

# Troubleshooting Return Path Interference Using the RFM151



With many operators now upgrading their cable networks to offer new digital services, there's an awakening taking place regarding the return spectrum. The once dormant return band, greatly under utilized in most systems, is now staging a remarkable comeback. Along with this new utilization of the return path, there's also a need for understanding its problems and the test equip-

ment that can help the technician troubleshoot and maintain it.

This application note includes information about the return path and its anomalies. It will also show how to troubleshoot the return spectrum in a typical hybrid-fiber coax (HFC) network using the Tektronix RFM151 Cable TV RF Analyzer.

## Utilization of the Return Path

The return path frequency range is usually from 5 to 47 MHz. Other frequency ranges include 5 to 100 MHz (mid split) and 5 to 175 MHz (high split) for upstream signal transmission. Since most operators are using 5 to 47 MHz for their upstream digital carrier transmission, this application note focuses on these frequencies.

Figure 1 shows the T channels and the off-air signals found in the 5 to 47 MHz return band. The T channels carry data, live or tape delayed RF video signals for schools, government agencies, and similar institutions. In many HFC architectures the facilities that once utilized the T channel frequencies are now using dedicated fibers directly to the Headend for downstream retransmission. This method allocates more of the return band spectrum for digital carriers used for new services such as: Telephony (see Figure 2), Cable Modems, and Digital Video Services.

### Types of Interference Found in the Return Path

- **Ingress** is defined as the entry of unwanted and interfering signals into the coax plant (see Figure 3). The most common sources of ingress are the many known off-air radio frequencies (see Figure 1) that share the same spectrum.
- **Impulse Noise** is a special case of ingress caused by electromagnetic interference from hair dryers, microwave ovens, air-conditioners and any other high-current, low-shielded device. It's best described as bursts of random noise as shown in Figure 4.

- **Common-Path Intermodulation Distortion (CPID/CPIM)** is second- or third-order distortion products from downstream signals caused by impedance changes and non-linear elements in portions of the plant where both upstream and downstream signals are present. These impedance changes cause a portion of the forward energy to be reflected back down the line where the lower frequency components are passed through the diplex filter and amplified by the return amplifier. CPID appears as spurious signals spaced at the visual carrier intervals of the system (see Figure 5).

### Causes of Return Path Interference

The majority of all ingress detected in the return band is introduced in the subscriber loop. Loose "F" connectors, poorly shielded drop cable, unshielded television tuners, and even the safety grounds are all places that can let ingress in. A common solution to this problem is to put return frequency traps in the lines of all customers. These traps keep any subscriber loop problems from getting

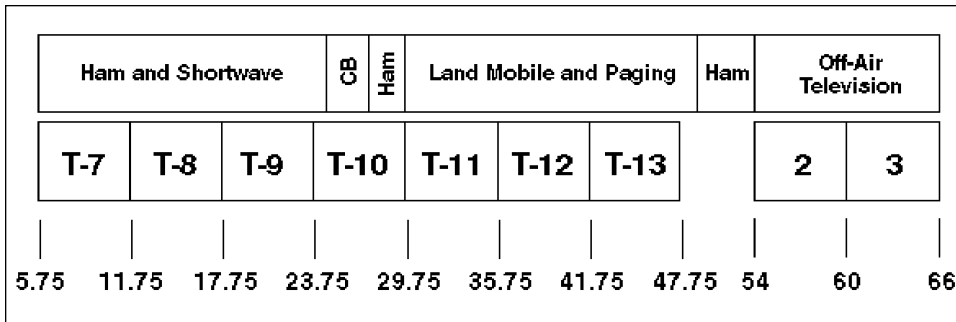


Figure 1. Frequency Allocation Spectrum for the T Channels and possible sources of ingress from other authorized users.

