acterna SDA-5000 w/Option 4 (http://www.acterna.com)
- Agilent 8591C, N1776A, 2010 or 3010 (http://www.tm.agilent.com)
- Sunrise Telecom AT-2000RQ, CM1000 or CR1200R (http://www.sunrisetelecom.com)
- Telsey DMA-120, DMA-121 or DMA122 (http://www.telsey.it)
- Trilithic 860DSP w/Option QA1 (http://www.trilithic.com)

If you complete these measurements using one of the previously mentioned options, your downstream signal can be verified as correctly configured and it can assist you with troubleshooting your network later on.

If you want to measure the downstream RF signal using the spectrum analyzer channel power option, proceed to the following section, “Measuring the Downstream RF Signal Using the Channel Power Option on a Spectrum Analyzer.” If you want to measure the downstream RF signal using CATV mode, proceed to the “Measuring the Downstream RF Signal Using CATV Mode on a Spectrum Analyzer” section on page 4-11.

**Measuring the Downstream RF Signal Using the Channel Power Option on a Spectrum Analyzer**

The following sections describe how to measure the downstream RF signal using the channel power option on a spectrum analyzer:

- Measuring the Downstream IF Signal at the Cisco uBR7225VXR Router, page 4-5
- Measuring the Downstream RF Signal at the Upconverter Output, page 4-7

**Measuring the Downstream IF Signal at the Cisco uBR7225VXR Router**

| Note | Refer to the user guide that accompanied your spectrum analyzer to determine the exact steps required to use your analyzer to perform these measurements. |

**Step 1**
Connect a spectrum analyzer to the downstream connector on a Cisco cable interface line card installed in a Cisco uBR7225VXR router.

**Step 2**
Turn the power switch on the spectrum analyzer to the ON position.

**Step 3**
Set the spectrum analyzer to view the downstream intermediate frequency (IF) signal with a center frequency of 44 MHz for a North American headend or 36.125 MHz for a European headend.

**Step 4**
Set the span to 10 MHz. Your analyzer should display a signal similar to the one shown in Figure 4-3.
Step 5  Measure the IF signal using the channel power option on your spectrum analyzer. Set your channel spacing and your channel bandwidth to 6 MHz. Your analyzer should display a signal similar to the one shown in Figure 4-4.

Note  The IF channel power in Figure 4-4 is +34.23 dBmV, as displayed on the spectrum analyzer.

Step 6  Select the video averaging feature. Your spectrum analyzer should display a signal similar to the one shown in Figure 4-5.
Figure 4-5  Measuring the IF Channel Power Using Video Averaging

Note
The approximate in-channel peak-to-valley flatness may be verified using the spectrum analyzer’s video averaging feature. Be aware, however, that amplitude values registered while in the video averaging mode are typically around 2.5 dB below the actual channel power.

Measuring the Downstream RF Signal at the Upconverter Output

Step 1  Disconnect the spectrum analyzer from the cable interface line card downstream connector.

Step 2  Connect the downstream output of the cable interface line card to the upconverter input connector.

Step 3  Connect the spectrum analyzer to the RF output of the upconverter. If your spectrum analyzer input is overloaded, you might see artifacts that are internally generated by the spectrum analyzer. The artifacts are circled on the analyzer trace shown in Figure 4-6. Add attenuation as necessary to correct the overload condition.
Step 4  Set the input of the upconverter to a digital QAM signal and the output level to the manufacturer’s recommended settings. Typical output amplitudes range from +50 to +58 dBmV, although DOCSIS specifies +61 dBmV.

Step 5  Set the spectrum analyzer to view the RF signal at the center frequency you selected for your headend. In this example, the RF center frequency is 699 MHz. Set your span to 20 MHz. Finally, set your channel spacing and your channel bandwidth to 6 MHz.

If the RF signal is causing an overload condition on the spectrum analyzer input, your analyzer might display a signal similar to the one shown in Figure 4-7. The sloping of the lines at the sides of the signal indicates a false reading.

Step 6  If you add attenuation to the input to the spectrum analyzer you can correct the overload condition as shown in Figure 4-8.
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Measuring the Downstream RF Signal

**Step 7**
Change the spectrum analyzer settings to view the digital channel power. This setting enables you to see if there is too much power on the upconverter output. In Figure 4-9, the upconverter output is reading +64.31 dBmV, which is beyond the DOCSIS-specified range of +50 to +61 dBmV.

**Tip**
A spectrum analyzer might become overloaded and produce false readings (such as internally generated spurs) when measuring a signal at this amplitude.

