Return Path Alignment

Node Return Laser set up.
Forward Path Unity Gain

452.9 meters
226.5 meters
288.3 meters

2 dB
8 dB
11 dB

+32 dBmV
+10 dBmV
+16 dBmV

IN
IN
IN

OUT
OUT
OUT

+10 dBmV
+13 dBmV
+32 dBmV

22 dB @ 750 MHz
14 dB @ 750 MHz
11 dB @ 750 MHz

(0 dB input atten.)
(3 dB input atten.)
(6 dB input atten.)
Reverse Path Unity Gain

IN +20 dBmV

452.9 meters
4 dB @ 30 MHz

OUT +24 dBmV
(11 dB output atten.)

226.5 meters

OUT +20 dBmV

288.3 meters
3 dB @ 30 MHz

IN +20 dBmV

+20 dBmV
(10 dB output atten.)

OUT +30 dBmV
(5 dB output atten.)

IN +20 dBmV
Values shown are at 750 MHz

Amplifier downstream output: +40 dBmV

Modem input:
- +3 dBmV
- +2 dBmV
- +1 dBmV
- -1 dBmV
- -3 dBmV
- -3 dBmV

Feeder cable: 0.500 PIII, 2.16 dB/100 ft
Drop cable: 6-series, 5.65 dB/100 ft
CATV Return Distribution Network Design

Values shown are at 30 MHz

Amplifier upstream input:
+49 dBmV

Modem TX:
+49 dBmV

Feeder cable: 0.500 PIII, 0.4 dB/100 ft
Drop cable: 6-series, 1.22 dB/100 ft
Setting up the Return Path

- Finding the “X” Level
- Determining the Return Transmitter “Window”
- Padding the Transmitter
- Return Receiver Setup
- Distribution out of the Return Receiver
- Padding the inputs to the Headend Equipment
Setting Upstream Signal Levels

X level

- The easiest way to set upstream signal levels is to establish what is called the X level.
  - This is a headend upstream signal level that is the result of providing the proper level at the input to the last reverse amplifier (the first amplifier or node out of the headend).

- To establish the X level, go to the first downstream amplifier or node location out of the headend.
  - Here you should inject a signal into that location’s reverse amplifier module input at a level known to be correct.
  - This will result in a signal at the headend that is measured and defined as the X level.

- Assuming your system was designed for unity gain operation, when you go to the next amplifier location and inject the proper amplitude test signal there, the resulting signal at the headend will be the same as the original X level.
Setting the Transmitter “Window”

- RF input levels into a return laser determine the CNR of the return path.
  - Higher input – better CNR
  - Lower input – worse CNR
- Too much level and the laser ‘clips’.
- Too little level and the noise performance is inadequate
- Must find a balance, or, “set the window” the return laser must operate in
  - Not only with one carrier but all the energy that is in the return path.
  - The return laser does not see only one or two carriers it ‘sees’ the all of the energy (carriers) that in on the return path that is sent to it.
Energy in the Return Path

- What does your return path look like?
- The return laser ‘sees’ all the energy in the return path.
  - The energy is the sum of all the power of all the carriers in the spectrum from about 1MHz to 42 MHz.
  - The more energy that is put into the laser the closer you are to clipping the laser.
  - A clean return path allows you to operate your system more effectively.
  - The type of return laser you use has an associated window of operation
  - We can show you the window of operation of each laser using a NPR (Noise Power Ratio) curve.
Ingress Changes over Time

Node x Instant
Looks Pretty Good

Node x Overnight
Oh No!
What is NPR?

- NPR = Noise Power Ratio
- Is means of easily characterizing an optical link’s linearity and noise contribution
- NPR and CNR are related, but not the same...

\[ NPR = 10 \log \left( \frac{P_S(Hz)}{P_N(Hz)} \right) \]
FP and DFB NPR Curves

- FP and DFB NPR curves at room temperature.
Signal Clipping

- RF ingress and impulse noise may cause signal clipping
  - Can affect Composite power into return laser
- Excessive signals from in-home devices such as pay-per-view converters also may cause signal clipping
- Clipping occurs in upstream amplifiers and fiber optics equipment
  - FP Upstream lasers most susceptible
- Energy that can cause clipping found mostly from 5 MHz to 15 MHz range
- Signals at all other frequencies are affected by cross-compression
  - Cross-compression affects all upstream frequencies
  - Can reduce data throughput (TCP/IP controlled resend)
Adding Carriers to the Return Path
Per Carrier Power vs. Composite Power

FSK Modulation

Power into Transmitter: 21 dBmV

FSK Modulation

Power into Transmitter: 24 dBmV
Per Carrier Power vs. Composite Power

FSK Modulation

Power into Transmitter: 24 dBmV

Power into Transmitter: 27 dBmV
As you add more carriers to the return path the composite power to the laser increases.

