
# Return Path Optimization

**Frank Eichenlaub**

**Systems Engineer**

# Return Path Familiarization and Node Return Laser Setup

## CATV Network Overview

## Coaxial Network (RF Distribution)

- Unity Gain
- Reverse Sweep
- Input Levels to Actives

## Fiber Network (Laser/Node/Receiver)

- Return Laser Setup
- NPR

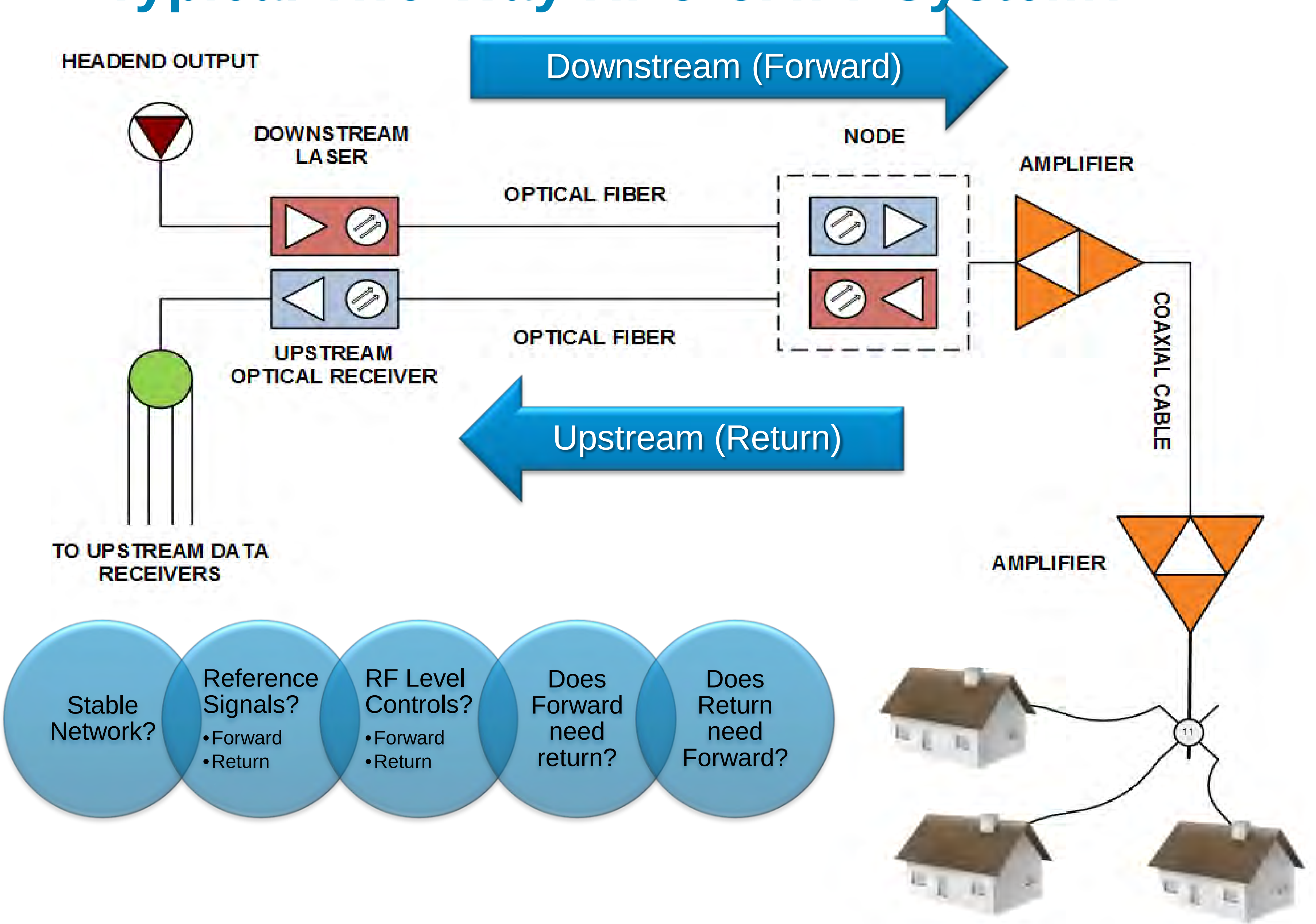
## Headend Distribution Network

- Optimal Return Receiver Setup
- Input into CMTS port

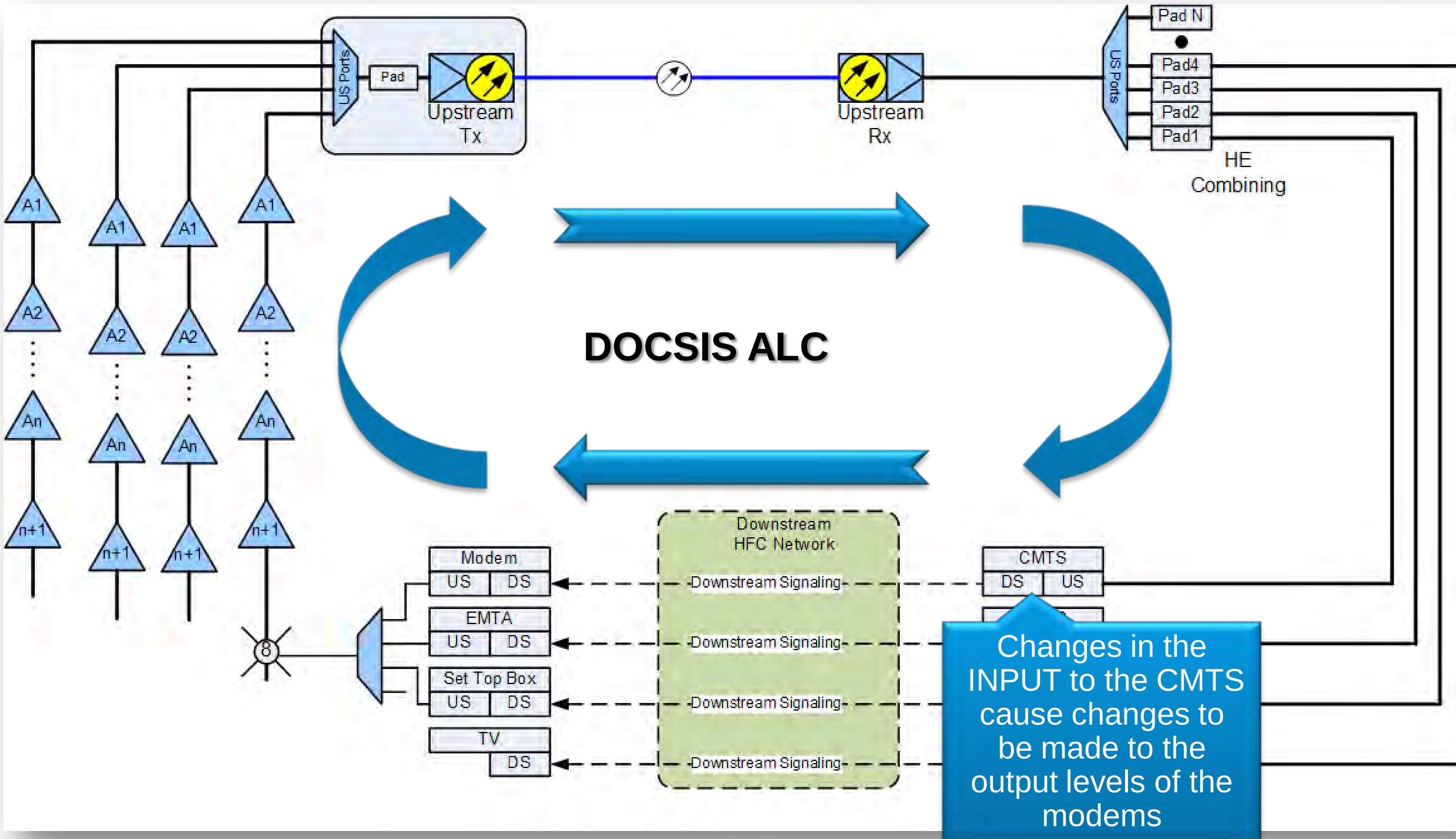
## The X Level

## Network Troubleshooting

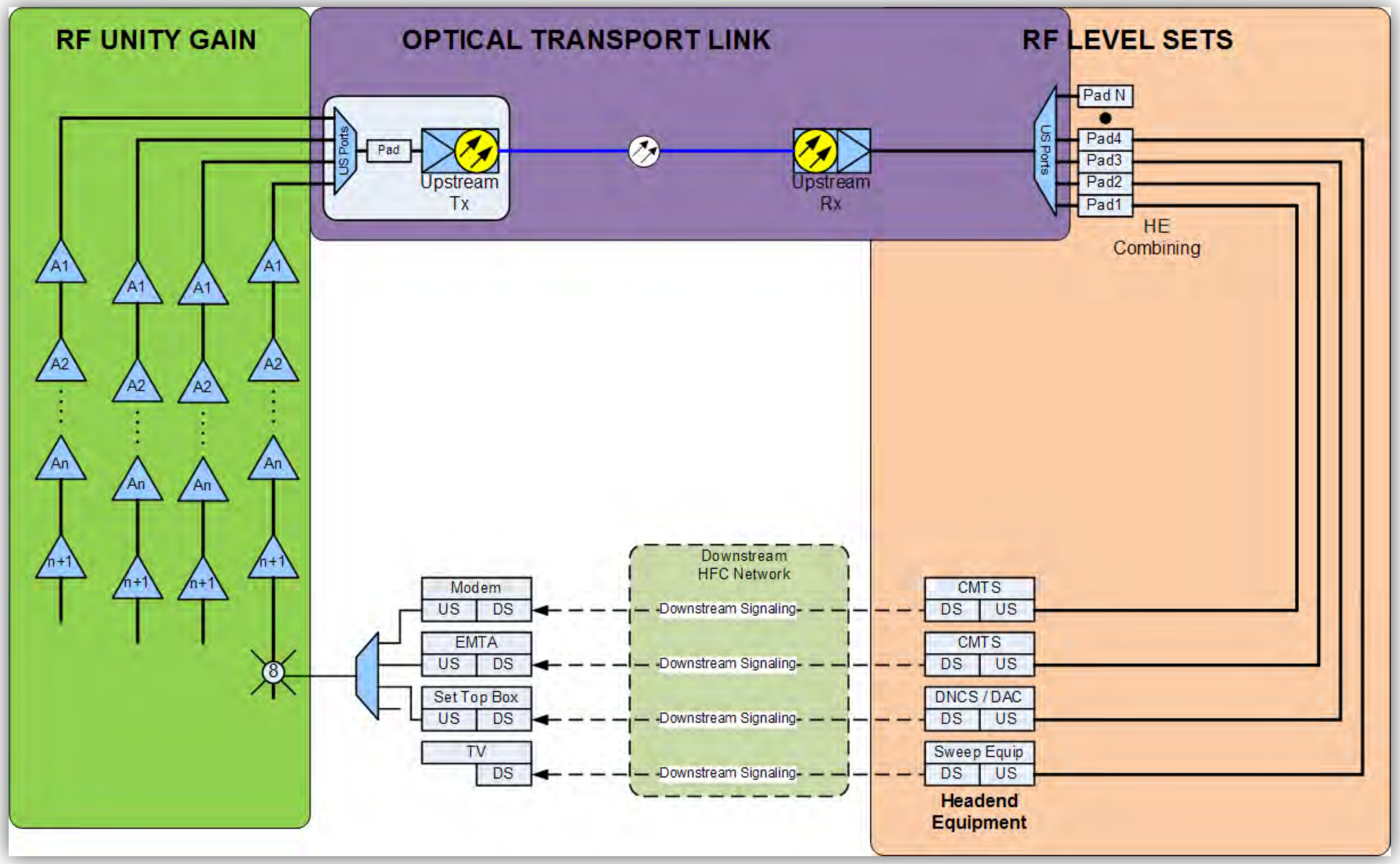
# Typical Two-Way HFC CATV System?



# With DOCSIS deployed in our Networks the system looks and functions more like a loop!



# Divide and Conquer the Return Path!



# RF Network

## Forward Path

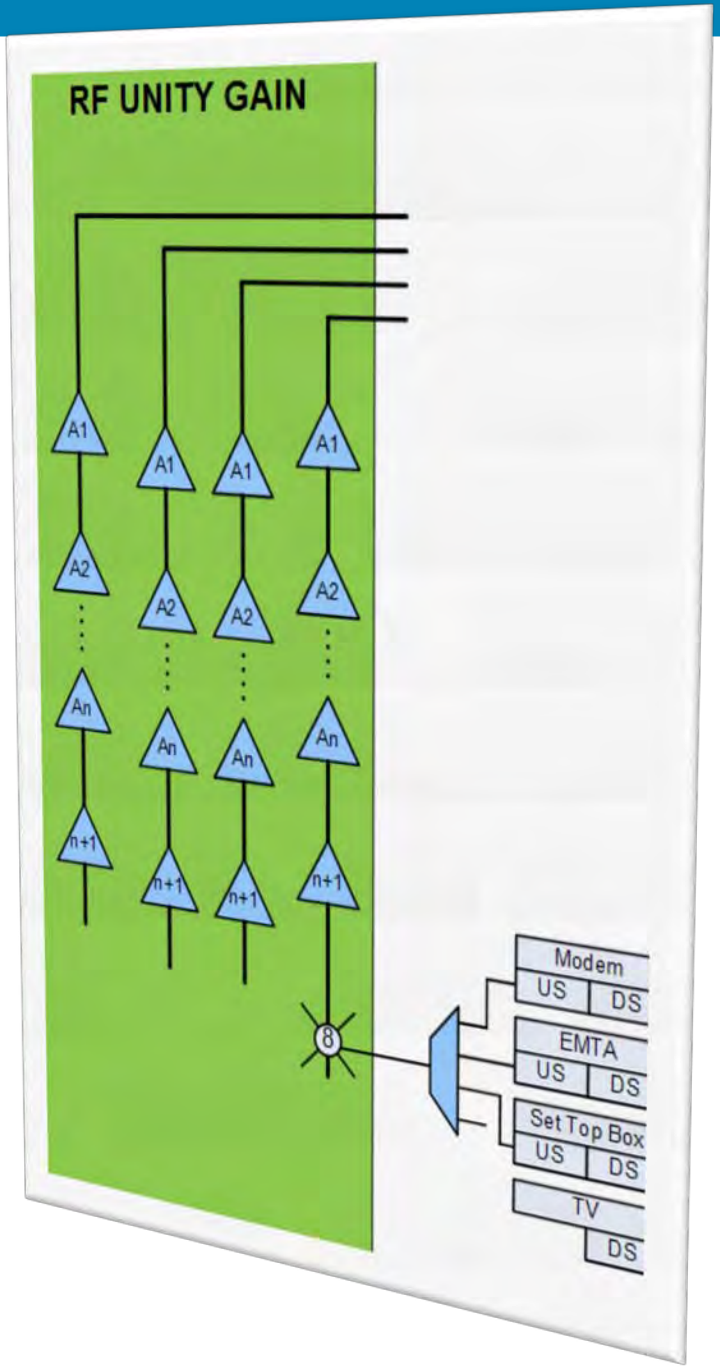
- Output of Node RX to TV, STB, or Modem

## Return Path

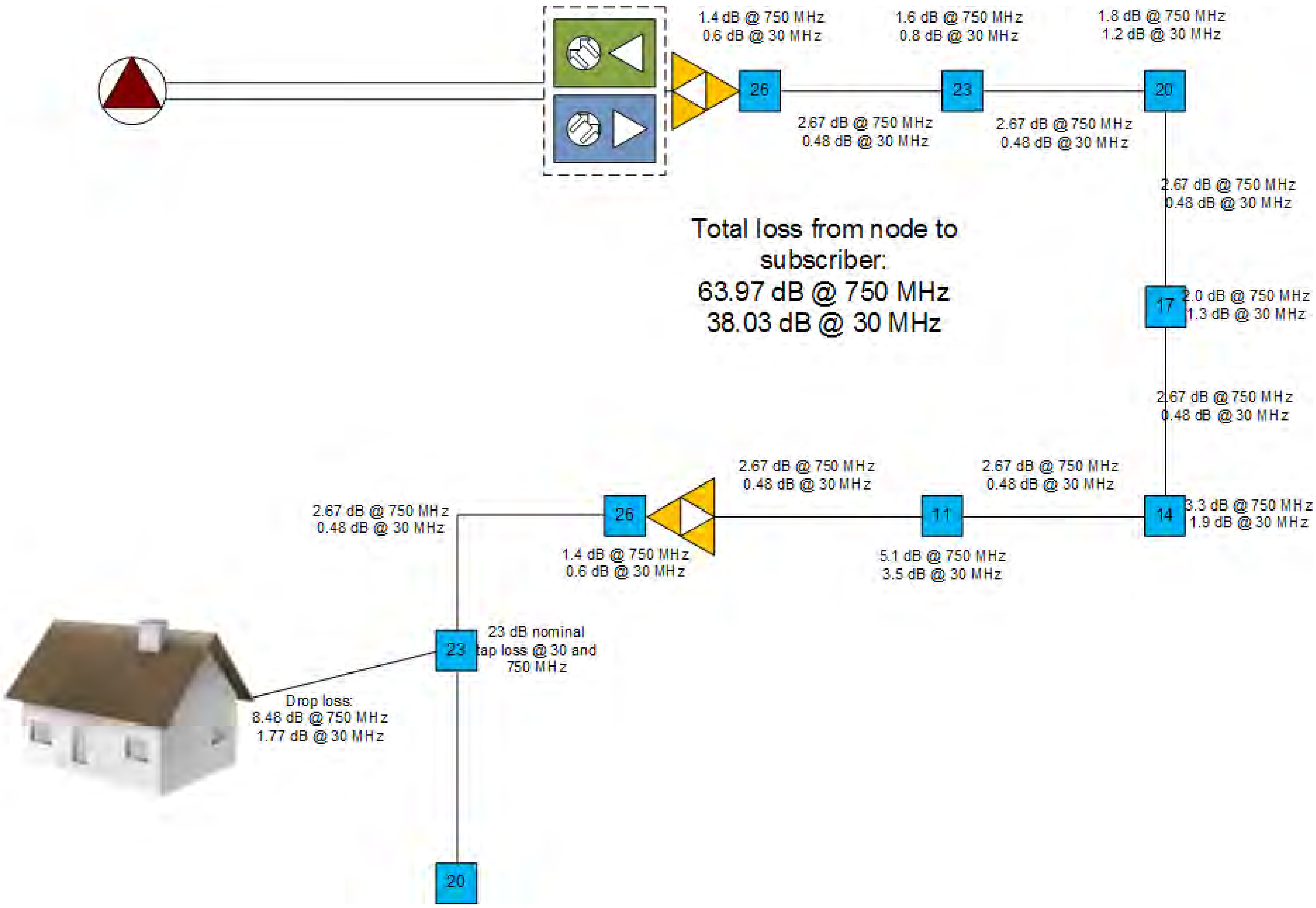
- Output of Set Top or Modem to Input of Node

## Unity Gain

- Forward Path
- Return Path

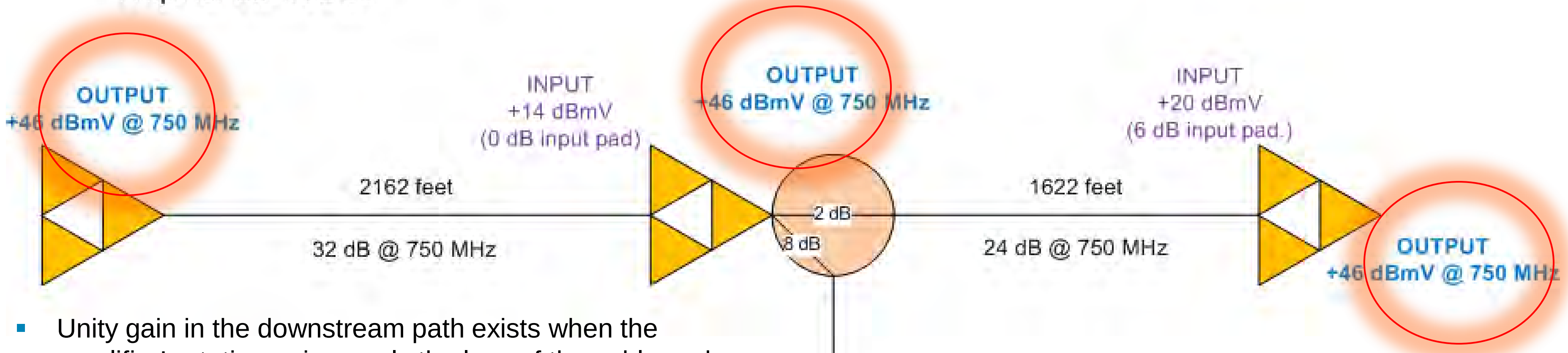


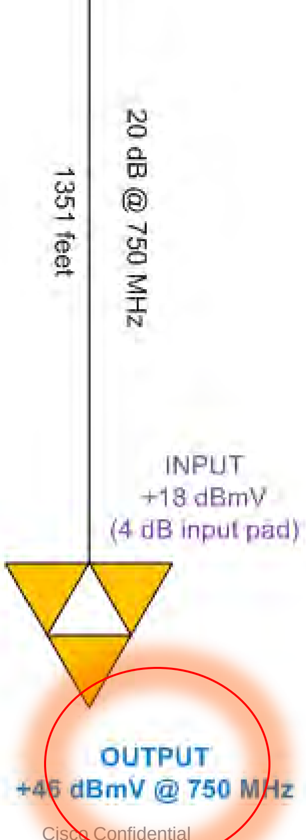
# Coaxial Cable Attenuation



# Forward Path Unity Gain

Assumptions:
Cable: 750 PIII 1.48 dB/100 ft.
Amplifier Gain: 32 dB




- Unity gain in the downstream path exists when the amplifier's station gain equals the loss of the cable and passives before it.
- In this example, the gain of each downstream amplifier is 32 dB. The 750 MHz losses preceding each amplifier should be 32 dB as well.

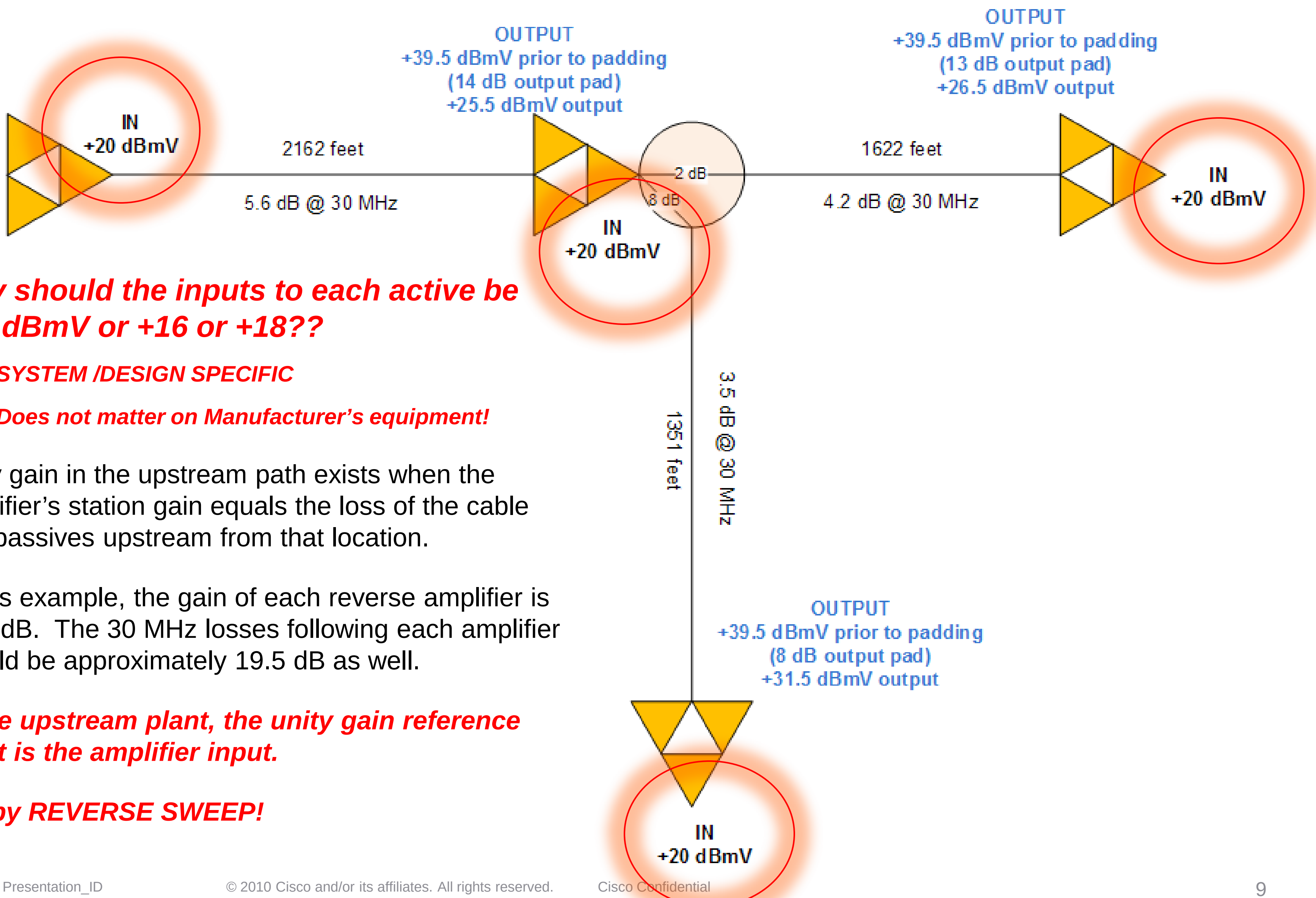
  For example, the 22 dB loss between the first and second amplifier is all due to the cable itself, so the second amplifier has a 0 dB input attenuator. Given the +14 dBmV input and +46 dBmV output, you can see the amplifier's 32 dB station gain equals the loss of the cable preceding it.