**Step 8**
Adjust the power on the upconverter output to ensure that it is between +50 and +61 dBmV. In Figure 4-10, the upconverter output is reading +57.06 dBmV, which is within the correct range.
Step 9 Select the video averaging feature on the spectrum analyzer. The signal becomes smoother and frequency response problems might become visible. Your analyzer now displays an RF signal similar to the one shown in Figure 4-11.

![Figure 4-11 Measuring the RF Signal at the Upconverter Output Using Video Averaging](image)

Note The approximate in-channel peak-to-valley flatness may be verified using the spectrum analyzer’s video averaging feature. Be aware, however, that amplitude values registered while in the video averaging mode are typically around 2.5 dB below the actual channel power.
Step 10 Verify that your headend RF measurements meet the recommended DOCSIS parameters listed in the tables in Appendix B, “RF Specifications.” Record your headend settings and measurements in your headend site log (Appendix G, “Site Log”). This will assist in troubleshooting the Cisco uBR7225VXR router installation later in the process.

This completes the procedure to measure the downstream RF signal using the channel power option. Proceed to the “Measuring the RF Signal at the Forward Test Point on a Laser Transmitter” section on page 4-37.

Measuring the Downstream RF Signal Using CATV Mode on a Spectrum Analyzer

The following two sections describe the methods you may use to measure the downstream RF signal using CATV mode (digital channel power option) on a spectrum analyzer:

- Measuring the Downstream IF Signal at the Cisco uBR7225VXR Router Using CATV Mode, page 4-11
- Measuring the Downstream RF Signal at the Upconverter Output Using CATV Mode, page 4-14

Note We recommend using as recent a model of spectrum analyzer as possible to perform the two analyses described here. You can use spectrum analyzers, such as the Agilent 8591C (http://www.tm.agilent.com) or the Tektronix 2715 (http://www.tek.com) to help you perform the tasks outlined in this section.

Measuring the Downstream IF Signal at the Cisco uBR7225VXR Router Using CATV Mode

Note Refer to the user guide that accompanied your spectrum analyzer to determine the exact steps required to use your analyzer to perform these measurements.

Step 1 Connect a spectrum analyzer to the downstream connector on a Cisco cable interface card installed in a Cisco uBR7225VXR router.

Step 2 Turn the power switch on the spectrum analyzer to the on position.

Step 3 Set the spectrum analyzer to CATV mode (CATV analyzer option) and select the channel measurement option to view the downstream intermediate frequency (IF) signal. Your analyzer should display a signal similar to the one shown in Figure 4-12.

Note Figure 4-12 shows the first of three screens that will be displayed by an Agilent 8591C when you use the analyzer in this mode. Figure 4-13 is the last of the three screens displayed.
Step 4  Advance to the last of the three screens in this display. Your analyzer should display a signal similar to the one shown in Figure 4-13.

Step 5  Enter a digital channel to measure and select digital channel power. Your spectrum analyzer will display a signal similar to the one shown in Figure 4-14.
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Figure 4-14  Measuring the IF Signal on a Spectrum Analyzer in CATV Mode—Digital Channel Power Screen

Step 6  Using the spectrum analyzer’s reference level control, adjust the amplitude of the displayed signal until the shape of the signal is clearly distinguishable as a digitally modulated carrier, as shown in Figure 4-15.

Figure 4-15  Measuring the IF Signal on a Spectrum Analyzer in CATV Mode—Adjusted Digital Channel Power Screen

Note  The IF channel power in Figure 4-15 is +33 dBmV, as displayed on the spectrum analyzer.

Step 7  Select the video averaging feature. Your spectrum analyzer should display a signal similar to the one shown in Figure 4-16.
Measuring the Downstream RF Signal

Measuring the Downstream RF Signal at the Upconverter Output Using CATV Mode

**Step 1** Disconnect the spectrum analyzer from the cable interface card downstream connector.

**Step 2** Connect the downstream output of the cable interface card to the upconverter input connector.

**Step 3** Connect the spectrum analyzer to the RF output of the upconverter.

**Step 4** Set the upconverter output level to the manufacturer’s recommended settings. Typical output amplitudes range from +50 to +58 dBmV, although DOCSIS specifies levels as high as +61 dBmV.

**Step 5** Set the spectrum analyzer to view the RF signal at the center frequency you selected for your headend. In this example, the RF center frequency is 705 MHz.

**Step 6** Set the spectrum analyzer to CATV mode (CATV analyzer option) and select the channel measurement option to view the downstream RF signal. Your spectrum analyzer should display a signal similar to the one shown in Figure 4-12.

