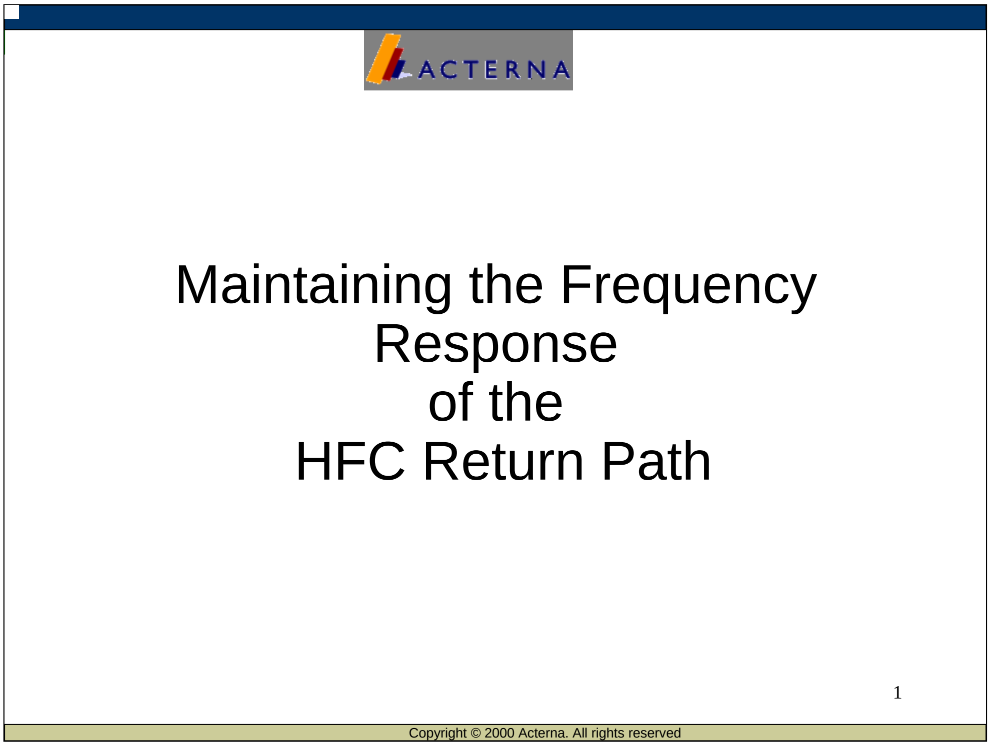
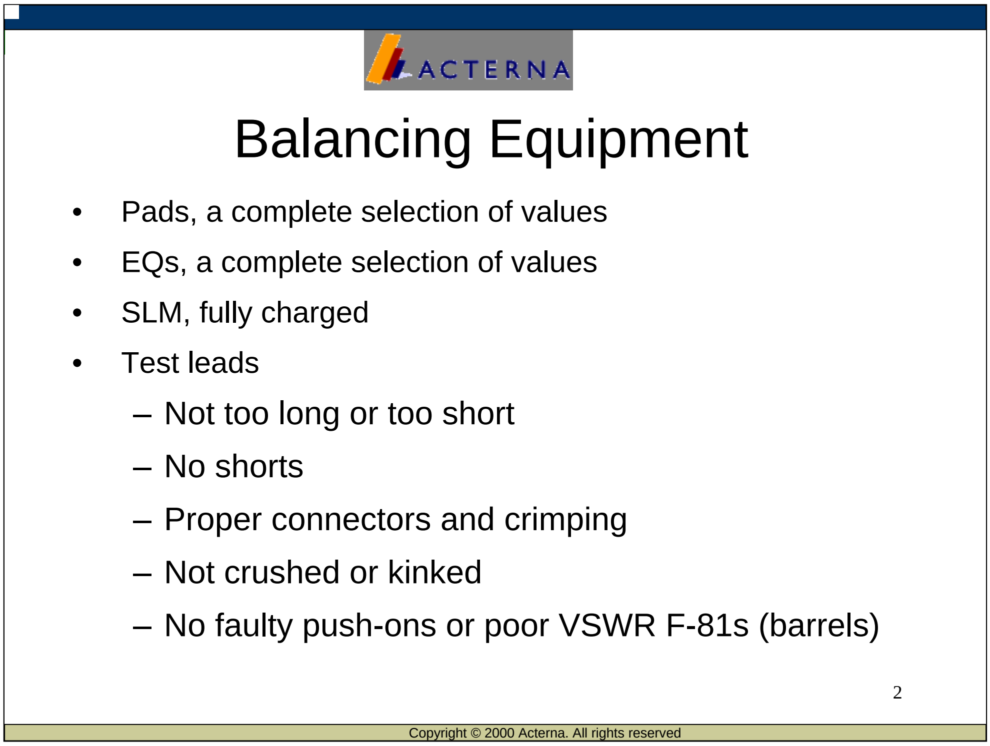


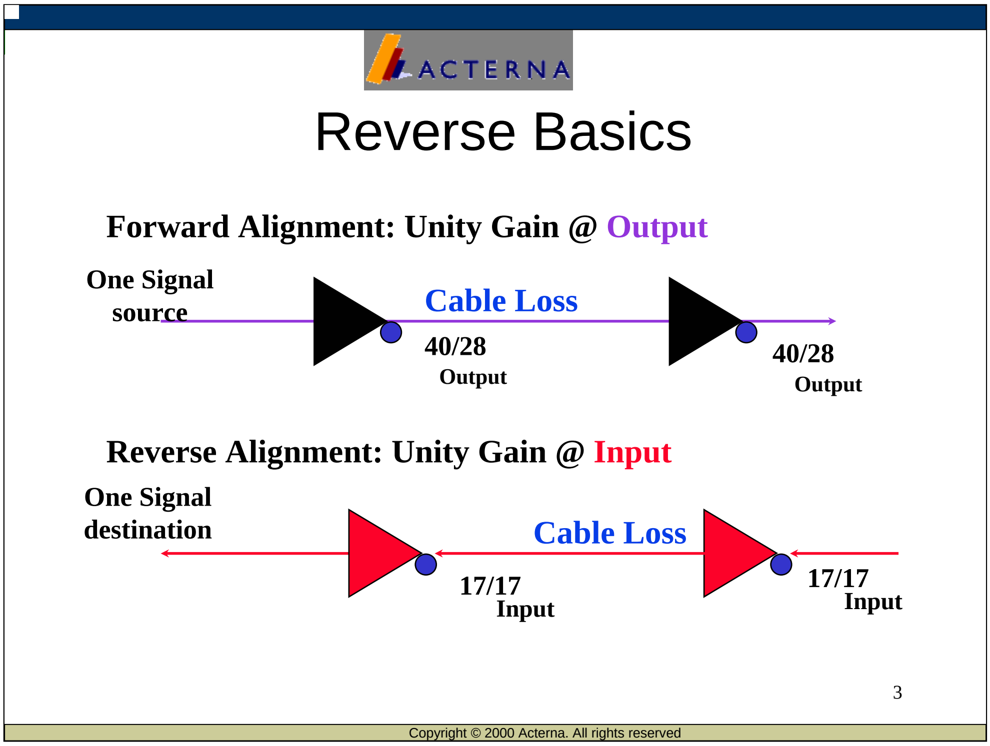
Maintaining the Frequency Response of the HFC Return Path



Balancing Equipment

- Pads, a complete selection of values
- EQs, a complete selection of values
- SLM, fully charged
- Test leads
  - Not too long or too short
  - No shorts
  - Proper connectors and crimping
  - Not crushed or kinked
  - No faulty push-ons or poor VSWR F-81s (barrels)

- Many of the same accessories for the forward path are needed for the return plant.



Reverse Basics

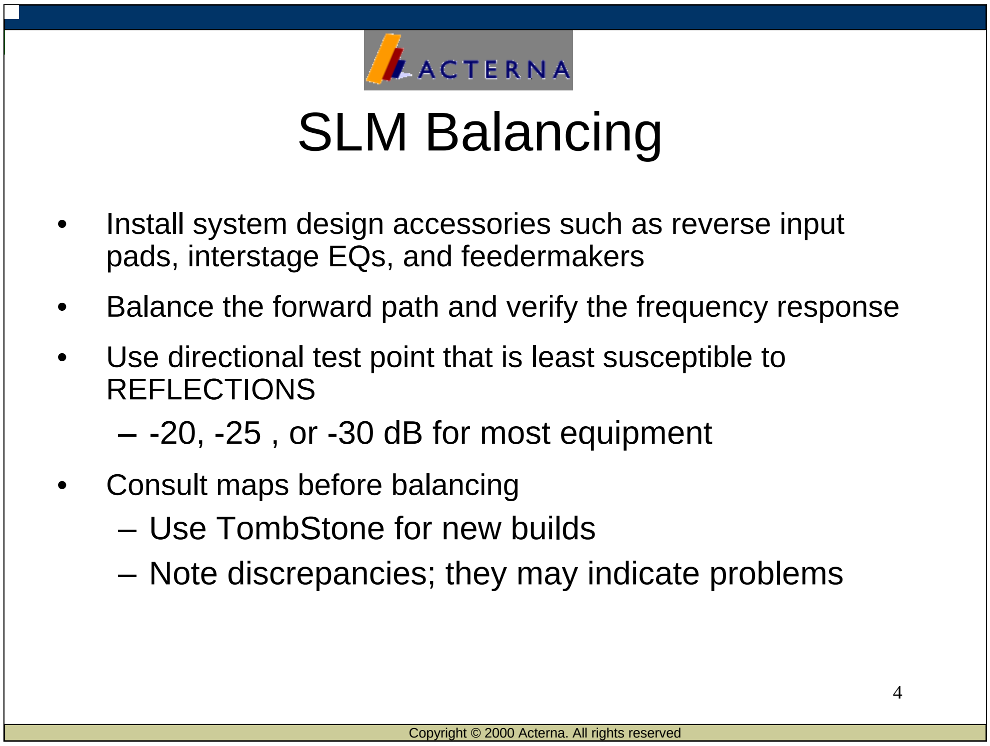
Forward Alignment: Unity Gain @ Output

Reverse Alignment: Unity Gain @ Input

- The hardest thought for a cable person. We just balanced in the forward, have unity gain, and now what is the fuss over the reverse?

- Here the unity gain concept is different. We now balance an amplifier to compensate for the loss it will incur, and are looking at the input to the next amplifier.

- The old method required two people, but modern equipment permits one person to balance and sweep both directions of the system in one pass.



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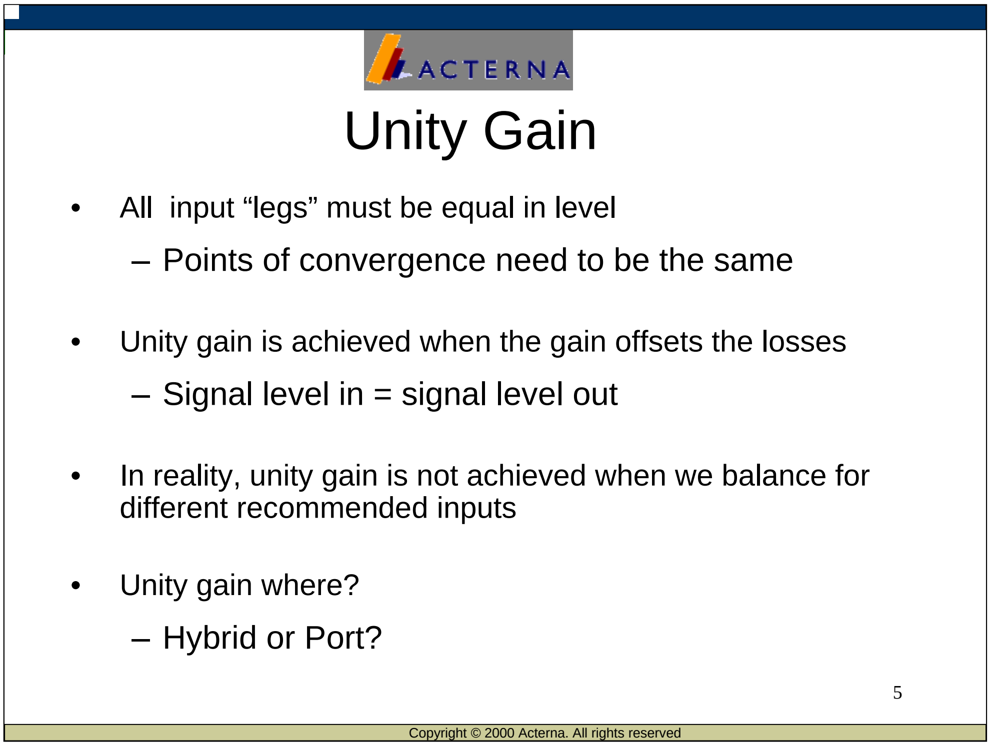
SLM Balancing

- Install system design accessories such as reverse input pads, interstage EQs, and feedermakers
- Balance the forward path and verify the frequency response
- Use directional test point that is least susceptible to REFLECTIONS
  - -20, -25 , or -30 dB for most equipment
- Consult maps before balancing
  - Use TombStone for new builds
  - Note discrepancies; they may indicate problems

4

•The system designer recommended certain accessories for performance reasons. Do not arbitrarily deviate from their recommendations. It could have detrimental effects. If they call for a 3 dB reverse input pad, use it.