- The third amplifier (far right) is fed by a span that has 24 dB of loss in the cable and another 2 dB of passive loss in the directional coupler, for a total loss of 26 dB. In order for the total loss to equal the amplifier's 32 dB of gain, it is necessary to install a 6 dB input attenuator at the third amplifier.
- ***In the downstream plant, the unity gain reference point is the amplifier output.***

Assumptions:
Cable: 750 PIII 0.26 dB/100 ft.
Amplifier Gain: 19.5 dB

# Reverse Path Unity Gain




- ***Why should the inputs to each active be +20 dBmV or +16 or +18??***

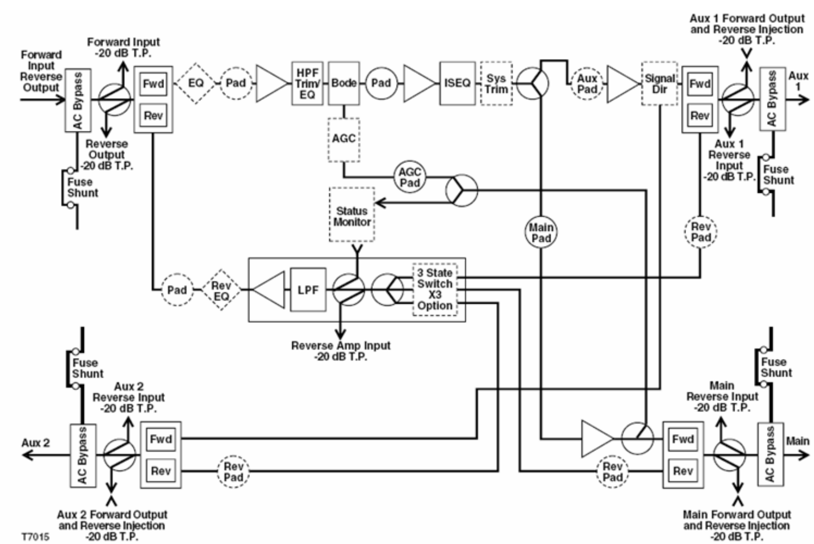
  ***SYSTEM /DESIGN SPECIFIC***

  ***Does not matter on Manufacturer's equipment!***

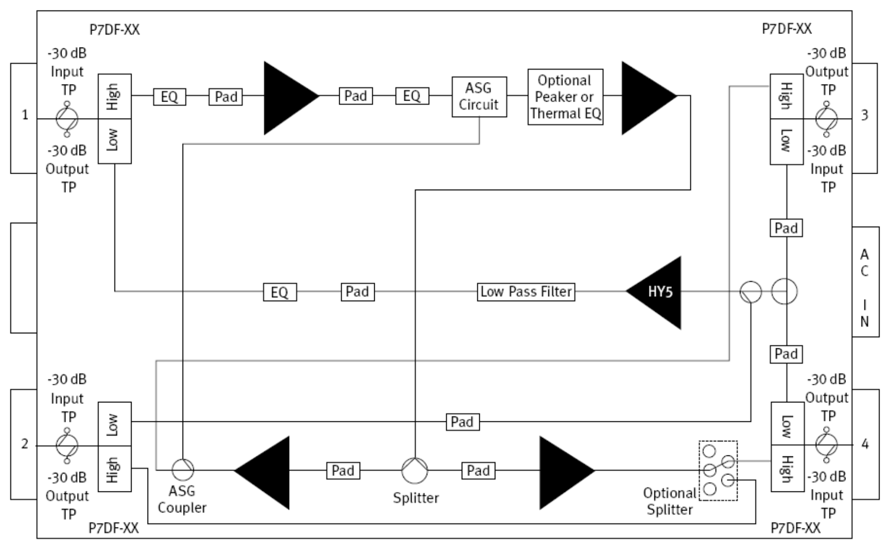
- Unity gain in the upstream path exists when the amplifier's station gain equals the loss of the cable and passives upstream from that location.
- In this example, the gain of each reverse amplifier is 19.5 dB. The 30 MHz losses following each amplifier should be approximately 19.5 dB as well.
- ***In the upstream plant, the unity gain reference point is the amplifier input.***
- ***Set by REVERSE SWEEP!***

# Telemetry Injection

- Injections levels may vary due to test point insertion loss differences from various types of equipment.
- The **PORT** Design level is the important Level to remember!
- ***The Port Design level determines the Modem TX Level***

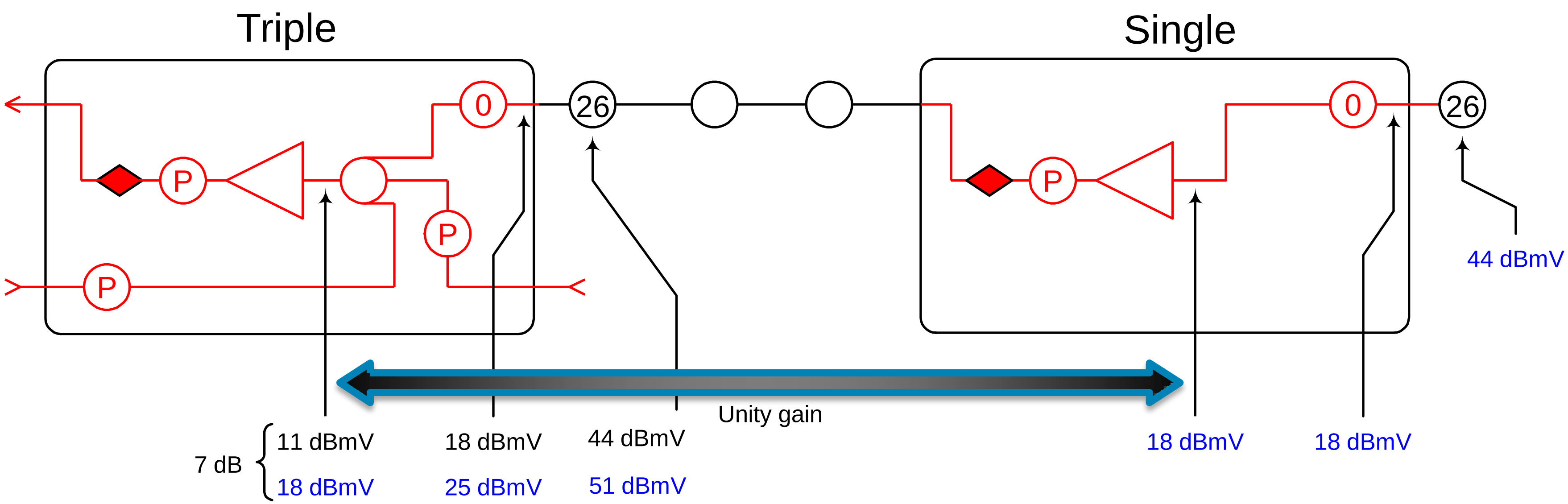



-20 dB Forward Test Point



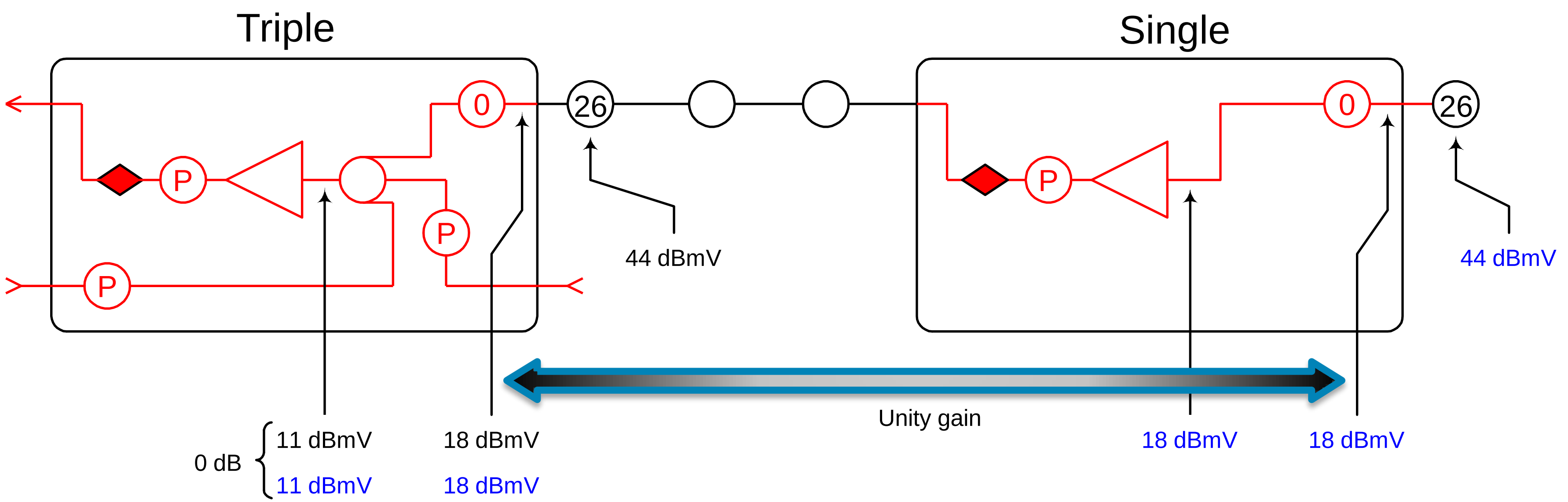

-30 dB Forward Test Point

# Reverse alignment the wrong way




**Terminal transmit levels do not set correctly!**

# Reverse alignment the right way

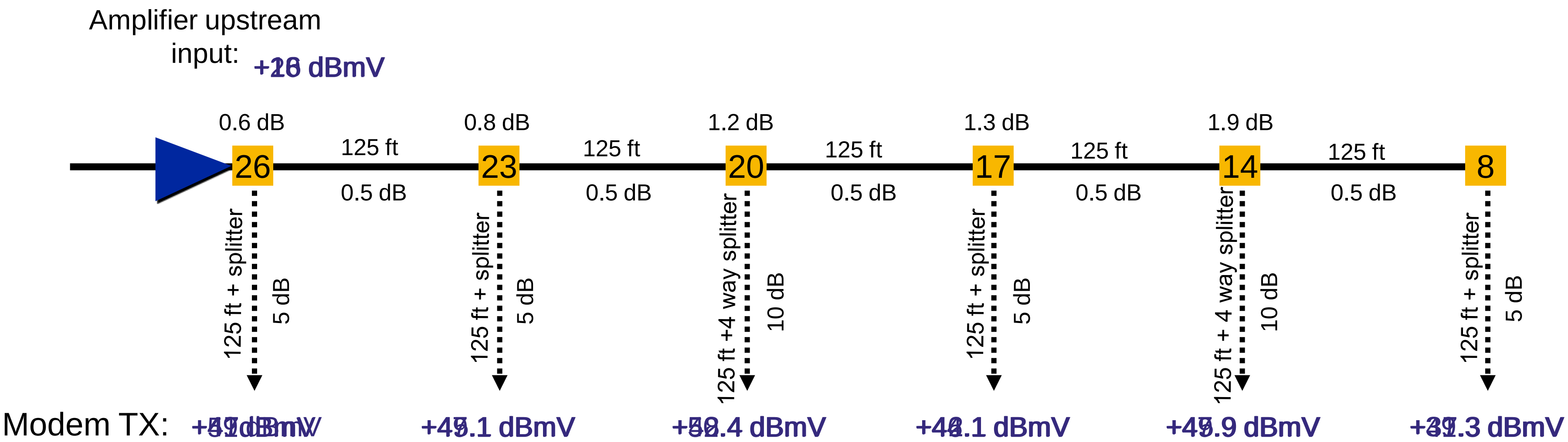



Reverse levels should be specified at the amplifier port

# CATV Return Distribution Network Design Modem TX Levels

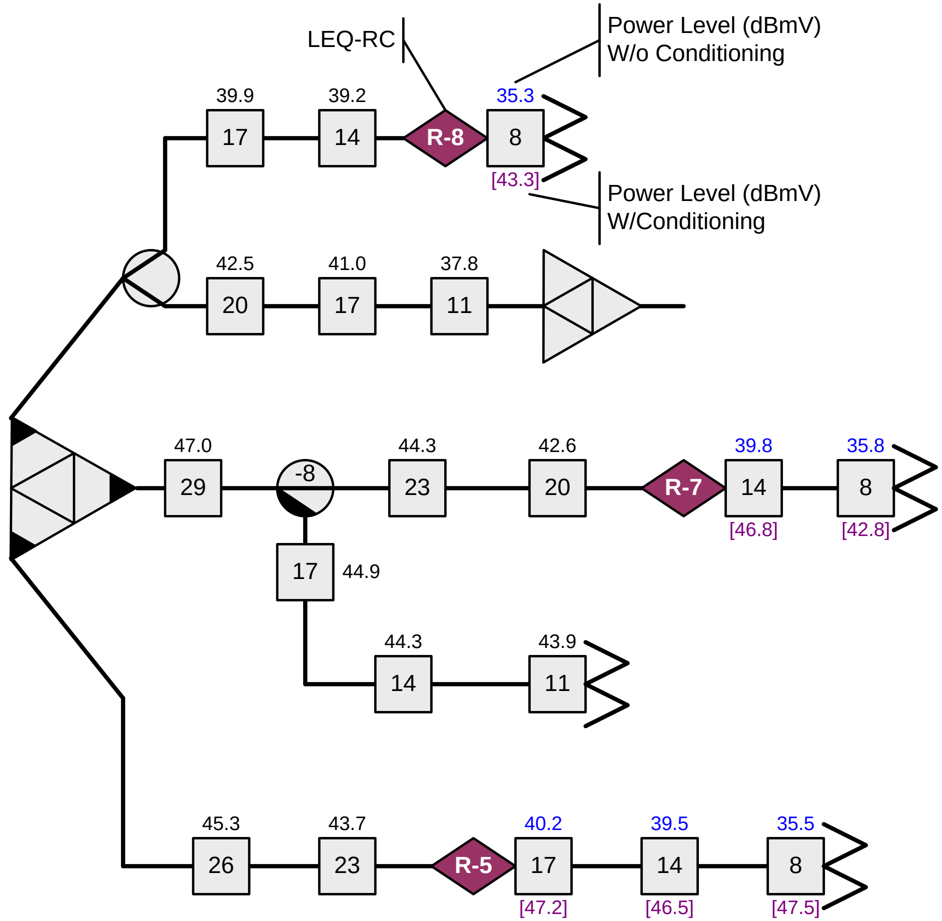
Values shown are at 30 MHz

Feeder cable: 0.500 PIII, 0.4 dB/100 ft
Drop cable: 6-series, 1.22 dB/100 ft

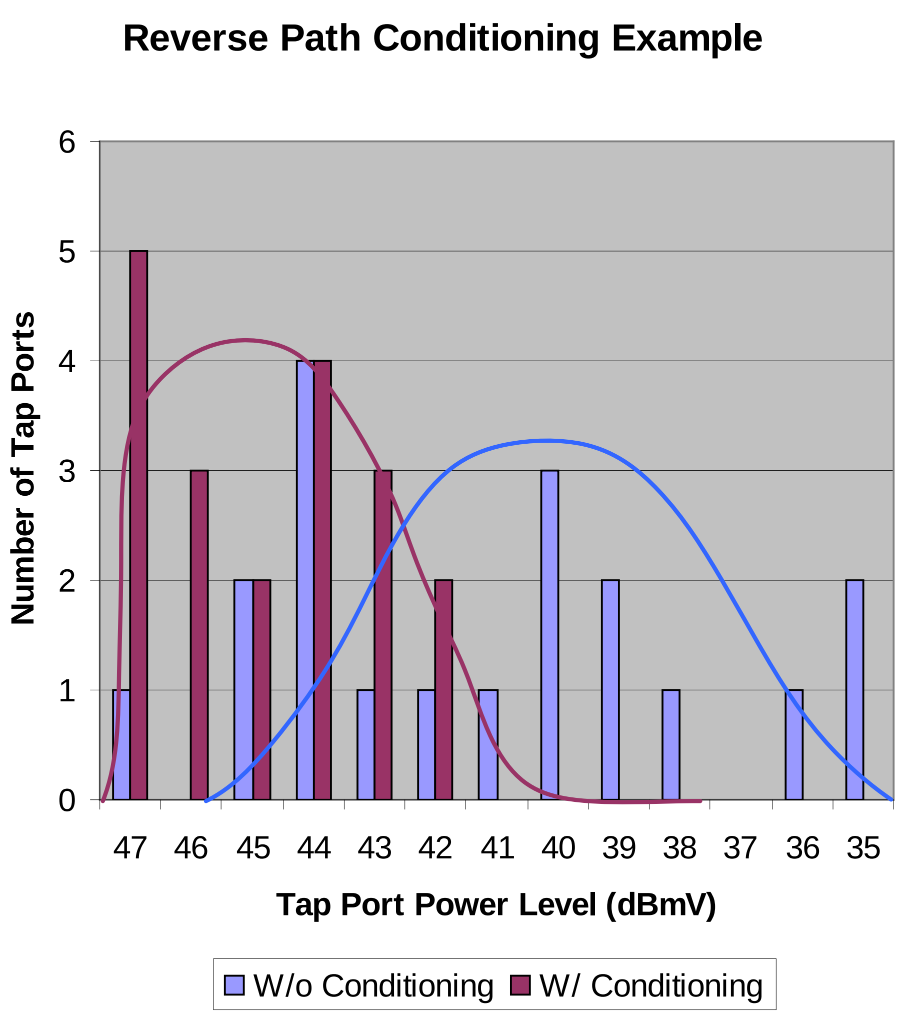



- The **telemetry amplitude** is used to establish the modem transmit level.
- The modem transmit levels should be engineered in the RF design.
- There is no CORRECT answer. IT is SYSTEM SPECIFIC.
- Unity gain must be setup from the last amplifier's return input to the input of the node port. The same level what ever is chosen or designed into the system!

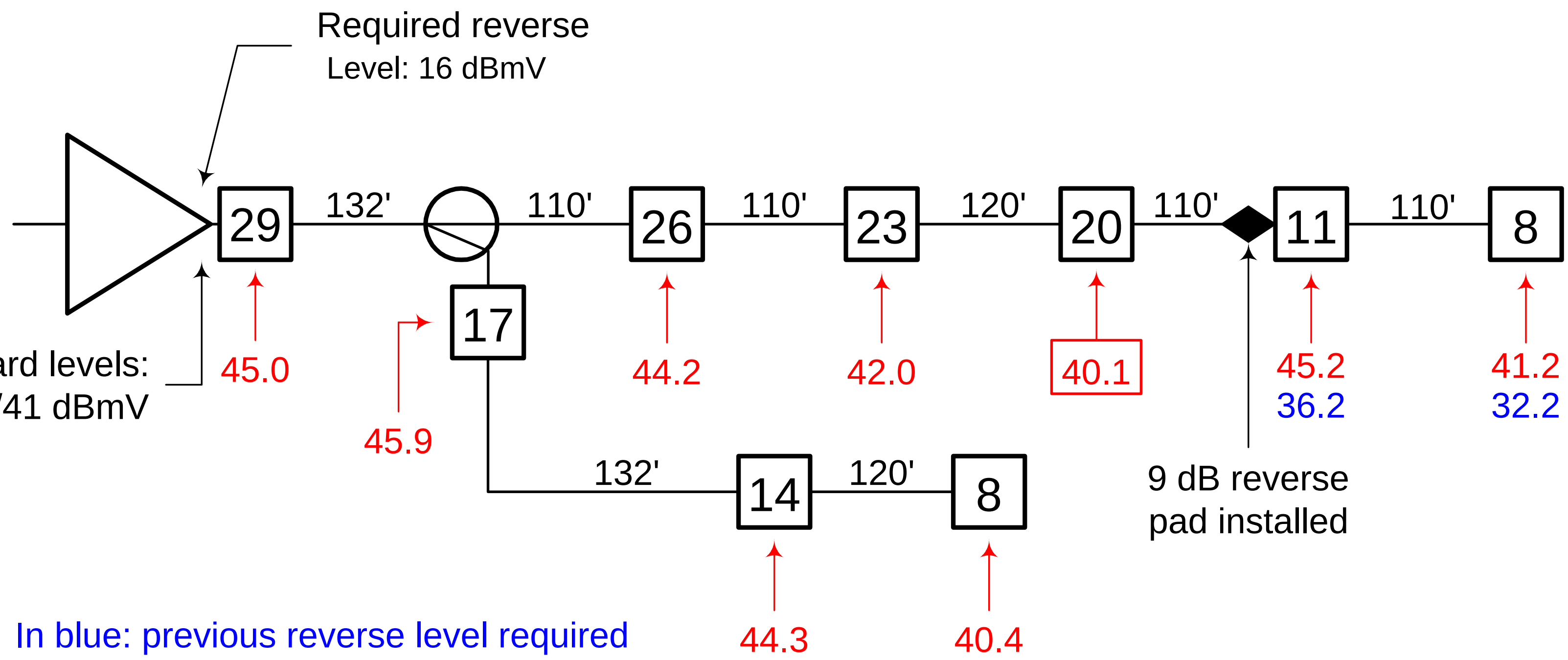
# Reverse Path Conditioning
## Design Example Using LEQ-RC's




Reverse Conditioning Example



# Practical effects of reverse conditioning:

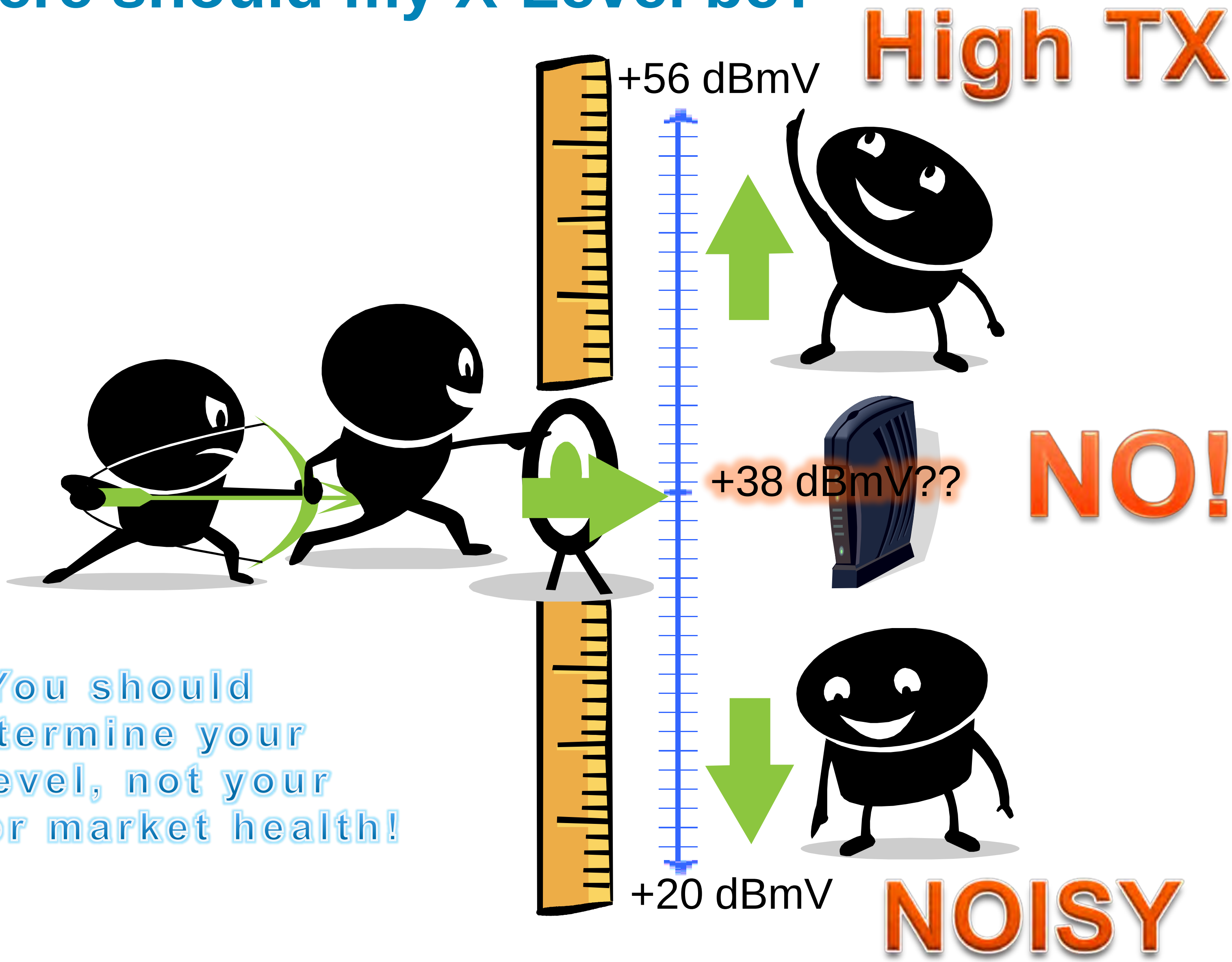



Reverse ‘window’ narrowed from 13.7 to 4.6 dB

# Reverse Window Tap Specs

| | | 2-Way | | | 4-Way | | | 8-Way | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Tap Value** | 26 dB | 29 dB | 32 dB | 26 dB | 29 dB | 32 dB | 26 dB | 29 dB | 32 dB |
| **Tap Loss** (± 1 dB) | Frequency | | | | | | | | | |
| | 5 | 22.0 | 22.0 | 22.0 | 22.4 | 22.5 | 22.5 | 22.1 | 22.1 | 22.2 |
| | 10 | 22.7 | 22.7 | 22.7 | 23.2 | 23.2 | 23.2 | 22.7 | 22.7 | 22.8 |
| | 40 | 23.2 | 23.2 | 23.6 | 23.7 | 23.8 | 24.1 | 23.0 | 23.2 | 23.4 |
| | 50 | 23.3 | 23.5 | 23.8 | 23.7 | 24.0 | 24.3 | 23.1 | 23.3 | 23.8 |
| | 100 | 23.7 | 24.1 | 24.5 | 24.2 | 24.7 | 25.1 | 23.4 | 23.9 | 24.9 |
| | 300 | 24.0 | 25.1 | 26.1 | 24.9 | 26.1 | 26.7 | 24.2 | 25.4 | 27.0 |
| | 450 | 24.1 | 25.5 | 27.1 | 25.4 | 27.0 | 28.0 | 24.9 | 26.5 | 28.5 |
| | 550 | 24.2 | 26.0 | 27.9 | 25.8 | 27.7 | 29.0 | 25.1 | 27.1 | 29.4 |
| | 750 | 24.9 | 27.4 | 29.9 | 26.3 | 28.8 | 30.5 | 25.1 | 27.8 | 30.2 |
| | 870 | 25.7 | 28.7 | 31.2 | 26.4 | 29.1 | 30.9 | 25.2 | 28.1 | 30.8 |
| | 1000 | 26.6 | 30.2 | 32.1 | 26.2 | 28.8 | 31.0 | 26.0 | 29.1 | 31.9 |

# Where should my X-Level be?

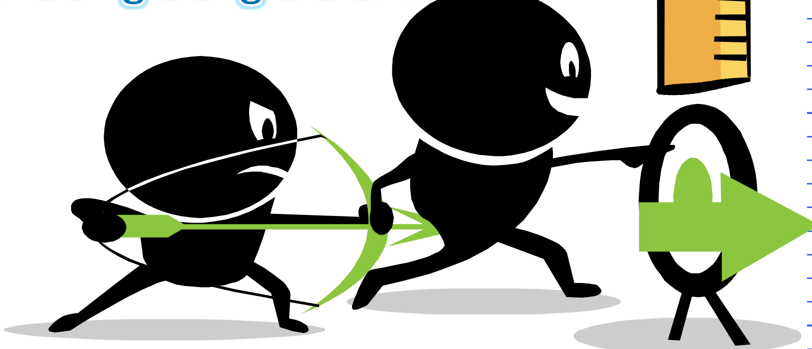



You should Determine your X-Level, not your plant or market health!

# Must tighten our TX window!

Running with the proper system designed X-Level requires plant maintenance.

Need good quality noise sources to get good MER!

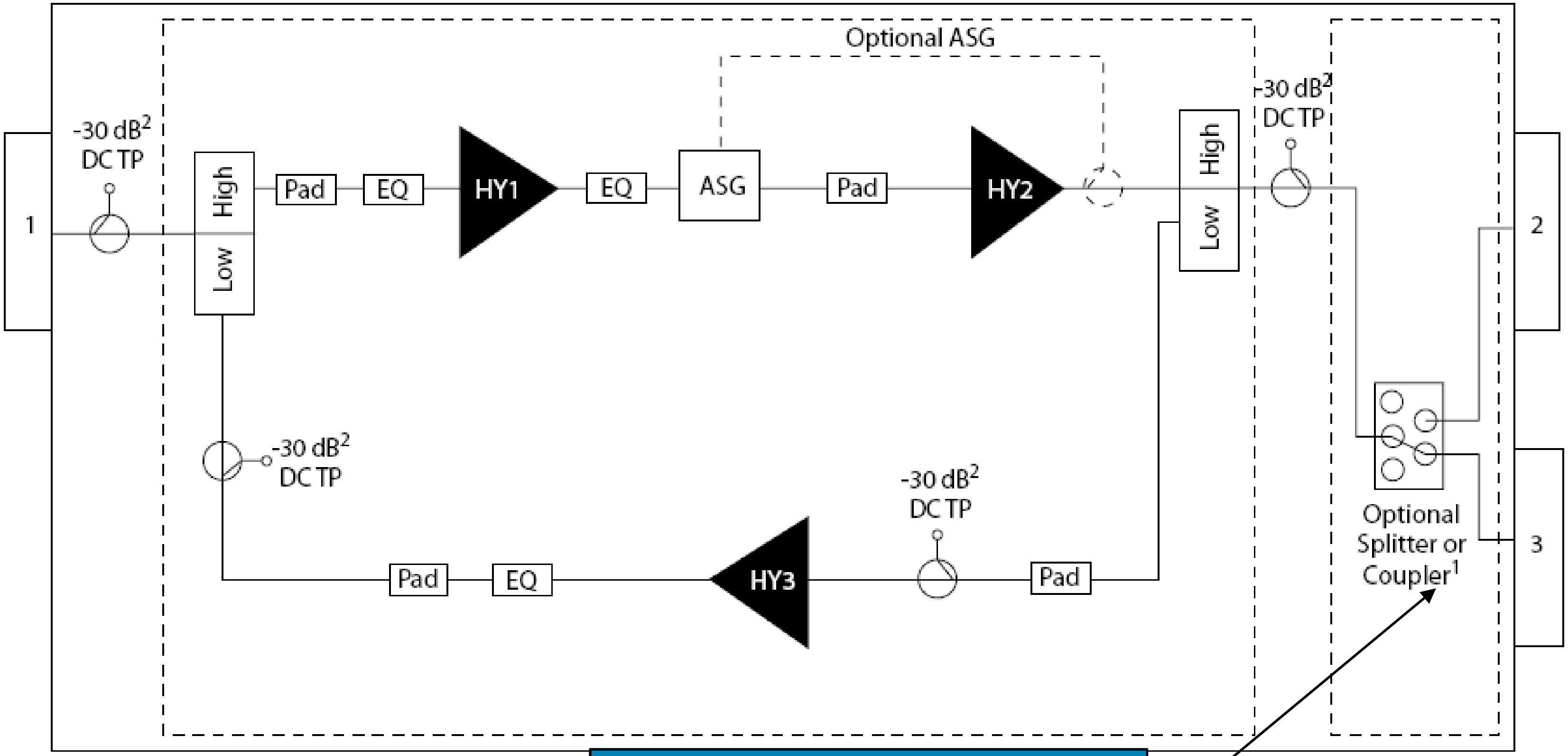



**MER 2 – 3 dB<CNR**

# Reverse Sweep

| | | |
|---|---|---|
| Must use consistent port design levels for the return path. | Sets Modem TX Levels | Establishes the X Level for the network! |
| Telemetry levels may vary due to insertion losses of test points | May vary from LE to MB to Node! – PORT LEVEL IS THE KEY! | Think about the input to the Diplex Filter |
| Must use a good reference | How often should a reference be taken? | Does Temperature effect your reference? |
| Amplifier Return Pad Selection | Normally 0 dB pad (Unless) there is a optional plug in splitter or Directional Coupler | Return port pad should match insertion loss of optional plug in device if prior to diplex filter |

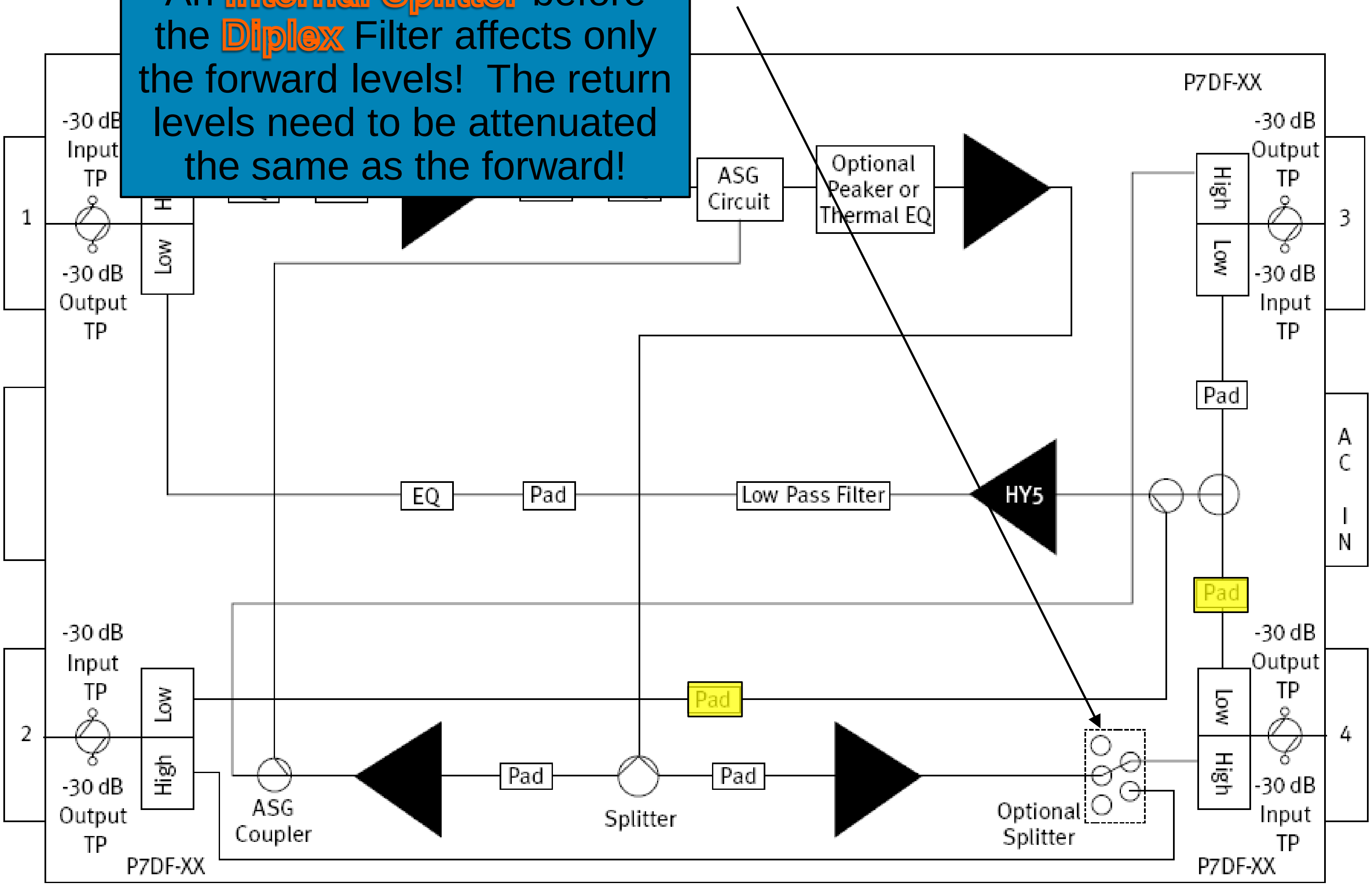
# Internal Splitters




An Internal Splitter after the Diplex Filter affect the forward and return levels!

