Theory Behind Optimizing Your Return Path Using the 9581 SST R4

Introduction

Before you begin using your 9581SST R4 system, let's review the theory behind return path alignment and maintenance. To provide complex interactive services on cable, operators must ensure that they provide a reliable return path or customers won't have access to pay services, which will result in a loss of business. The high power transmissions from CB, ham radio and shortwave operators in the 5 to 30 MHz range, as well as other RF noise generating devices, present a threat to the return path as they can enter the cable system and interfere with upstream traffic. Additionally, the ever present signals from AM broadcast can enter the cable system and increase the power loading on the return laser to problematic levels.

As the return paths converge on their way to the headend or node, they act as interference concentrators. The various sources of ingress tend to add together and these independent sources of noise can merge to form a single strong ingress where the branches converge.

Since return path problems get worse as the branches converge, the best place to measure return path performance is at the headend; just before the upstream data is recovered. Return path performance monitored at the headend needs to be available to the technician in the field for alignment and troubleshooting. The 9581 SST R4 system simplifies this process as follows:

The SST Headend Unit measures the system ingress as well as the test signals from the SSR Field Unit(s) and then transmits the results as data back to the SSR Field Unit(s), thus enabling the field technician to align the system and trouble shoot ingress problems from anywhere in the system.

Return Path Performance Parameters

Reliable upstream performance depends upon:

- Proper Gain and Tilt
- Adequate signal-to-ingress ratio

It is important to balance Gain and Tilt in order to get the optimum performance from your system. Refer to Figure 1 Balance Gain and Tilt.

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Signal-To-Noise Ratio

Gain in a particular branch, if set either high or low, can adversely affect the signal-to-noise ratio in some part or the entire return path.

- If set low, signals on this branch could be "swamped" by the noise of other branches.
- If set high, noise on this branch might be amplified enough to interfere with signals on other branches.

To minimize noise-induced communications errors, upstream data systems use robust modulation schemes like Quadrature Phase Shift Keying (QPSK), which typically operates at a data rate of 1.544 Mbps. However, even when using QPSK as the modulation format, your return system must provide a signal-to-noise ratio of at least 10 dB, as measured in a 1 MHz bandwidth around the data carrier center frequency to provide a marginally adequate Bit Error Rate (BER) of 10E-5

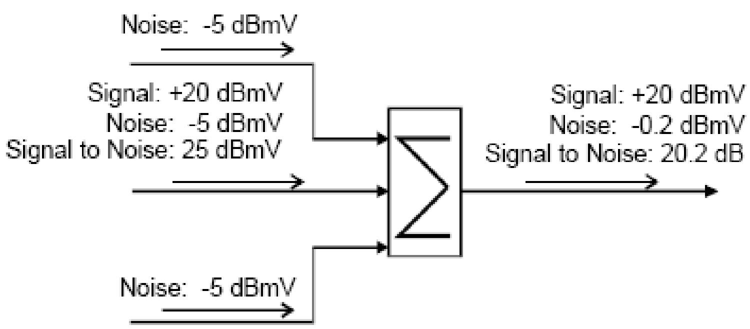
Incorrect gain settings, in some or all of the return paths, degrade the signal-to-noise ratio and increase the BER of the return path system.

Signal-To-Ingress Ratio

When using QPSK, the sum of all ingressing signals lying within the data signal bandwidth (approximately 1 MHz for the data signal as discussed in *SIGNAL TO NOISE RATIO* above) should be at least 20 dB below the level of the data signal. As the sum of ingressing signals exceeds this level, the BER performance of the return path system is degraded. If ingress levels approach -10 dBc, communication may be seriously degraded.

A Balanced System

When the system is balanced, a signal on one branch is degraded equally by noise on ALL branches to the same node.