•Any unit that requires additional padding or equalization above or below 2 dB should be rechecked or at least questioned.



Unity Gain

- All input “legs” must be equal in level
  - Points of convergence need to be the same
- Unity gain is achieved when the gain offsets the losses
  - Signal level in = signal level out
- In reality, unity gain is not achieved when we balance for different recommended inputs
- Unity gain where?
  - Hybrid or Port?

•The big difference between the forward path and reverse path is the mere fact that multiple outputs on an amplifier are probably also inputs. These multiple inputs all feed one reverse hybrid and each input may have different losses to the hybrid.

•This concept, Unity Gain, is to provide all similar amplifiers with equal operating parameters. This is done so that simple formulas can be used to provide accurate performance numbers, indicating whether a system is operating at levels as prescribed, or suggested by the manufacturer. This also allows easier implementation because of consistent numbers and less variables.

•Typically, we use output signal levels for the outbound signals, and input levels to set the inbound path. When all units have the same characteristics, we have achieved Unity Gain. Consult system maps or the system engineer if questions arise concerning levels.

•The big question is, where is the unity gain point? Do I balance for constant inputs to the amplifier diplex filter or the actual hybrid. Also, how was it designed and spaced? This subject is beyond the scope of this paper and is covered in other modules. Many systems now balance constant inputs to the diplex filter and disregard the internal losses from the port to the hybrid. This is to accommodate the modem outputs, design, and better C/I and C/N.

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Reverse Balancing

- The original method was to balance the last active and work back towards the Headend
- Each amplifier will typically maintain the same flat signal input level
- We condition the signal after the hybrid to achieve an output that will offset the losses to the next active
- The amplifier is aligned to compensate for the losses towards the Headend
- Only EQs and pads are available - no cable simulators needed

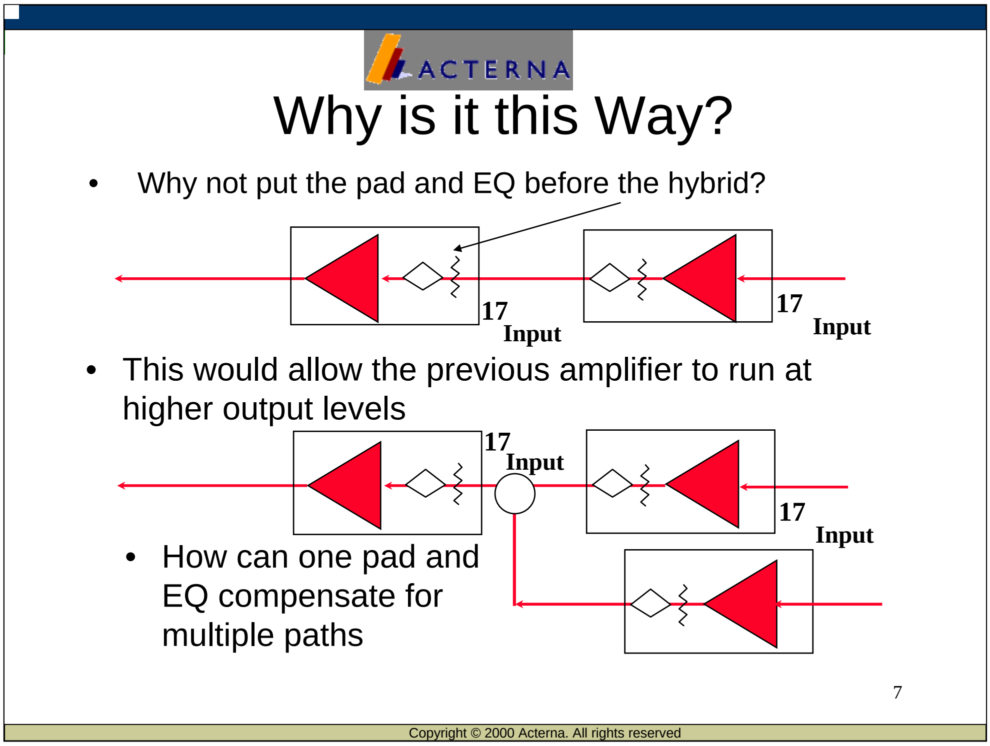
- The goal is to hit the hybrid with matching inputs so that one service doesn’t override another.

- Keep in mind that all noise is funneled back towards the Headend.

- If the signals are data, and are destined to be returned in the forward direction, it now may have noise from both directions to deal with. This depends on the master modem in the Headend. If it is a pure translator like the early proprietary modems (Zenith, LanCity), it will upconvert the upstream signal to a forward signal for broadcast on the downstream. This utilized a MAC protocol of CSMA/CD. DOCSIS compliant modems utilize a request and grant protocol, which is much more efficient.

- Translators don’t care where the signal comes from or where it goes. Noise in, noise out.

- Because reverse balancing is setup with flat inputs and the amplifiers don’t have built-in tilt, the input to the next amplifier would have negative tilt because of cable loss characteristics. This would be flattened with the use of a Reverse EQ. There should never be a need for cable simulators in the reverse.



Why is it this Way?

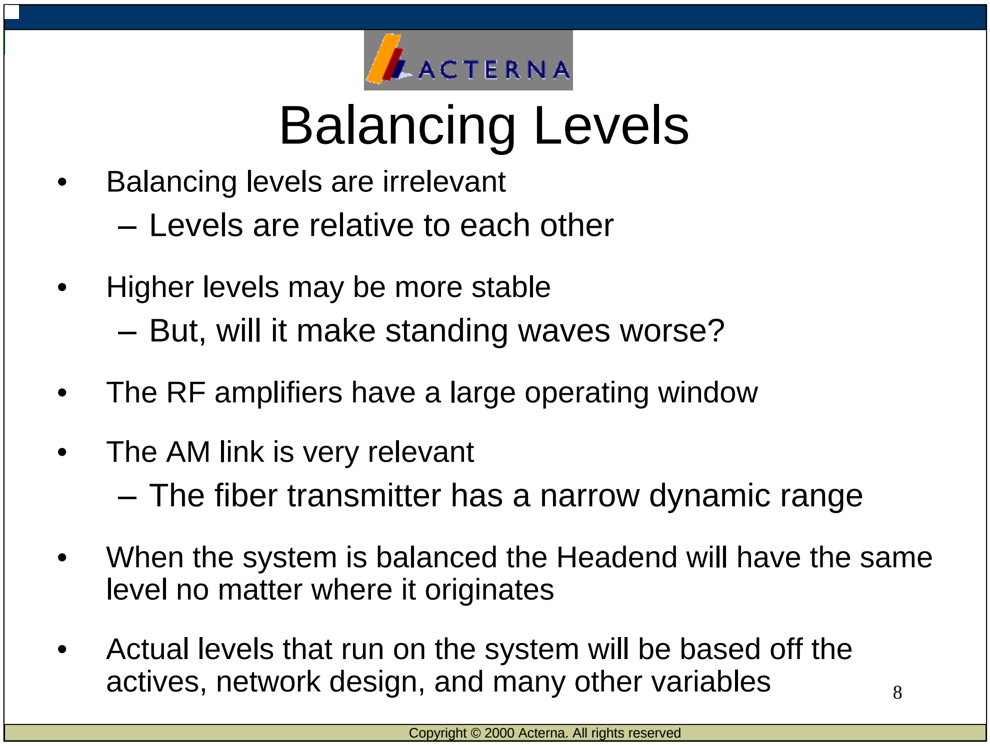
- Why not put the pad and EQ before the hybrid?

- This would allow the previous amplifier to run at higher output levels

- How can one pad and EQ compensate for multiple paths

•Some of the early GI amplifiers actually did this before they truly understood the nature of the reverse plant.

•Many amplifiers now have reverse input pads, but these are not meant for balancing. They are used for troubleshooting and special design considerations.



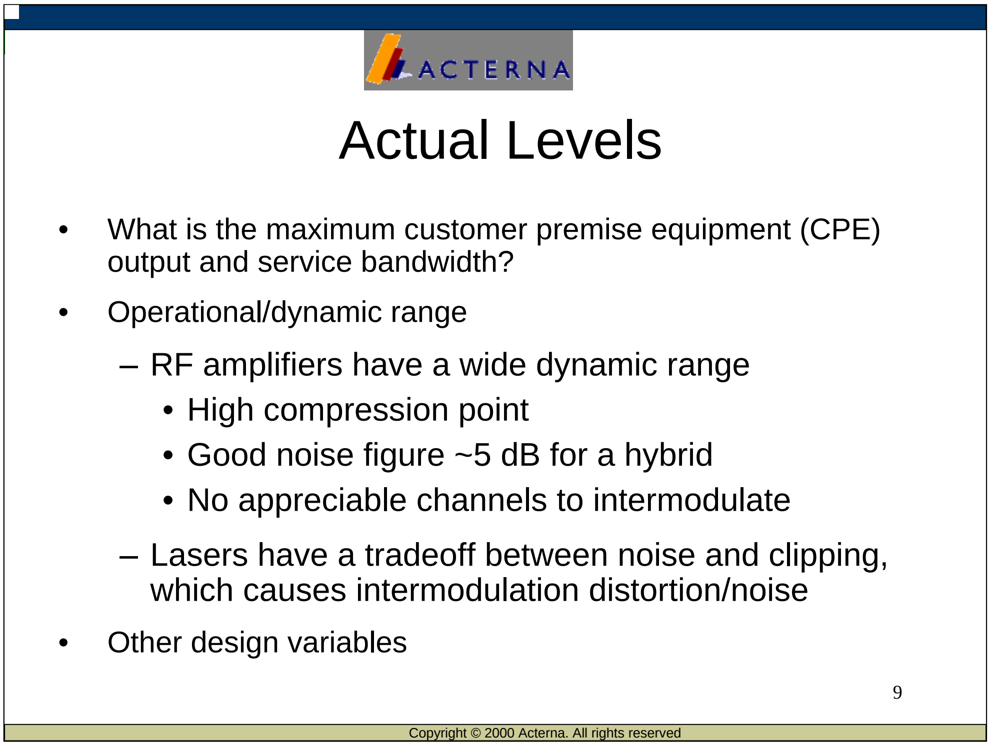
Balancing Levels

- Balancing levels are irrelevant
  - Levels are relative to each other
- Higher levels may be more stable
  - But, will it make standing waves worse?
- The RF amplifiers have a large operating window
- The AM link is very relevant
  - The fiber transmitter has a narrow dynamic range
- When the system is balanced the Headend will have the same level no matter where it originates
- Actual levels that run on the system will be based off the actives, network design, and many other variables

•Some signal generators may not be able to achieve a high enough level to overcome test point and accessory losses and still provide the recommended level. These levels are relative to each other. If I balance the first line extender for 6 dBmV instead of 17, then the second LE input would be 6 dBmV instead of 17 dBmV.