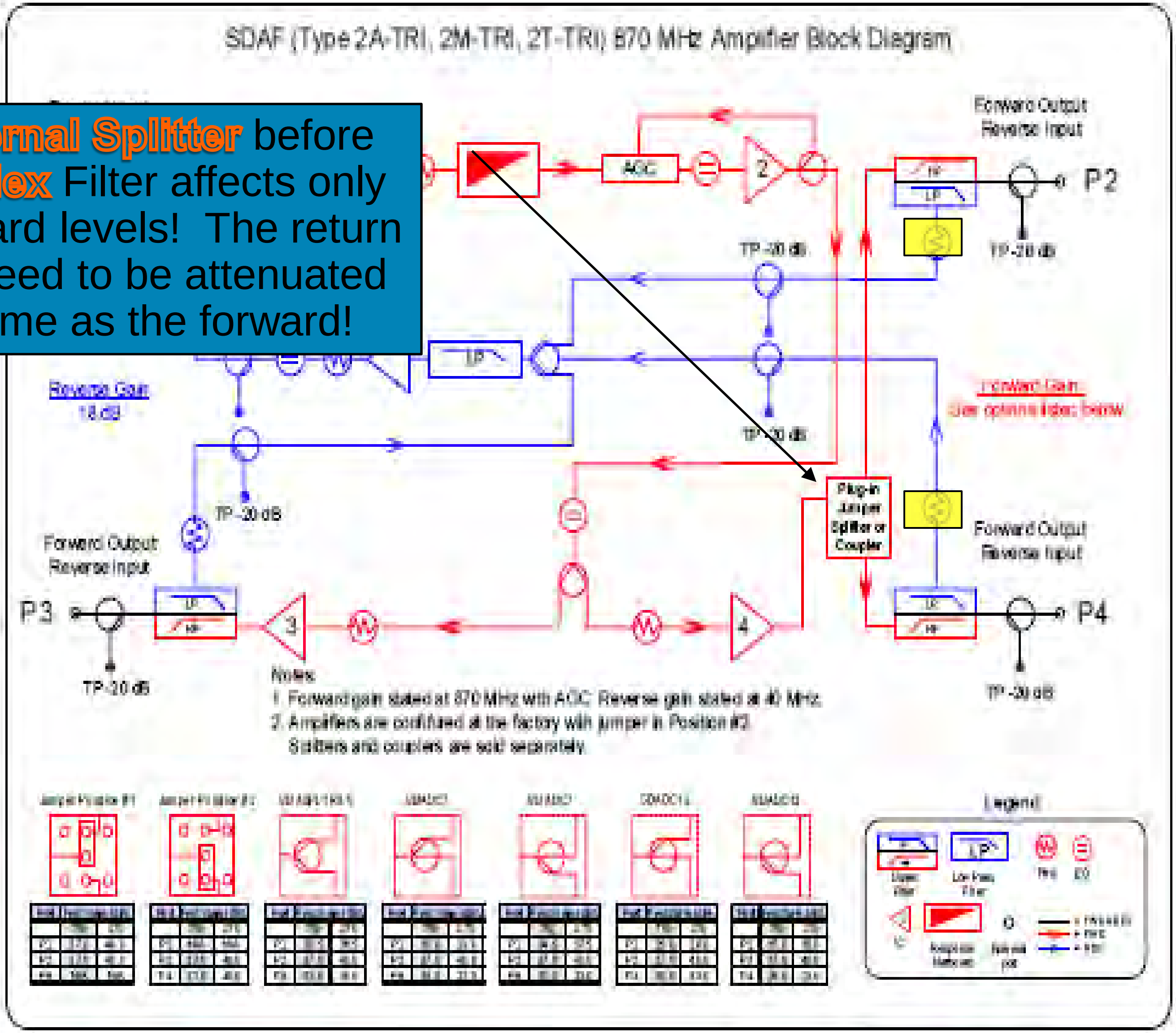
# Internal Splitter Prior to Diplex Filter

An **Internal Splitter** before the **Diplex** Filter affects only the forward levels! The return levels need to be attenuated the same as the forward!

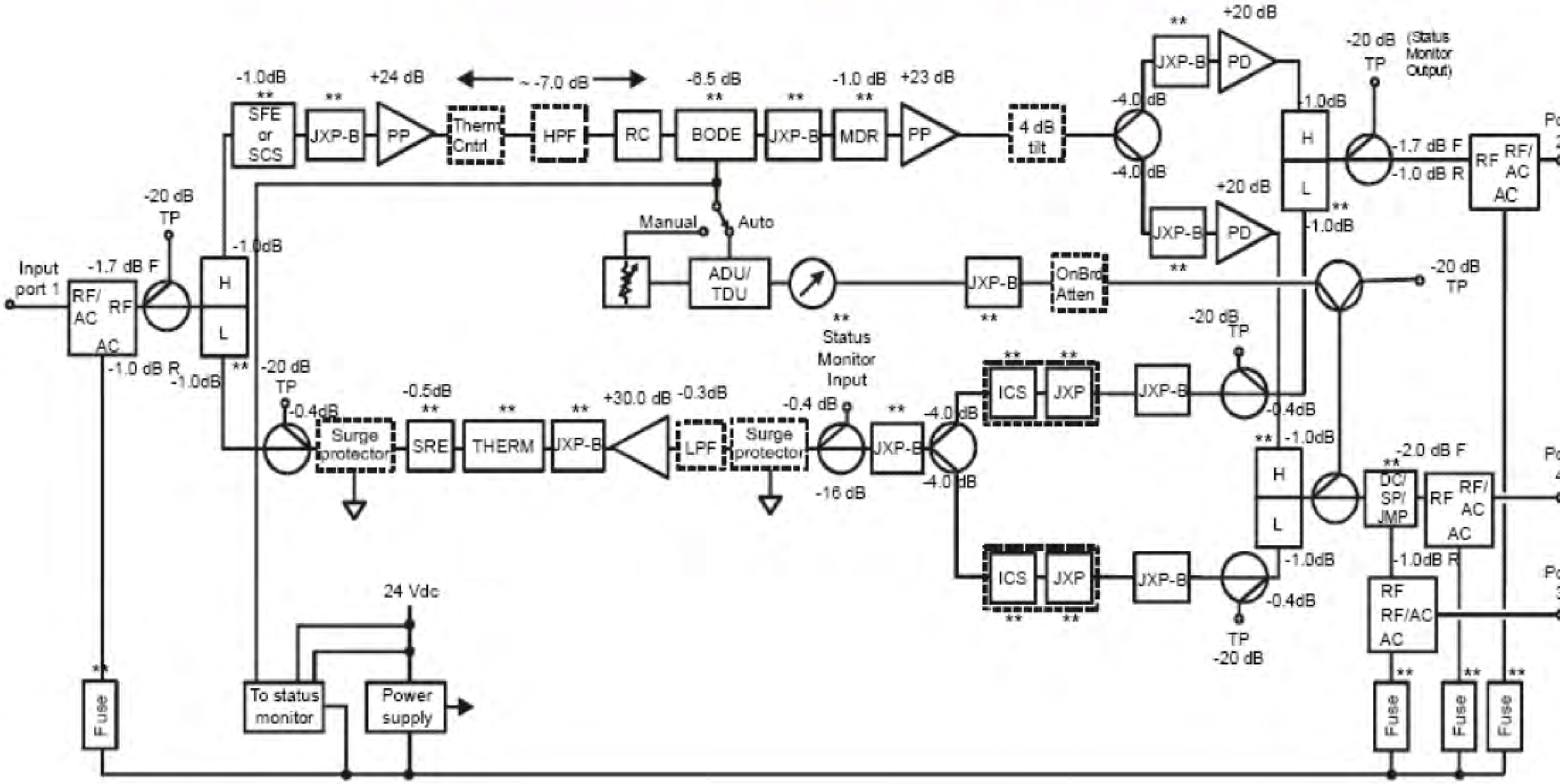


# Internal Splitter Prior to Diplex Filter

An **Internal Splitter** before the **Diplex** Filter affects only the forward levels! The return levels need to be attenuated the same as the forward!



# MB100 Block Diagram

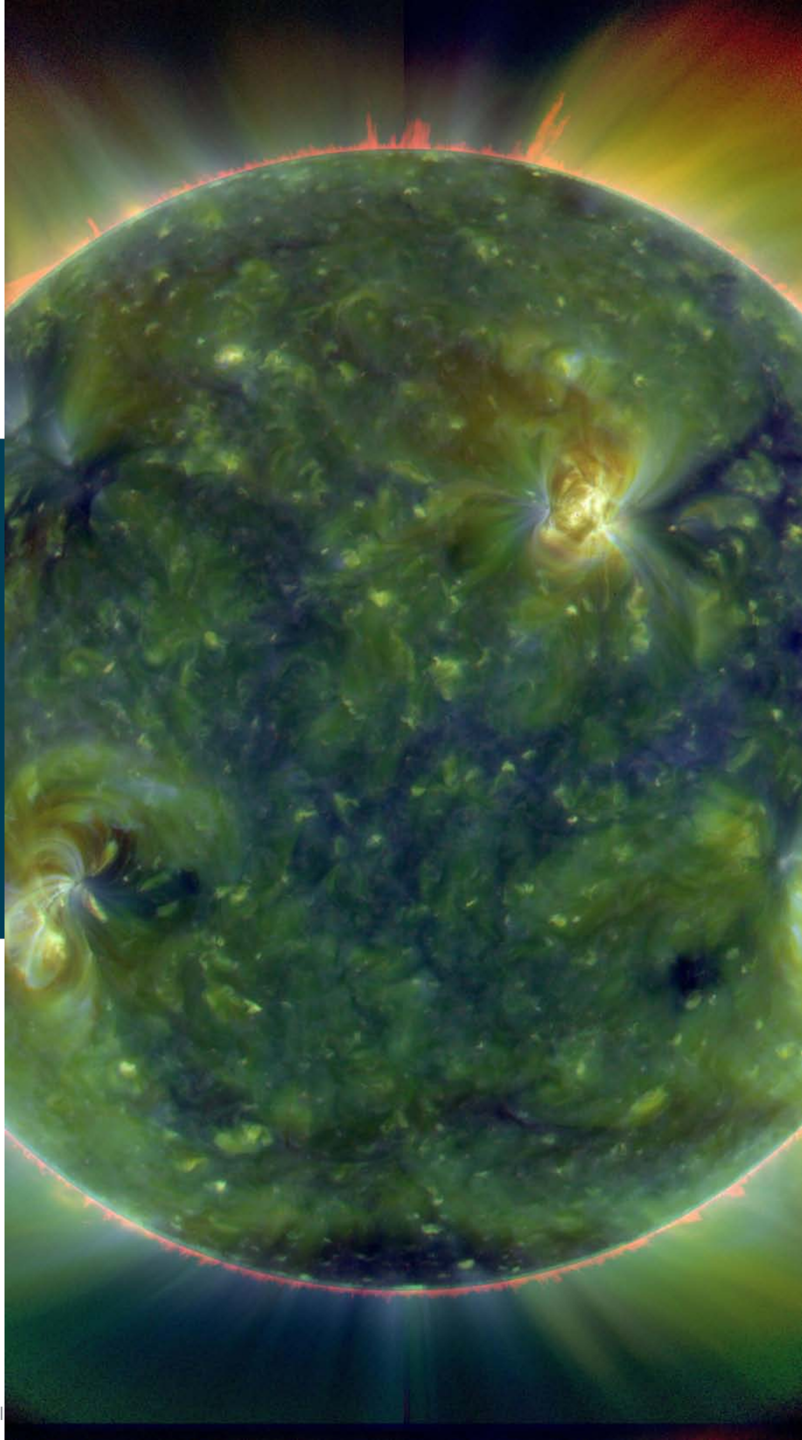


# SO FAR SO GOOD?

# ANY QUESTIONS?

# Return Path Optical Transport



# Return Path Optical Transport

Begins at the INPUT to the Node

Ends at the OUTPUT of the return receiver

Can have the greatest effect on the SNR (MER) of the return path

Most misunderstood and incorrectly setup portion of the return path

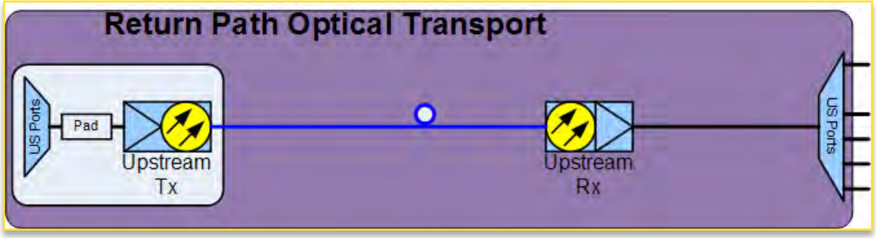
Must be OPTIMIZED for the current or future channel load.

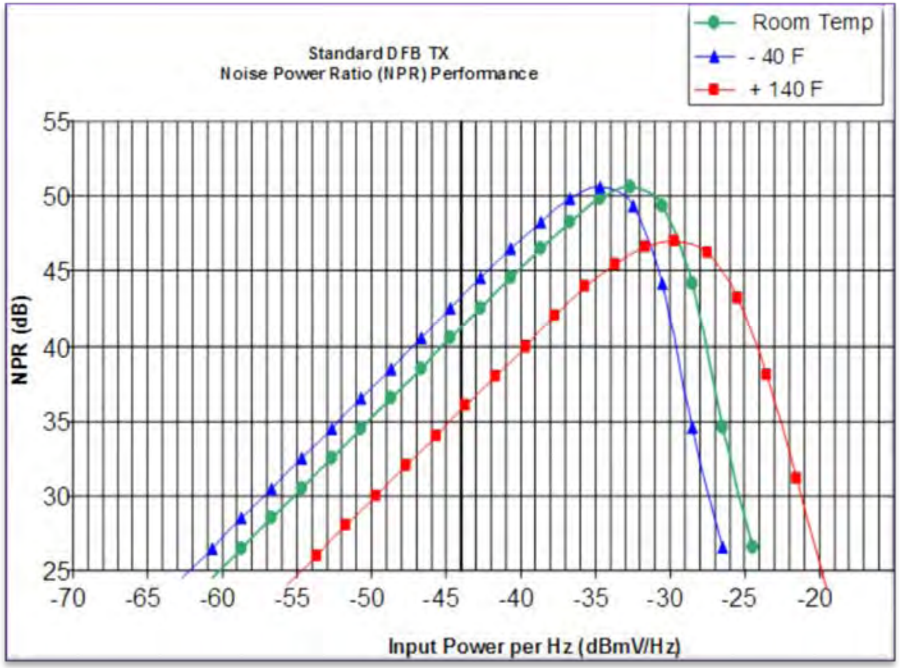
Is not part of the unity gain of the return path

Must be treated separately and specifically.

Setup Return Laser/Node Specific

Requires cooperation between Field and Headend Personnel



# 3 Steps to Setting up the Return Path Optical Transport

**Have Vendor Determine the Return Path Transmitter “Setup Window” for each node or return laser type in your system**

- Must use same setup for all common nodes/transmitters

**Set the input level to the Return Transmitter**

- Set levels using telemetry and recommended attenuation to the transmitter
- Understand NPR

**Return Receiver Setup – It is an INTEGRAL part of the link!**

- Using the injected telemetry signal ensure the return receiver is “optimized”

# Setting the Transmitter “Window”

In general, RF input levels into a return laser determine the CNR of the return path.

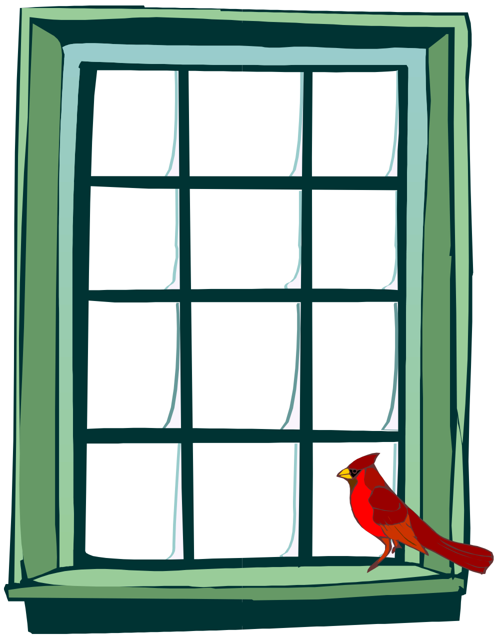
- Higher input – better CNR
- Lower input – worse CNR

Too much level and the laser ‘clips’.

Too little level and the noise performance is inadequate

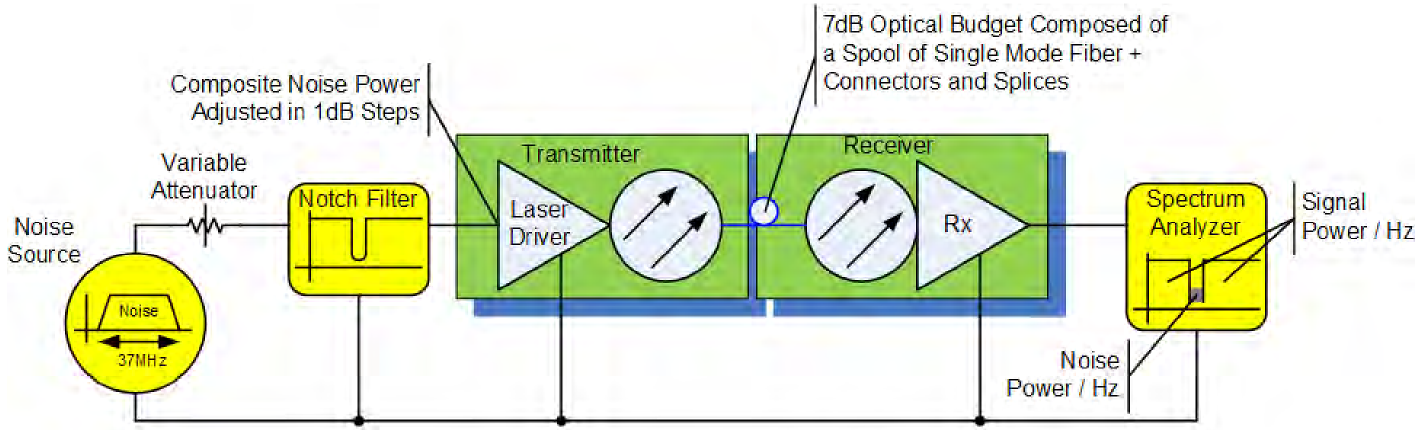
Must find a balance, or, “set the window” the return laser must operate in

- Not only with one carrier but all the energy that in in the return path.
- The return laser does not see only one or two carriers it ‘sees’ the all of the energy (carriers, noise, ingress, etc.) that in on the return path that is sent to it.



# What is NPR?

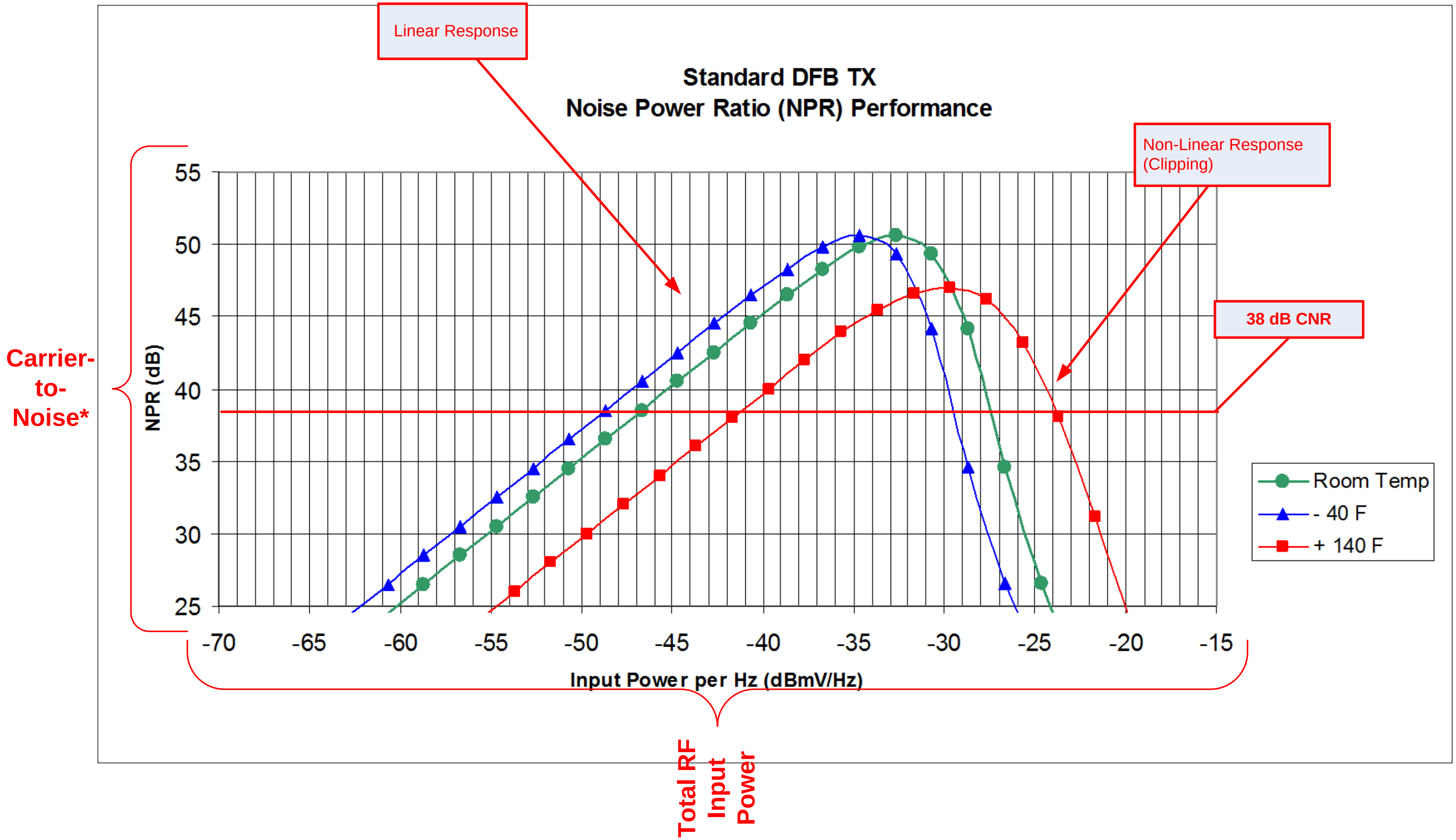
- NPR = Noise Power Ratio
- NPR is a means of easily characterizing an optical link's linearity and noise contribution
- NPR and CNR are related, but not the same…but close
- NPR is measured by a test setup as demonstrated below.