---

**Note**

Figure 4-17 shows the first of three screens that will be displayed by an Agilent 8591C when you use the analyzer in this mode. Figure 4-18 is the last of the three screens displayed.
**Figure 4-17** Viewing the Downstream RF Signal on a Spectrum Analyzer in CATV Mode—Initial Screen

Step 7  
Advance to the last of the three screens in this display. Your analyzer should display a signal similar to the one shown in Figure 4-18.

**Figure 4-18** Viewing the RF Signal on a Spectrum Analyzer in CATV Mode—Preliminary Digital Channel Power Screen

Step 8  
Enter a digital channel to measure and select digital channel power. Your spectrum analyzer will display a signal similar to the one shown in Figure 4-19.
Figure 4-19  Measuring the RF Signal at the Upconverter Output in CATV Mode—Digital Channel Power Screen

Step 9  Using the spectrum analyzer’s reference level control, adjust the amplitude of the displayed signal until the signal peak is within the top graticule of the analyzer’s display grid, as shown in Figure 4-20.

Figure 4-20  Measuring the RF Signal at the Upconverter Output in CATV Mode—Adjusted Digital Channel Power Screen

Step 10  Select the video averaging feature. Your spectrum analyzer should display a signal similar to the one shown in Figure 4-21.
The approximate in-channel peak-to-valley flatness can be verified using the spectrum analyzer’s video averaging feature. Be aware, however, that amplitude values registered while in the video averaging mode are typically around 2.5 dB below the actual channel power.

**Step 11** Verify that your headend RF measurements meet the recommended DOCSIS parameters listed in the tables in Appendix B, “RF Specifications.”

**Step 12** Record your headend settings and measurements in Appendix G, “Site Log,” as you verify them. This will assist in troubleshooting the Cisco uBR7225VXR router installation later in the process.

**Step 13** After you have analyzed and adjusted the RF signal according to the steps outlined on the preceding pages, proceed to the “Connecting and Configuring the Upstream” section on page 4-18.
Connecting and Configuring the Upstream

The following sections describe how to connect and configure the upstream for digital data.

Connecting the Upstream to the Optical Receiver

To connect the upstream to the optical receiver, use a 2-way splitter as a combiner to leave the DOCSIS cable modem connected at the headend, and connect the upstream headend cable to the optical receiver. (See Figure 4-22.)

The default upstream input level to the Cisco uBR7225VXR cable interface line card is 0 dBmV. You may adjust the upstream input level to other values using the Cisco IOS software running on your router. The Cisco uBR7225VXR router uses automatic power control when transmitting to remote cable modems. Accurately setting the power level helps to ensure reliable cable modem operation.

Table 4-1 provides upstream input power ranges for the various cable interface line cards available for the Cisco uBR7225VXR router, depending on the channel bandwidth you are using.

<table>
<thead>
<tr>
<th>Channel Bandwidth</th>
<th>Cisco MC11 FPGA</th>
<th>Cisco MC16E and MC16S</th>
<th>DOCSIS Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 KHz</td>
<td>N/A</td>
<td>-10 to +25 dBmV</td>
<td>-16 to +14 dBmV</td>
</tr>
<tr>
<td>400 KHz</td>
<td>N/A</td>
<td>-10 to +25 dBmV</td>
<td>-13 to +17 dBmV</td>
</tr>
<tr>
<td>800 KHz</td>
<td>N/A</td>
<td>-10 to +25 dBmV</td>
<td>-10 to +20 dBmV</td>
</tr>
<tr>
<td>1.6 MHz</td>
<td>-10 to +10 dBmV</td>
<td>-10 to +25 dBmV</td>
<td>-7 to +23 dBmV</td>
</tr>
<tr>
<td>3.2 MHz</td>
<td>N/A</td>
<td>-10 to +25 dBmV</td>
<td>-4 to +26 dBmV</td>
</tr>
</tbody>
</table>

Note: If you have a Cisco uBRMC16x cable interface line card (six upstream ports and one downstream port) installed in your Cisco uBR7225VXR router, the 2-way splitter described above would be replaced by six 2-way splitters (one splitter per upstream port). This would enable you to connect to all of the available upstream ports on the Cisco uBRMC16x.
Figure 4-22 Connecting and Configuring the Upstream

Testing the Upstream Configuration

To test the upstream configuration, insert a test signal of known amplitude (+17 dBmV is shown in this example) into the fiber node and measure the amplitude output level at the output of the headend’s optical receiver. This measurement depends on return laser performance and optical distance. This procedure is known as establishing the “X-level” test point. (See Figure 4-23.)