•Sometimes a higher level will be more stable because of the dynamic range of the signal level meter (SLM). Example: At one site when I balanced with the recommended input of 17/17, the SLM was jumping all over because of ingress and noise. I injected with 20 dBmV and balanced for 20 and the levels stabilized!

•One concern is: will the higher sweep level cause worse standing waves when sweeping into a bi-directional test point. Technically, the standing wave response is a combination of a main signal and reflected signal. Since both signals are increases proportionally, the standing wave severity would be the same.



Actual Levels

- What is the maximum customer premise equipment (CPE) output and service bandwidth?
- Operational/dynamic range
  - RF amplifiers have a wide dynamic range
    - High compression point
    - Good noise figure ~5 dB for a hybrid
    - No appreciable channels to intermodulate
  - Lasers have a tradeoff between noise and clipping, which causes intermodulation distortion/noise
- Other design variables

•Some CPE equipment can transmit in excess of 55 dBmV.

•For narrow data carriers, transmit levels may not need to be as high because of the data derating factor.

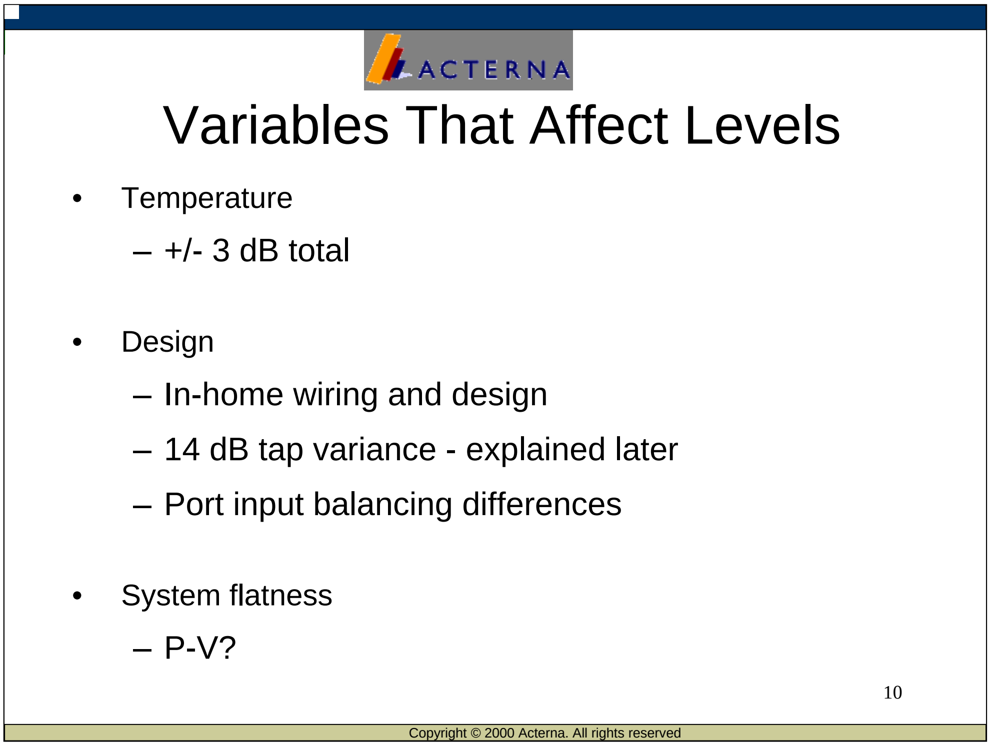
•The RF hybrids used for the return amplification have a much wider dynamic range than the lasers.

•The laser input may be specified for 50% OMI or 100 OMI. It may also be specified for different loading than what will actually be carried.

•Balance the reverse RF path with the recommended procedure. Balance the AM path with 1 video channel at its recommended level and observe the respective level in the Headend.

•After services become saturated it may be necessary to adjust/derate the data levels to be lower than originally measured in the Headend by: 10*log(reverse bandwidth/X) where X = BW of the single data carrier. The derating pad should be placed prior to the AM transmitter, possibly the reverse port pad or OMI control. Different modulation type carriers may need derated more and will have to be done at the source (Modem, NID, etc.)

•Note: The widest carrier intended to be used will require the least amount of derating. This derating factor could be calculated and designed into the Node.



Variables That Affect Levels

- Temperature
  - +/- 3 dB total
- Design
  - In-home wiring and design
  - 14 dB tap variance - explained later
  - Port input balancing differences
- System flatness
  - P-V?

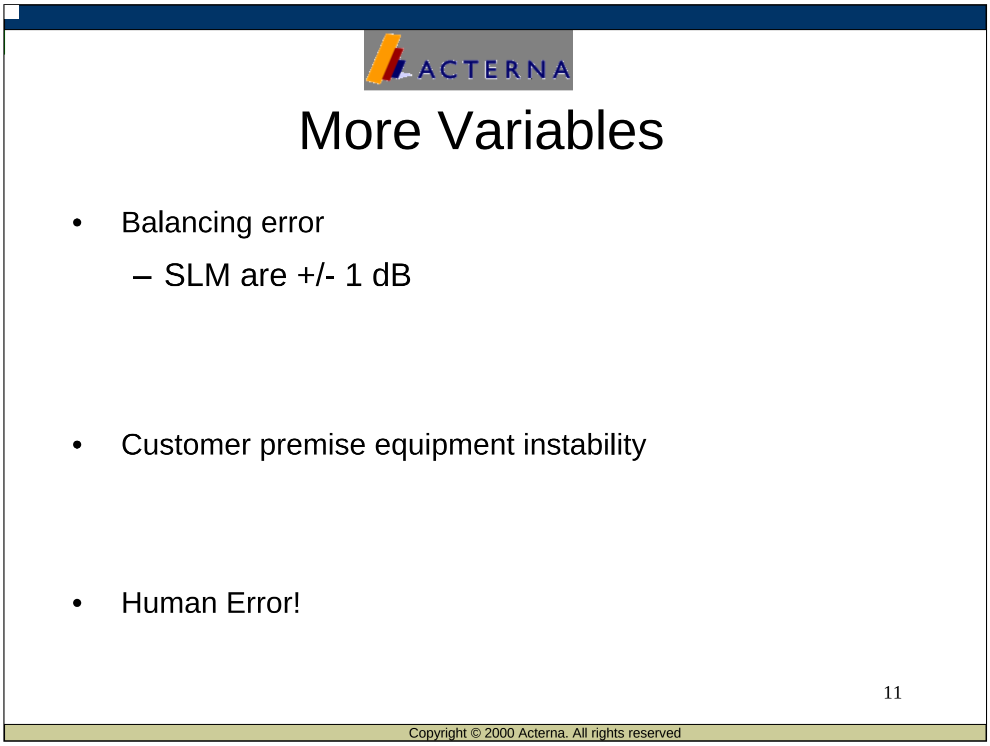
- Temperature will affect cable loss, hybrid gain, and passive responses. Sunloaded, black jacketed cable is worsened by temperature swings. ~ 45 degrees above ambient!

- If constant input to the port is not followed this will cause more variances. Especially between a multiple output trunk amp and a single output LE.

- If LE derating is done, tapped trunk design, or multiple vendor equipment is used and no special considerations are made, this will cause even more variances.

- What is the highest and lowest value taps in your plant?

- The system peak-to-valley (P-V) will cause a variance for signals located at different frequencies in the passband.



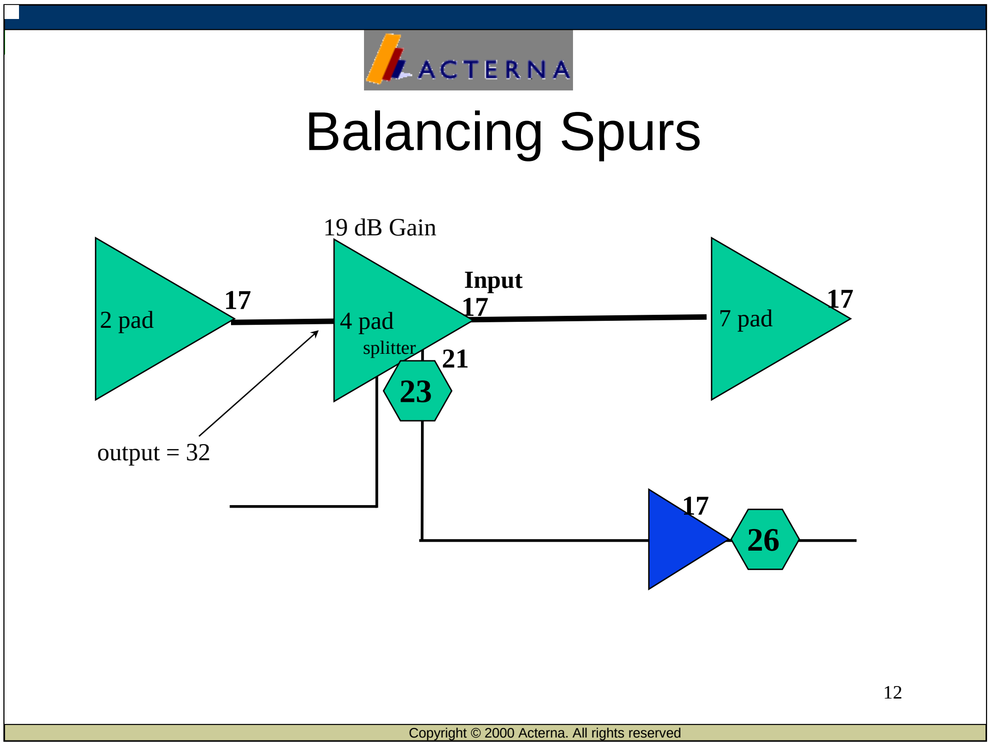
More Variables

- Balancing error
  - – SLM are +/- 1 dB
- Customer premise equipment instability
- Human Error!

- Signal level meters (SLMs) are not created equal. Also, temperature swings during the day can cause misbalancing.

- Customer premise equipment is not as accurate as one would think.

- This is all in addition to human error!



Balancing Spurs

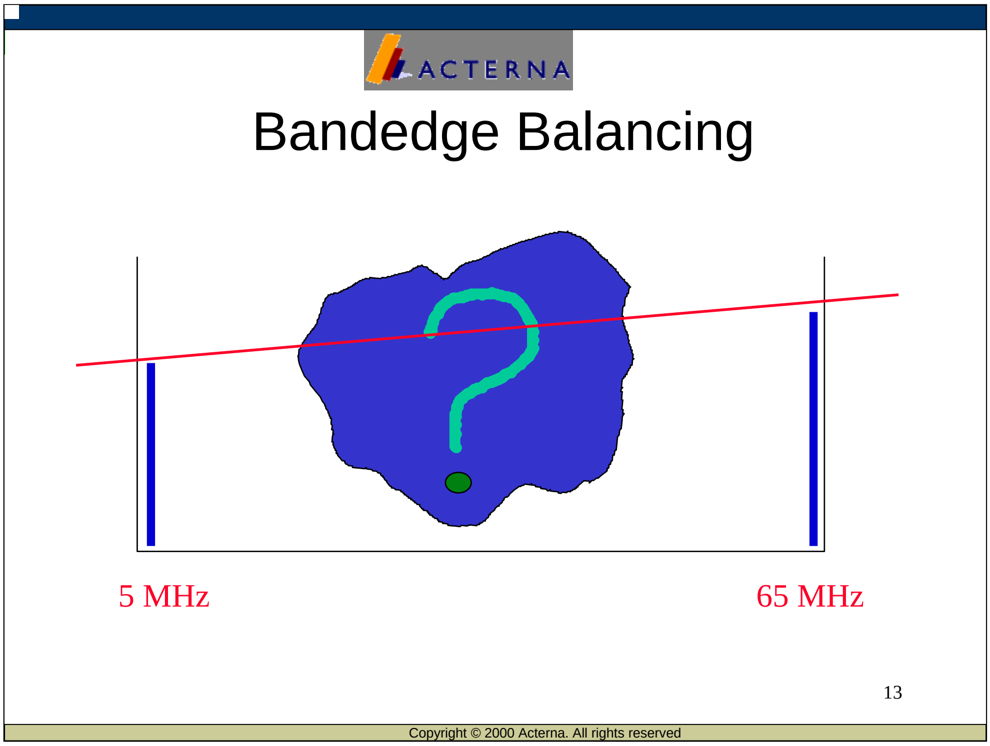
- Start balancing at the end-of-line active on the longest cascade.