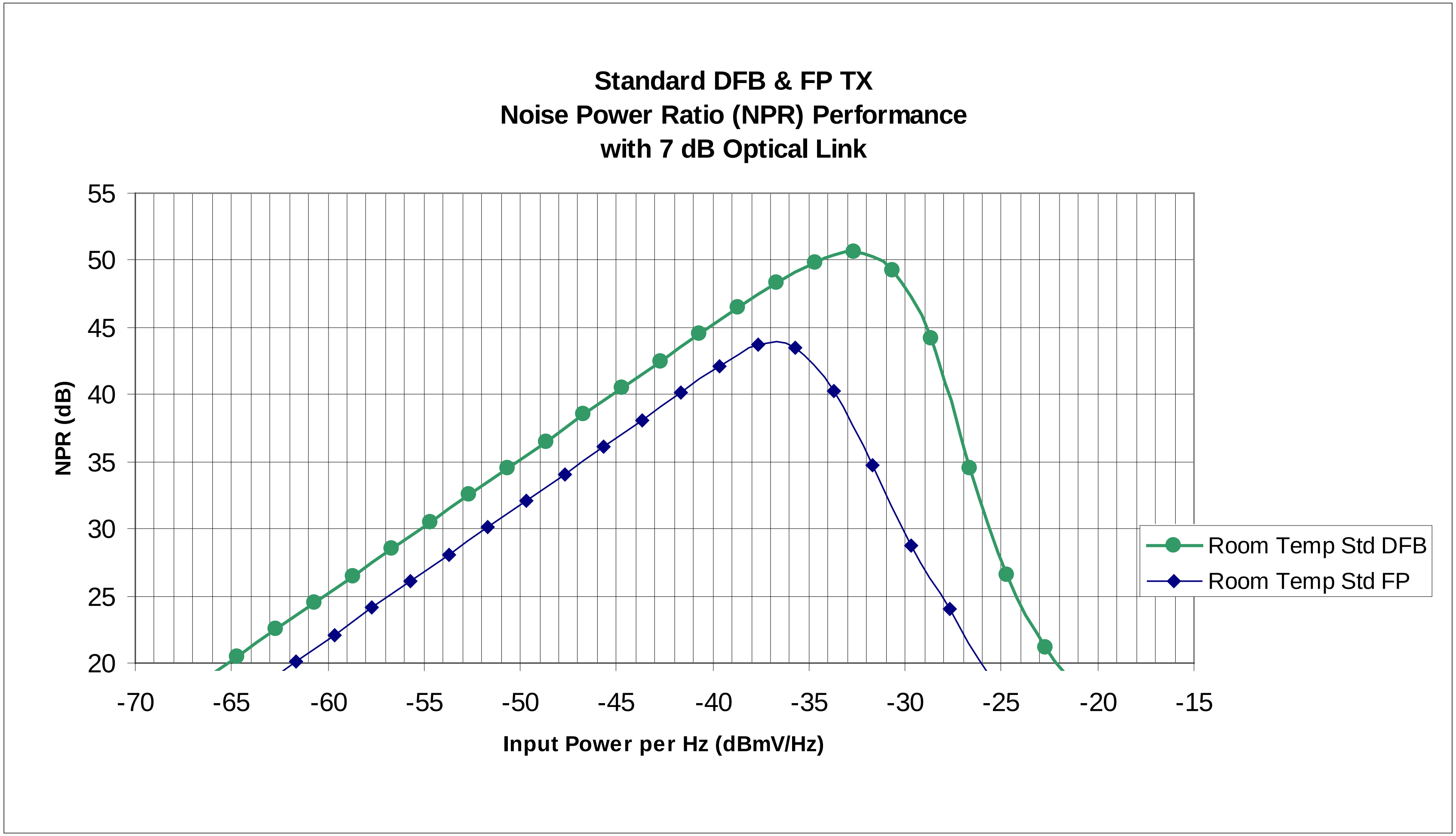

$$NPR = 10Log(\frac{P_S(Hz)}{P_N(Hz)})$$

$P_s$ = *Signal Power*
$P_n$ = *Noise Power*

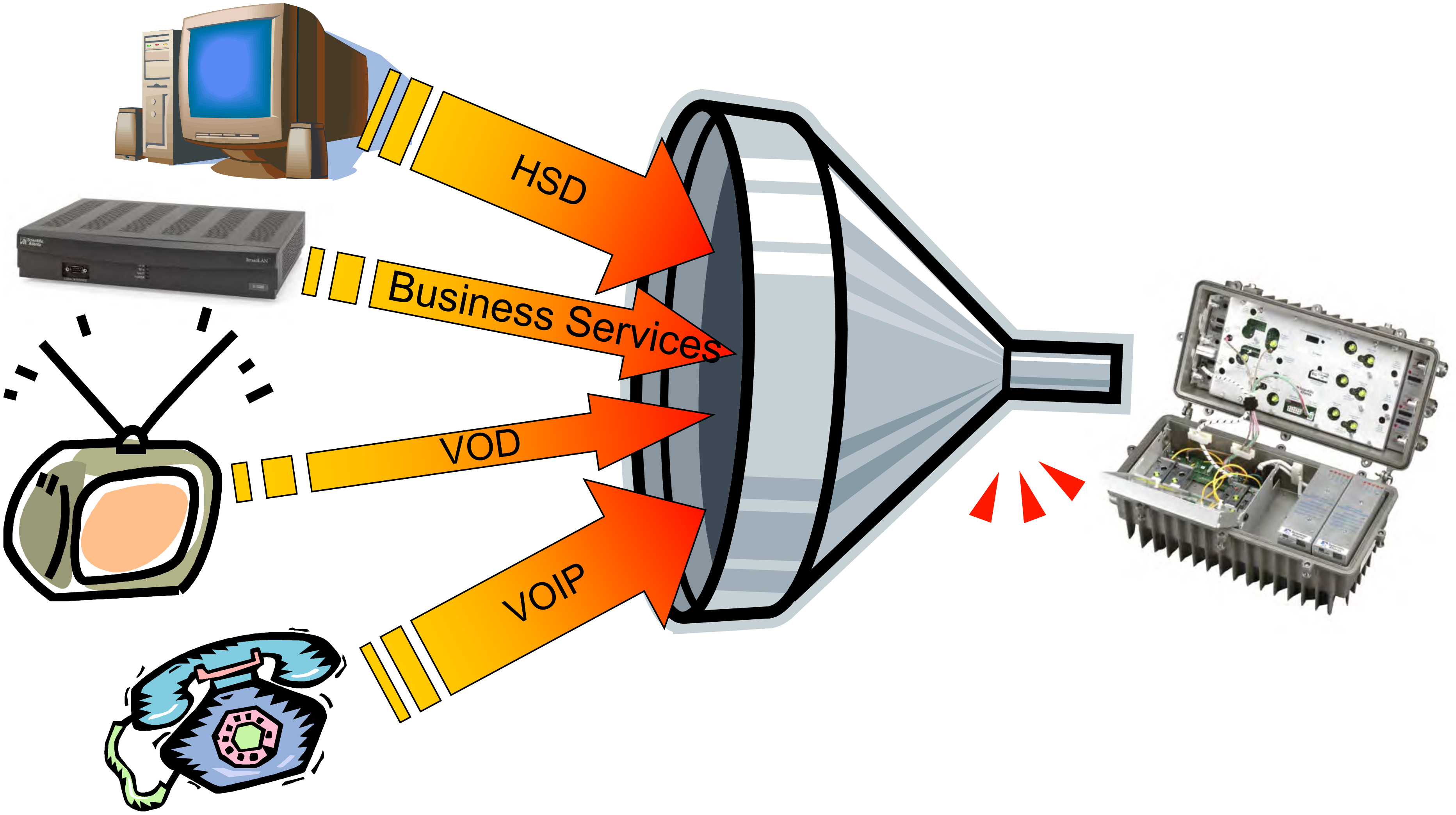
# DFB NPR Curves



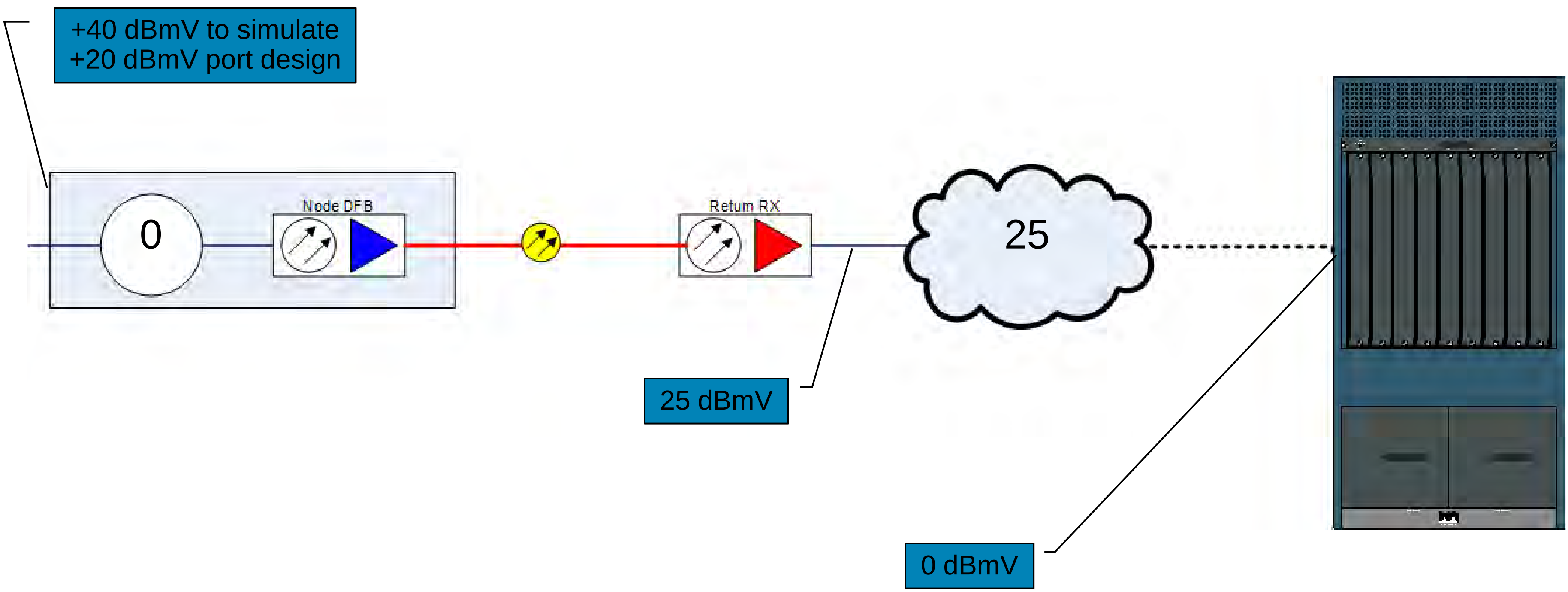
# S-A FP and DFB NPR Curves



# What's the Big Deal with NPR?



# Your Network




Setup based around manufacturer's specification when installed

# What's the Big Deal with NPR?

**Have we changed the number of or type of signals in the return path?**

- How many channels?
- What Types of Signals?

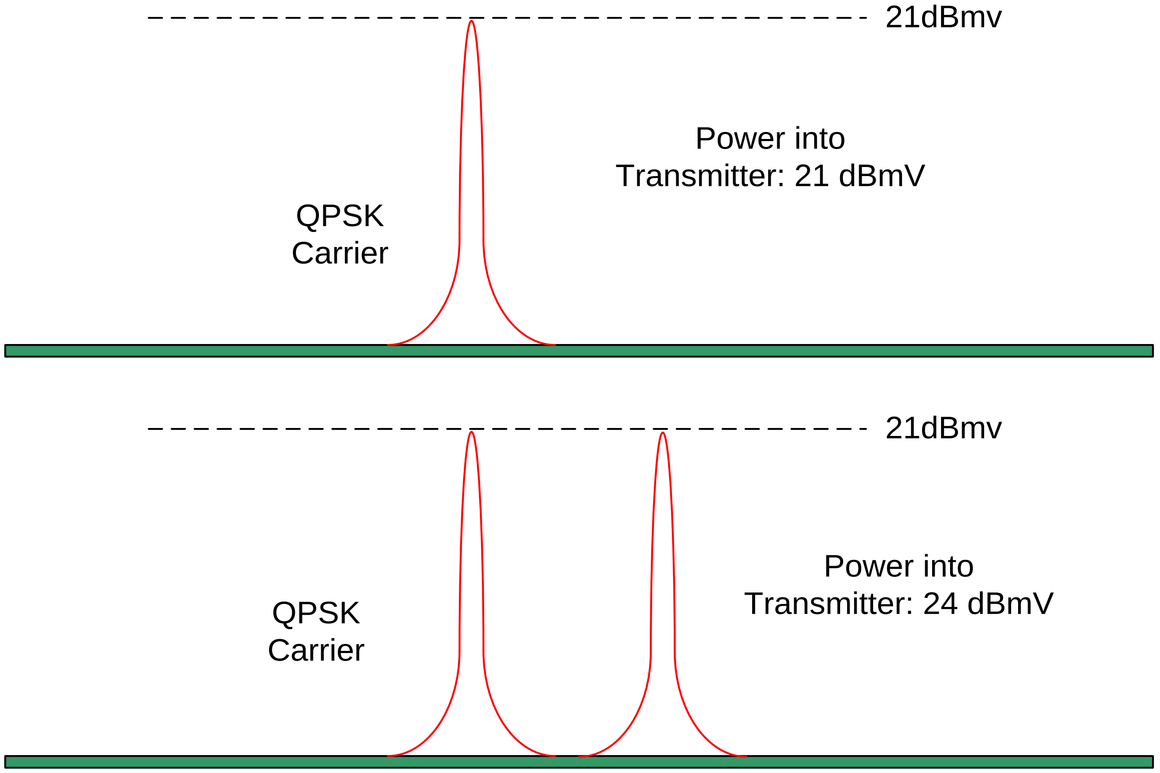
**Why do the number of channels matter?**

- Higher Channel Count yields more power into node return path transmitters.
- May put transmitters into Clip (non-linear condition)

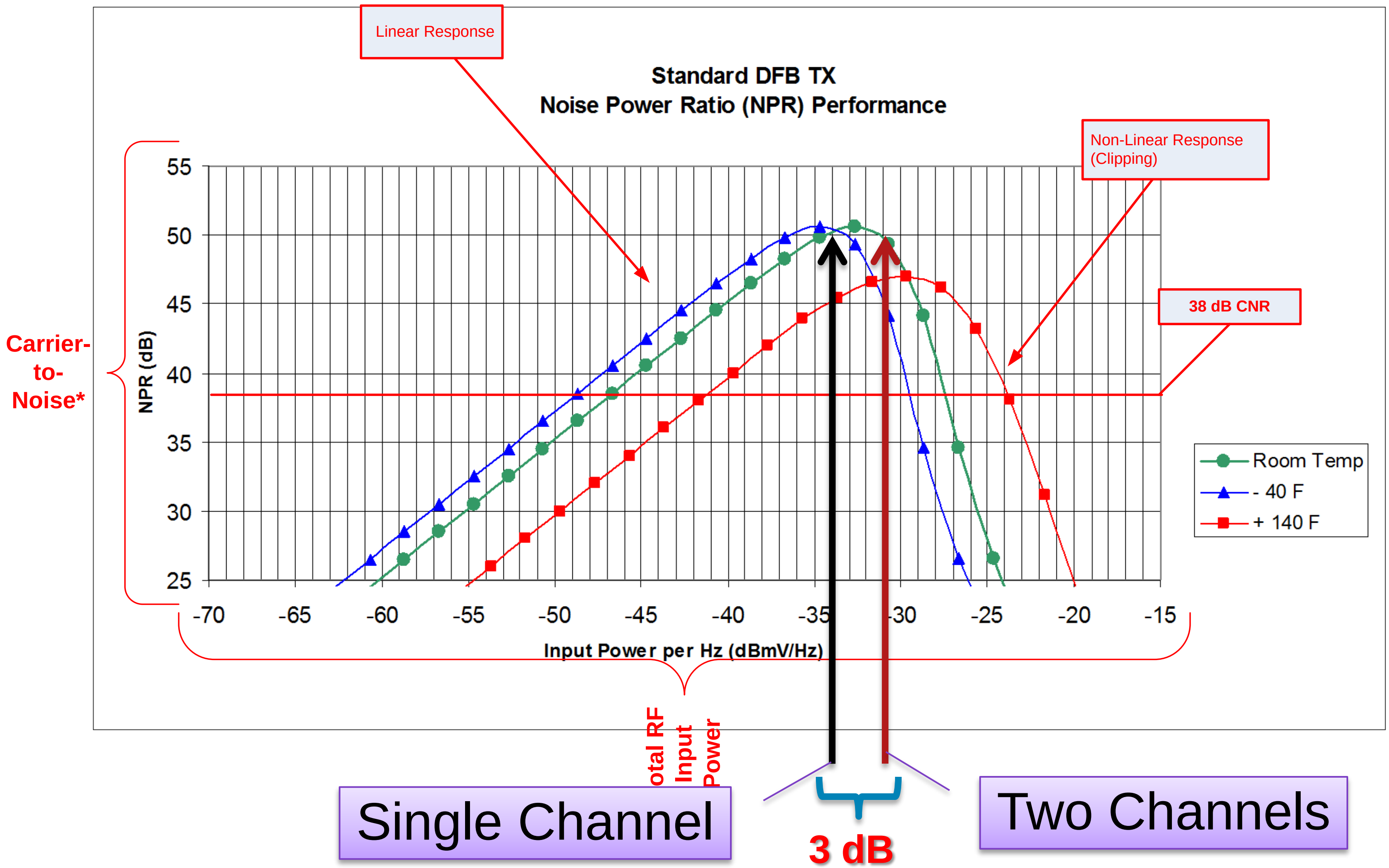
**Why does the modulation scheme matter?**

- QPSK, 16 QAM, 64 QAM
- Why does my 6.4 MHz wide carrier look 3 dB lower than my 3.2 ?
- MER / BER

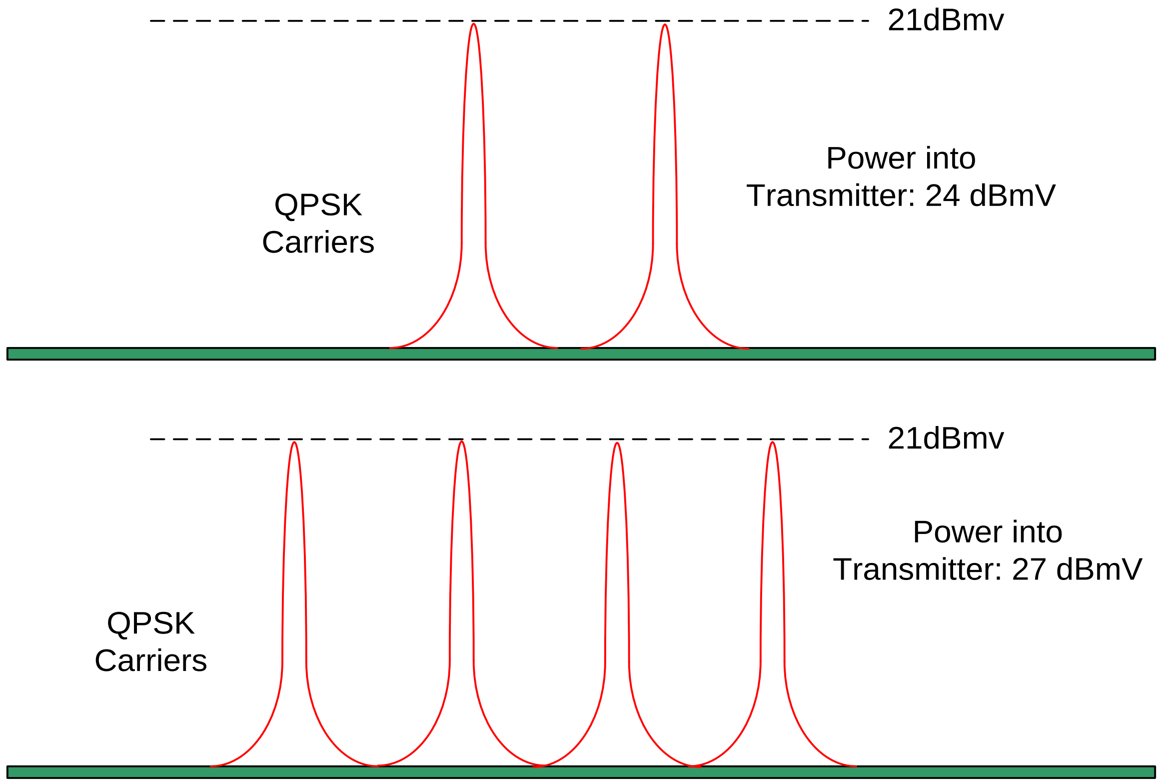
# Per Carrier Power vs. Composite Power



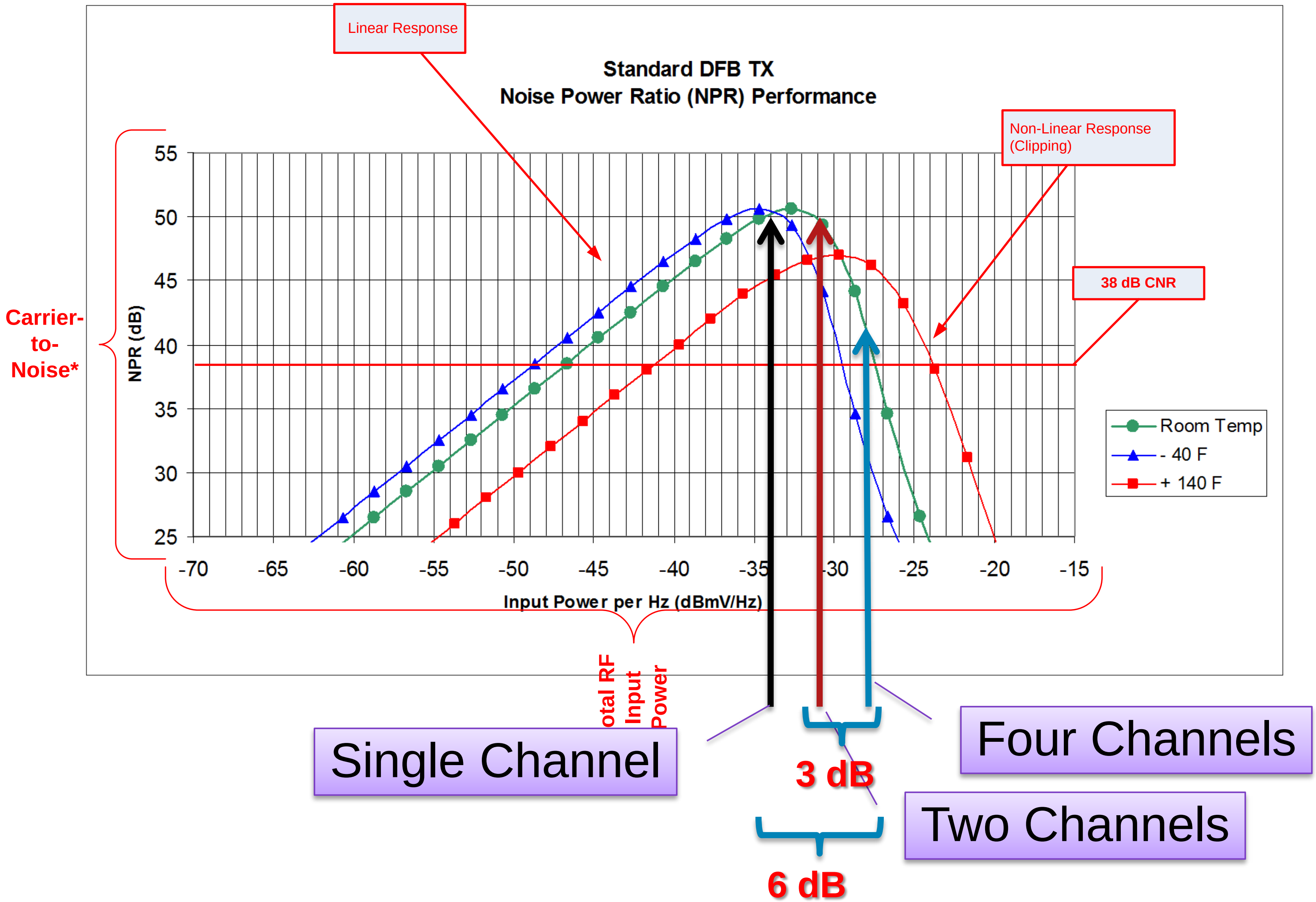
# DFB NPR Curves



# Per Carrier Power vs. Composite Power



# DFB NPR Curves



# Per Carrier Power vs. Composite Power

As you add more **carriers** to the return path the **composite power** to the laser increases.

- By 10 x Log(number of channels)

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

- Have we reduced the power of our network signals into our laser?
- How do we do it?

Won't our modem TX levels change when we lower our input to our laser?

- Depends   :  )
- What about the bandwidth of our carriers?

# Per Carrier Power vs. Composite Power

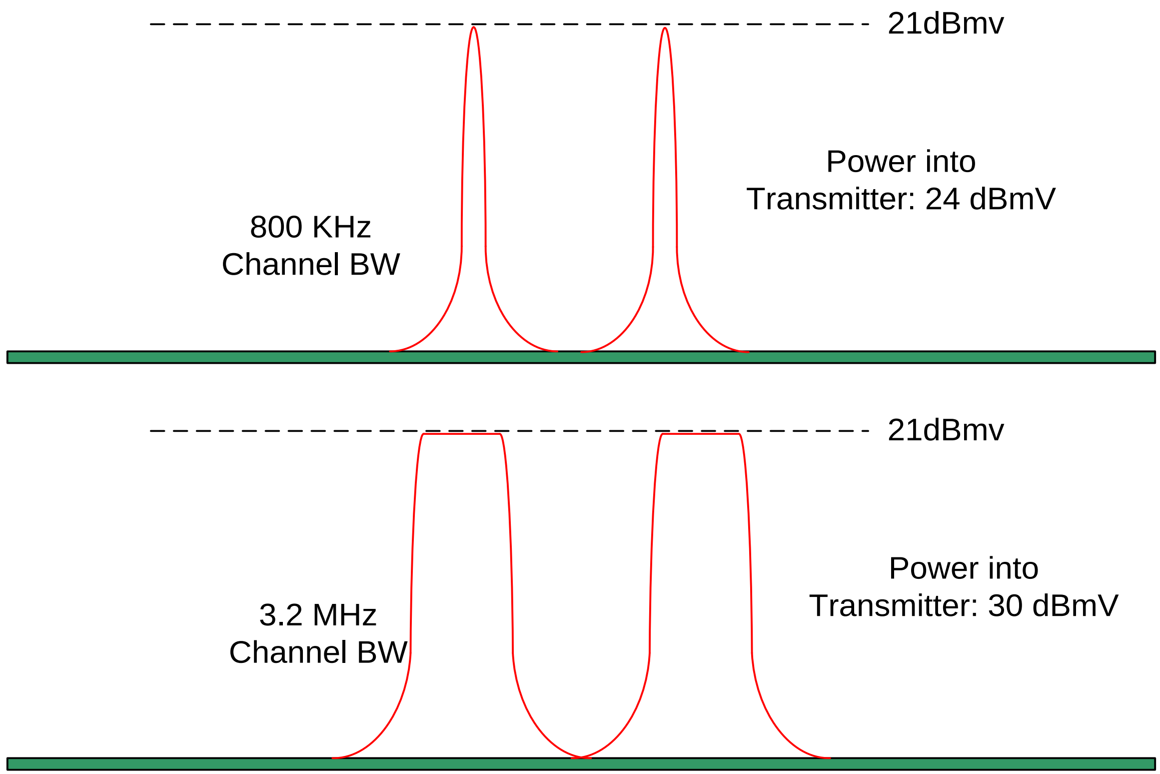
When **channel bandwidth** is changed, the channel's power changes.

- The wider the channel the more power it has!
- If a 3.2 MHz-wide signal is changed to 6.4 MHz bandwidth, the channel has 3 dB more power even though the "haystack" appears to be the same height on a spectrum analyzer!

Let's change our example!

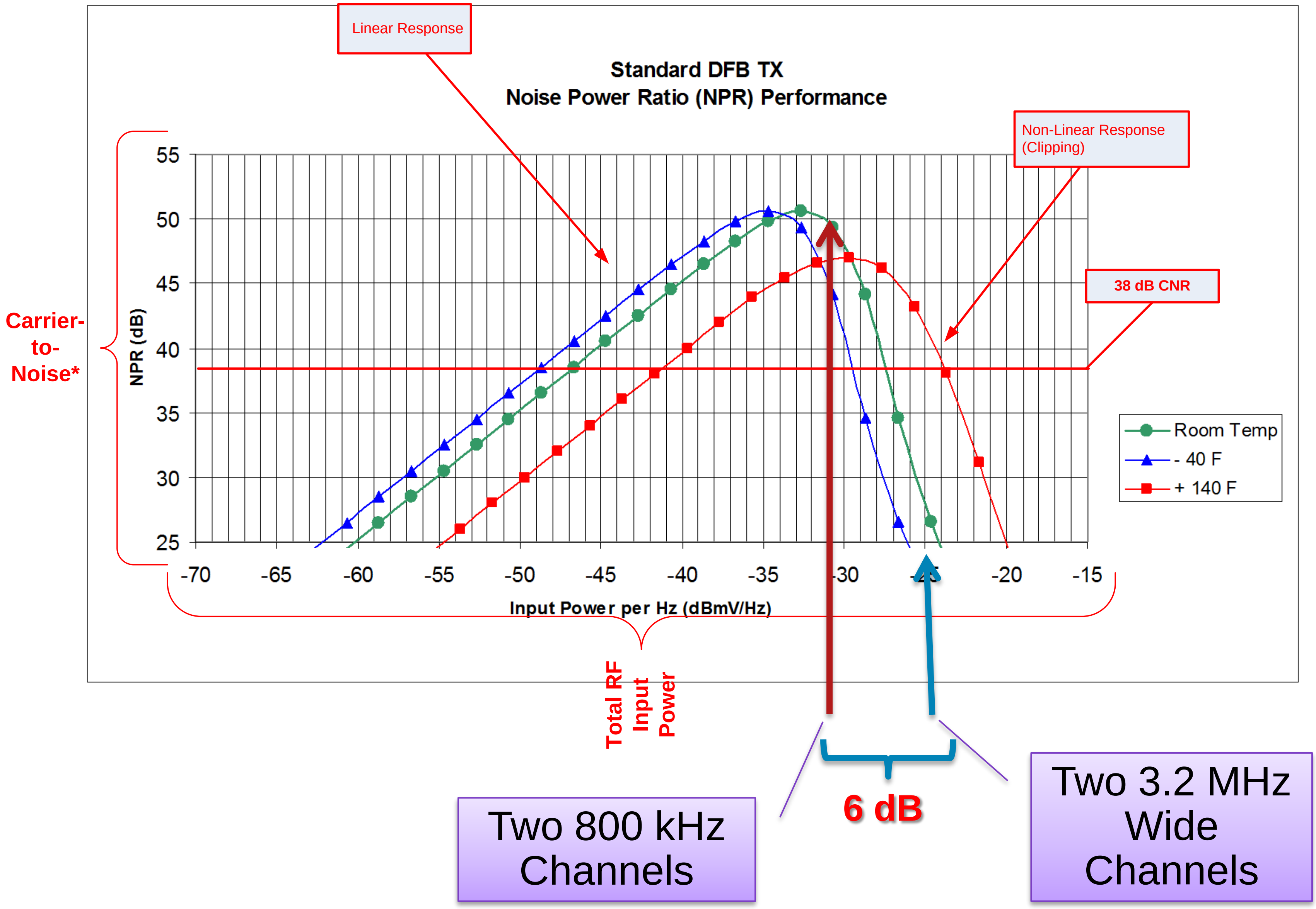
- How will changing the bandwidth of our signals increase power into the return path laser?