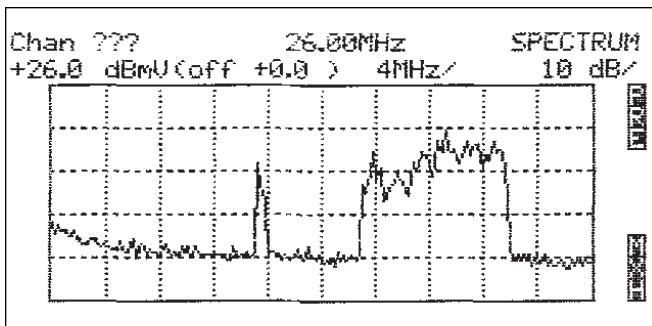


Figure 2. Return Path from 6 to 46 MHz displaying Telephony and Data Carriers.

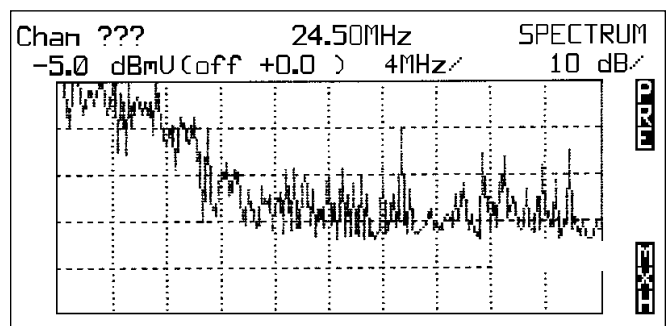


Figure 3. Ingress distortion.

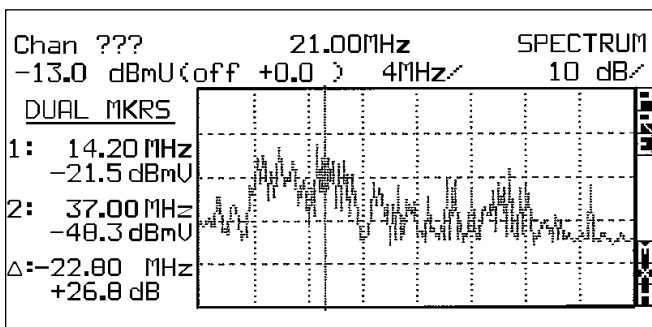


Figure 4. Impulse Noise generated by a hair dryer.

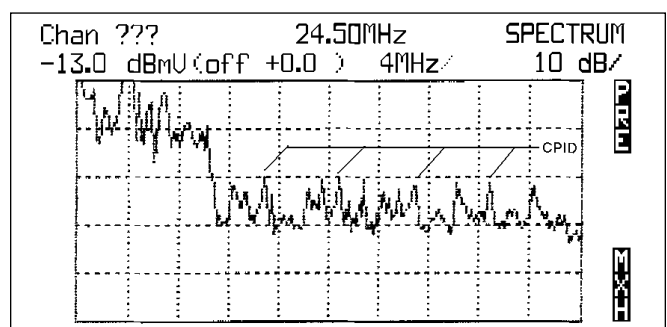


Figure 5. CPID.

into the rest of the plant. This is a satisfactory solution, until the customer wants a service that requires the return path – then the wiring will have to be “tightened.”

The trunk and distribution plant accounts for a small percentage of the ingress detected in the system. The root causes of interference problems are loose line connectors, line connectors improperly installed, and damaged trunk or distribution cables. Good plant maintenance helps prevent these problems from reaching critical proportions.

Common Path Intermodulation Distortions directly relate to poor connectorization, corrosion, dissimilar metals used in connections, and kinks and radial cracks in the cable. Common path distortions are hard to troubleshoot because they tend to come and go. A gentle breeze,

can cause a loose seizure screw to generate small impedance mismatches which, in turn, creates reflections of the forward path through the diplex filter and into the return amplifier where the reflections are amplified and sent upstream.