- Proceed by balancing the spurs or feeders off of that cascade.

- It may be advantageous to balance through a point of convergence by balancing for the recommended input to the next amp upstream.

- It would also be possible to balance for the convergence point output which was achieved and recorded when the original trunk line was balanced.

- This eliminates guess work on the internal and extra accessory losses.



Bandedge Balancing

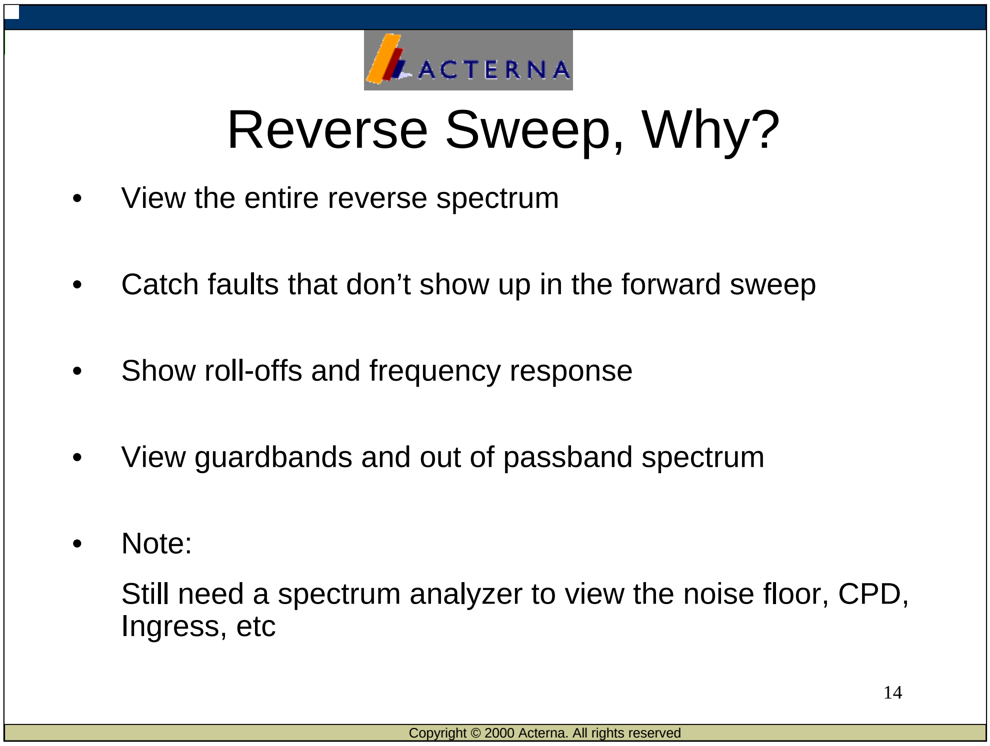
5 MHz

65 MHz

- Rough, or Bandedge balancing, is the technique that is used to verify the operation of the amplifier. It is also the starting point for the fine balancing, and sweep of the system.

- Remember, the SLM is a frequency selective voltmeter.

- SLMs are being replaced by sweep systems. During the alignment, the sweep is a natural progression into the testing. A channel sweep can also show problems occurring within the channel, between the video and audio.



Reverse Sweep, Why?

- View the entire reverse spectrum
- Catch faults that don’t show up in the forward sweep
- Show roll-offs and frequency response
- View guardbands and out of passband spectrum
- Note:

  Still need a spectrum analyzer to view the noise floor, CPD, Ingress, etc

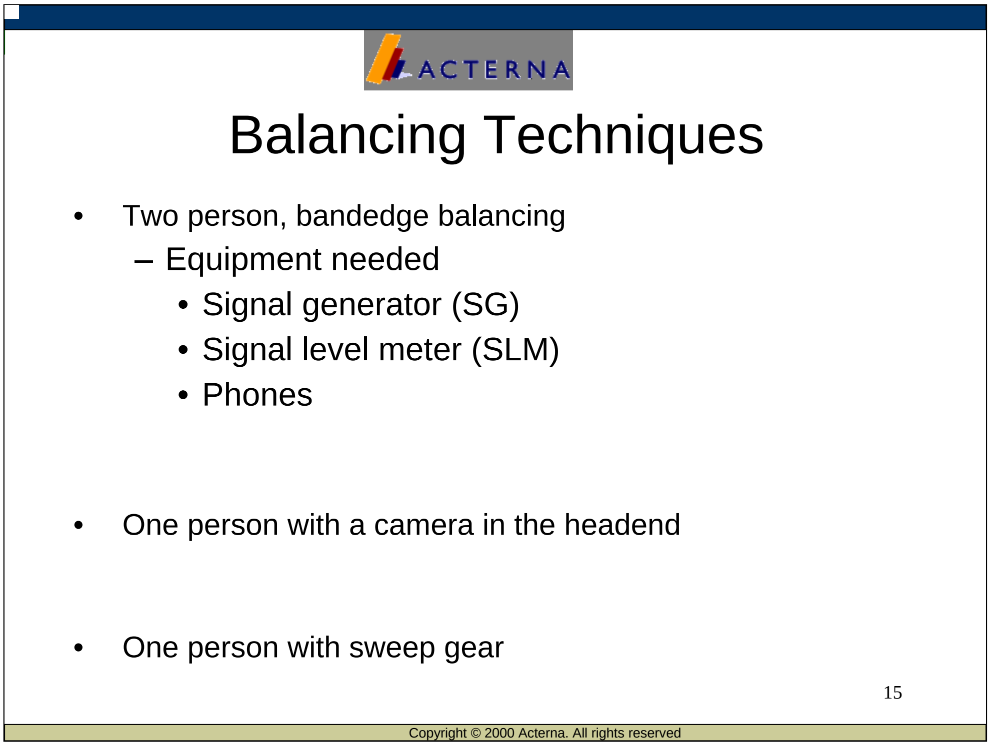
- The use of carriers for balancing does not permit the viewing of the reverse spectrum in its entirety. By utilizing a sweep, the entire spectrum can be tested, showing roll-offs, standing waves, and/or frequency sensitive suck-outs. Standwaves can affect the group delay of some digital data.

- Loose seizure screws, moisture, broken components, damaged cable and other problems become evident.

- Some problems in the return passband do not necessarily show up in the forward sweep.

- Even areas within the guardbands, and out of the passband spectrum need attention.

- The random noise, elevated noise floor, and other problems may not be evident on a sweep or observed when balancing, necessitating the use of a spectrum analyzer mode for complete spectrum testing.

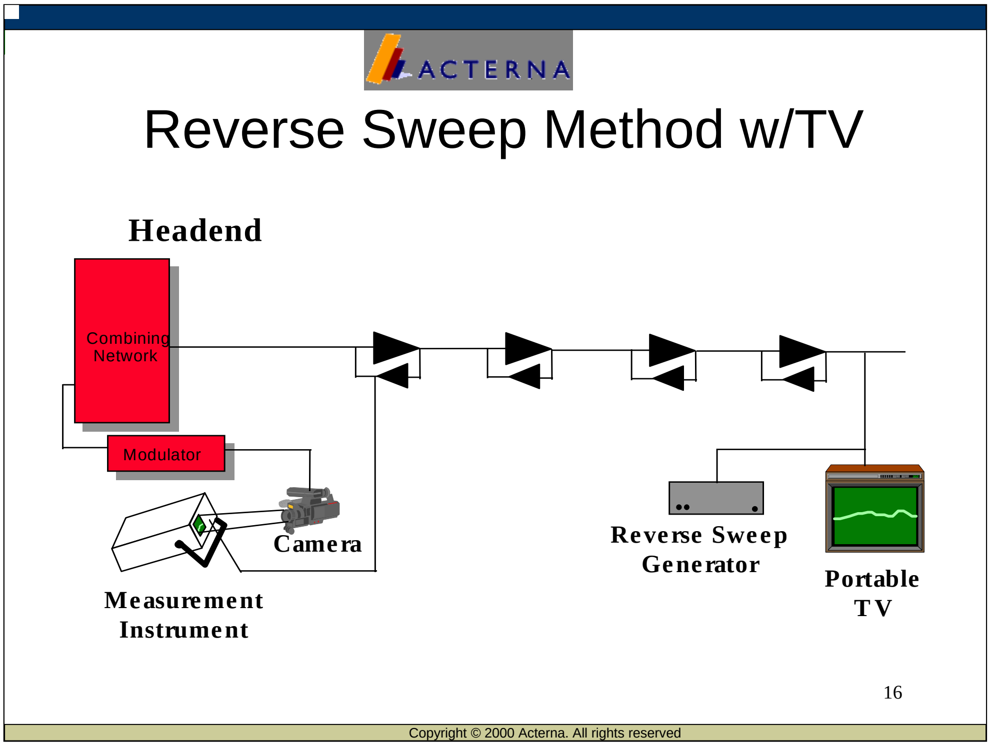


Balancing Techniques

- Two person, bandedge balancing
  - Equipment needed
    - Signal generator (SG)
    - Signal level meter (SLM)
    - Phones
- One person with a camera in the headend
- One person with sweep gear

•Bandedge balancing is accurate to a degree and the active is balanced for the losses proceeding/after it. If one amplifier is misbalanced, only itself and the first actives off of it will need to be rebalanced. It is also not as susceptible to ingress and standing wave problems. The disadvantage is the fact that two people are required and problems in between the carriers aren’t seen.

•Another way to do two person balancing is to have one person stationed at the node or Headend while the other person works his way out. This very much resembles the one person method #1 without the added equipment.



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Reverse Sweep Method w/TV

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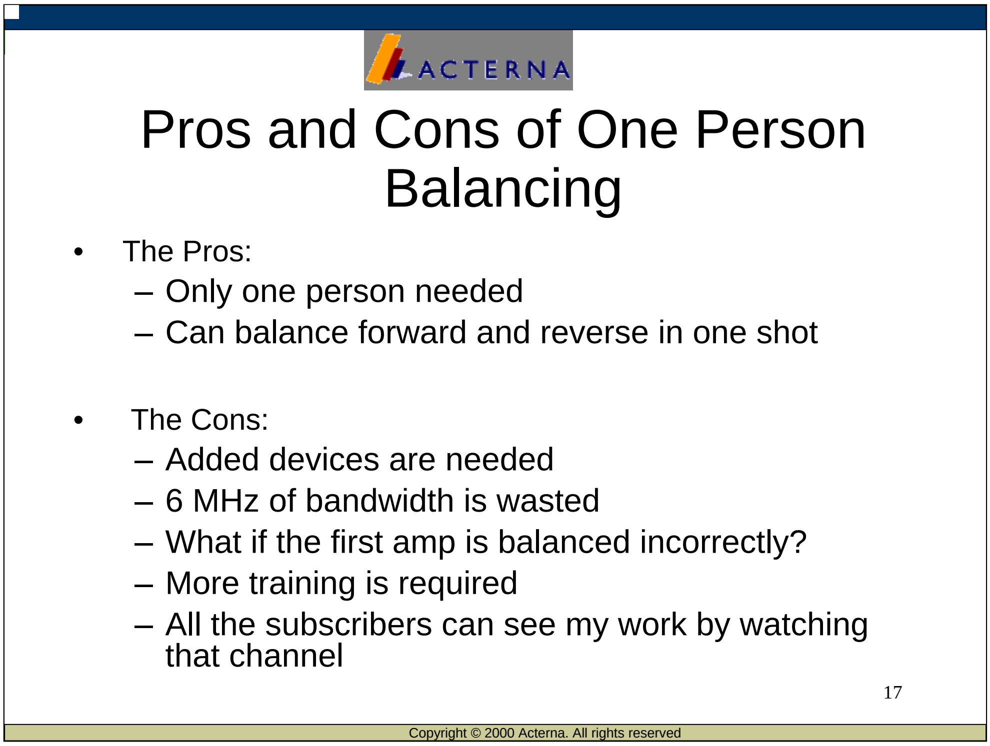
- This was one of the first methods of reverse balancing with one person starting at the HE and working outwards.