# Changing Modulation Type – Wider Channel

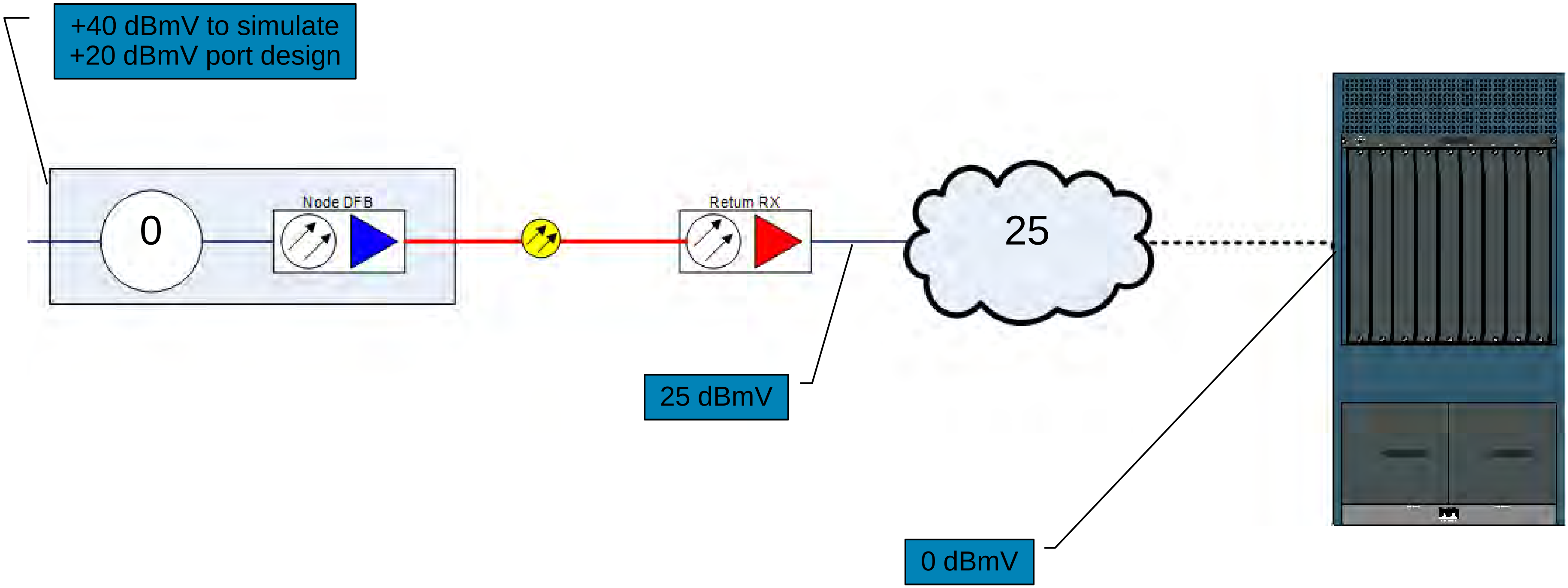



Note: This example assumes test equipment set to 300 kHz RBW

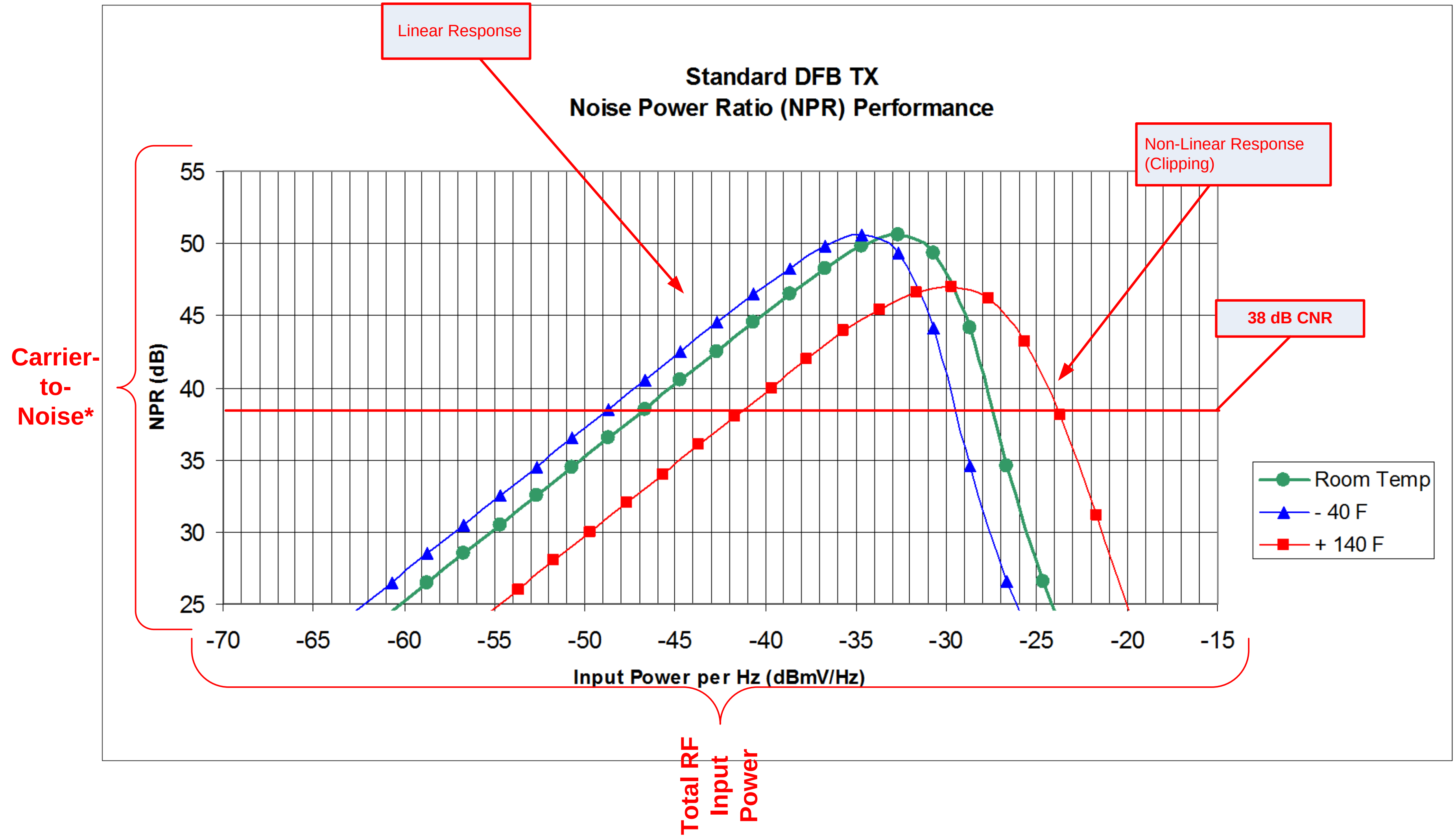
# DFB NPR Curves



# How do we Fix It?



# How do we Fix it?



# But the Levels Look Different

Modems and EMTAs are constant power devices

→

Your meter will read digital channels low!

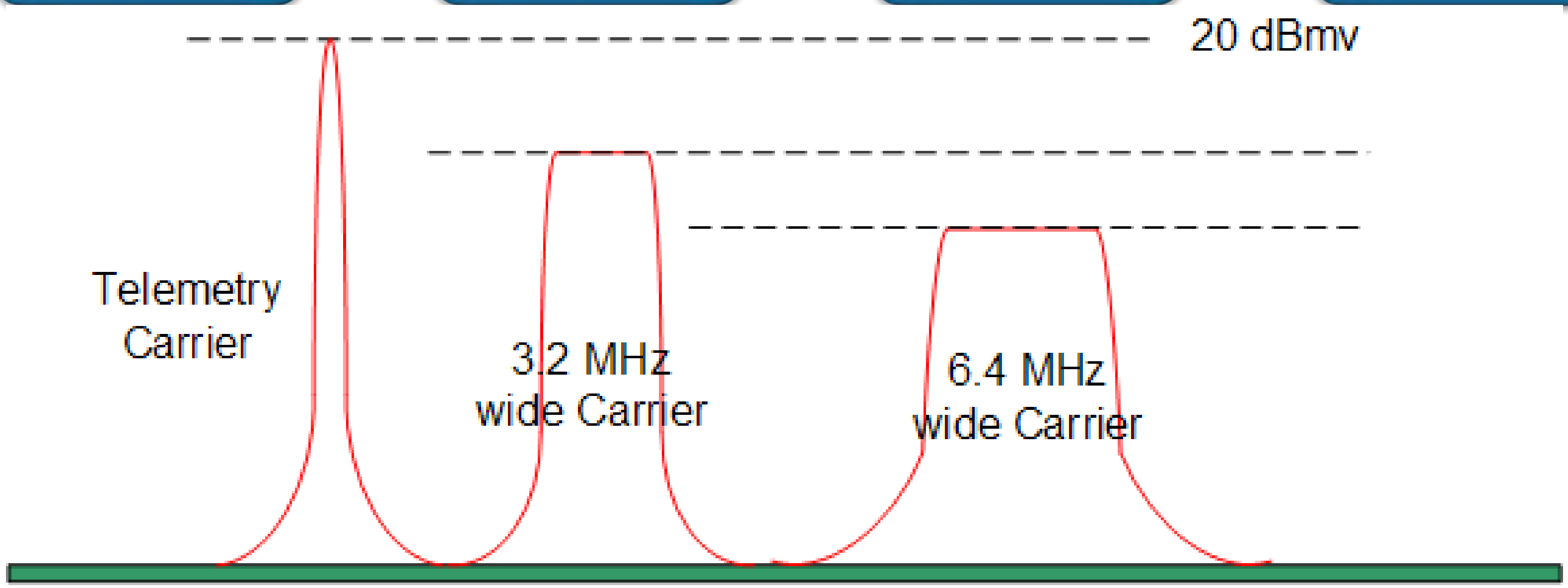
- Apparent amplitude will depend upon the instrument's resolution bandwidth (IF bandwidth).

→

Must use the Telemetry Signals for the SETUP of a reference of your return path!

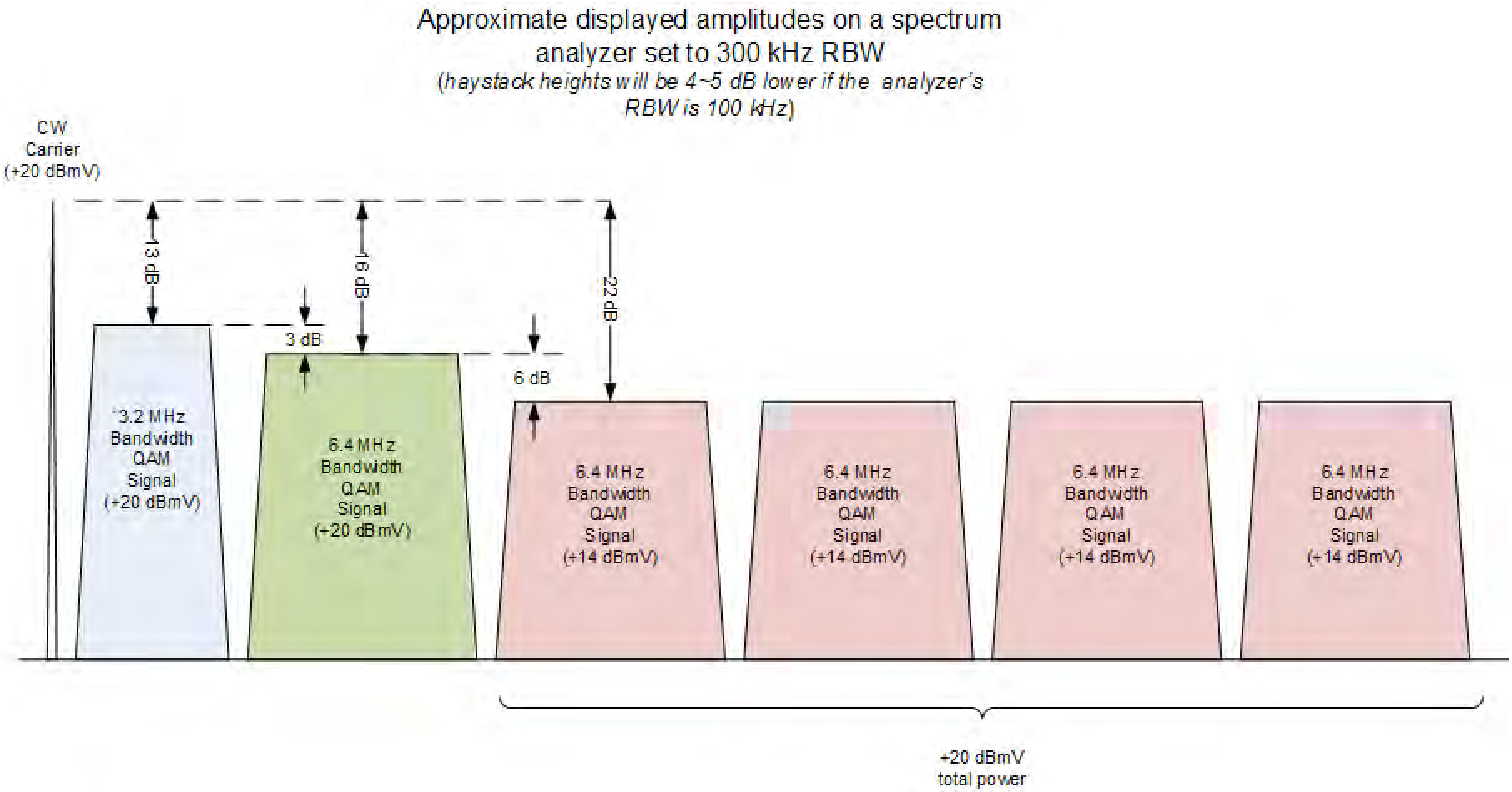
→

This is why we cannot use the eMTA or Modem to establish levels




Each carrier has the same amount of energy even though they "look" like they have different levels

# Modem Output is Power Limited



# Different Modulation Techniques Require Different SNR (MER)

- Modulation Type Required CNR

  Required CNR for various modulation schemes to achieve 1.0E-8 ($1x10^{-8}$) BER

  BPSK: 12 dB

  QPSK: 15 dB

  16-QAM: 22 dB

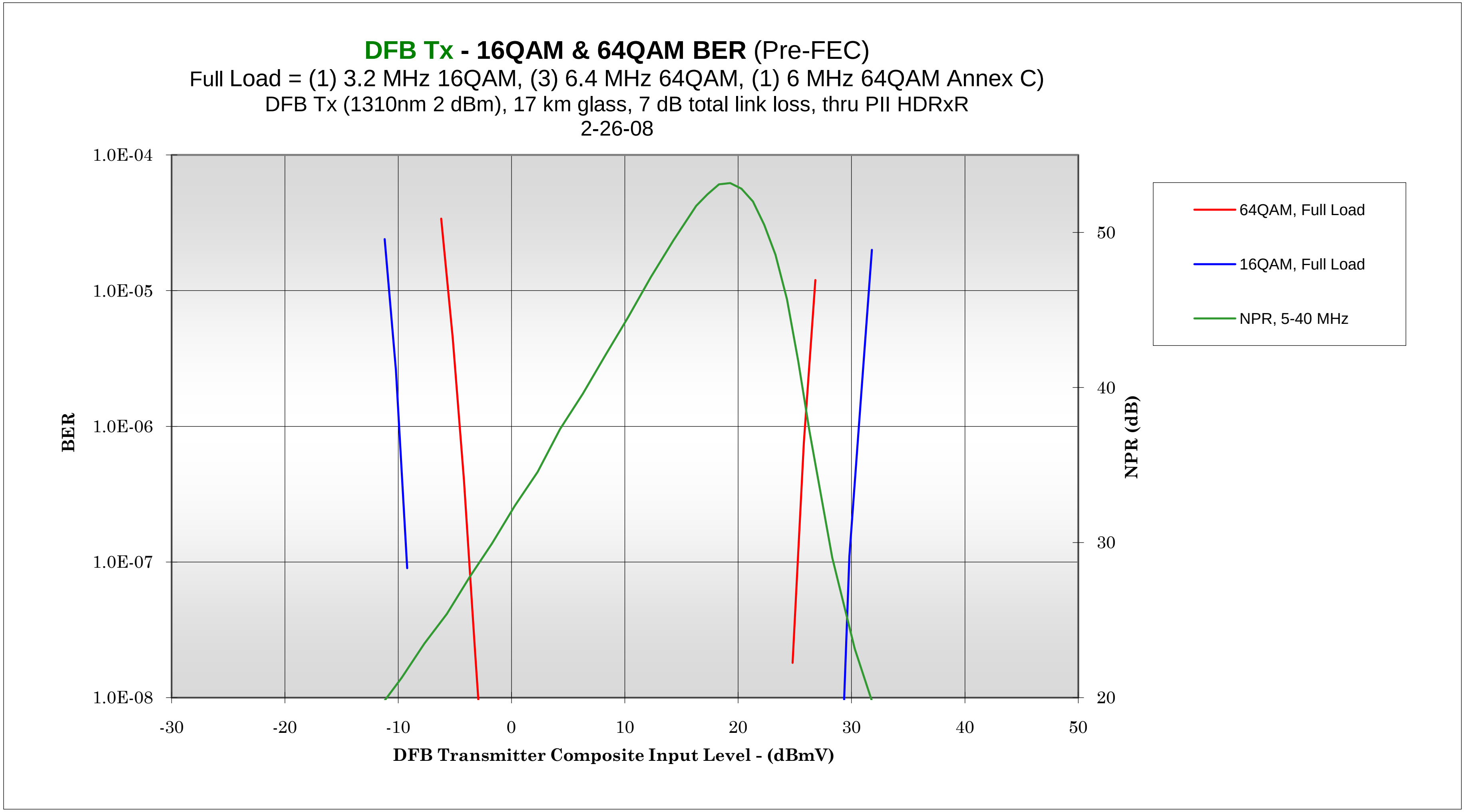
  64-QAM: 28 dB

- Multiple services on the return path with different types of modulation schemes will require allocation of bandwidth and amplitudes.

  Can be engineered.

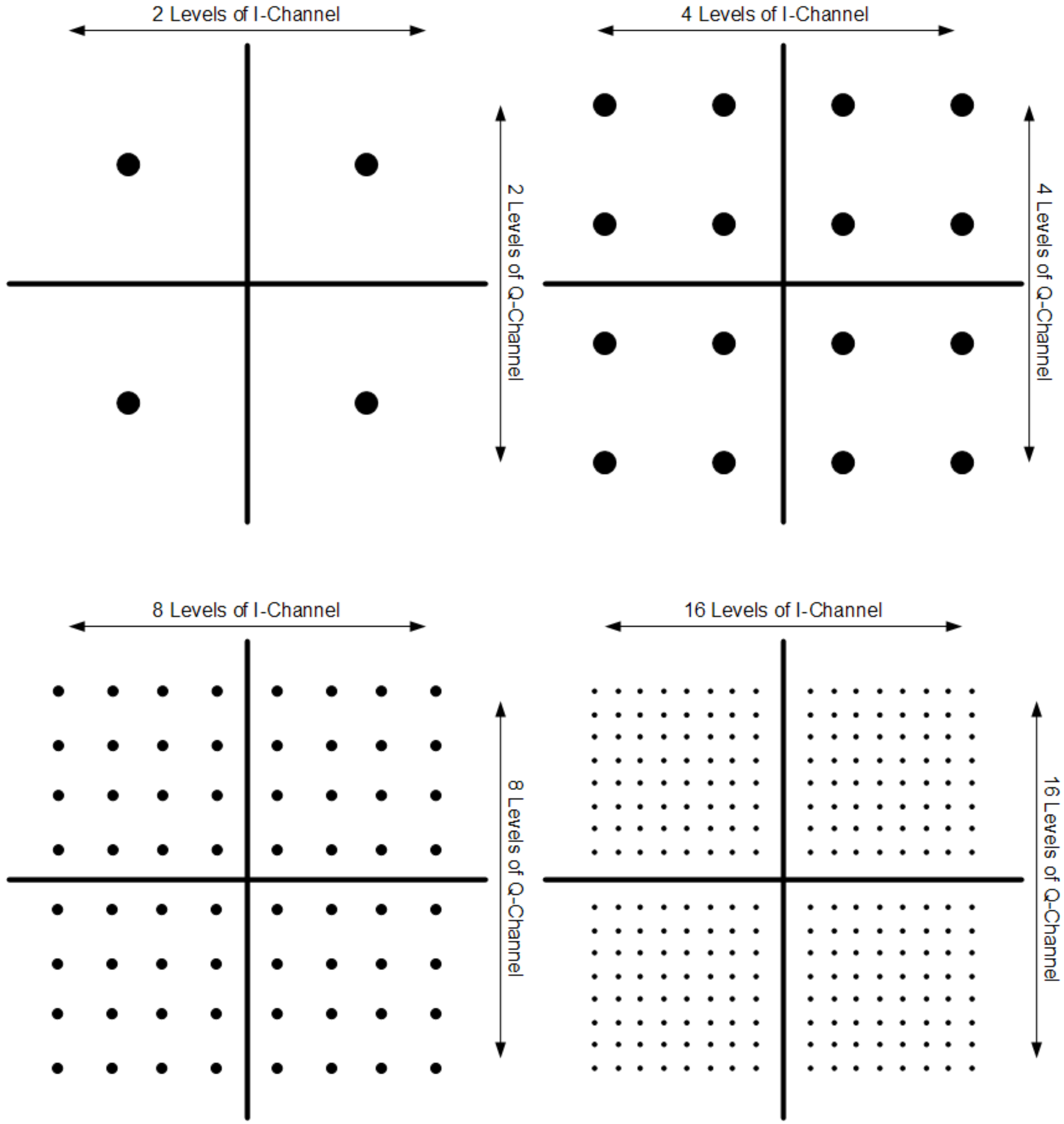
  Requires differential padding in Headend

# BER vs NPR

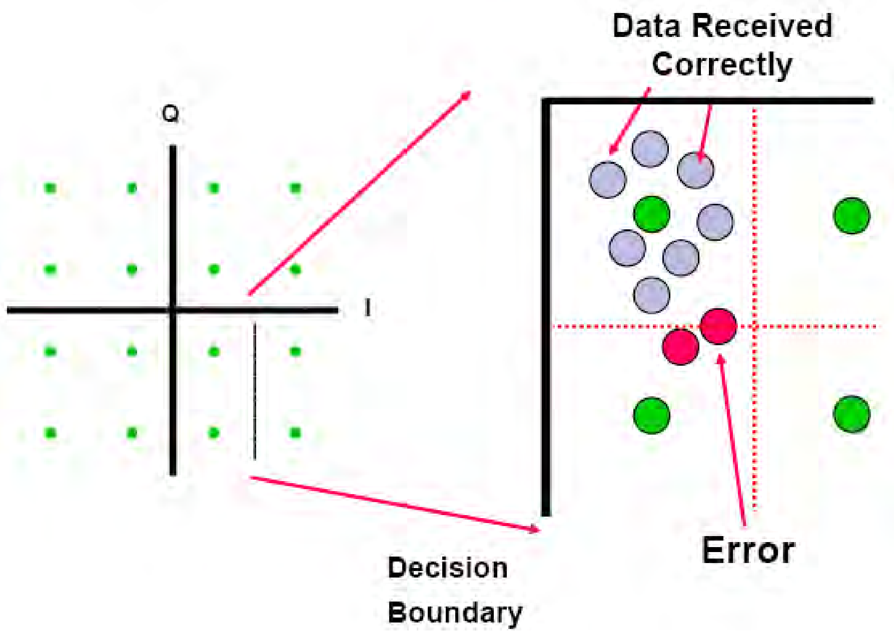


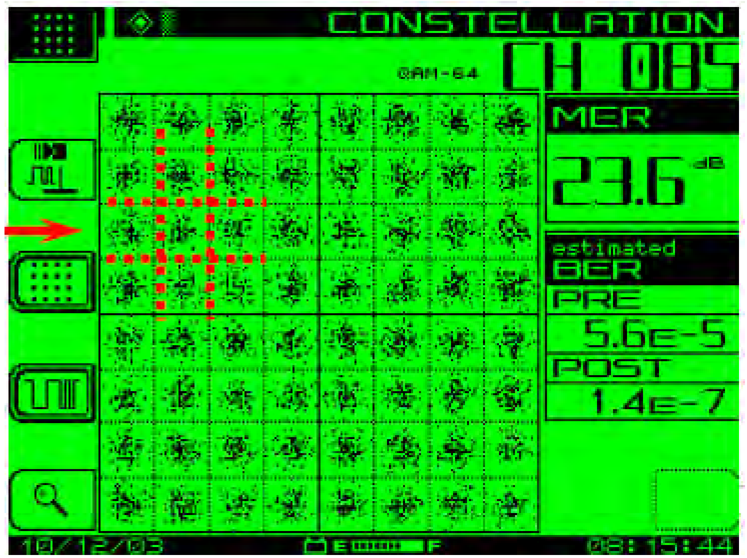
DFB Tx - 16QAM & 64QAM BER (Pre-FEC)
Full Load = (1) 3.2 MHz 16QAM, (3) 6.4 MHz 64QAM, (1) 6 MHz 64QAM Annex C)
DFB Tx (1310nm 2 dBm), 17 km glass, 7 dB total link loss, thru PII HDRxR
2-26-08
BER
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
NPR (dB)
50
40
30
20
-30
-20
-10
0
10
20
30
40
50
DFB Transmitter Composite Input Level - (dBmV)
64QAM, Full Load
16QAM, Full Load
NPR, 5-40 MHz

# QPSK vs 16 QAM vs 64 QAM vs 256 QAM Constellations



# QAM MER / BER


Data Received
Correctly
Q
I
Decision
Boundary
Error

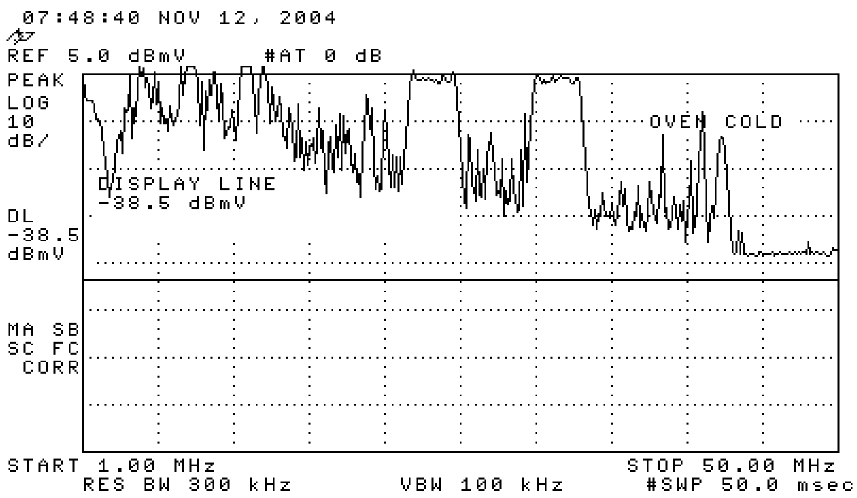

CONSTELLATION
QAM-64
CH 085
MER
23.6 dB
estimated
BER
PRE
5.6E-5
POST
1.4E-7
10/12/03
08:15:44

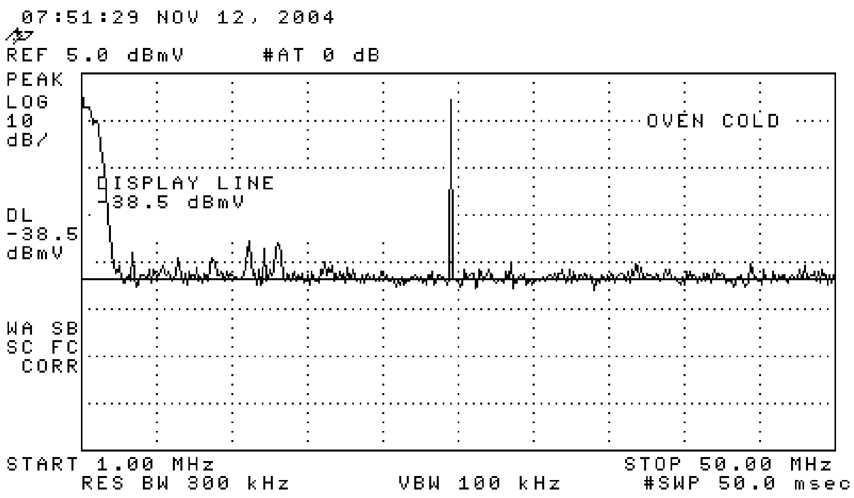
# Why do we have to reset our Return Transmitter Input Levels?

- The laser performance is determined by the composite energy of all the carriers, AND CRAP in the return path.
- What is return path CRAP?
- Can it make a difference in return path performance?
- How does it effect system performance?
- How can you increase your Carrier-to-Crap Ratio (CTC)?