#### Effects of Return Path Interference

Return path interference can cause telephony transmission over the HFC network to have unpredictable dropouts. Since the talk path and the listen path are in different parts of the spectrum, only the talk path will be affected by return path ingress. This can create a scenario where the listener hears only bits and pieces of the conversation. For cable systems offering “life line” telephone service, the FCC requires that the system have a 99.99% availability. This allows only 53 minutes per line per year

for outages, both planned and unplanned. To meet this requirement, ingress must be identified and corrected before it can cause problems.

With cable modem services, interference can cause sessions to end abruptly without the users knowledge. It can also increase the time it takes to establish communications with the Internet Service Provider (ISP) due to high bit-error rates requiring re-transmission of the data packets.

For digital interactive video services, the customer will be unable to establish communication between the server and the set-top box, causing transmit error messages to be displayed on the television screen.

Return interference can also have a significant effect on the laser diode inside the optical transmitter. As interference is transmitted from more than one trunk leg, as shown in Figure 6, carriers that are at the same frequency can combine together increasing the carrier power. This combining of signals is known as the “Funnel Effect.” There will also be a significant increase in the noise floor. As this continues to occur by recombining the carriers at each station, the amplitude of the combined carriers can cause the laser diode at the node to begin clipping. Rather than affecting only one digital carrier, it now affects the entire return band for that node.

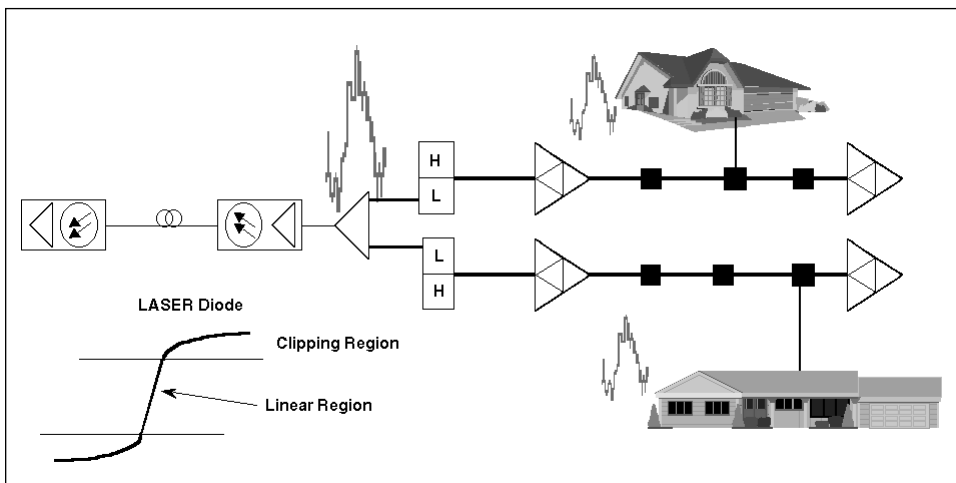


Figure 6. Ingress from two different points in the system can combine to create a larger pulse causing the laser to clip, possibly resulting in disruption of services.

### Setting up the RFM151 for Ingress Troubleshooting

*NOTE: Familiarity with the operation of the RFM151, and specifically the Spectrum Modes, is recommended for this section.*

**Step 1.** Select the spectrum mode by pressing the SPECT key.

**Step 2.** Select the General Purpose mode using the F1 key.

**Step 3.** Set the center frequency to 25.00 MHz, the span to 4 MHz/div, and the vertical scale to 15 dB/div.

**Step 4.** Adjust the reference level so that the trace is within the top division of the display.

**Step 5.** Adjust the vertical scale until the noise is at least 1 division high.

**Step 6.** Press the F5 key to enter the measurement setup menu. There you can select the following:

- Marker mode – none, dual, or noise
- Pre-amp – on or off
- Detection mode – peak or average
- Noise marker bandwidth

With no markers selected, there will be 10 divisions displayed for a total span of 40 MHz. With a center frequency of 25 MHz, the ends are now at 5 and 45 MHz.