- This required that a TV and portable sweep generator be used in the field and possibly on a pole.



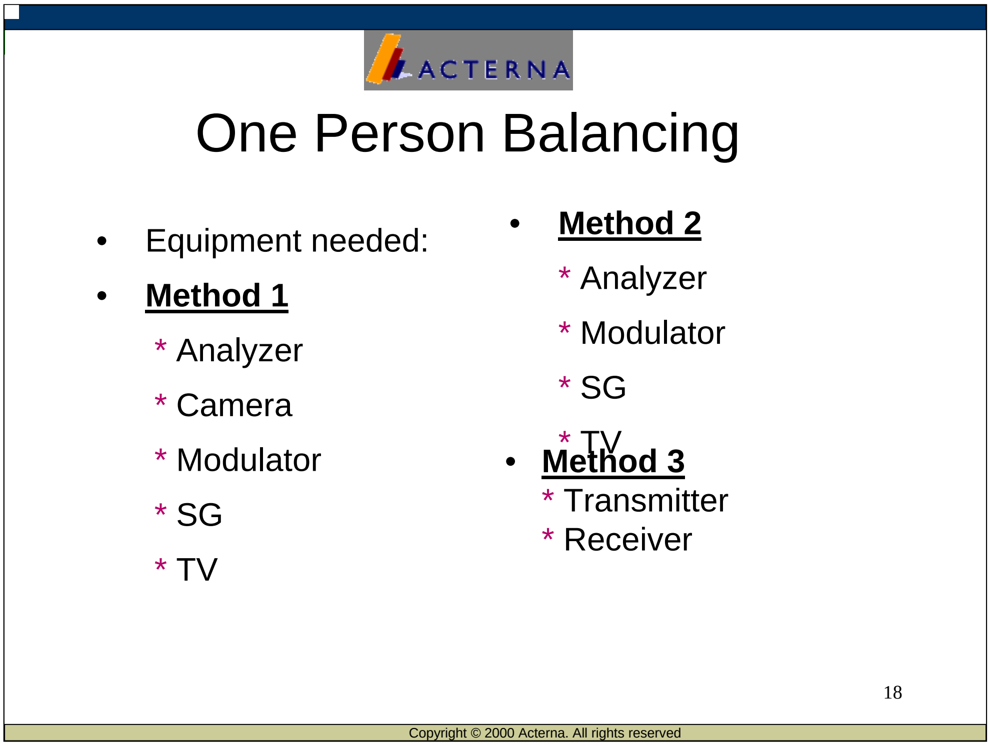
Pros and Cons of One Person Balancing

- The Pros:
  - Only one person needed
  - Can balance forward and reverse in one shot
- The Cons:
  - Added devices are needed
  - 6 MHz of bandwidth is wasted
  - What if the first amp is balanced incorrectly?
  - More training is required
  - All the subscribers can see my work by watching that channel

- There is a compromise or Pro-and-Con to everything we do.

- It turns out that because of unity gain we would only have to rebalance the amplifier in question and the first one off of it. Everything else should fall back in place.

- One way to eliminate customers from viewing this spectrum analyzer plot would be to remap the forward channel to a settop box. Now we have more devices in the field!



One Person Balancing

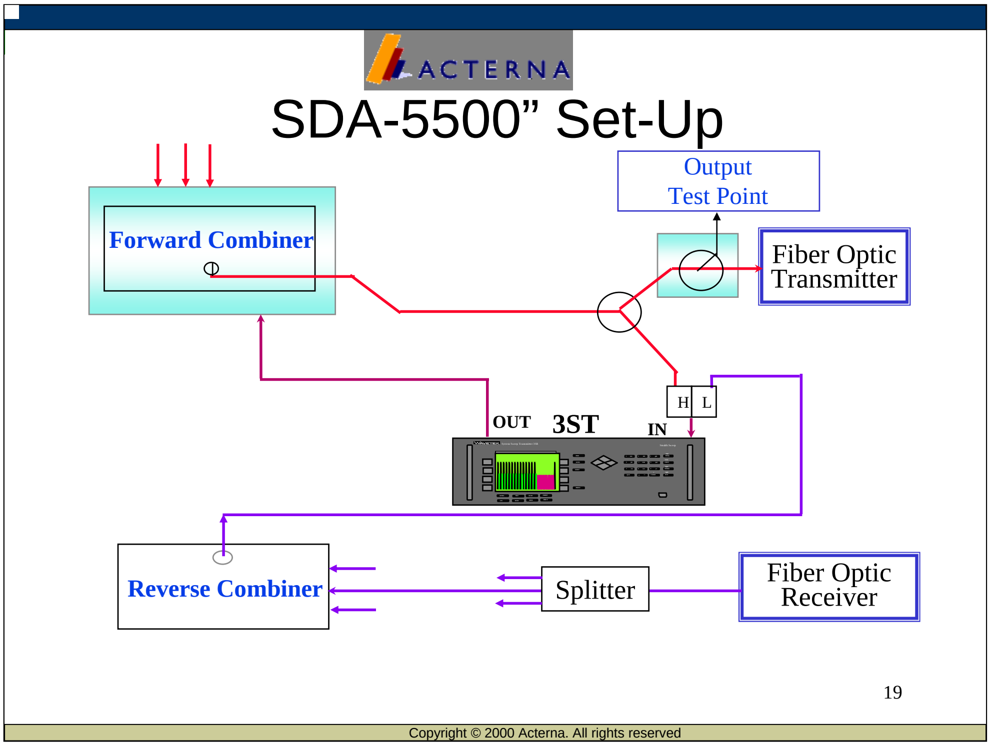
- Equipment needed:
- **Method 1**
  - * Analyzer
  - * Camera
  - * Modulator
  - * SG
  - * TV
- **Method 2**
  - * Analyzer
  - * Modulator
  - * SG
  - * TV
- **Method 3**
  - * Transmitter
  - * Receiver

•Method 3 is a Stealth and CaLan type sweep. Each has its own advantages and disadvantages.

•The “sweep” is the best tool for testing the full operational spectrum of the system. The “swept” response requires that the sweep system injects a signal into “empty” areas of the spectrum, and produces a photo of the system that has exceptional resolution. This is a bit more extensive for setup, but will display problems in areas where data or no signals are present. Both systems are essentially “connect-the-dots” displays. We will use the WWG Stealth in our examples.

•After setup of the 3ST, copy the forward channel plan to the field unit. When editing the channel plan, be sure to include the bandedge channels used for the “tilt”, balancing, and level adjustment of the system.

•Go to the first amplifier or node and obtain a reference. This is what all other similar units will be compared to. Store the reference, proceed to the next amplifier. Take a sweep, and the displayed results are the difference between the actual and stored sweep. Adjust the amplifier for correct levels, repair the system for a flat sweep, and store the finished trace.



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SDA-5500" Set-Up

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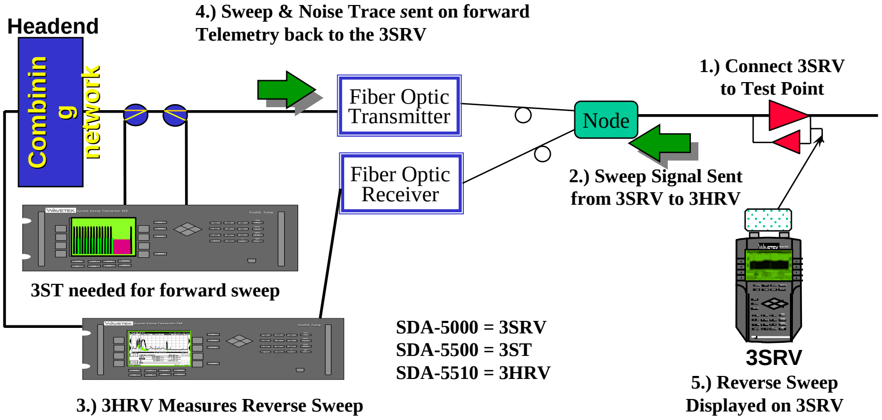
- Reverse input levels to the 3ST 0 dBmV + 2 dB

- It will work between +10 and - 10 but depends on the aggregate noise floor.

Reverse Sweep Only Package; 3HRV & 3SRV- Option



Headend

Combining network

4.) Sweep & Noise Trace sent on forward Telemetry back to the 3SRV

Fiber Optic Transmitter

Fiber Optic Receiver

Node

1.) Connect 3SRV to Test Point

2.) Sweep Signal Sent from 3SRV to 3HRV

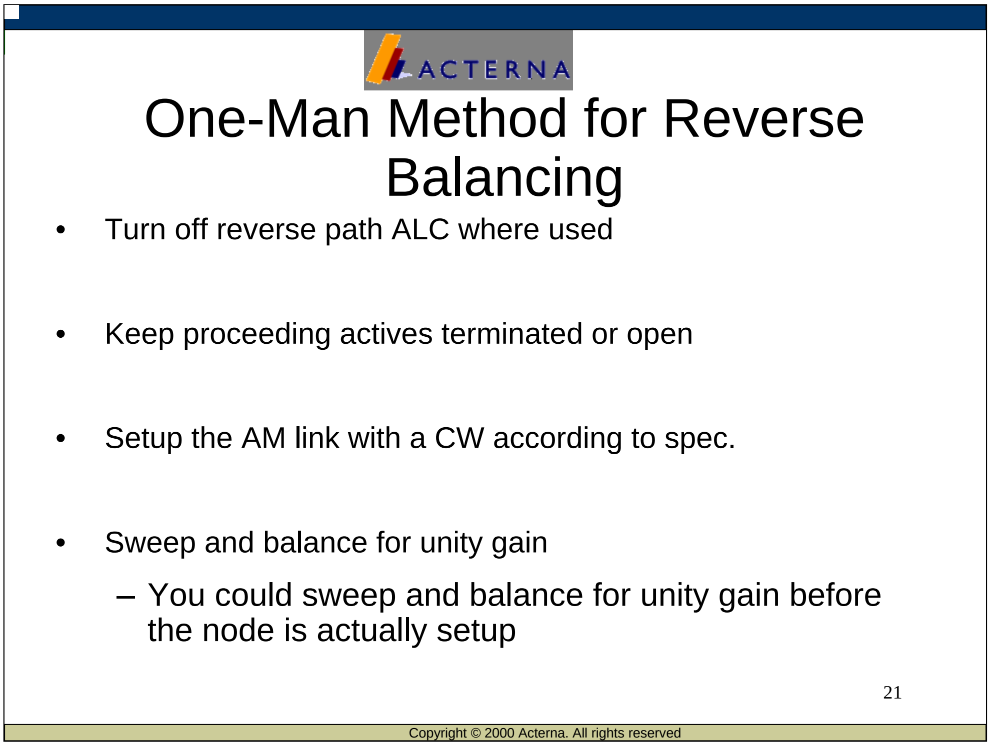
3ST needed for forward sweep

SDA-5000 = 3SRV
SDA-5500 = 3ST
SDA-5510 = 3HRV

3SRV

5.) Reverse Sweep Displayed on 3SRV

3.) 3HRV Measures Reverse Sweep



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One-Man Method for Reverse Balancing

- Turn off reverse path ALC where used
- Keep proceeding actives terminated or open
- Setup the AM link with a CW according to spec.
- Sweep and balance for unity gain
  - You could sweep and balance for unity gain before the node is actually setup