# Energy in the Return Path

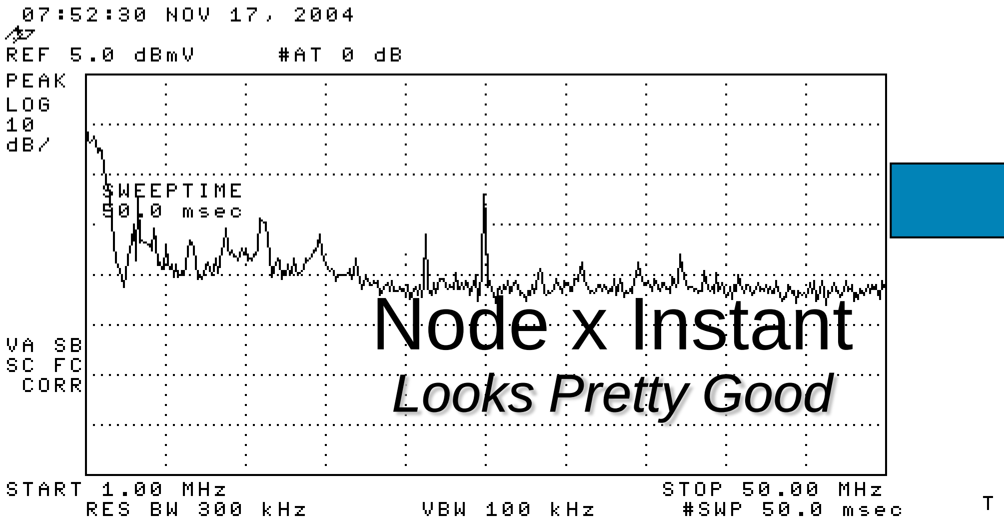
- What does your return path look like?
- The return laser 'sees' all the energy in the return path.
  - The energy is the sum of all the RF power of the carriers, noise, ingress, etc., in the spectrum from about 1 MHz to 42 MHz
  - The more RF power that is put into the laser the closer you are to clipping the laser.
  - A clean return path gives allows you to operate your system more effectively.
  - The type of return laser you use has an associated window of operation

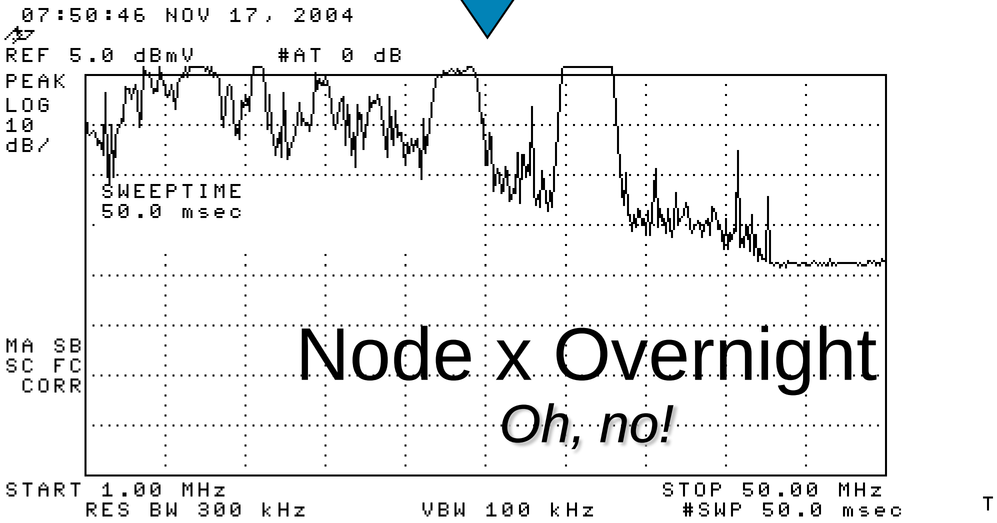


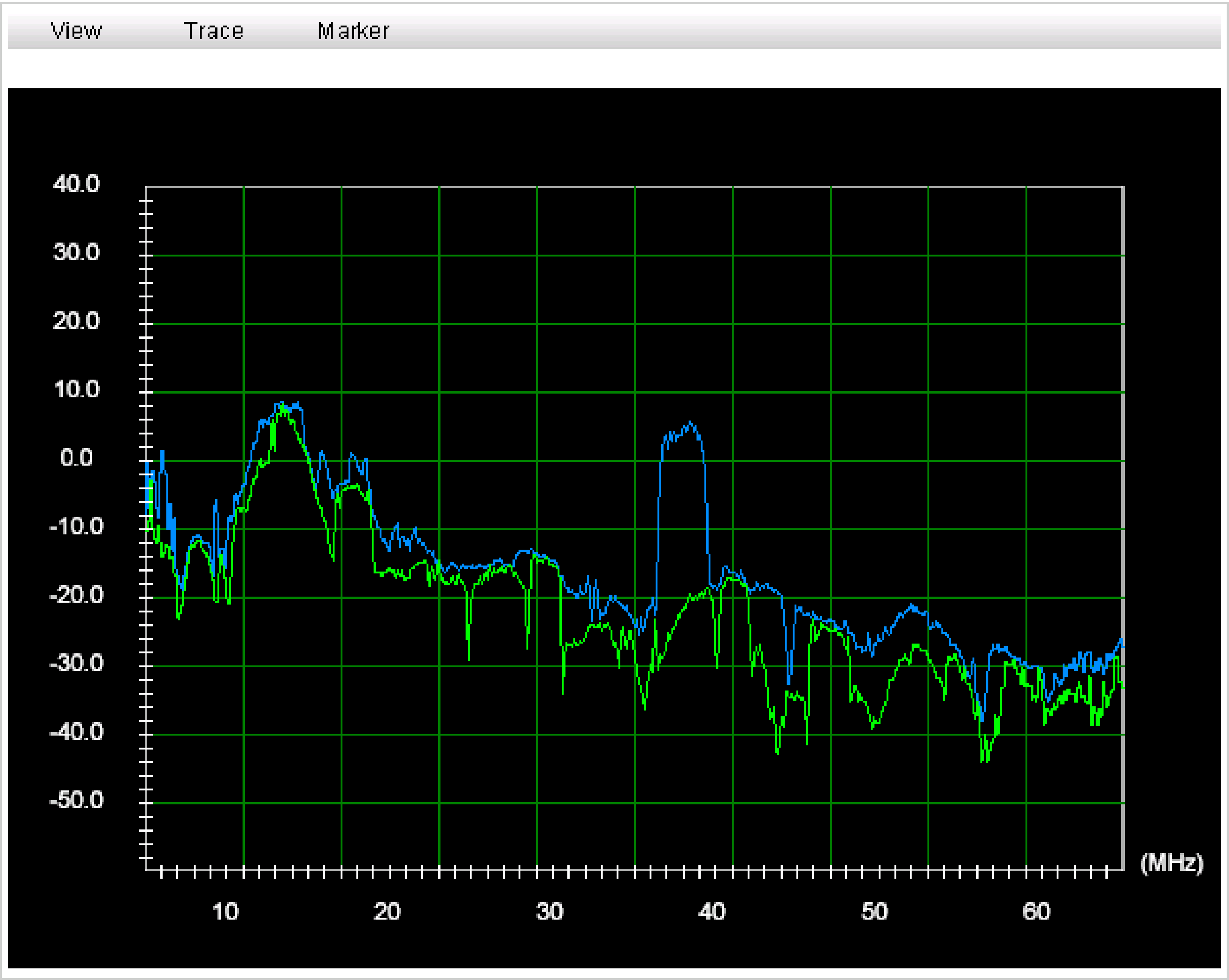

T

# Ingress Changes over Time

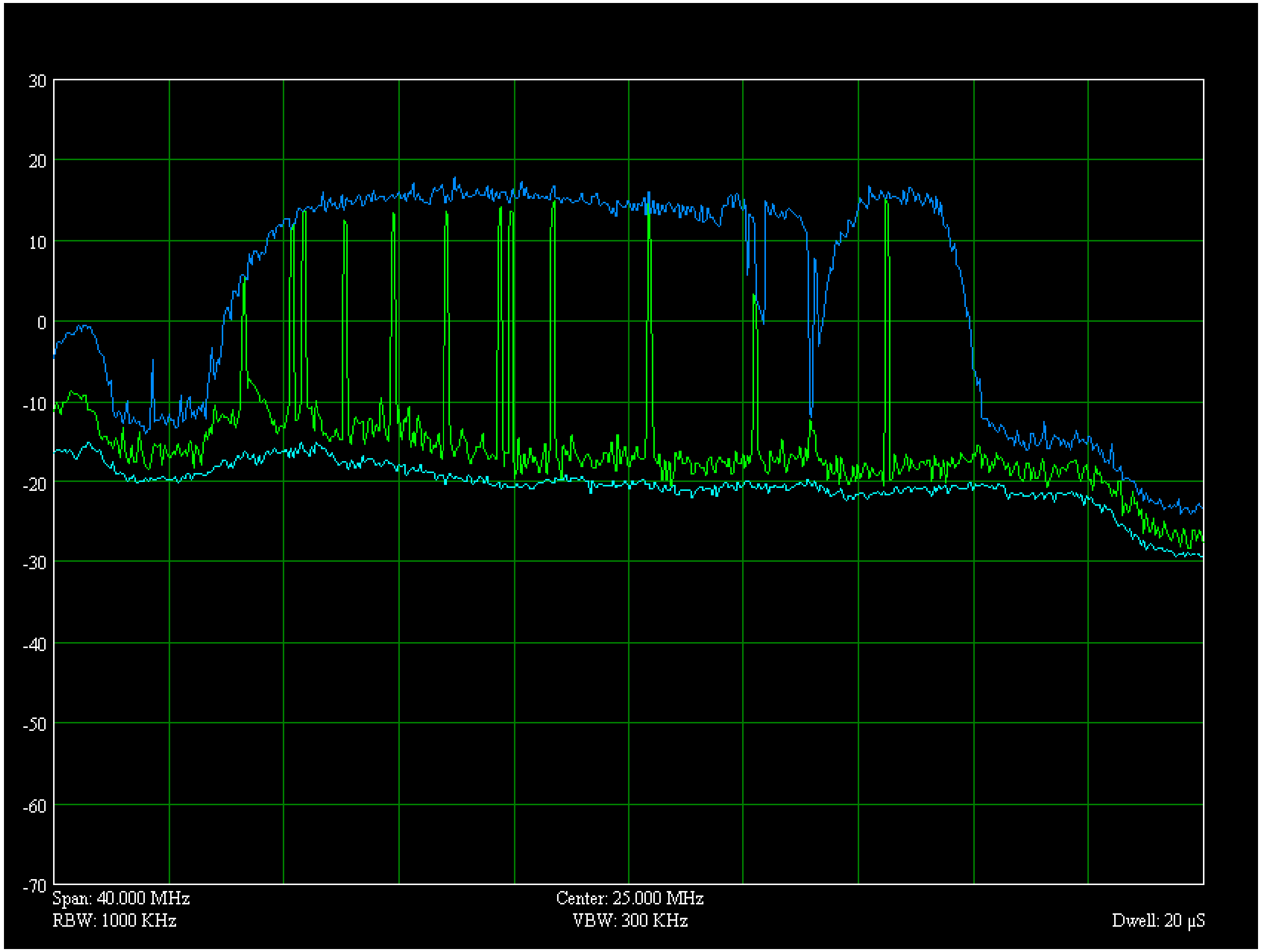


# One Bad TV takes out a Node



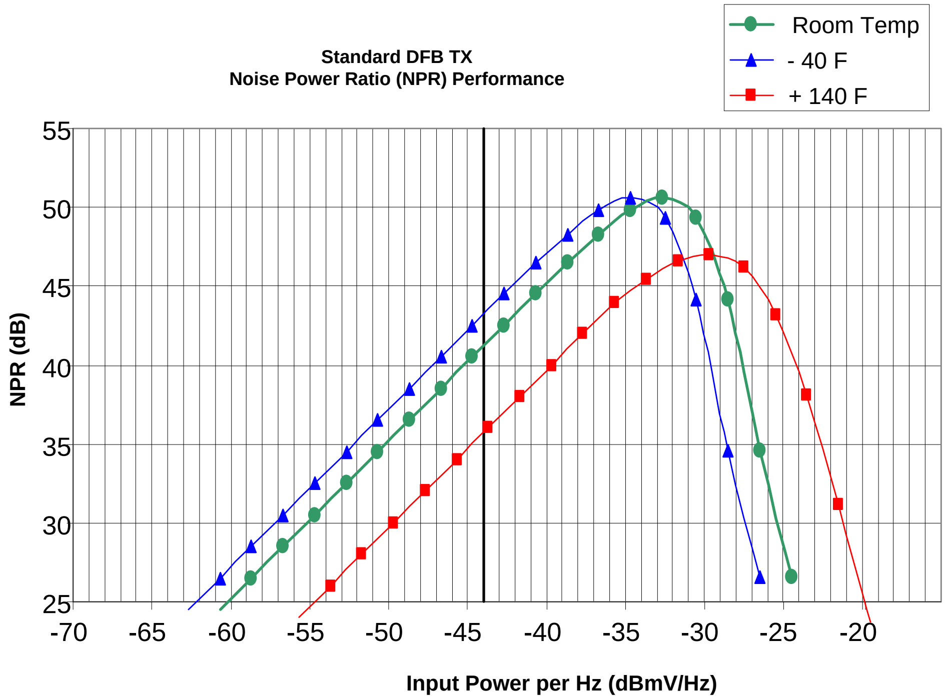
# AT&T in the Return Path!



# Return Laser Performance Summary

What Affects Return Path Laser Performance?

- Number of Carriers
- Carrier Amplitude
- Symbol Rate (Bandwidth)
- Ingress

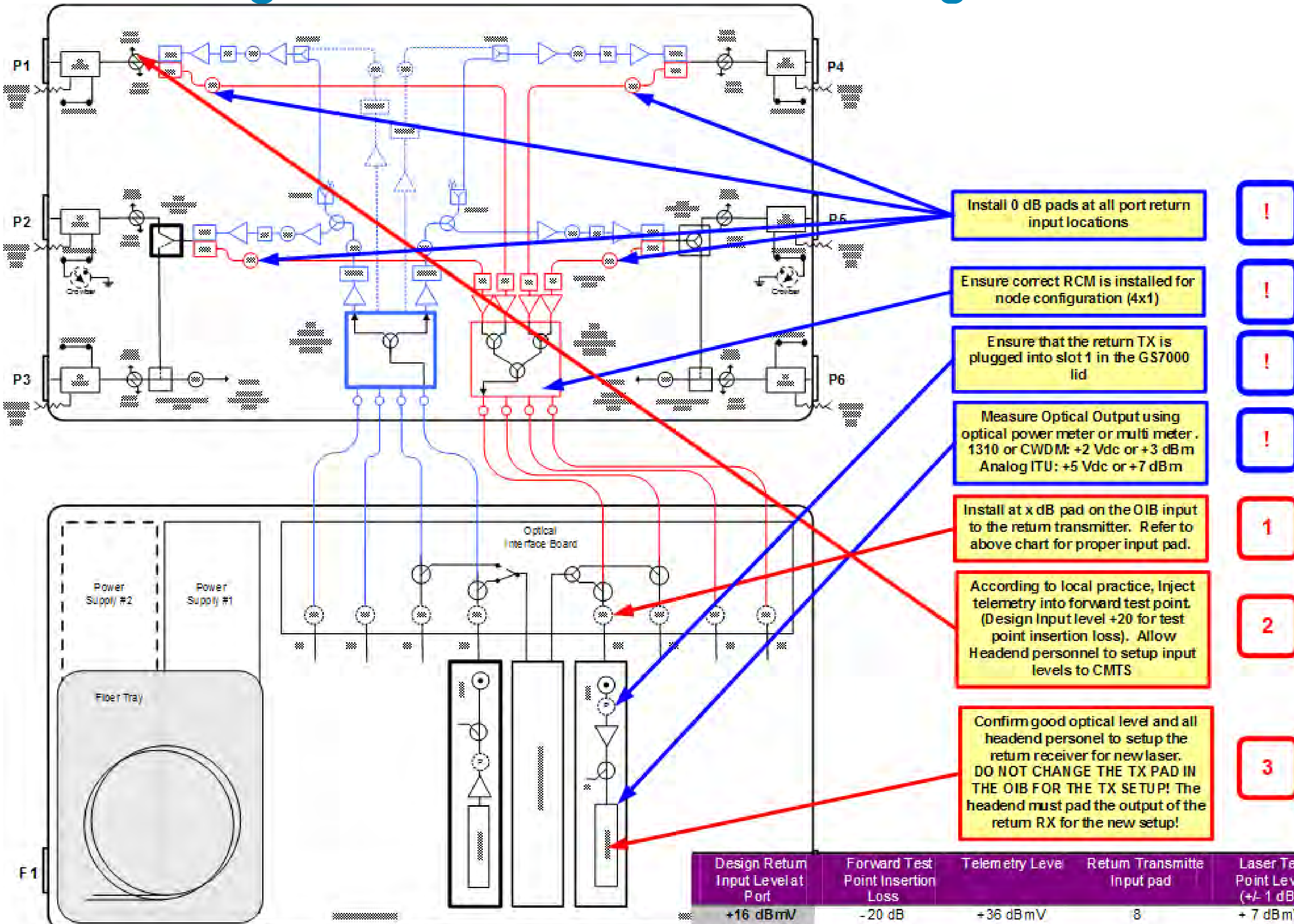



Will Laser Performance Change over Temperature?

At what temperature should you setup your optical return path transport?

Always follow your manufacture's setup procedure for the return laser input level!

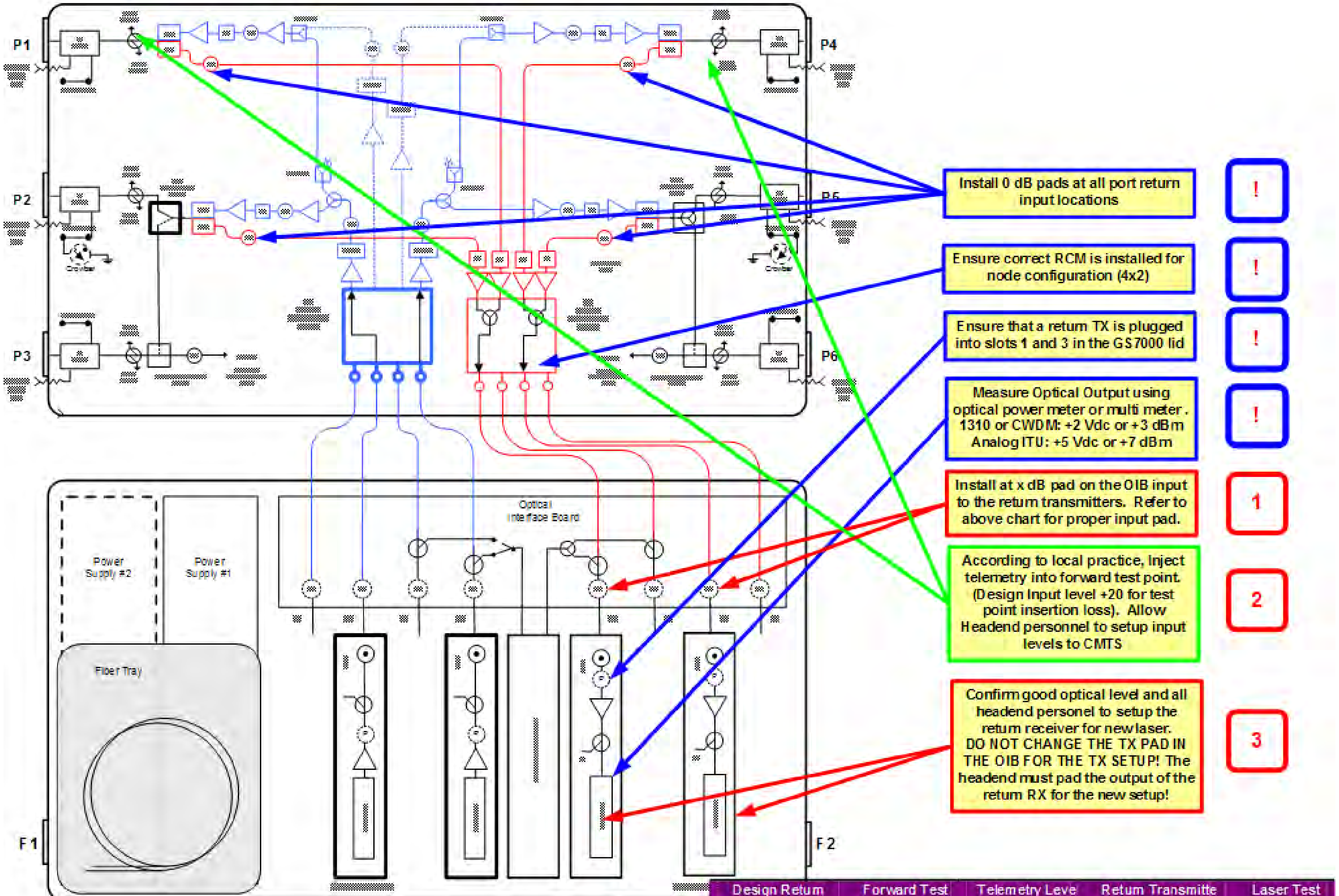
# Setting Return Levels in a Non Segmented Node




**Input Pad Selection Chart – All Analog Return Transmitters**

| Design Return Input Level at Port | Forward Test Point Insertion Loss | Telemetry Level | Return Transmitte Input pad | Laser Test Point Level (+/- 1 dB) |
|---|---|---|---|---|
| +16 dBmV | -20 dB | +36 dBmV | 8 | + 7 dBmV |
| +17 dBmV | -20 dB | +37 dBmV | 9 | + 7 dBmV |
| +18 dBmV | -20 dB | +38 dBmV | 10 | + 7 dBmV |
| +19 dBmV | -20 dB | +39 dBmV | 11 | + 7 dBmV |
| +20 dBmV | -20 dB | +40 dBmV | 12 | + 7 dBmV |
| +21 dBmV | -20 dB | +41 dBmV | 13 | + 7 dBmV |

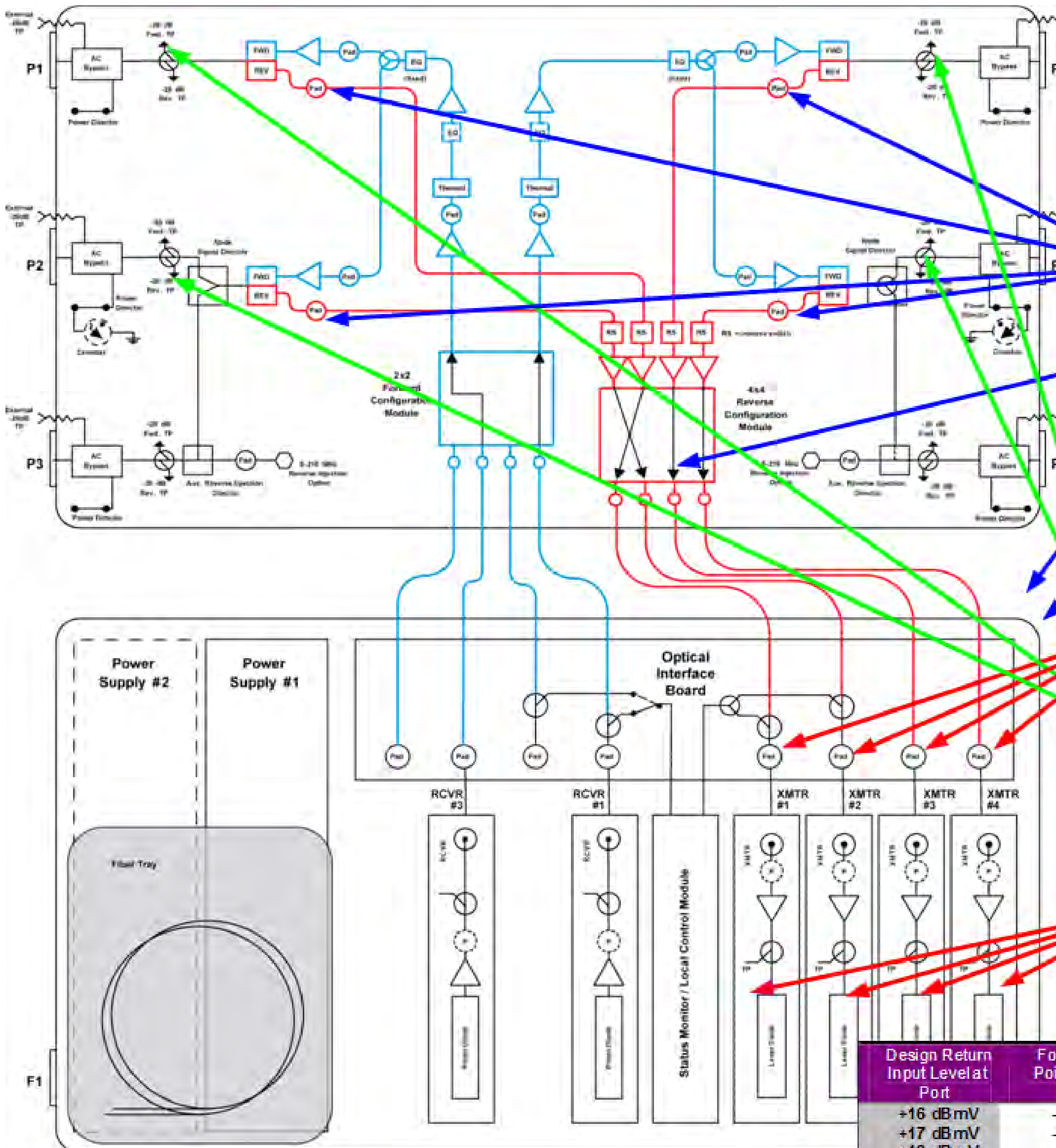
# Setting Return Levels in a Half Segmented Node




Input Pad Selection Chart – All Analog Return Transmitters

| Design Return Input Level at Port | Forward Test Point Insertion Loss | Telemetry Level | Return Transmitter Input pad | Laser Test Point Level (+/- 1 dB) |
|---|---|---|---|---|
| +16 dBmV | -20 dB | +36 dBmV | 8 | + 7 dBmV |
| +17 dBmV | -20 dB | +37 dBmV | 9 | + 7 dBmV |
| +18 dBmV | -20 dB | +38 dBmV | 10 | + 7 dBmV |
| +19 dBmV | -20 dB | +39 dBmV | 11 | + 7 dBmV |
| +20 dBmV | -20 dB | +40 dBmV | 12 | + 7 dBmV |
| +21 dBmV | -20 dB | +41 dBmV | 13 | + 7 dBmV |

# Setting Return Levels in a Fully Segmented Node




| Injection Port | Transmitter Location |
|---|---|
| Port 2/3 | 2 |
| Port 1 | 1 |
| Port 4 | 3 |
| Port 5/6 | 4 |

Install 0 dB pads at all port return input locations — !

Ensure correct RCM is installed for node configuration (4x4) — !

Ensure that a return TX is plugged into slots 1 - 4 in the GS7000 lid — !

Measure Optical Output using optical power meter or multi meter. 1310 or CWDM: +2 Vdc or +3 dBm Analog ITU: +5 Vdc or +7 dBm — !