With the markers enabled, the display reduces to 8 divisions for a total span of 32 MHz, from 9 to 40 MHz. Use the markers when accurate frequency and amplitude measurements are needed.

Since we are just trying to find out what the return path looks like, the widest possible view is desired, so select Marker Mode

OFF. For best measurement of ingress near the noise floor, the dual or noise markers should be selected along with using a span of 400 kHz or 200 kHz. These spans use the 30 kHz resolution bandwidth filter instead of 300 kHz that is used for spans >400 kHz.

The pre-amp and detection mode controls should be used according to the situation and personal preferences. The pre-amp adds an additional 12 to 15 dB of dynamic range to the instrument and is useful when pulling signals out of a low noise floor. Peak detect shows all noise while Average mode averages out the nuisance noise and allows greater focus on the signals of interest. Starting in Peak mode lets you see all of the noise; switching to Average allows you to sort out CPID and off-air interference from impulse noise.

To recap the instrument settings, the display should resemble that shown in Figure 7.

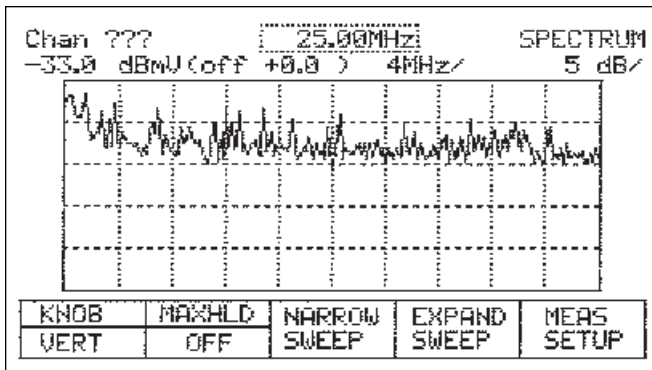


Figure 7. Settings for the Spectrum Mode.

### Troubleshooting Return Path Interference

Troubleshooting the return path is different from troubleshooting the forward path. In the forward path, you have a known branch, sub-branch, or house with a problem. The number and geographic location of trouble calls can help pinpoint what part of the plant has a problem. In the return path, you are now looking for a problem that could be coming from anywhere in the plant.

Imagine that your cable plant is a large oak tree. Forward path problems show up as a bunch of dead leaves all connected to a broken branch and are fairly easy to find. The return path is more like having a leaf or two painted with a systemic poison, and you need to find out which leaves were painted before the whole tree dies. You must now trace the path of the poison from the trunk back out to the branch and then to the tainted leaf.

**Headend Troubleshooting** – Connect the RFM151 to the RF Test Point at the fiber receiver in the Headend as shown in Figure 8. At this combined test point, you can observe all of the signals in

the return spectrum – wanted signals as shown in Figure 1, and unwanted signals as shown in Figures 3, 4, and 5. The ingress found at this test point is your reference as you move down the branch. The spectrum display should either be stored or printed for making comparisons. To store the display, just press the STORE button and then the F1 button. To print, connect a compatible printer to the RS232 port and hold the ESC key until the RFM151 begins to beep. Once interference has been observed on the return test point, proceed to the node that is feeding the optical receiver.

**Fiber Node Troubleshooting** – At the fiber node, connect the RFM151 to one of the RF output ports. Note that there may be several different places where return path signals can be observed. Be sure to determine where in the system the test point is located and how much attenuation it has. If the test point's attenuation were 20 dB, then you would compensate by adding 20 dB to the measurement, or by setting the RFM151's Probe Loss for 20 dB.

Test points located outside of the duplex filter have both forward and return path signals. In these situations, the RFM151's pre-amp can be used to increase measurement sensitivity. Just remember to limit the amount of spectrum above 40 MHz that is in the span. Once the meter is set up, check each trunk until the problem is isolated to one or more trunks.