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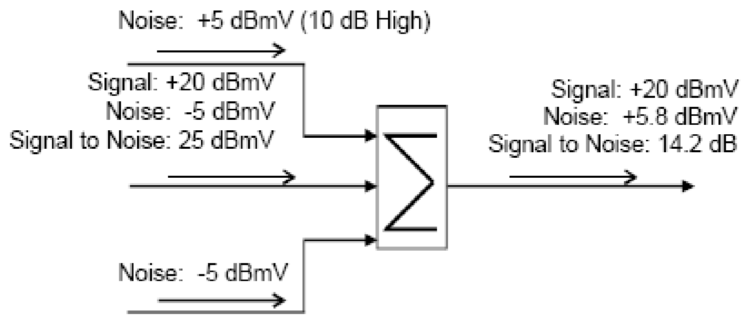
If, however, the gain of one path is set HIGHER than the others, its noise could disrupt traffic on ALL other paths.



If the gain of one path is set LOWER than the others, its signals are disrupted by the noise of ALL other paths.

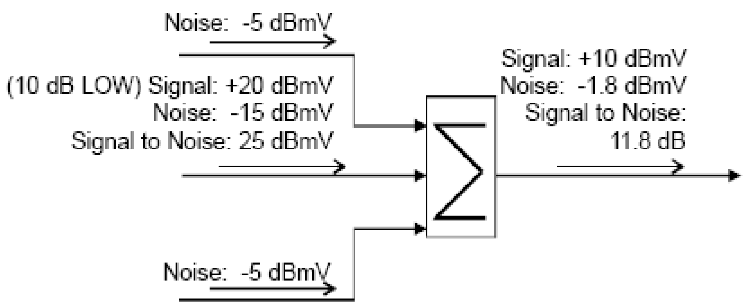


Figure 1 Balance Gain and Tilt

Balancing the Return Path

In the basic test architecture, test signals are injected upstream by the field piece. The SST measures these signals automatically at the headend. Then, the measurement data is transmitted back to the field piece for display.

In order to balance the return path of your system, you need to consider several alignment objectives. You need to set the fiber return path link to the system's design specifications. You must also set each line amplifier so that it will compensate for the gain and tilt of the cable and passives to the next amplifier.

The 860 DSPi and 9580 SSR have two types of displays, which will accommodate amplifier adjustment differences:

- Eight-carrier line graph for amplifiers that require screwdriver adjustments.
- Calculated gain and tilt values for amplifiers that use pads and equalizers.

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Measuring Ingress and Noise

In the basic test architecture, the 9581 SST R4 Headend Unit's spectrum analyzer measures the incoming ingress and noise. It then transmits this measurement data to the field pieces. The field pieces display the ingress data as a spectrum pattern.

> **REMINDER:** If your 9581 SST R4 is equipped with the Test Point Manager option, you can analyze sixteen return paths individually.

When you are analyzing the return path, you need to determine if the return frequencies carrying "traffic" have an adequate signal/ ingress ratio. To do this, you must first calculate the effective ingress power.

For narrow band ingress, such as CB or shortwave, measure the ingress power directly.

For broadband ingress, such as interference from machinery, treat the ingress as noise and correct for video or data bandwidth. In the formulas below, Measured Power (MP) equals the reading from the 9581 SST R4 and IP equals the effective Ingress Power.

- Compute the effective noise in a 4 MHz video bandwidth, take the reading from the 9581 SST R4 and add 10.3 dB. **IP = MP + 10.3 dB**
- Compute the effective noise for data bandwidth, take the reading from the 9581 SST R4 and add 10 times the log (data BW divided by .375MHz). **IP = MP + 10 x log (data BW/.375 MHz)**
- Maintain good picture quality, video signals require narrow band ingress to be between -40 to 60 dBc, depending on the offset from the video carrier and broadband ingress to be at least -40 dBc.

Quadrature Phase Shift Keying (QPSK) should have an effective ingress power of -20 dBc for either type of ingress for a Bit Error Rate (BER) of approximately 1 x 10E-6.

HOT TIP
When the SST is setup properly, it reserves about 15 dB of its amplitude measurement range to prevent the digitizer from being overloaded by powerful ingress transients. 10 dB of this "guard band" is visible as the top division on the SST's spectrum display with an additional 5 dB above that. Experience has indicated that 15 dB is much more margin than is needed in all but the "dirtiest" systems. Up to 10 dB of the "guard band" can be reassigned to extend the SST's measurement dynamic range. For more information, see the Extending the Measurement Range of the 9581 SST R4 Application Note.

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