Install at x dB pad on the OIB input to the return transmitters. Refer to above chart for proper input pad. — 1

According to local practice, Inject telemetry into forward test point. (Design Input level +20 for test point insertion loss). Allow Headend personnel to setup input levels to CMTS — 2

Confirm good optical level and all headend personel to setup the return receiver for new laser. DO NOT CHANGE THE TX PAD IN THE OIB FOR THE TX SETUP! The headend must pad the output of the return RX for the new setup! — 3

| Design Return Input Level at Port | Forward Test Point Insertion Loss | Telemetry Leve | Return Transmitte Input pad | Laser Test Point Level (+/- 1 dB) |
|---|---|---|---|---|
| +16 dBmV | -20 dB | +36 dBmV | 8 | +7 dBmV |
| +17 dBmV | -20 dB | +37 dBmV | 9 | +7 dBmV |
| +18 dBmV | -20 dB | +38 dBmV | 10 | +7 dBmV |
| +19 dBmV | -20 dB | +39 dBmV | 11 | +7 dBmV |
| +20 dBmV | -20 dB | +40 dBmV | 12 | +7 dBmV |
| +21 dBmV | -20 dB | +41 dBmV | 13 | +7 dBmV |

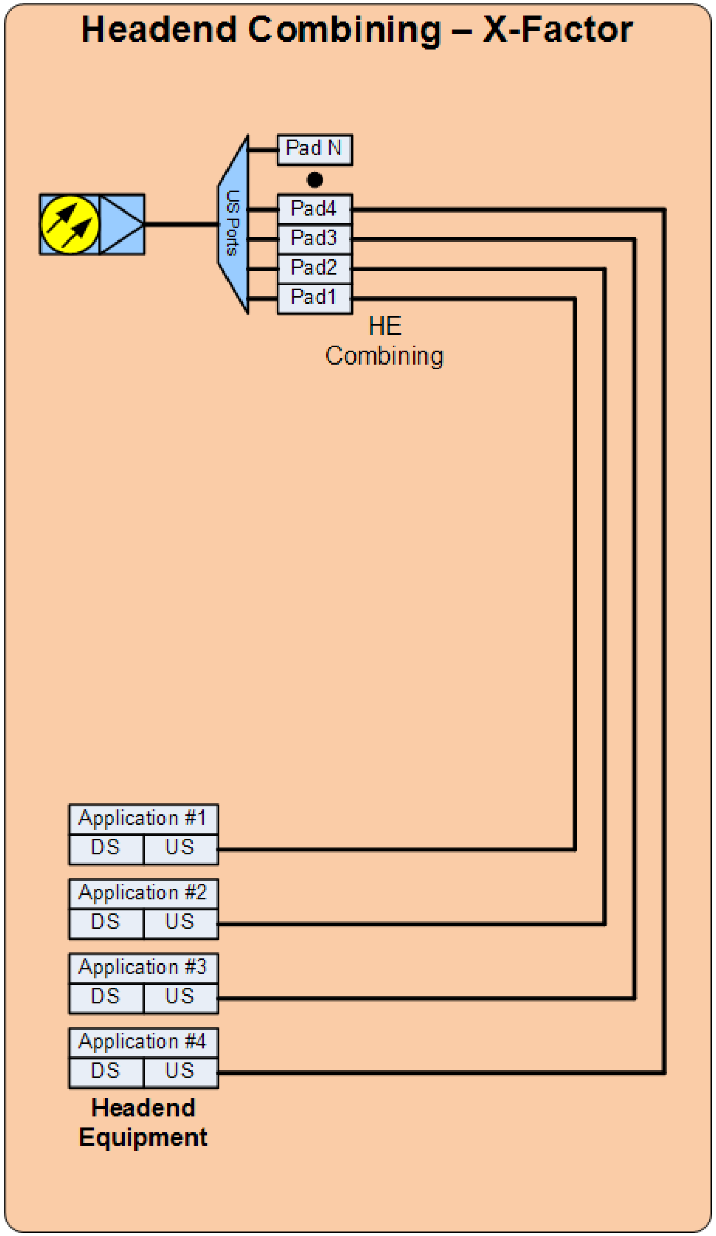
**Input Pad Selection Chart – All Analog Return Transmitters**

## Headend Distribution Network

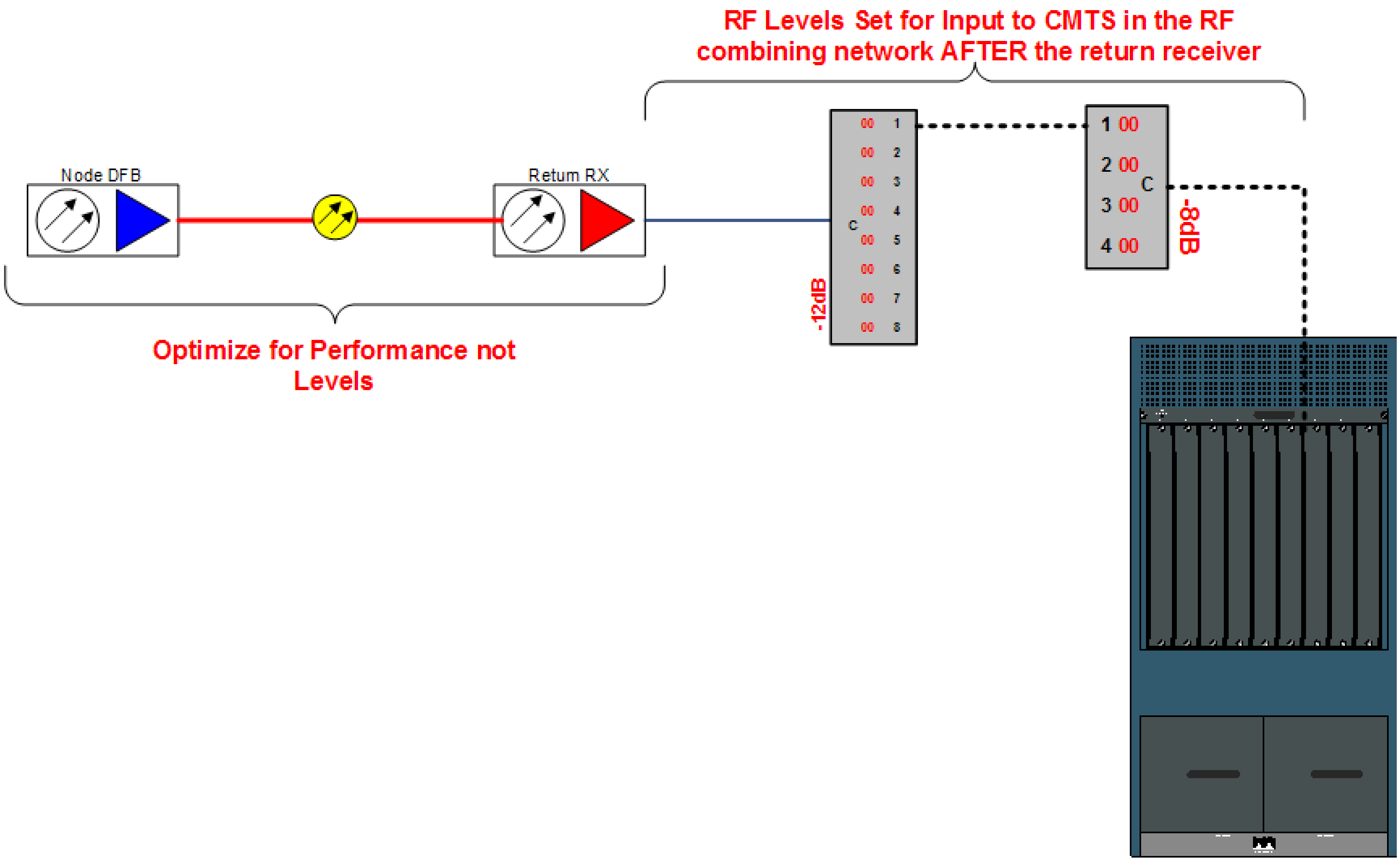
Begins at the OUTPUT of the optical return path receiver(s)

Ends at the Application Devices

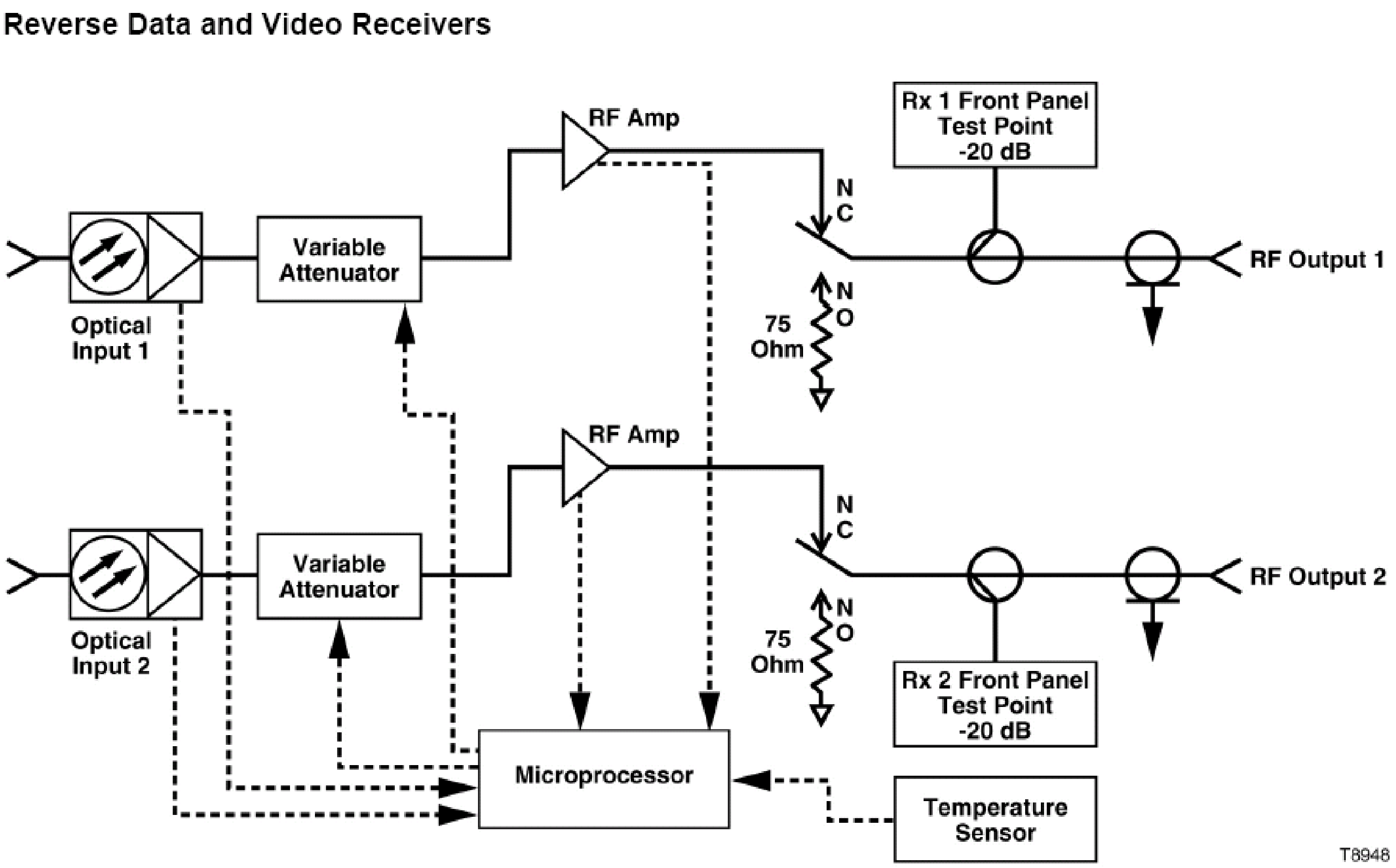
- CMTS, DNCS, DAC, etc.



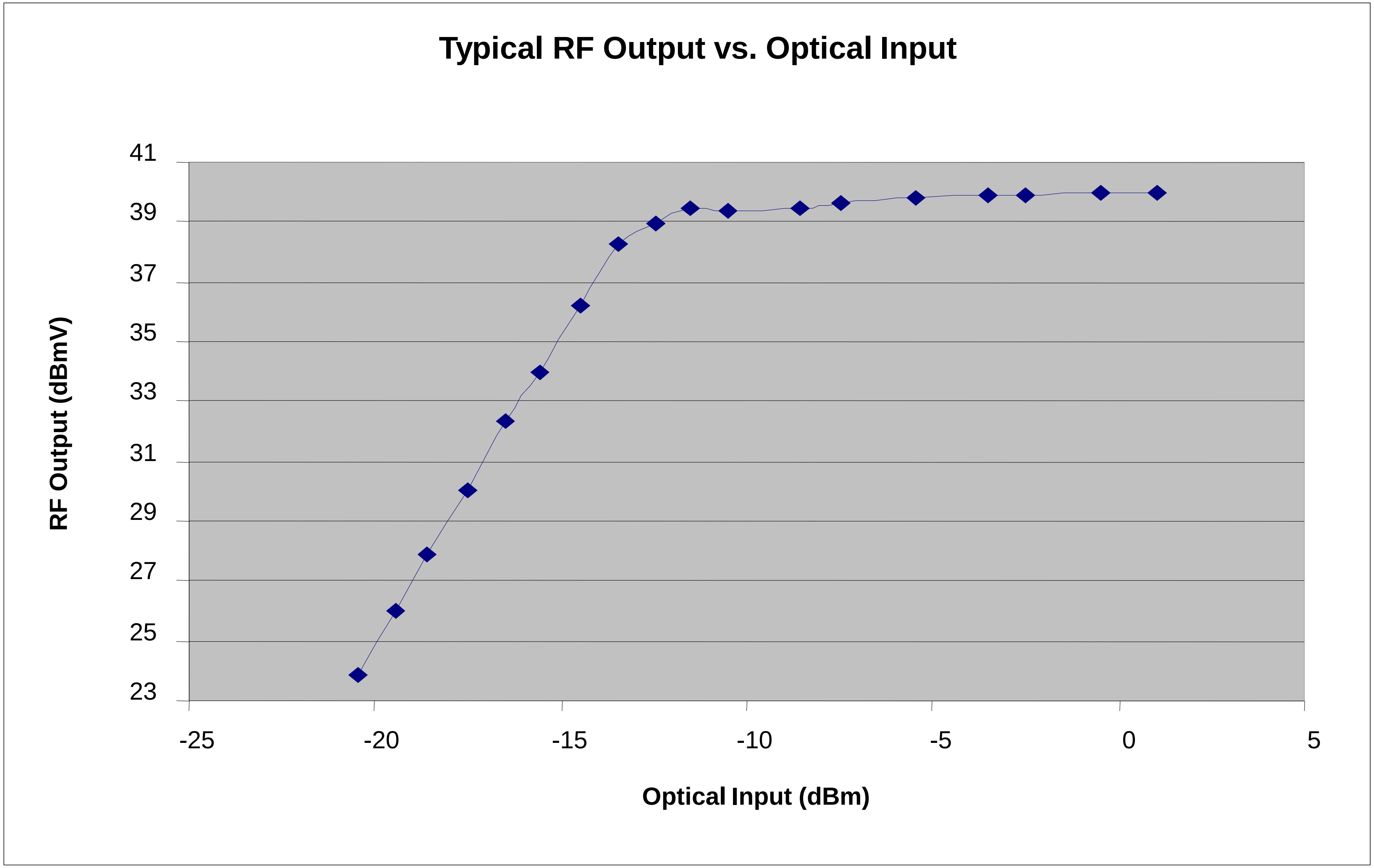
# Return Path Headend RF Combining



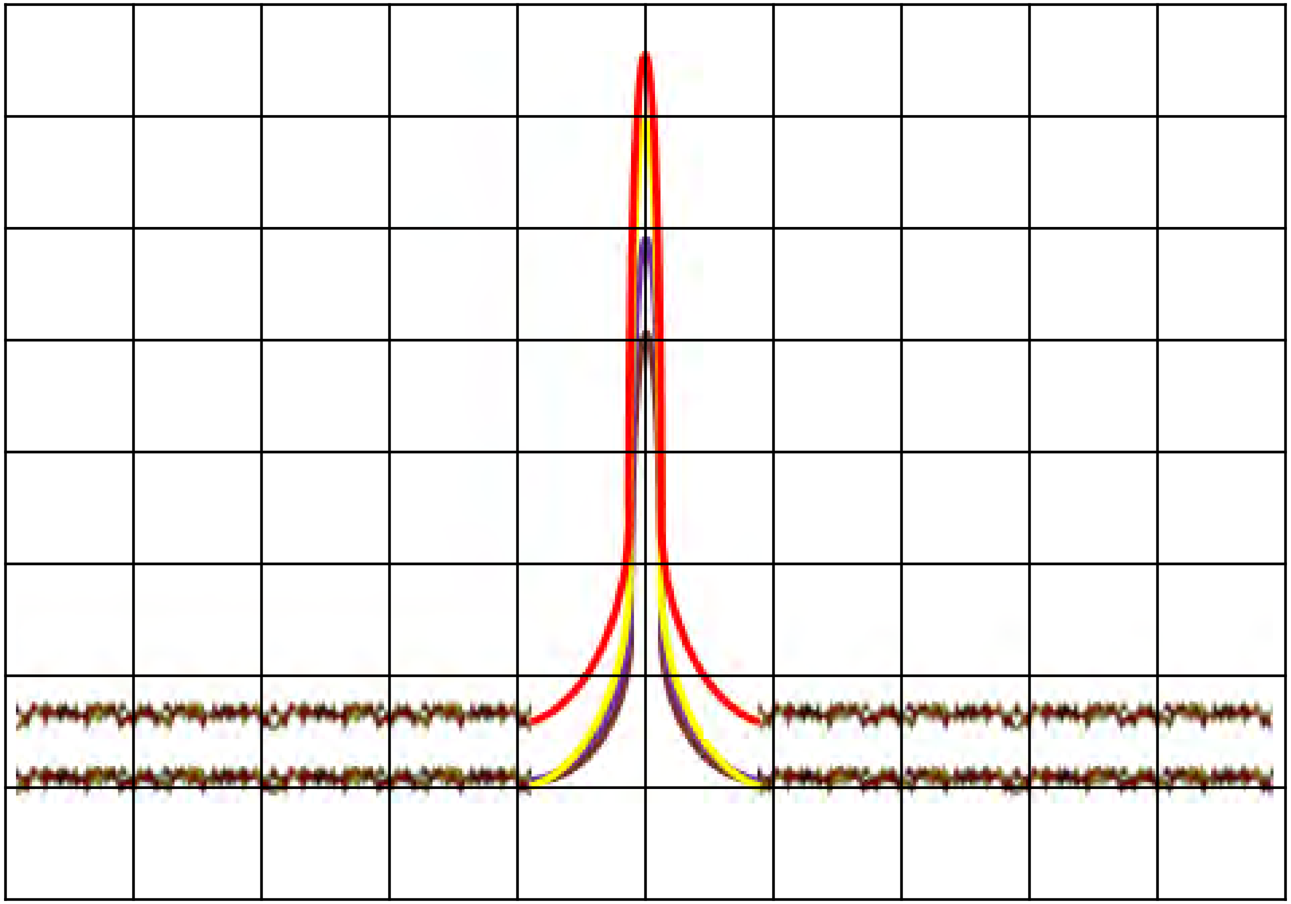
# PII HD Dual Return RX



# Output RF vs Input Light



# Optimal Input Optical Level



# Headend Optical Return RX Setup

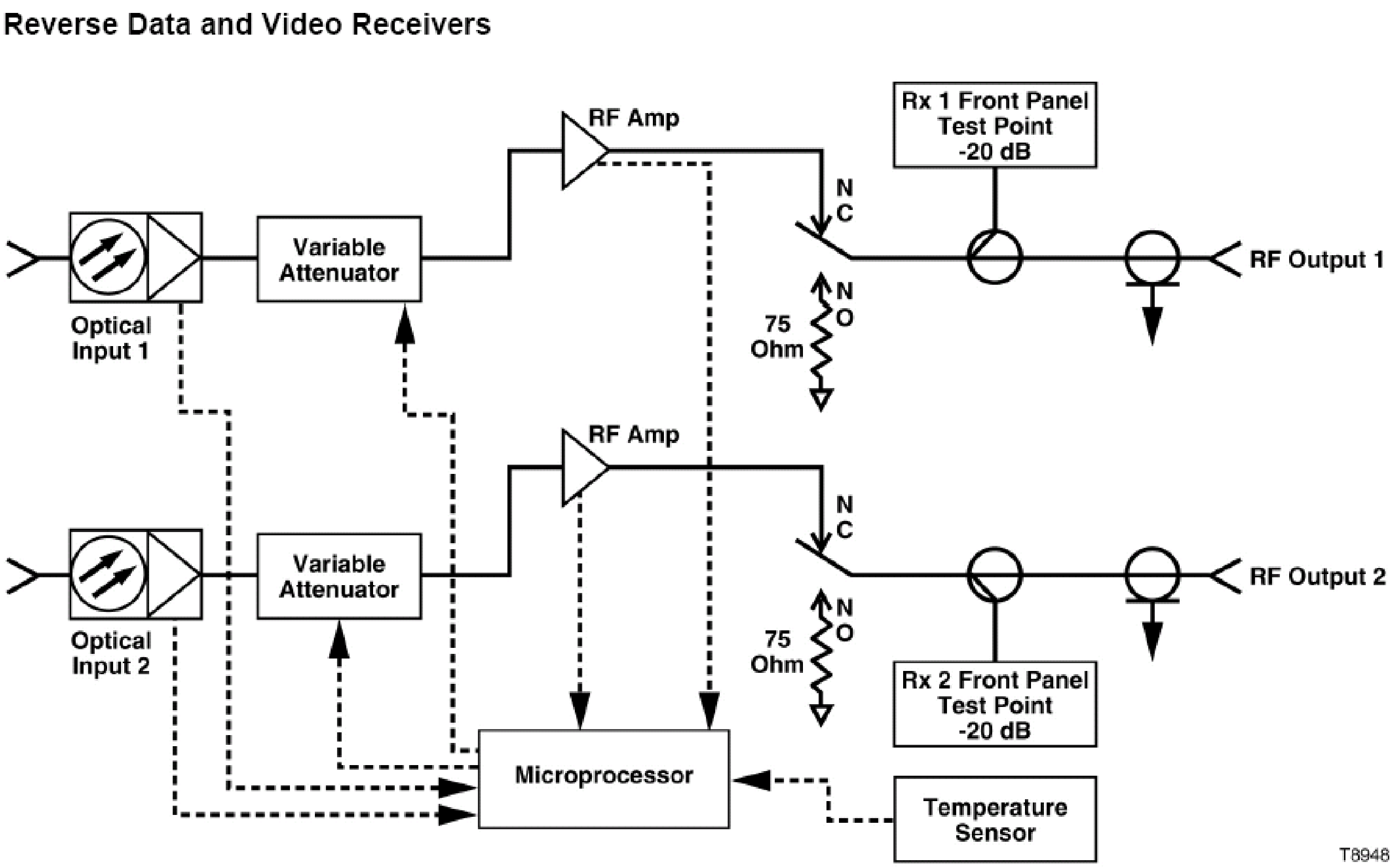
## OPTICAL INPUT POWER

- To much optical power can cause overlaoding (clipping) in the receiver
  - Typical maximum input -3 dBm, minimum input typical -17 dBm
- Use optical attenuators on extremely short paths or where too much optical power exists into a receiver
- To little optical power can cause CNR problems with that return path, even if the node's transmitter is optimized.
- For **BEST RECEIVER PERFORMANCE, DO NOT** optically attenuate optical receivers to the lowest level in the headend (farthest node).
- Find the level with which you get the best noise performance out of the receiver.
  - From experimentation most receiver are at their "sweet spot" from -12 dBm inputs to -6 dBm optical inputs.

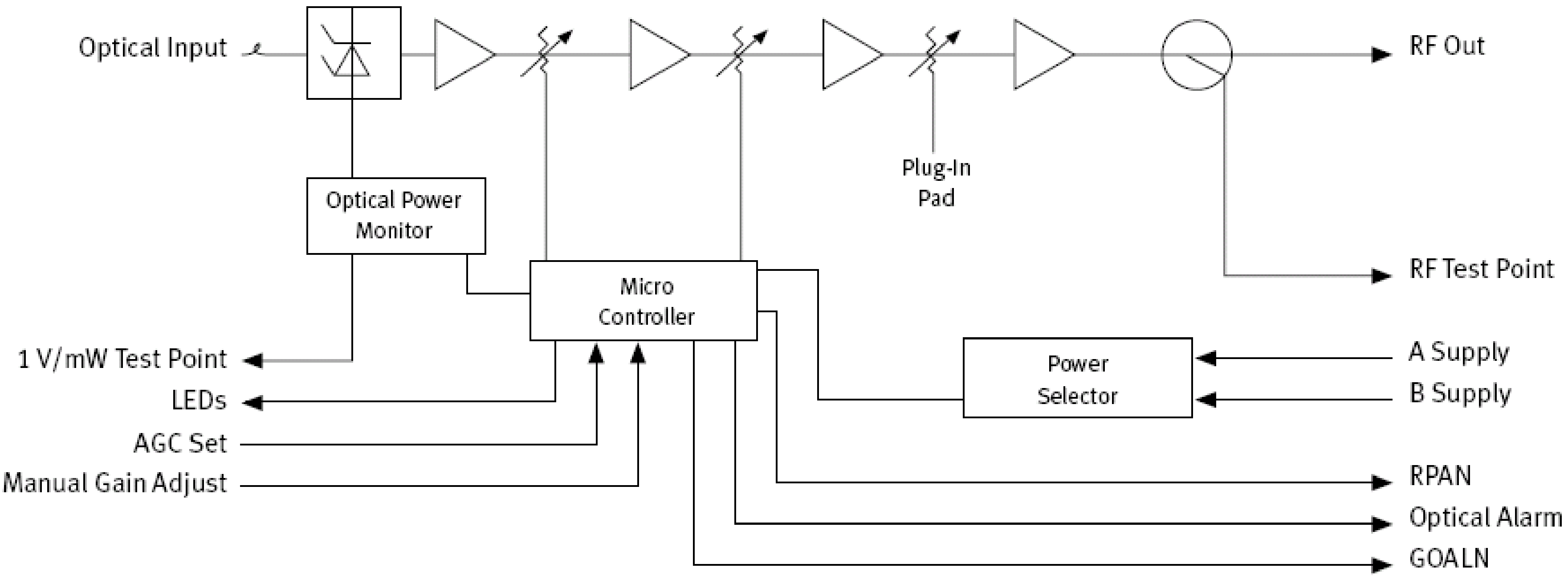
## RF OUTPUT LEVEL

- RF Level should NOT be attenuated using the internal attenuator on analog return receivers
- Attenuates the RF input the output gain blocks of the receiver
- Lowers the CNR
- Levels should be attenuated on the output of the receiver in the RF management
  - In line pads
  - Plug in pads on splitters/combiners
- If combined with other return receiver outputs can create noise issues on more paths