**Distribution Troubleshooting** – Follow the problem trunk to the next amplifier in the cascade, connect the RFM151 to each of the RF output ports until ingress has been identified. Continue down the trunk until the ingress has been isolated to a tap distribution leg.

**Tap Troubleshooting** – As the interference is identified on the tap distribution leg, ride-out the distribution legs in question for leakage before proceeding to the next passive or active device. The RFM151's relative field strength mode and an antenna can be used for this ride-out. Simply connect the optional antenna to the RFM151 and enter the field strength mode by pressing the MEAS button, then the F5 button. Set the frequency to that of the ingress you are looking for, adjust the attenuation and sensitivity controls so that the displays are in the lower portion of their bands, and drive down the plant. Leaks will show up as an increase in field strength. Take corrective action for the leakage as required. If interference still exists, begin troubleshooting the tap distribution leg.

To isolate interference to a specific device in the tap distribution leg (see Figure 8), connect the RFM151 to the through output of the tap with an impedance matching probe. Impedance matching probes have a high-impedance side that goes on the seizure screw, and a low-impedance (75 Ohm) side that connects to the instru-

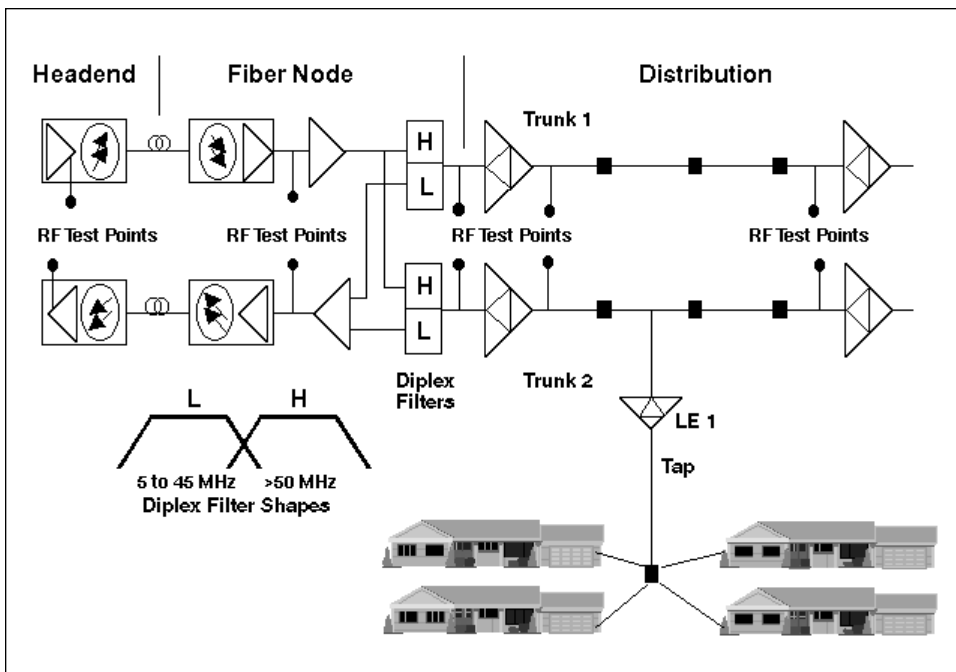


Figure 8. A typical HFC network showing typical RF test points.

ment. This minimizes loading of the cable plant by the instrument. In addition it provides a mechanical connection through the seizure screw port.

If interference exists, the problem is originating from the output side of the tap. If there is no interference on the output, connect the RFM151 to the input of the tap. If the interference is at the input port, begin disconnecting each house drop (connected to the tap) one by one until the interference clears.