Figure 4-23 The “X-level” Test Point
This “X-level” test point measurement will be different for every fiber node in the HFC network until you adjust the attenuation on the upstream. You must adjust the attenuation so that this measurement is the same on every fiber node. If you change a receiver or a transmitter at the fiber node, or if you unplug a connector and plug it back in, you must recheck this amplitude measurement. Figure 4-24 shows how three distribution network “X-level” test points connected to the same upstream port are all calibrated to +10 dBmV using different attenuators.

**Figure 4-24 Calibrating Multiple “X-level” Test Points Connected to One Upstream Port**

![Diagram showing calibrating multiple “X-level” test points](image)

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**Figure 4-25** shows how three distribution network “X-level” test points connected to the three different upstream ports are all calibrated to +10 dBmV using different attenuators.
Figure 4-25  Calibrating Multiple “X-level” Test Points Connected to Multiple Upstream Ports
Measuring the Upstream RF Signal

You can use a spectrum analyzer to measure the upstream signal from one or more remote cable modems in a two-way data cable network. Performing this procedure can help alert you to potential problems in your cable network’s upstream configuration before a problem occurs. This helps to avoid trying to solve a problem after a remote cable modem has experienced a failure in service. This procedure is referred to as the “zero-span” method.

Measuring the Upstream RF Signal Using a Spectrum Analyzer

This procedure is designed to help you accurately measure an upstream RF signal where no adjacent channels are in use. To measure an upstream RF signal with active adjacent channels, refer to the “Using the Zero-Span Method with Adjacent Upstream Channels” section on page 4-28.

Note
Refer to the user guide that accompanied your spectrum analyzer to determine the exact steps required to use your analyzer to perform these measurements.

Step 1
Connect the spectrum analyzer to the upstream signal from your cable network.

Step 2
Turn the power switch on the spectrum analyzer to the on position.

Step 3
Set the spectrum analyzer to view the upstream RF signal with a center frequency matching the actual upstream center frequency defined in your Cisco uBR7225VXR router configuration file.

Step 4
Set the spectrum analyzer’s span to 0 MHz.

Note
You can view the configuration file for your Cisco uBR7225VXR router by using the show controller cable slot/upstream/port command, available in Cisco IOS Release 11.3(6)NA or later releases and Cisco IOS Release 12.0(5)T1 or later releases. For example, if you wanted to view the center frequency of port 0 on a cable interface card in slot 3, you would enter the show controller cable 3/0 command.

If you have assigned spectrum groups in your configuration file, use the show cable hop command to display the current upstream center frequency for each cable interface.

Step 5
Set both the resolution bandwidth and the video bandwidth on the spectrum analyzer to 3 MHz and the sweep rate to 20 microseconds. Provided there is a large amount of activity on your upstream channel, the spectrum analyzer should display a signal similar to the one shown in Figure 4-26.
Figure 4-26  Measuring the Upstream RF Signal—Setting the Resolution and Video Channel Bandwidth

The horizontal line passing through the center of the spectrum analyzer display in Figure 4-26 is the trigger line.

Step 6  Set the sweep value to 80 microseconds. Your spectrum analyzer should display a signal similar to the one shown in Figure 4-27.

Note  Be sure that your particular spectrum analyzer is capable of supporting sweep times as short as 80 microseconds.

Figure 4-27  Measuring the Upstream RF Signal—Setting the Sweep Time Period

Step 7  Position the trigger line on the spectrum analyzer so that it is roughly in the middle (approximately halfway between the highest and lowest portions) of the upstream RF signal.
**Note** Refer to the documentation that accompanied your particular spectrum analyzer for detailed instructions on activating and positioning the trigger line.

A known workaround exists for the Agilent 8591C spectrum analyzer. After activating and positioning the trigger line in video mode, you must press the “video” button on the spectrum analyzer once more to enable proper functionality.

**Step 8** Adjust the amplitude on your spectrum analyzer so that the uppermost portion of the upstream RF signal is in the top graticule of the analyzer’s display grid and adjust the trigger line accordingly. Your spectrum analyzer will then display an upstream RF signal similar to the one shown in Figure 4-28.

**Note** We do not recommend using the spectrum analyzer’s “max-hold” feature while analyzing upstream signals in the frequency domain. “Max-hold” readings in the frequency domain can be inaccurate because the analyzer focuses on the peak power of the strongest ranging modem rather than the power levels of cable modems that are operating in a more ideal range.

**Figure 4-28** Measuring the Upstream RF Signal—Accurately Measured Amplitude on Spectrum Analyzer

**Step 9** Position a marker about 7/8 of the way into the preamble of the signal, as illustrated in Figure 4-28. (The preamble is the regular pattern displayed at the front of the signal and the length of the preamble is a function of the channel width/data rate, modulation format, and DOCSIS burst-profile configurations.) The peak amplitude of the marker, which registers +31.07 dBmV in this case, will be within 1 dB of the true burst power.