To maintain a specific amount of composite power into the transmitter the carrier power must be reduced.

When modulation schemes are changed the composite power into the transmitter changes.

- The higher the order of modulation the more energy the channel contains.

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Rel Power</th>
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<tbody>
<tr>
<td>FSK</td>
<td>-22.6</td>
</tr>
<tr>
<td>BPSK</td>
<td>-19.0</td>
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<tr>
<td>QPSK</td>
<td>-19.0</td>
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<tr>
<td>QAM-16</td>
<td>-12.1</td>
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<tr>
<td>QAM-32</td>
<td>-8.2</td>
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<tr>
<td>QAM-64</td>
<td>-6.0</td>
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<tr>
<td>Video</td>
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</tbody>
</table>
Changing Modulation Type

FSK Modulation

Power into Transmitter: 24 dBmV

QAM 16 Modulation

Power into Transmitter: 34 dBmV
Changing Modulation Type

QAM 16 Modulation
Power into Transmitter: 34 dBmV

QAM 64 Modulation
Power into Transmitter: 40 dBmV
Different Services require Different CNR

- HSD
  - 16 QAM
- STB (VOD)
  - QPSK
- Telemetry
  - FSK
- Business Services
  - QPSK to 16 QAM
- Modulation Type Required CNR
  - Required CNR for various modulation schemes to achieve 10E-8 BER
    - BPSK: 12dB
    - QPSK: 15dB
    - 16QAM: 22dB
    - 64QAM: 28 dB
    - NOTE: DOCSIS calls out 25dB min CNR

- Multiple services on the return path with different types of modulation schemes will require allocation of bandwidth and amplitudes.
  - Can be engineered.
  - Requires differential padding in Headend
Determining Power Levels

- **Power per Hz:**
  - $\text{Power per Hz} = \text{total power} - 10\log(\text{total bandwidth in Hz})$

- **Channel power from power per Hz**
  - $\text{Channel power} = \text{power per Hz} + 10\log(\text{channel bandwidth in Hz})$
Example: Calculate allocated channel power for a 2 MHz wide QPSK digitally modulated signal carried in the reverse path of the previous example.

- Channel power = power per Hz + 10\log(\text{channel bandwidth in Hz})
- Channel power = -30.44 + 10\log(2,000,000)
- Channel power = +32.57 dBmV
RF Level Changes at Transmitter

- As pad values are changed the input to the Headend devices change
  - 1:1 Ratio
  - Must change headend attenuation (setup) to maintain the 'X' level.
- Do not change pad value or increase RF level into the node once the Laser operational window has been set.
Return RX Setup

- On analog returns from the node the less optical power into a receiver the less RF you will have on the output.
- The RF levels on the output of the return receivers should be set with internal or external RF attenuation such that with the X level that is placed into the forward test point on the node X level will exist on the output of all receivers.
- Too much optical power can cause intermodulation in the receiver
  - Typical maximum input -3 dBm
  - Use optical attenuators on extremely short paths or where too much optical power exists into a receiver
- Too little optical power can cause CNR problems with that return path.
  - If combined with other return receiver outputs can create noise issues on more paths
Return RX Setup

- Rule of Thumb (company specific):
  - Do not optically attenuate the return path so all the optical inputs are the same as the lowest.
  - The lower the optical input power the lower the CNR of the receiver.
  - Attenuate RF internally or externally of the device

- Must have enough level so that the CMTS or other devices receiving the signals from the return path operate acceptably.
  - There can be excessive passive loss from the output of the optical receiver to the terminating device.
    - 8-way splitter/combiner – 10.2 dB typical
    - 4-way splitter/combiner – 6.8 dB typical
  - Typical input into terminating device.
    - CMTS – 0 dBmV
ANY CHANGES TO THE RETURN PATH FROM THE SUBSCRIBER TO THE HEADEND CAN AFFECT IT’S PERFORMANCE

- Planned
  - Segmentation of Return
    - Changes in HE or Node
- Un-Planned
  - Bad tap
  - Optronics Failure
  - Ingress
  - Technician – Laser RF input level changes in the field
Questions