*NOTE: While all HFC architectures are not the same, the basic elements of troubleshooting them are similar. The idea is to isolate the problem to a given subscriber loop. To do this, you must go down the cascade of amps (line extenders or trunk), until the ingress is no longer present, then go back to a tap that is half way between the two amps and determine if the ingress is up or down stream from there. Continue splitting the distance in half until the problem tap is isolated.*

### Identifying Interference Types

As mentioned previously, there are three types of interference signals: off-air ingress, impulse noise, and CPID. The RFM151 has several features that make differentiating these signals easier. These features are AM/FM demodulators with speaker, Max Hold, Average Detection mode, and Relative Field Strength.

Lets start by using the demodulators to find off-air interference. Enter the Demod Spectrum mode by pressing the SPECT button and selecting DEMOD MODE (F2). The RFM151 goes into

the marker mode with each marker capable of both measurement and selection of the signal to demodulate. To listen to a signal, set either marker on it and press the F3 button; the instrument will make one more sweep and then begin demodulation. Pressing the F2 button turns the knob into a volume control, and pressing the F4 button toggles between AM, FM and AM/FM modes.

The three most common off-air sources in the return band are: Short-wave broadcasters, CB radio operators, and radio amateurs. By listening to them, you may be able to determine their call signs and/or location. This will help locate the leak in the cable plant, although it won't help you too much if it's a CBer with a 200-watt linear driving along your plant! Paging signals also have their own unique sound that you will become accustomed to. Another indicator of a leaky plant is reception of off-air TV stations. Use the demodulator to determine if the signal is indeed "off-air" or the cable channel.

Max Hold will capture and hold all peaks. This feature is useful for finding impulse noise, and any other signals that are only around for a short time. It will also find sweep/status monitoring telemetry signals as well as cable modem traffic. Max Hold is available in all of the Spectrum modes. In the General Purpose mode, it is toggled with the F2 button.

Average Detection mode averages out the spurious noise products and allows you to better see other signals of interest. When combined with Max Hold, this can help

detect the elusive CPID that likes to hide in the noise floor. The one thing to remember is that CPID can go from noise floor to "ceiling" in a matter of seconds. When found, it should be corrected as soon as possible. Since loose connectors cause most CPID, simply touching the bad connector can cause the problem to either go away or get worse.

Always note that it's possible to get into the noise floor and dig out ingress by changing the reference level, vertical scaling, and span.

Relative Field Strength mode, along with the optional antenna, allows the RFM151 to find both off-air sources as well as leaks in the plant. This mode features a tuning control that covers the same range as the RFM151, a pre-amp control, and an attenuation control. Field strength is indicated by both a visual bar-graph display and an audio beep. The beeps get faster as the field strength increases.

To find off-air sources; tune the RFM151 to the frequency of the ingress; set the sensitivity to high and the attenuation to 0 dB. Slowly turn around looking for increases in signal level; when the level increases, follow that direction to the source, and probably to the leak.

To find leaks, tune the RFM151 to a signal that is active within the cable system, close to the ingress frequency and not an off-air signal (such as channels 2, 3, or 4). Set the attenuation to 0 dB and sensitivity for high. The plant in question can be checked by listening to the speed of the audio indicator on the RFM151.

### Using Ingress Monitor Mode

The Ingress Monitor Mode allows you to monitor any section of spectrum with up to 32 different frequency windows, each with its own level threshold, and save any violations into memory. This is useful in at least two applications: keeping track of general interference levels at the nodes and finding ingress problems that are time dependent (such as household appliances in the early evening). The Ingress Monitor can be set up to sweep continuously or at intervals from 2 to 60 minutes, allowing both attended and unattended operation.

Use the following steps to set up the Ingress Monitor:

**Step 1.** Press the SPECT button and select INGRESS MONITOR (F3).

**Step 2.** Select MEAS SETUP (F5).

**Step 3.** Select LIMITS SETUP (F5) – this is where the frequency windows and thresholds are set up.

**Step 4.** To define a limit, select NEW LIMIT (F1).

**Step 5.** Enter the parameters for the window you want to create. When creating threshold windows, a hardcopy of a normal ingress spectrum can be used as a template. Figure 9 shows a sample ingress spectrum that has been marked up for threshold windows. Figure 10 shows the limits as entered into the RFM151.