**Note** To verify this reading, you can also measure the power rating with an Agilent 89441A vector signal analyzer (http://www.tm.agilent.com).

If the preamble of your upstream signal is displayed with a significantly lower amplitude than the rest of the RF signal, refer to the “Using the Zero-Span Method with Adjacent Upstream Channels” section on page 4-28 for instructions on how to overcome this phenomenon.
**Step 10** Verify that your headend RF measurements meet the recommended DOCSIS parameters listed in the tables in Appendix B, “RF Specifications.”

**Step 11** Record your headend settings in Appendix G, “Site Log.” This will assist in troubleshooting the Cisco uBR7225VXR universal broadband router installation later in the process.

---

**Note**

Be sure not to narrow the focus of your analysis any further than approximately 3-MHz channel width. Doing so can yield incorrect readings. For example, if you were to view an upstream RF signal with a resolution bandwidth of only 300 kHz and a video channel bandwidth of only 100 kHz, your measurements would register lower than the actual transmission levels.

---

**Analyzing the Upstream RF Signal**

When you have set up your spectrum analyzer to accurately read the upstream RF signal, you can verify that a remote cable modem is operating as it should by pinging the modem via a console terminal.

**Step 1** Log in to your Cisco uBR7225VXR universal broadband router with a console terminal.

**Step 2** Adjust the sweep time on your spectrum analyzer to 20 microseconds.

**Step 3** Ping the remote cable interface card using first a 64-byte, then a 1500-byte ping packet request, and take note of the upstream RF signal in each case. Several hundred or thousand ping packets might be required for a usable pattern to emerge.

**Figure 4-29** and **Figure 4-30** provide two examples of an ideal upstream RF signal based on a simple 64- or 1500-byte ping of a single remote cable interface. The more slender of the data spikes in the RF signal (the first and third spikes in **Figure 4-29**) are bandwidth request packet transmissions, while the larger spikes are the actual 64- or 1500-byte ping packet returns.

**Figure 4-29** Analyzing the Upstream RF Signal—64-Byte Data Packets
Measuring the Upstream RF Signal

Chapter 4 Connecting the Cisco uBR7225VXR Router to the Cable Headend

Both of the previous examples feature 16-QAM transmission with a channel width of 3.2 MHz, yielding a 10-Mbit/sec data rate. In addition, these examples have an optimal upstream carrier-to-noise ratio of approximately 50 dB.

Now it is time to view your upstream RF signal with multiple remote cable modems. Figure 4-31 and Figure 4-32 both display upstream RF signals encompassing more than one remote cable modem. In each case, there are two bandwidth requests followed by their respective ping packet returns, both at slightly different amplitudes. This situation is most commonly caused by a difference in the receive power from the two cable modems in question. In the example, the remote cable modem with the lesser amplitude is “cable modem A” and the other is “cable modem B.”

In the following example, cable modem A and cable modem B have been artificially configured to yield a larger than normal difference in amplitude between their respective upstream RF transmissions. Under normal conditions, the maximum difference in amplitude between any cable modems will be about 1.5 dB. Differences greater than 1.5 dB indicate a possible cable plant or remote cable modem problem.

To further illustrate this point, you can log in to your Cisco uBR7225VXR router using a console terminal and enter the `show cable modem` command to obtain a report of the receive power ratings for each modem. In the example, the receive power ratings for remote cable modems A and B are –2 dBmV and 0 dBmV, respectively.

The two bandwidth requests and ping packet returns on the upstream RF signal for cable modems A and B are slightly different in Figure 4-31 and Figure 4-32. Differences in the distance between bandwidth requests are primarily caused by the contention-based nature of multiple remote cable modems on the same line. Differences in the distance between ping packet returns are primarily caused by factors such as packet size and system loading.
When viewing the upstream RF signal on your spectrum analyzer, two ping packet returns (for example, from remote cable modems A and B) can be so close together that they appear to be one rather large packet with a slight jump or decline in amplitude halfway through the measurement. This is an indication that the upstream is 100 percent occupied during this time.

Figure 4-33 shows an upstream RF signal from a remote cable modem in a “real-life” scenario including outside plant noise. Notice the relatively tall spike at the very left edge of the ping packet return. This spike is mainly additive noise associated with an upstream RF signal mired by excessive amounts of severe outside plant noise (as in this example). In addition, notice that the carrier-to-impulse noise ratio measurement between the two diamond-shaped markers is only about 12 dB. (A few other noise peaks are even worse.)
The importance of this example is to bring to your attention the need for minimal outside plant noise. Time-varying, fast noise can cause bit errors in packet transmissions, rendering your communication link unreliable, if not unusable.