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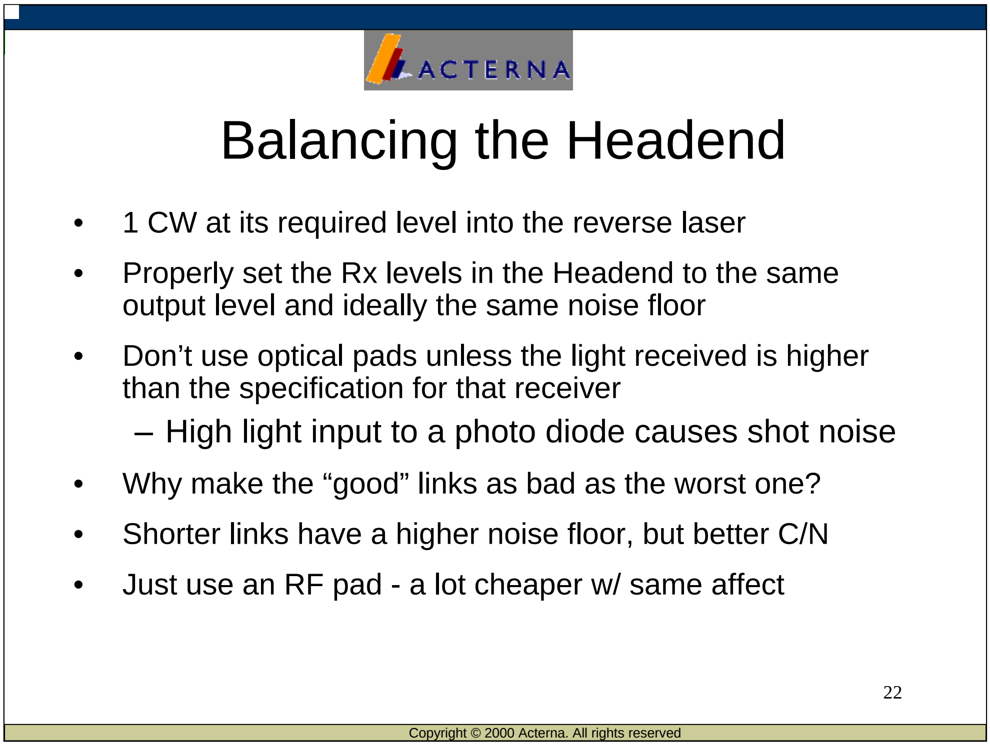
•Be sure to turn off the ALC in the reverse rack mount receiver if present. Also turn off the ALC in any LAN return amplifiers. Each ALC sensitivity will have to be adjusted after complete balancing.

•Because this is a sweep, ingress can affect the outcome. It may be advantageous to terminate all reverse port pads or keep all amplifiers terminated until activation. The Stealth also has a "noise/ingress" feature, which can be used for troubleshooting. This displays the noise seen in the Headend. Version 9.x transmits the ingress seen in the Headend on the forward telemetry frequency. So if no reverse communication is achieved, you will still get a display of the noise/ingress floor.



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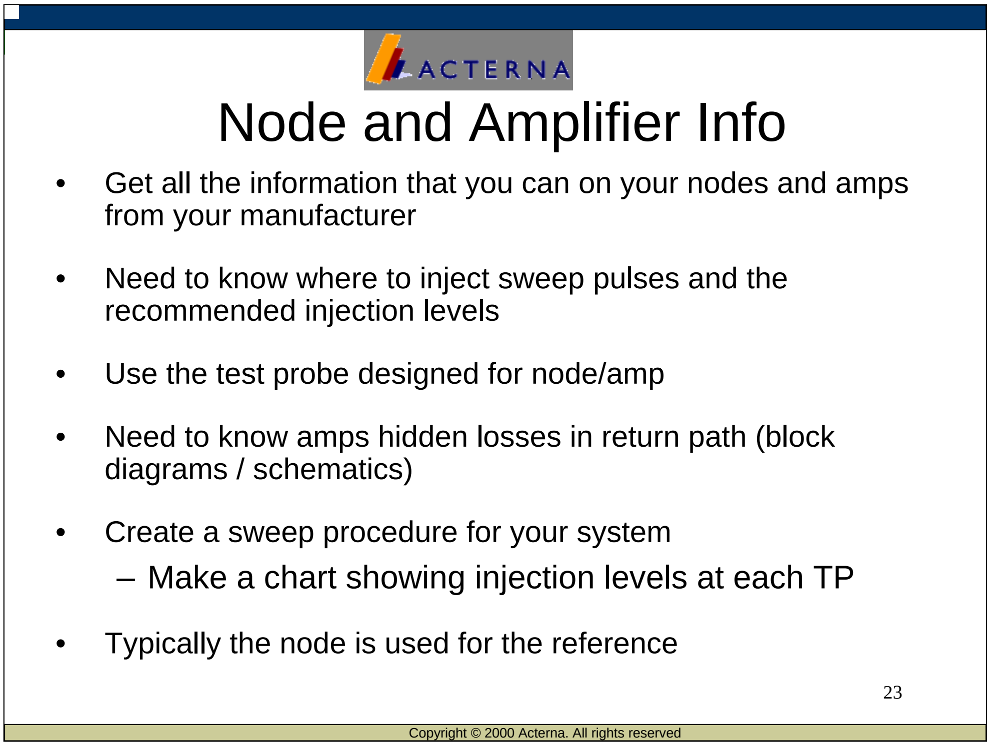
Balancing the Headend

- 1 CW at its required level into the reverse laser
- Properly set the Rx levels in the Headend to the same output level and ideally the same noise floor
- Don’t use optical pads unless the light received is higher than the specification for that receiver
  - – High light input to a photo diode causes shot noise
- Why make the “good” links as bad as the worst one?
- Shorter links have a higher noise floor, but better C/N
- Just use an RF pad - a lot cheaper w/ same affect

•Balance the AM path with 1 CW carrier at its recommended level and properly set the receiver levels.

•It’s probably not wise to combine receivers from different manufacturers unless they are specified for the same output level and S/N.

•If combining different noise floors, you’ll never be better than the worst link. It may be advantageous to combine 4 (2 dB optical links) with a 10 dB optical link. Make sure the RF levels are the same by creatively utilizing in-line pads.



Node and Amplifier Info

- Get all the information that you can on your nodes and amps from your manufacturer
- Need to know where to inject sweep pulses and the recommended injection levels
- Use the test probe designed for node/amp
- Need to know amps hidden losses in return path (block diagrams / schematics)
- Create a sweep procedure for your system
  - Make a chart showing injection levels at each TP
- Typically the node is used for the reference

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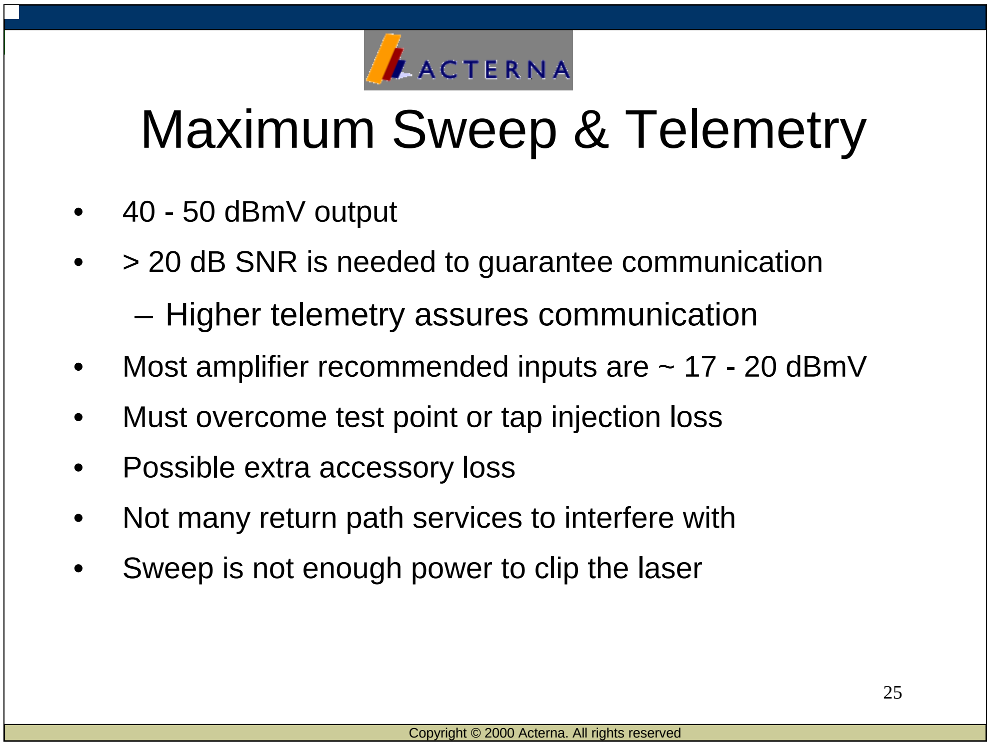
•Once the transmitter is configured properly, the next step is to store a reference in the receiver to enable accurate normalized tests at each amplifier output test point. This reference is usually stored at the node. The response at subsequent amplifiers is compared with this reference to verify operation according to the unity gain principle (theoretically every amplifier will have the same input levels and response).

Aligning the Return Path

- Choose operating levels that maximize the performance of your return path services
  - What's the highest tap value?
  - Laser 50% OMI point?
  - Maximum CPE output and bandwidth?
- Establish reference points to simplify maintenance
  - Use sweep file overlay
- It's a good engineering practice to store a new reference each day
- Set the sweep and telemetry reasonably high



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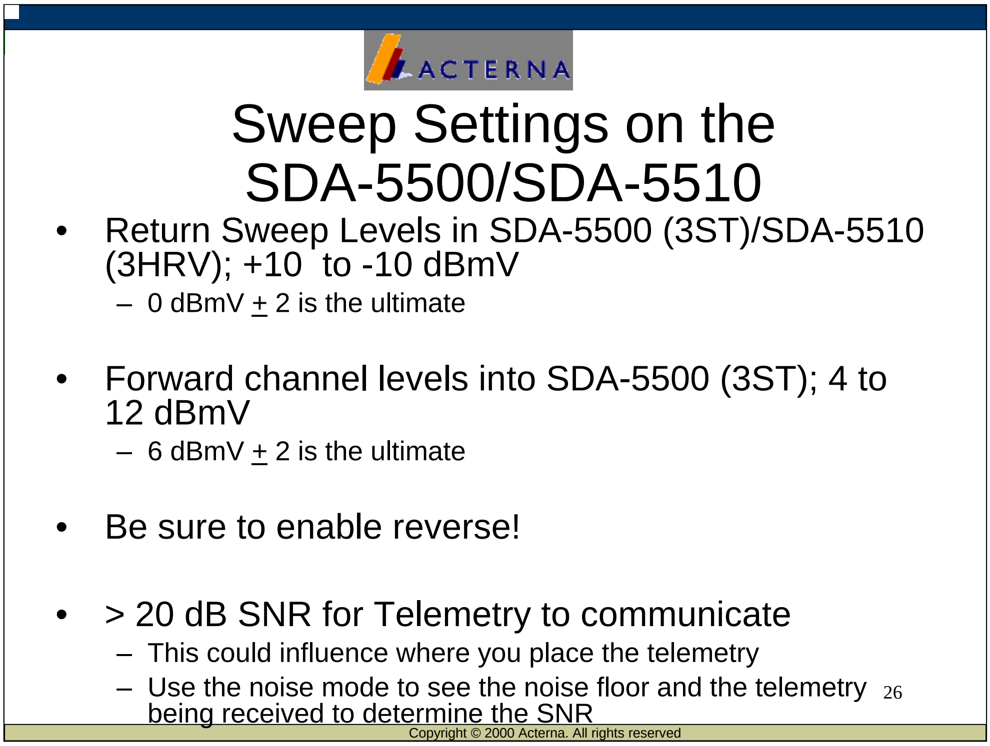
Maximum Sweep & Telemetry

- 40 - 50 dBmV output
- > 20 dB SNR is needed to guarantee communication
  - Higher telemetry assures communication
- Most amplifier recommended inputs are ~ 17 - 20 dBmV
- Must overcome test point or tap injection loss
- Possible extra accessory loss
- Not many return path services to interfere with
- Sweep is not enough power to clip the laser

•15 dB above recommended levels may cause erroneous readings and an unstable sweep due to laser clipping or amplifier compression.