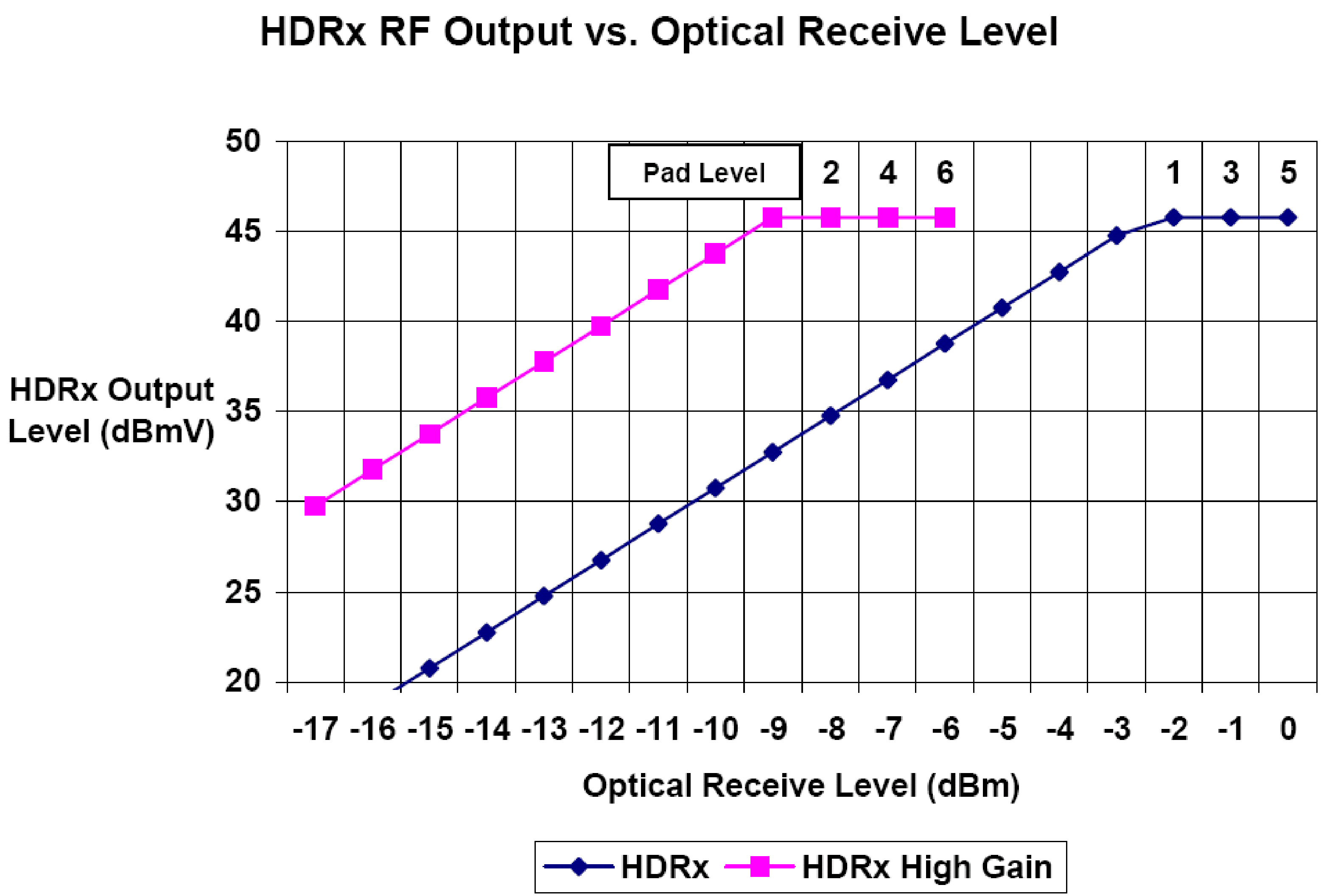
# PII HD Dual Return RX



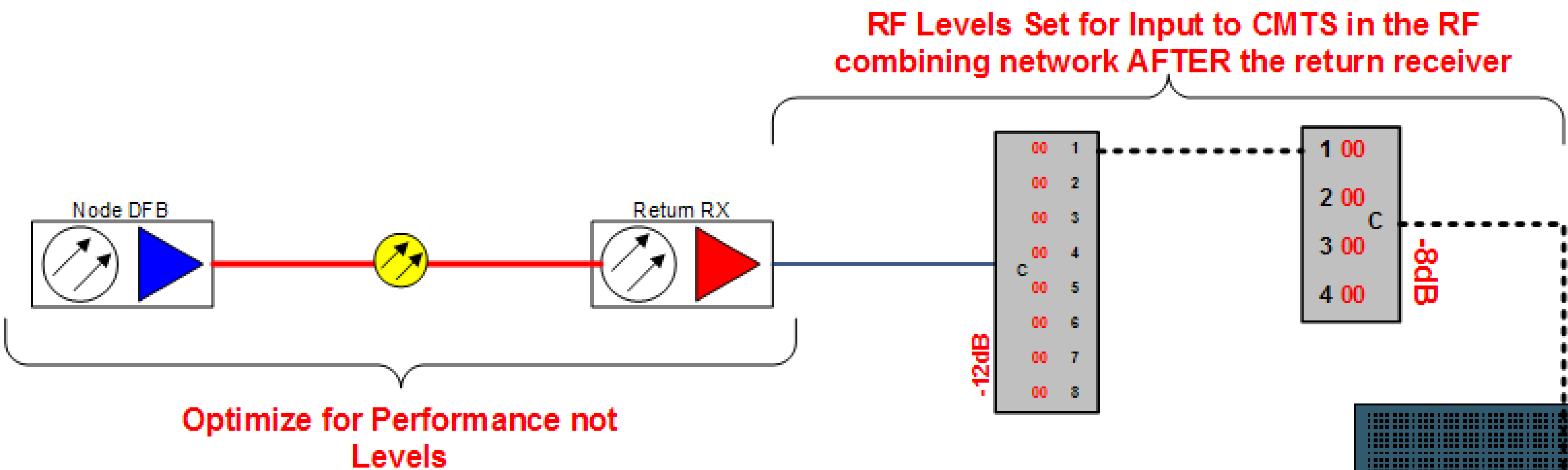
# ELLRR Schematic

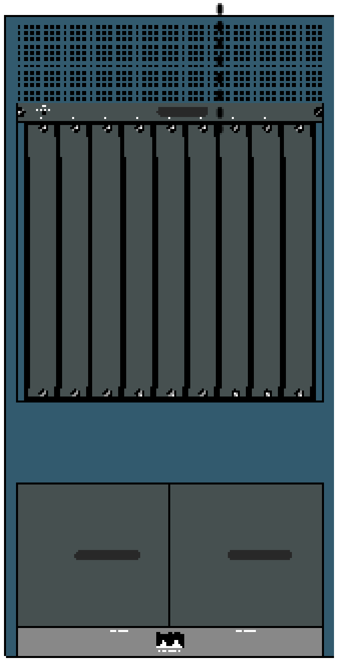


# Cisco HDRx Receiver Pad Use



# Return Path Headend RF Combining

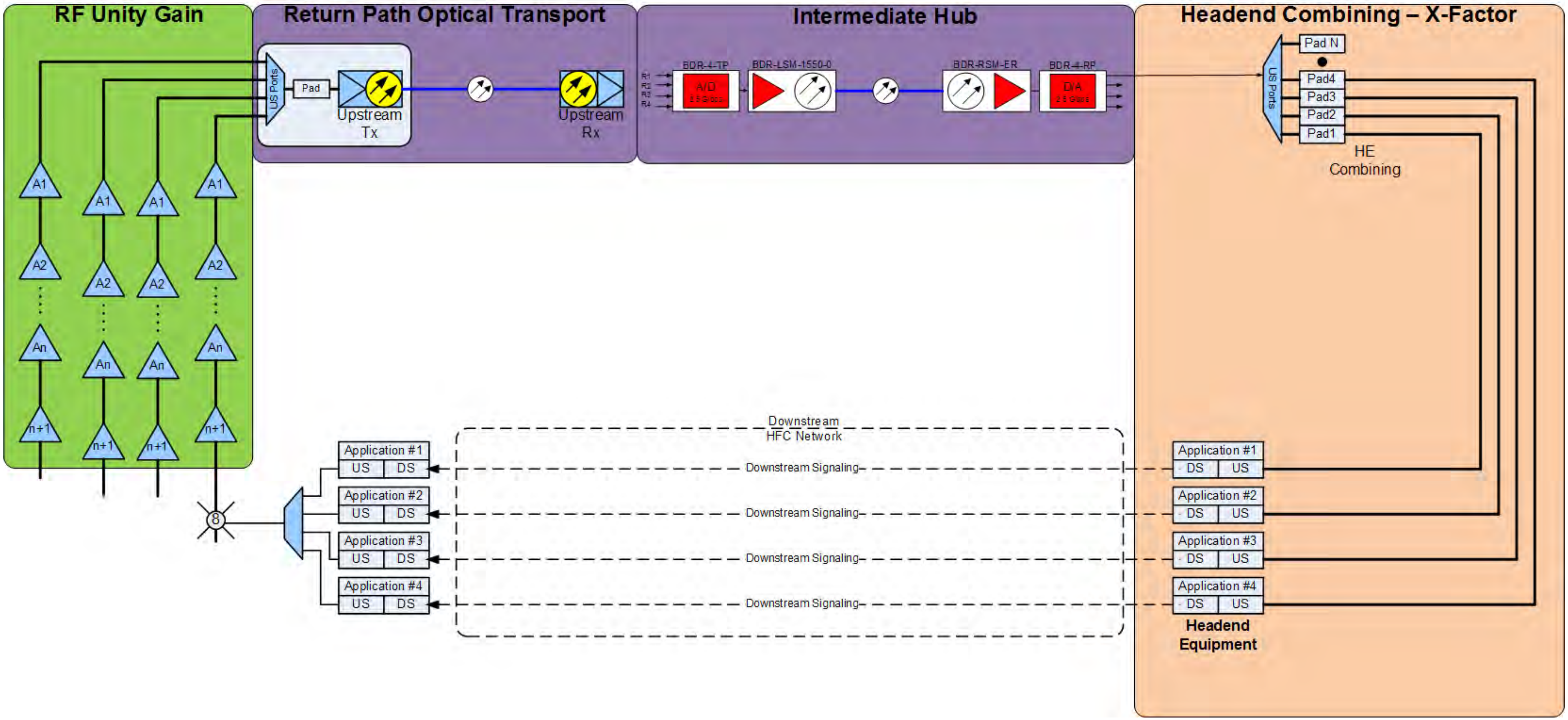


The RF pad at the node TX sets the PERFORMANCE!

The RF pads at the HE or Hub set the LEVEL!

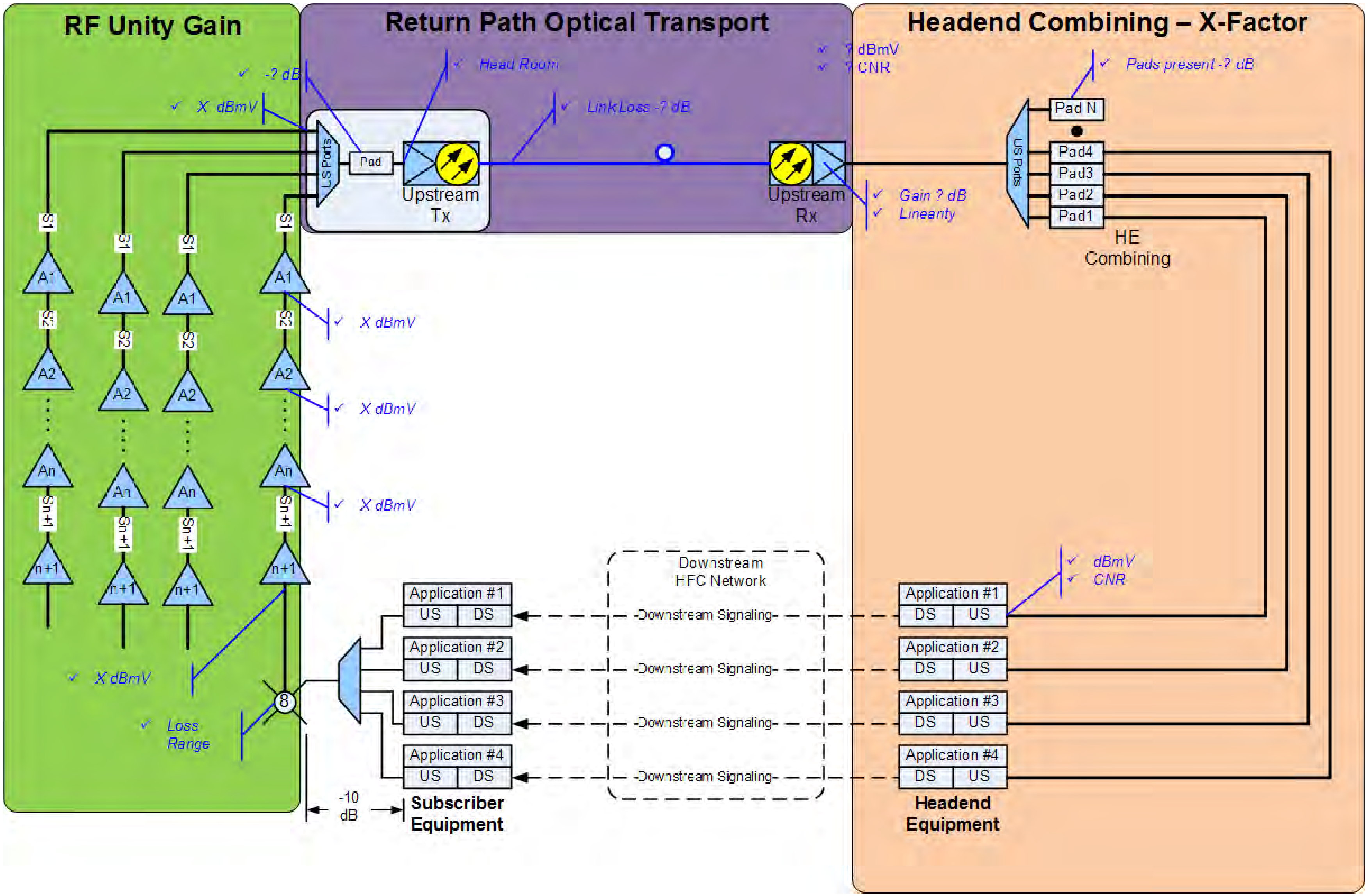
# Intermediate Hub Setup




- Must optimize each section separately
- Must continue to use telemetry!

# THE X LEVEL!

# X Level



RF Unity Gain
Return Path Optical Transport
Headend Combining – X-Factor
-? dB
X dBmV
Head Room
Link Loss -? dB
? dBmV
? CNR
Pads present -? dB
US Ports
Pad
Upstream Tx
Upstream Rx
Gain ? dB
Linearity
Pad N
Pad4
Pad3
Pad2
Pad1
HE Combining
S1
A1
S2
A2
An
Sn+1
n+1
X dBmV
X dBmV
X dBmV
X dBmV
Loss Range
8
Downstream HFC Network
Downstream Signaling
Application #1
Application #2
Application #3
Application #4
US
DS
dBmV
CNR
-10 dB
Subscriber Equipment
Headend Equipment

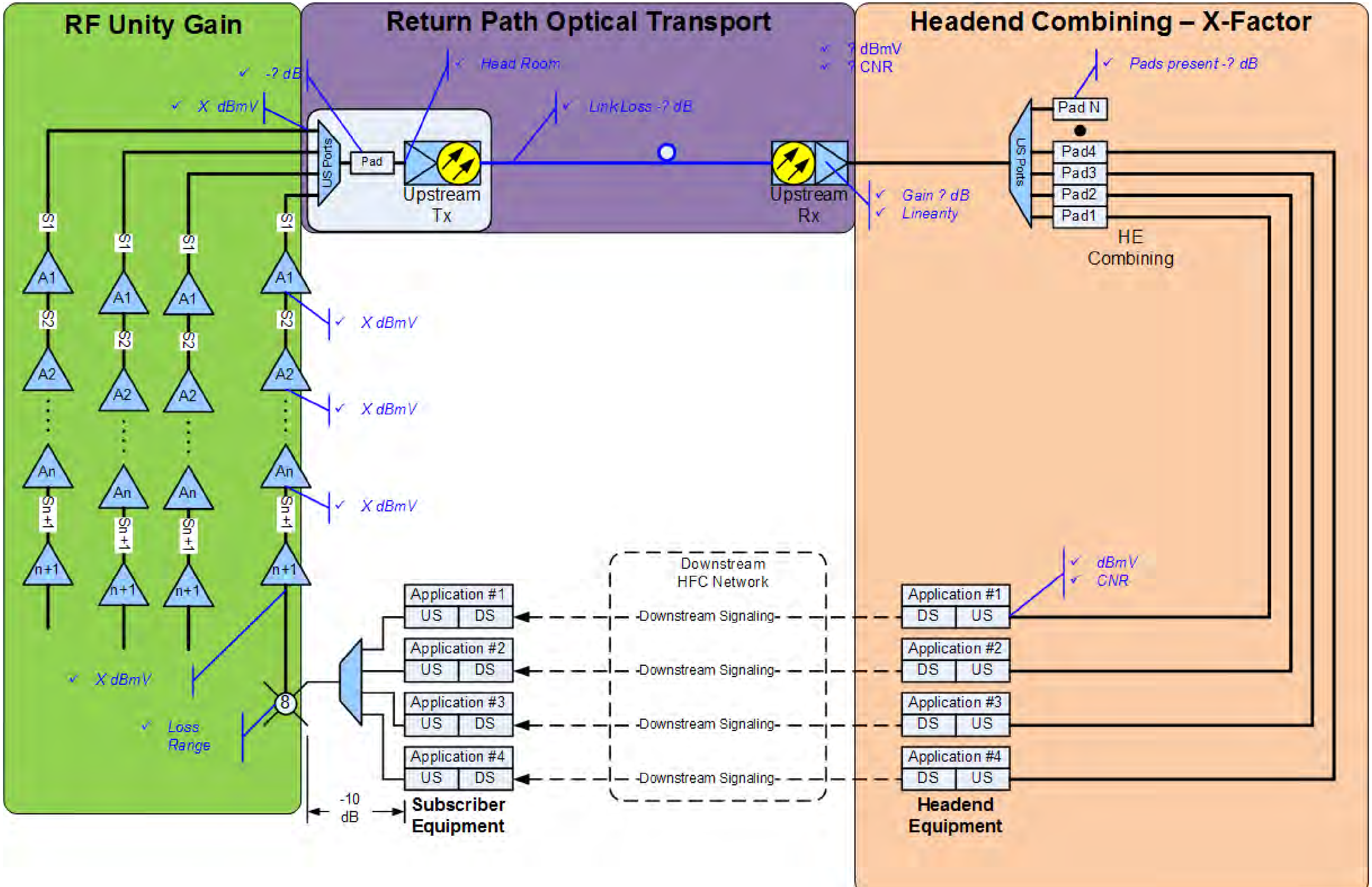
# Setting up the Return Path

- Determine your system “X” Level
- Determine the Return Transmitter “Window”
- Padding the Transmitter
- Optimize Return Receiver Setup
- Distribution out of the Return Receiver
- Padding the inputs to the Headend Equipment

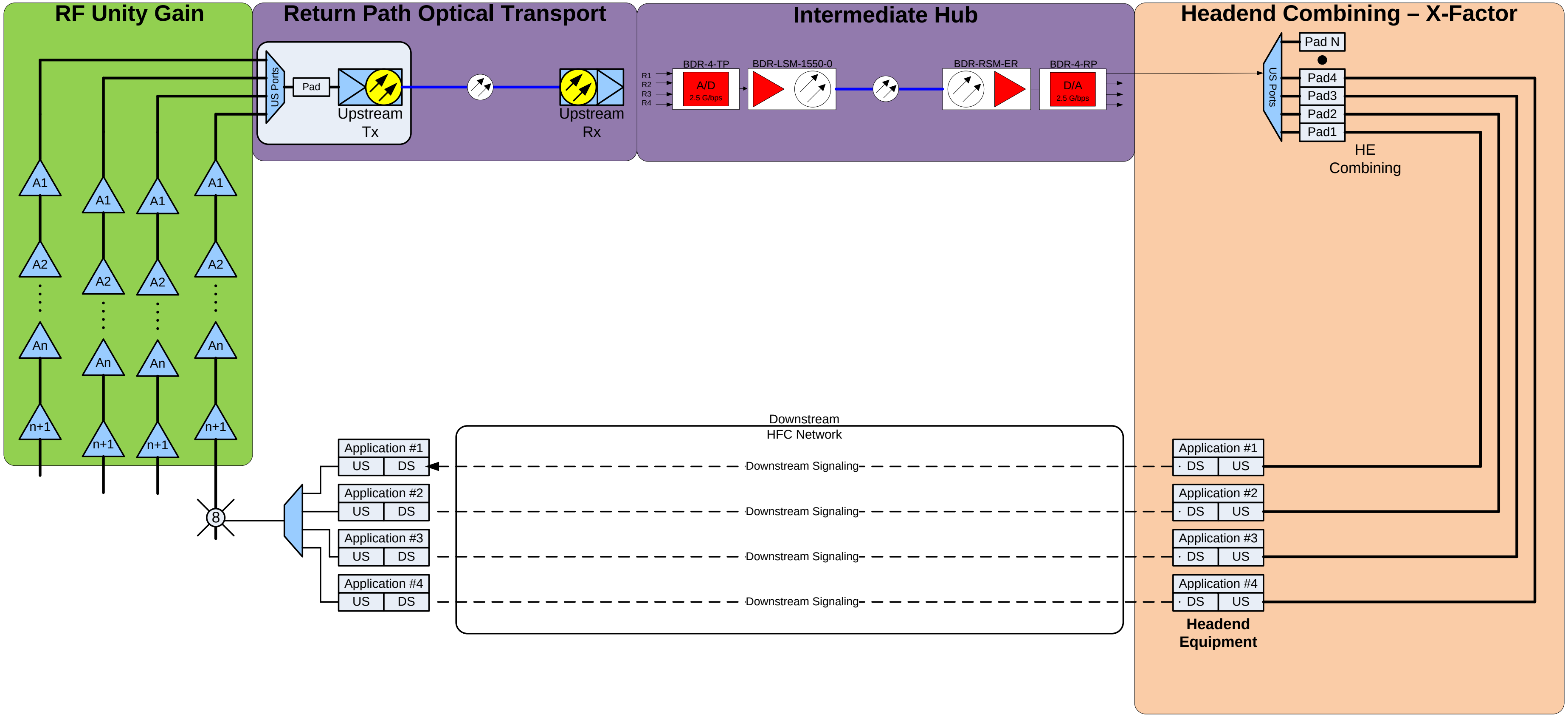
# Changes to the Return Network

- ANY CHANGES TO THE RETURN PATH FROM THE SUBSCRIBER TO THE HEADEND CAN EFFECT ITS PERFORMANCE
- Planned
  - Segmentation of Return
    - Changes in Headend or Node
- Un-Planned
  - Bad tap
  - Optoelectronics Failure
  - Ingress
  - Technician – Laser RF input level changes in the field

# ANY CHANGES TO THE RETURN PATH FROM THE SUBSCRIBER TO THE HEADEND CAN AFFECT ITS PERFORMANCE



# ANY CHANGES TO THE RETURN PATH FROM THE SUBSCRIBER TO THE HEADEND CAN AFFECT ITS PERFORMANCE



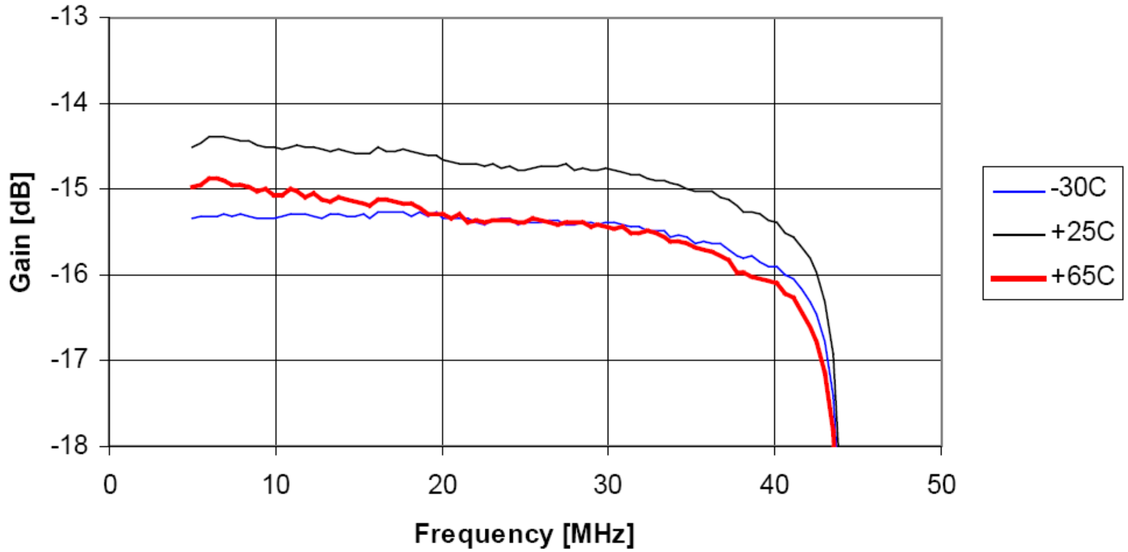

# Return Path Maintenance and Troubleshooting

# Group Delay

- Group delay is defined in units of time, typically nanoseconds (ns)
- In a system, network or component with no group delay, all frequencies are transmitted through the system, network or component with equal time delay.
- Frequency response problems in a CATV network will cause group delay problems.
- If a cable network's group delay exceeds a certain amount, data transmission and bit error rate may be affected.
- As long as group delay remains below a defined threshold—DOCSIS specifies 200 nanoseconds/MHz in the upstream—group delay-related BER shouldn't be a problem.

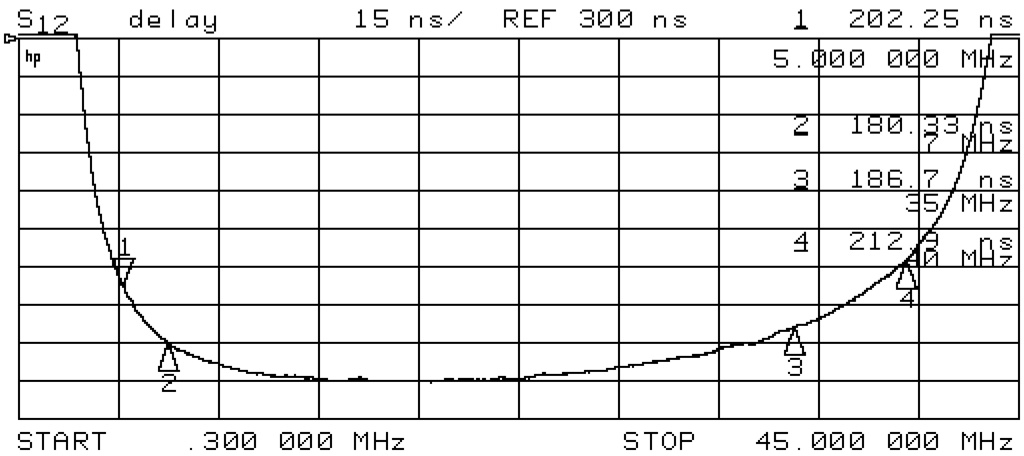
# Group Delay

Amplitude (dB)




Frequency Response: What we see on our sweep gear

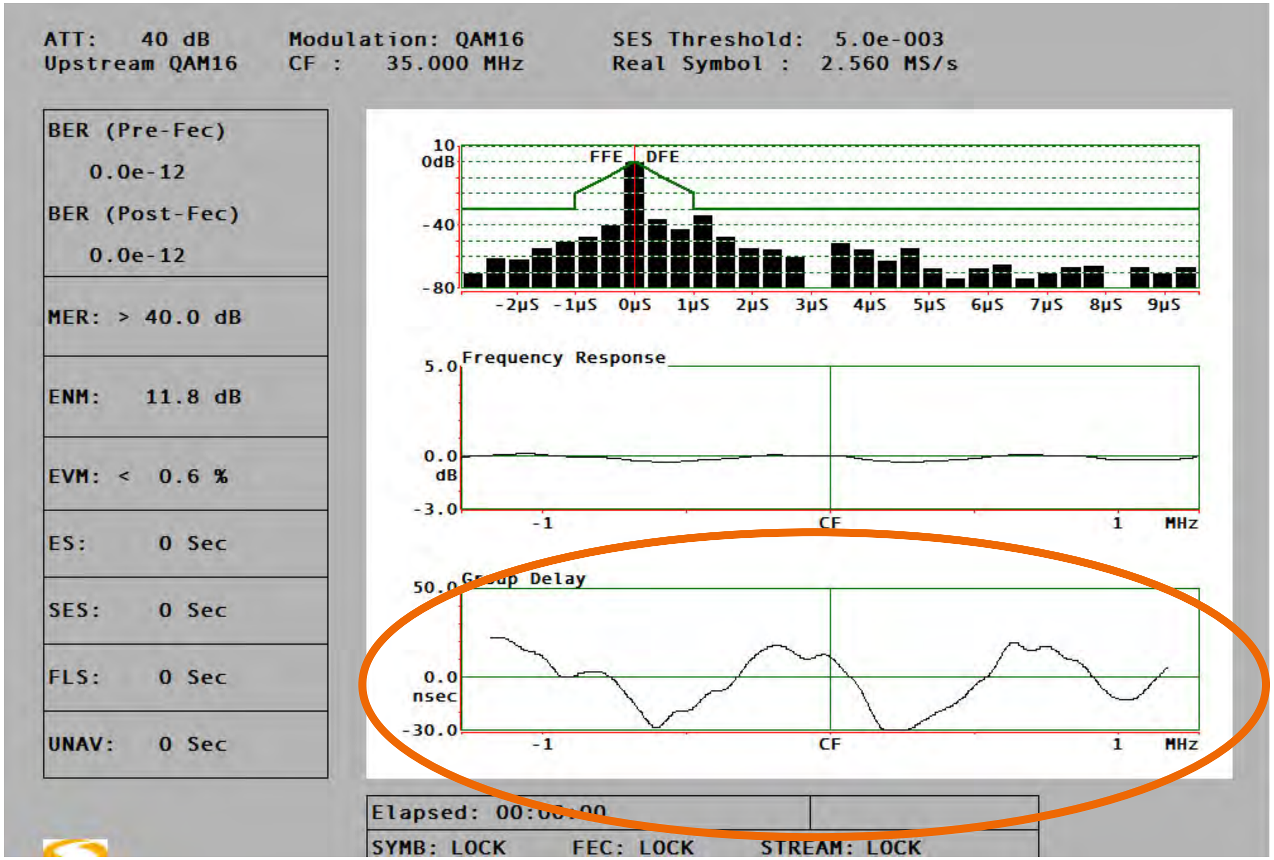
Time (nanoseconds)




Group Delay: What we *don't* see on our sweep gear

# Group Delay

- Specialized test equipment can be used to characterize upstream in-channel performance
- In this example, in-channel group delay ripple is about 60 ns




Courtesy of Sunrise Telecom

# Conclusions

- Return system is a loop
- Changes anywhere in the loop can effect the performance of the network
- Once the return laser is setup DON'T TOUCH IT

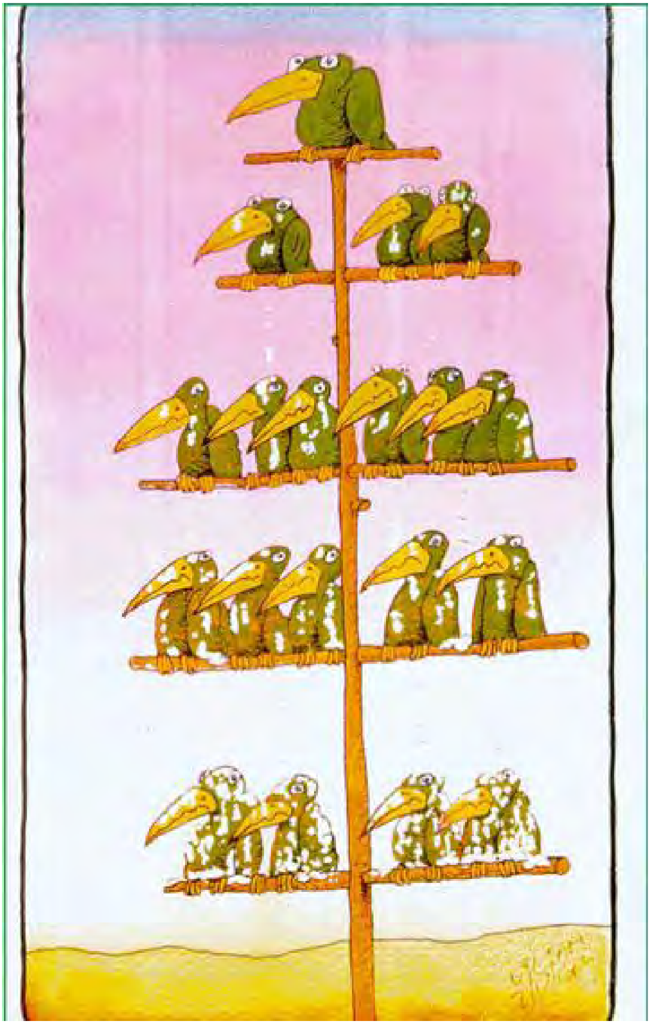
  Changing the drive levels can affect the window of operation of the laser

- Work as a team to diagnose system problems

  LMC

  Market Health, Scout, Score Card

- Avoid performing node setups during extremes in outdoor temperatures



# Questions


# Backup Slides

# Determining Power Levels

- Power per Hz:

  Power per Hz = total power – 10 log(total bandwidth in Hz)

- Channel power from power per Hz

  Channel power = power per Hz + 10 log(channel bandwidth in Hz)

# Power Levels

- Example: Calculate the power per Hz for a manufacturer’s +45 dBmV maximum laser input power specification in the 5-40 MHz reverse spectrum (35 MHz bandwidth)

Power per Hz = Total power - 10log(total bandwidth in Hz)

Power per Hz = +45 dBmV - 10log(35,000,000)

Power per Hz = -30.44 dBmV per Hz

-30.44 dBmV per hertz represents the maximum power into the laser allocated over 35 MHz

Now let’s calculate what a 2 MHz wide QPSK carrier would need to be to equate to that level.

# Determining Digital Power Levels

- 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 + 10log(channel bandwidth in Hz)

Channel power = -30.44 + 10log(2,000,000)

Channel power = +32.57 dBmV