**Figure 4-33  Analyzing the Upstream RF Signal—Outside Plant Noise Included**

![RF Signal Analysis](image)

**Note**

This illustration depicts an upstream RF signal whose carrier-to-impulse noise ratio does not meet DOCSIS 1.0 specifications. The data packet in Figure 4-33 was “dropped” due to severe noise interference with a more narrow resolution bandwidth.

### Using the Zero-Span Method with Adjacent Upstream Channels

When measuring upstream signals using the zero-span method, a very wide resolution and video bandwidth give very accurate readings, but render your readings susceptible to energy in adjacent channels. As the number of upstream services increases, so does the likelihood of interference from adjacent channels. This section describes using the zero-span power measurement method, with a more narrow resolution bandwidth.

Simply narrowing the resolution bandwidth will not yield accurate readings. See Table 4-2.

**Table 4-2  Sample Channel Width and Symbol Rate Combinations with Their Respective Minimum Resolution Bandwidth Measurements**

<table>
<thead>
<tr>
<th>Center Frequency</th>
<th>Channel Width</th>
<th>Symbol Rate</th>
<th>1/2 Symbol Rate</th>
<th>Center Frequency +/-1/2 Symbol Rate</th>
<th>Minimum Resolution Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.000</td>
<td>200 kHz</td>
<td>160</td>
<td>80</td>
<td>20.080 and 19.020 MHz</td>
<td>10 kHz</td>
</tr>
<tr>
<td>30.000</td>
<td>400 kHz</td>
<td>320</td>
<td>160</td>
<td>30.160 and 29.840 MHz</td>
<td>30 kHz</td>
</tr>
<tr>
<td>40.000</td>
<td>800 kHz</td>
<td>640</td>
<td>320</td>
<td>40.320 and 39.680 MHz</td>
<td>100 kHz</td>
</tr>
<tr>
<td>25.000</td>
<td>1.6 MHz</td>
<td>1280</td>
<td>640</td>
<td>25.640 and 24.360 MHz</td>
<td>100 kHz</td>
</tr>
<tr>
<td>28.000</td>
<td>3.2 MHz</td>
<td>2560</td>
<td>1280</td>
<td>29.280 and 27.720 MHz</td>
<td>300 kHz</td>
</tr>
</tbody>
</table>
Step 1  Display a signal complete with preamble and upstream data transmission information similar to the resulting signal from Step 3 through Step 10 under the “Measuring the Upstream RF Signal Using a Spectrum Analyzer” section on page 4-22. Your spectrum analyzer should display a signal similar to the one in Figure 4-34.

*Figure 4-34  Preamble Amplitude Before Resolution and Video Bandwidth Reduction*

![Figure 4-34](image)

Note  Figure 4-34 is a display from a standard spectrum analyzer. The following figures, Figure 4-35 through Figure 4-38, are taken from a vector signal analyzer. If you do not have access to a vector signal analyzer, or want to skip the following section describing its use when viewing your upstream signal, proceed to Step 3.

Step 2  (Optional) View your upstream signal using a vector signal analyzer such as the Agilent 89441A.

The advantage of displaying these signals with the vector signal analyzer is that you can view them over the time domain for a specified time interval. In addition, the vector signal analyzer enables you to measure the digital channel power of a very short duration data transmission, like the preamble of a digital signal.

a. Set up your vector signal analyzer to view both the “frequency” domain and “time” domain of your upstream signal. Your vector signal analyzer should display a pair of signals similar to those in Figure 4-35.
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Figure 4-35  Vector Signal Analyzer Plot of Upstream Data Burst

The upper graph in Figure 4-35 represents the frequency domain and the lower graph represents the time domain.

In the time domain, the channel power of the preamble of a digital upstream signal is not spread across the entire channel. However, the channel power of the remainder of the digital transmission is spread across the entire channel. Even though it may not seem so, the total channel power across both the preamble and the subsequent data segment remains constant.

b. Narrow the view on your vector signal analyzer to display only the preamble of the digital data signal in both the frequency domain and time domain.

The upper display in Figure 4-36 is a plot of only the preamble portion of the digital signal in Figure 4-35. Notice how the amplitude of the signal experiences many “peaks” and “valleys.” When you are measuring the preamble power using the zero-span method, be sure that you measure the actual signal energy (a peak), rather than accidentally measuring the power level of a valley in the preamble.
Figure 4-35 and Figure 4-36 illustrate the benefit of properly adjusting the center frequency of your spectrum analyzer to enable the power measurement of the preamble to match the power measurement of the rest of the digital transmission.