Now that the windows have been set, it is time to set up the monitor. Press ESC to get back to the ingress monitor mode set up menu and select MONITOR SETUPS (F4).

Here we will setup the RFM151's handling of ingress violations. For attended monitoring, the audible tone and/or stopping the sweep alerts the technician to violations. For unattended monitoring, the results should be stored in the instrument.

There are three options for storing violations. First is storing the entire spectrum display each time there's a

violation. In our example, this could mean that a large impulse could cause violations in all windows resulting in five stored displays. Each display would show the entire sweep with the violation window bracketed vertically by cursors and horizontally by a threshold line. This provides the most data, but also takes the most amount of memory (about 300 spectrum displays can be stored in the NVRAM).

The second option stores only the marker information for the violation (frequency, amplitude, and time). This method takes less space, allowing approximately 4,500 violations to be stored.

The last option stores the spectrum display for first violation in any given sweep. This captures the entire spectrum but only brackets the first window that contains a violation. To maximize efficiency in our example, the windows around the telemetry pulse and telephony data could be turned off.

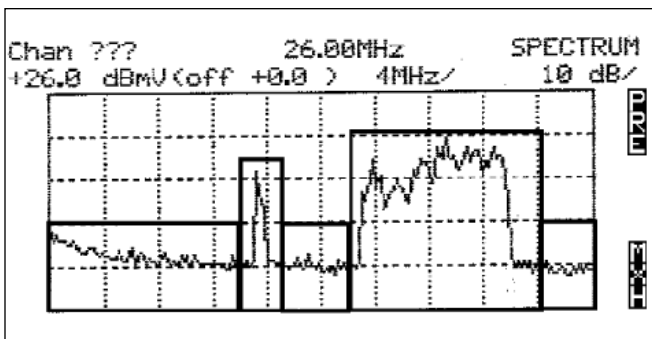


Figure 9. Using a hardcopy of the spectrum display to help define threshold windows.

INGRESS LIMITS MENU				5 LIMITS
START	STOP	THRESHOLD	TYPE	5 ACTIVE
6.00MHz	19.99MHz	-4.0dBmV	MAX	
20.00MHz	22.99MHz	+11.0dBmV	MAX	
23.00MHz	27.99MHz	-4.0dBmV	MAX	
28.00MHz	41.99MHz	+16.0dBmV	MAX	
42.00MHz	46.00MHz	-4.0dBmV	MAX	

NEW LIMIT	EDIT LIMIT	CLONE LIMIT	DEL	DEL ALL
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Figure 10. The resulting Ingress Limits as entered into the RFM151.

Now that the monitoring windows are set, it's time to set the spectrum mode controls. It doesn't matter where the windows are set, if the RF analyzer is not set up to view that spectrum, they won't work. The default display for this mode is 10 divisions and no markers. This allows a maximum display of 40 MHz. For the example in Figure 9, set the center frequency to 26 MHz and adjust the reference level and vertical resolution according to your preference. It's best to have the vertical set at 5 or 10 dB/div

and the reference level so that the lowest point in the displayed spectrum is just below the half-way point on the screen. This provides either 15 or 30 dB of range for interference. If the noise floor is low, add in the pre-amp to extend the dynamic range. Engage the Monitor Mode by pressing the F2 button to catch interference.

When the recording session is over, the results can be viewed on the screen, sent to a printer, or downloaded into a PC using the CSS151 software for further analysis.

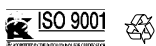
## Conclusion

With the advent of digital interactive services, there's a new awareness of the return spectrum and its associated problems. As these services grow in popularity, the use of passive trapping devices will no longer be viable and the plant will have to be "tightened." The need to monitor and troubleshoot this spectrum is a major issue with cable TV engineers and technicians. The RFM151 is a cost-effective tool to help solve ingress problems.

### For further information, contact Tektronix:

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