Sweep Settings on the SDA-5500/SDA-5510

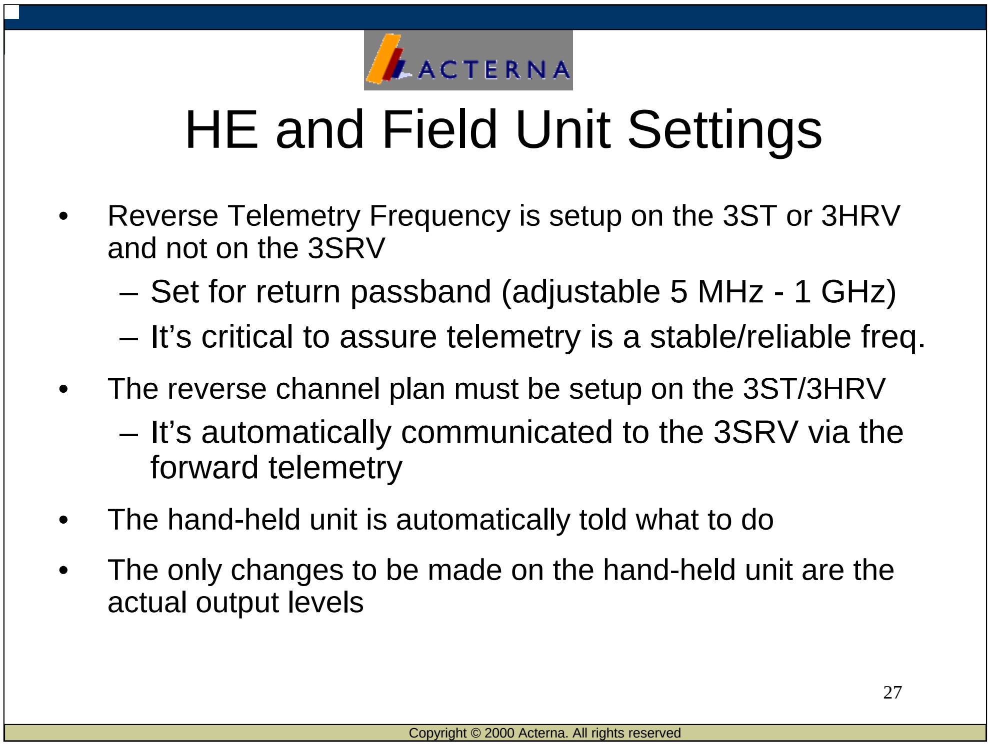
- Return Sweep Levels in SDA-5500 (3ST)/SDA-5510 (3HRV); +10 to -10 dBmV
  - 0 dBmV ± 2 is the ultimate
- Forward channel levels into SDA-5500 (3ST); 4 to 12 dBmV
  - 6 dBmV ± 2 is the ultimate
- Be sure to enable reverse!
- > 20 dB SNR for Telemetry to communicate
  - This could influence where you place the telemetry
  - Use the noise mode to see the noise floor and the telemetry being received to determine the SNR

•If the telemetry is in the lower passband of the return path, it may not have the required SNR because of the innate behavior of this noisy bandpass. Also the number of return paths funneling into the 3ST or 3HRV will affect this.

•Forward channel levels too high into the 3ST will cause overload and appear as CPD in the return path.

•The factory default on the 3ST for Forward Telemetry Frequency is 51 MHz.

•The factory default on the 3HRV for Forward Telemetry is 52 MHz.



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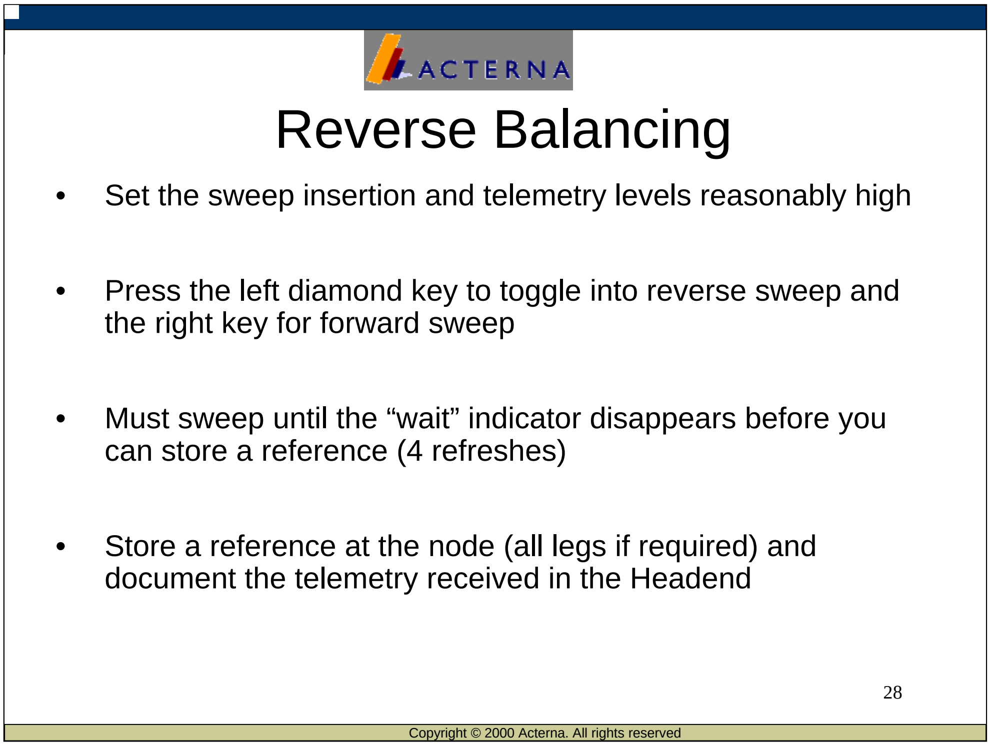
HE and Field Unit Settings

- Reverse Telemetry Frequency is setup on the 3ST or 3HRV and not on the 3SRV
  - Set for return passband (adjustable 5 MHz - 1 GHz)
  - It’s critical to assure telemetry is a stable/reliable freq.
- The reverse channel plan must be setup on the 3ST/3HRV
  - It’s automatically communicated to the 3SRV via the forward telemetry
- The hand-held unit is automatically told what to do
- The only changes to be made on the hand-held unit are the actual output levels



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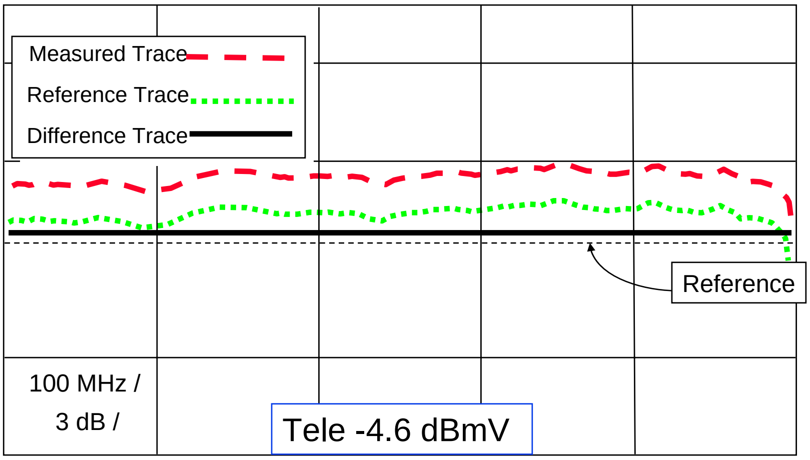
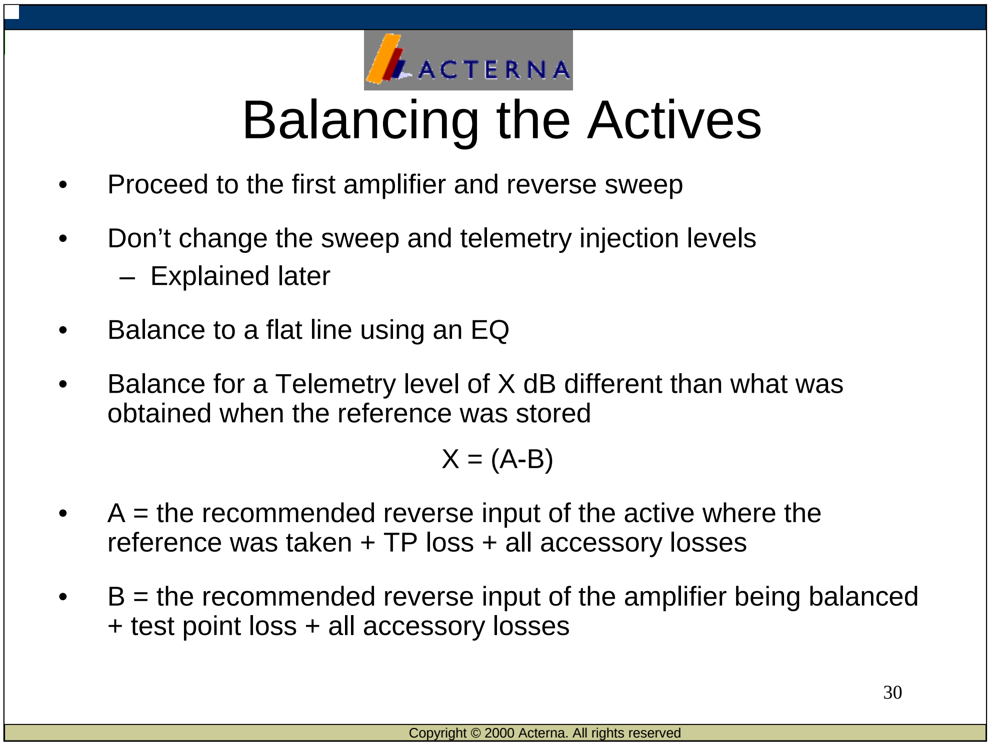
Reverse Balancing

- Set the sweep insertion and telemetry levels reasonably high
- Press the left diamond key to toggle into reverse sweep and the right key for forward sweep
- Must sweep until the “wait” indicator disappears before you can store a reference (4 refreshes)
- Store a reference at the node (all legs if required) and document the telemetry received in the Headend

AM Link Raw Sweep & Normalization



- Combining the Reference and the Measured Signal



Balancing the Actives

- Proceed to the first amplifier and reverse sweep
- Don’t change the sweep and telemetry injection levels
  - Explained later
- Balance to a flat line using an EQ
- Balance for a Telemetry level of X dB different than what was obtained when the reference was stored

X = (A-B)

- A = the recommended reverse input of the active where the reference was taken + TP loss + all accessory losses
- B = the recommended reverse input of the amplifier being balanced + test point loss + all accessory losses

- First amp off node; reverse sweep and balance to a flat line using an EQ.

- Use a pad to achieve a telemetry level of X dBmV.

- X=(A-B) where A= the recommended reverse input of the active where the reference was taken + test point loss + telemetry level + accessory losses + Summation Network loss. B= the recommended reverse input of the amplifier being balanced + test point loss + accessory losses + Summation Network loss.

- Only losses in the reverse injection path are considered.

- Some people may use test point compensation to account for extra accessories and different test points and balance to a 0 dB reference line.