Figure 4-35 and Figure 4-36 show how adjusting the spectrum analyzer in the time domain reveals this frequency domain phenomenon. The spectrum analyzer is unable to capture the data as shown in the vector signal analyzer plots.

The power level in the upstream channel fluctuates by approximately 1 dB between Figure 4-35 and Figure 4-36. This difference is within both the measurement tolerance of the vector signal analyzer and the accuracy requirement for any DOCSIS-based cable modem.

c. Switch your vector signal analyzer over to Digital Demodulation Mode. Your vector signal analyzer displays a set of screens similar to those in Figure 4-37.

Using this mode to view your upstream signal allows you to view the same time and frequency domain information found in Figure 4-36, as well as the upstream signal’s phase characteristics, shown in the bottom-right portion of the vector signal analyzer display screen.
d. Switch your vector signal analyzer over to quaternary phase shift keying (QPSK) demodulation mode. Your vector signal analyzer will display a set of screens similar to those in Figure 4-38. Figure 4-38 displays the QPSK demodulation information for the same upstream signal as in Figure 4-37. However, there are some notable differences in the information presented. For example, notice that the constellation and transition graphs (top and bottom left) both indicate only two of the four QPSK data points handling any bits. Because this graph is covering only the preamble of the data transmission, you get to see only a portion of the whole signal performance. (If you were to view the entire signal transmission in this mode, all four QPSK data points would display bits.)
Note Before moving on to Step 3, be sure to hook your spectrum analyzer back up to the upstream signal source.

Step 3 On your spectrum analyzer, narrow both the resolution and video bandwidth to 1 MHz. You will notice that the preamble of the signal has dropped in amplitude, yielding a spectrum analyzer display similar to the one in Figure 4-39.
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Figure 4-39  Preamble Amplitude Before Center Frequency Adjustment

Note
The slight amplitude variations shown in these figures are normal signal level variations between bursts in the upstream channel. Expect modems to vary upstream transmit power by nearly 1 dB between bursts. This is well within the requirements for DOCSIS compliance. The default variation between modems is up to 1.5 dB for most DOCSIS CMTS equipment.

Step 4
Using the examples in Table 4-2 on page 4-28 as a basis for the formula, calculate the correct center frequency offset necessary to measure the preamble peak power when viewed in a narrow bandwidth. In the example, the channel width is 1.6 MHz, which has a symbol rate of 1280 ksym/sec; therefore, the appropriate offset value is 640 kHz.

Step 5
Change the center frequency on the spectrum analyzer by this offset value (33.248 MHz in the example) and check to see that the preamble has regained its lost amplitude by comparing it to the amplitude of the rest of the signal. If so, the spectrum analyzer should display a signal similar to the one in Figure 4-40.
To get an even better look at the patterns and dramatic shifts in amplitude within the preamble itself, you can accelerate the sweep time for your zero-span signal processing.

**Step 6**
Tune the spectrum analyzer to the original center frequency (32.608 MHz in this example).

**Step 7**
Reset both the resolution and video bandwidth of the signal back to 3 MHz, but reduce the sweep time from 200 microseconds to 60 microseconds. The resulting display, similar to Figure 4-41, clearly shows the “tight” pattern of the preamble stretched across three-quarters of the spectrum analyzer display.

**Step 8**
Change the center frequency back to 33.248 MHz and both the resolution and video bandwidth values to 1 MHz, retaining the new sweep time of 60 microseconds. The peak amplitude is clearly displayed with approximately 4.25 dB difference between the preamble and the rest of the upstream data transmission. (See Figure 4-42.)
The 4.25 dB decrease in amplitude is due to a combination of half of the channel bandwidth (3 dB) and an additional 1.25 dB decrease attributed to the digital channel filter mask, known as the “alpha.” The value of alpha is 25 percent of an upstream DOCSIS channel’s width, and the peak signal energy spread across the entire upstream channel width.

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**Figure 4-42  Preamble with Decreased Amplitude and Condensed Sweep Time**

Step 9  Narrow the resolution bandwidth from 1 MHz to 100 kHz and increase the video bandwidth to 3 MHz, still retaining the 60 microseconds sweep time. Your spectrum analyzer should display a signal similar to Figure 4-43.

**Figure 4-43  Very Narrow Resolution Bandwidth Limits Range of Spectrum Analysis**
Note

The slight “ramp-up” at the beginning of the preamble when viewed in this mode is attributed to the time required to charge the spectrum analyzer’s detector circuit.

Figure 4-43 shows a smooth and easily measured signal amplitude, providing accurate measurement of a very fast burst upstream carrier. You can compare the measurements obtained using a spectrum analyzer with those of specialized test equipment. In general, the readings from the spectrum analyzer will be within 1 to 2 dB of the (more expensive) specialized equipment. Because 1 to 2 dB is well within the calibration accuracy of spectrum analyzers, you can reliably use these procedures in the cable headend environment.

Measuring the RF Signal at the Forward Test Point on a Laser Transmitter

This section describes RF signal measurements that should be taken with a spectrum analyzer at the downstream forward test point on the fiber-optic laser transmitter.

Use the following steps to measure the downstream forward test point on the fiber-optic laser transmitter:

Step 1
Connect the spectrum analyzer to the downstream forward test point on the fiber-optic laser transmitter. Figure 4-44 shows a typical measurement of the downstream forward test point.

Figure 4-44 Measuring the RF Signal at the Downstream Forward Test Point on the Laser Transmitter

Step 2
Using the spectrum analyzer zoom feature, zoom the display on the first individual video channel. In the example in Figure 4-45, the first video channel is channel 48.
**Step 3** Select the carrier level (or amplitude) function. Figure 4-46 shows the detailed display of the analog carrier level and frequency screen for the channel 48 (in this example).

**Figure 4-46**  
Downstream Forward Test Point on the Laser Transmitter—Detailed Video Channel Display

**Step 4** Return to the main menu on your spectrum analyzer.

**Step 5** Select a digital channel to measure. In the example in Figure 4-47, the digital channel shown is channel 50.

**Figure 4-47**  
Downstream Forward Test Point on the Laser Transmitter—Detailed Video Channel Display
Step 6  Go to the main menu on the spectrum analyzer and advance the screen displays (next screen) until the digital channel power display is shown. (See Figure 4-48.)

Note  The +3.6 dBmV digital power rating is nearly the same as the previously measured video carrier level (+4.3 dBmV). This value is too high to provide reliable digital data transmission.

Step 7  Set the upconverter output level so that the amplitude of the digitally modulated carrier is 6 dB to 10 dB below the amplitude found on the same frequency on an analog TV channel.
Step 8

Select the video averaging feature to verify flatness through the headend combiner. After 10 averages, the power rating decreases by approximately 2.5 dB from actual digital channel power. While video averaging is in progress, your spectrum analyzer should display a signal similar to the one shown in Figure 4-49.

Figure 4-49  Downstream Forward Test Point on the Laser Transmitter—Digital Channel Display Using Video Averaging

Configuring the Digital Signal

After you have configured the RF signal, you must configure the digital data signal that will be carried between the Cisco uBR7225VXR universal broadband router and cable modems.

We recommend installing a Cisco uBR900 series cable access router at the headend to verify the digital data configuration. For instructions on how to install a Cisco uBR900 series access router, refer to the installation and configuration guides for the Cisco uBR900 series access router that you are using at the following URL:


The output of the Cisco uBR7225VXR router is measured in RF signals through an internal upconverter. Upconverter output levels should be set to carry the digital signal data at 6 to 10 dB below the adjacent analog video signal. The value chosen is at the discretion of each cable operator.

Note

The value chosen for the digital data in relation to the adjacent video signal must be made available to field technicians installing DOCSIS cable modem.

At a cable interface connection, this value can be measured to verify the correct operation of the cable interface.
Careful system design and operation can prevent potentially serious intermittent performance problems across your cable interface network. Each cable operator should make use of the following guidelines and practices to ensure reliable operation of any 64-QAM based digital network:

- “NCTA Recommended Practices for Measurements on Cable Television Systems” ([http://www.ncta.com](http://www.ncta.com))
- DOCSIS 1.0 RF Interface Specification ([http://www.cablemodem.com](http://www.cablemodem.com))

For example, if your headend overdrives the fiber-optic lasers transmitters, in either the upstream or downstream path, clipping may occur. Laser clipping leads to degraded signal integrity. In minor doses, this signal damage is not immediately visible on an analog video signal, but it can completely disrupt the digital transmission path. (That is, digital signals are more sensitive to clipping than analog signals and will more readily display the negative effects of laser clipping.)

If a digital signal employing forward error correction (FEC) is near its impairment limit, it is very susceptible to changes in signal level—on the order of as little as 0.1 dB. If there is no amplitude margin available in the transmission path between the headend and any one cable modem, the typical signal level variations of a properly functioning cable system (3 to 6 dB) can create intermittent service outages that are difficult to isolate.

Typical CATV measurement equipment, such as digital signal level meters, measure to an accuracy of +/-1 dB. However, some older analog meters only measure to an accuracy of +/-3 dB; therefore, maintaining 6-dB margins above the minimum levels can provide reliable long-term service.