Example

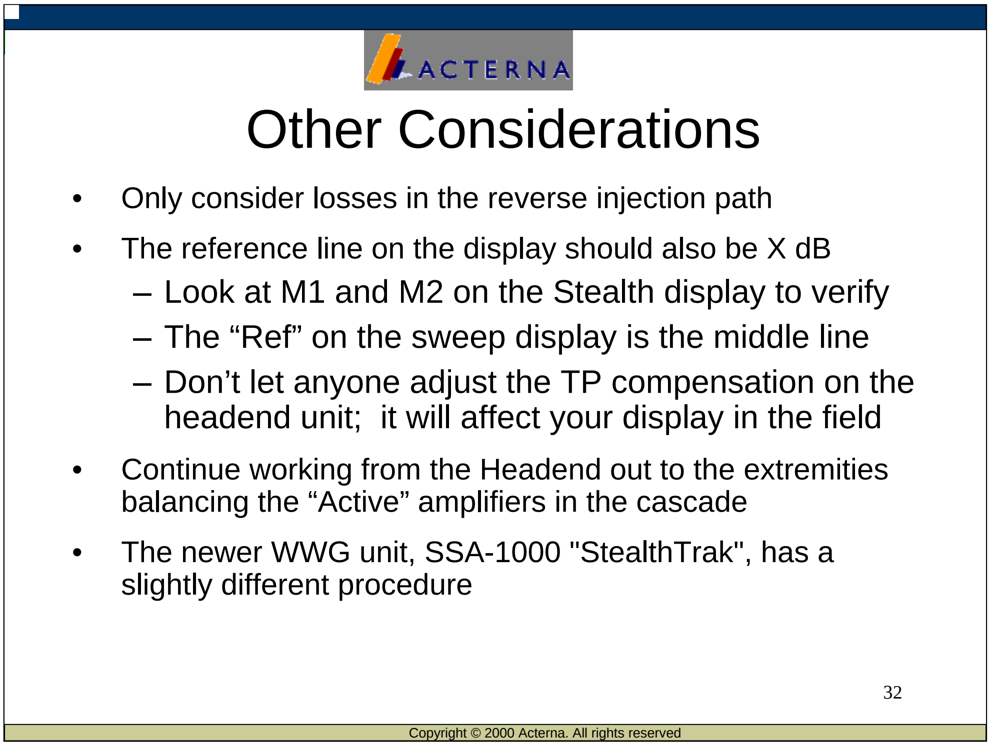
- Node with;
  - 20 dB TP,
  - Recommended input of 19 dBmV
  - No summation network
  - Ref stored with a telemetry reading of -4.6 dBmV
- A = 20 + 19 = 39

- LE with;
  - 26 dB tap used as a TP
  - Recommended input of 17 dBmV
  - Diplex filter used for a summation network
- B = 26+17+1 = 44

X = 39 - 44 = -5

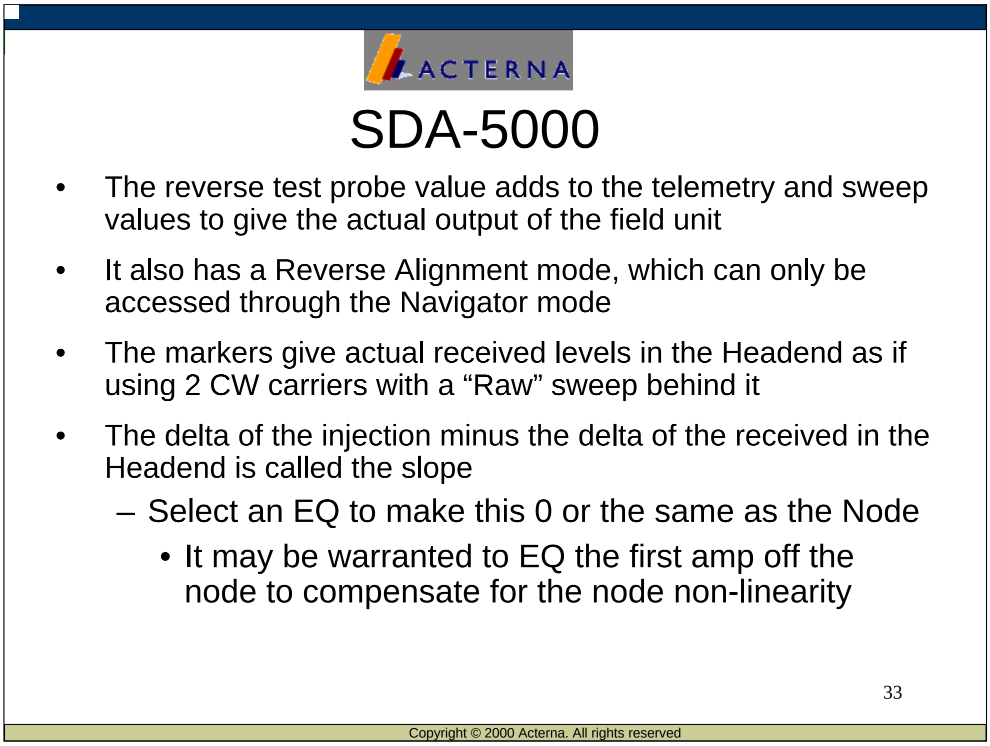
- This amplifier is balanced when the telemetry reads

-4.6 - 5 = -9.6 dBmV



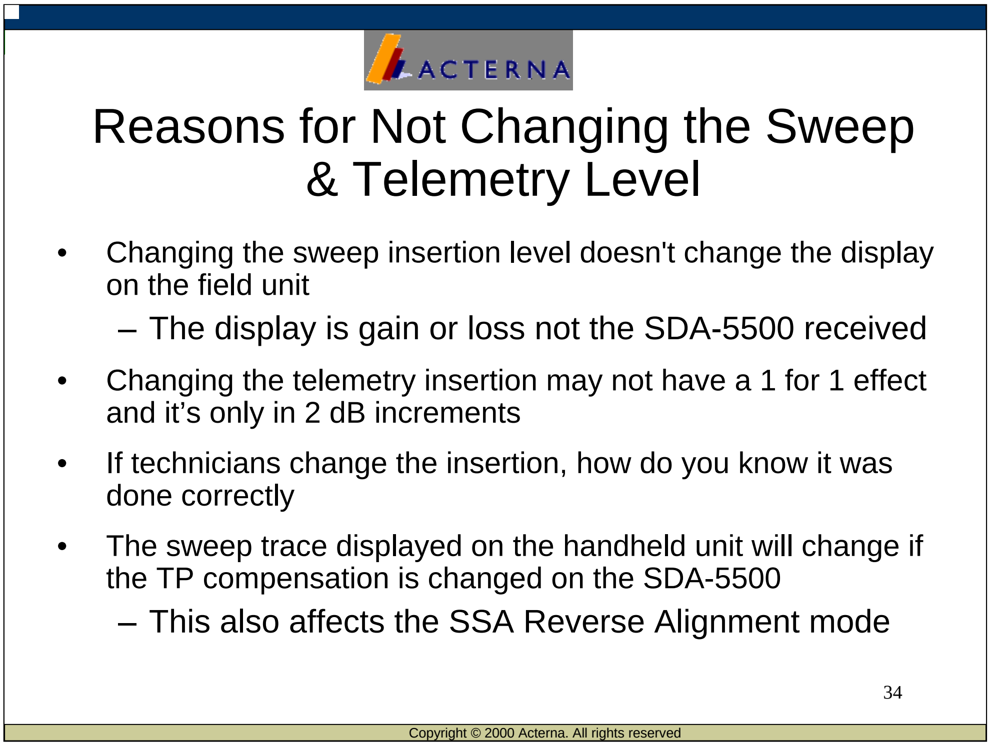
Other Considerations

- Only consider losses in the reverse injection path
- The reference line on the display should also be X dB
  - Look at M1 and M2 on the Stealth display to verify
  - The “Ref” on the sweep display is the middle line
  - Don’t let anyone adjust the TP compensation on the headend unit; it will affect your display in the field
- Continue working from the Headend out to the extremities balancing the “Active” amplifiers in the cascade
- The newer WWG unit, SSA-1000 "StealthTrak", has a slightly different procedure



SDA-5000

- The reverse test probe value adds to the telemetry and sweep values to give the actual output of the field unit
- It also has a Reverse Alignment mode, which can only be accessed through the Navigator mode
- The markers give actual received levels in the Headend as if using 2 CW carriers with a “Raw” sweep behind it
- The delta of the injection minus the delta of the received in the Headend is called the slope
  - Select an EQ to make this 0 or the same as the Node
    - It may be warranted to EQ the first amp off the node to compensate for the node non-linearity



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Reasons for Not Changing the Sweep & Telemetry Level

- Changing the sweep insertion level doesn't change the display on the field unit
  - The display is gain or loss not the SDA-5500 received
- Changing the telemetry insertion may not have a 1 for 1 effect and it’s only in 2 dB increments
- If technicians change the insertion, how do you know it was done correctly
- The sweep trace displayed on the handheld unit will change if the TP compensation is changed on the SDA-5500
  - This also affects the SSA Reverse Alignment mode

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•These are some reasons why I hesitate to change the sweep and telemetry level for different balancing scenarios.

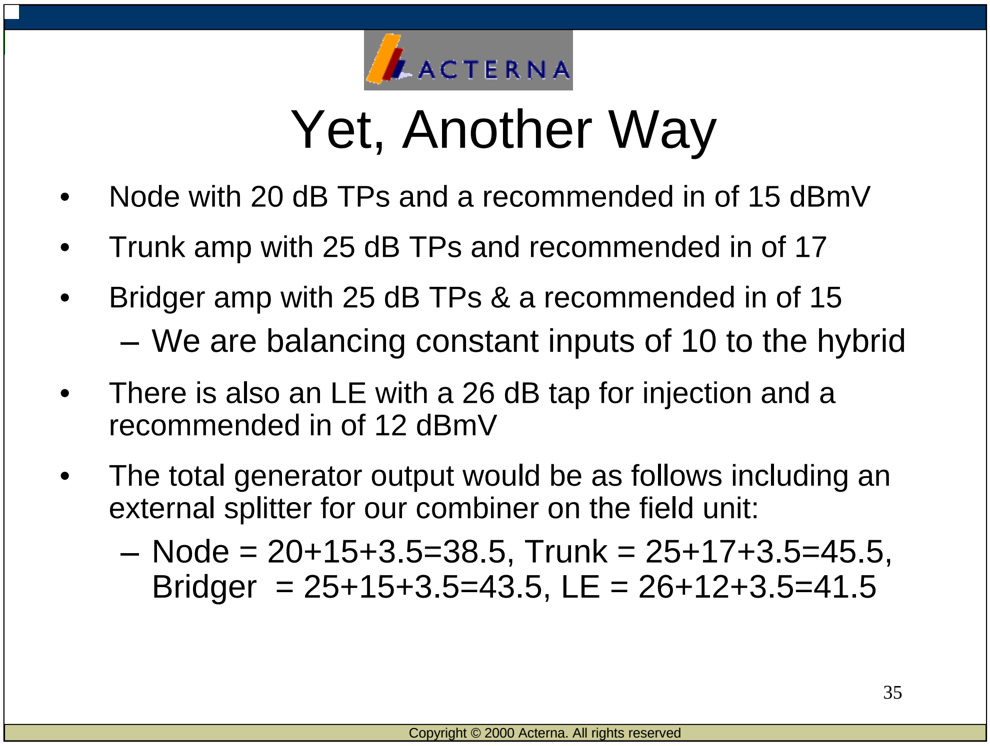
•If every amplifier had the same losses and recommended inputs, you would never have to change the field unit output level.

•This would make life easy and every amplifier would be balanced to the same ref and telemetry level that was recorded when the reference was stored.

•In reality, we have different balancing scenarios, different amplifier types, and different points of injection (taps, test point, probes, etc.).

•By creating a specific procedure for your system there would be no questions and the sweep and telemetry level could be set once and never changed.

•The only thing that makes the display move is changing the test point compensation.



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Yet, Another Way

- Node with 20 dB TPs and a recommended in of 15 dBmV
- Trunk amp with 25 dB TPs and recommended in of 17
- Bridger amp with 25 dB TPs & a recommended in of 15
  - We are balancing constant inputs of 10 to the hybrid
- There is also an LE with a 26 dB tap for injection and a recommended in of 12 dBmV
- The total generator output would be as follows including an external splitter for our combiner on the field unit:
  - Node = 20+15+3.5=38.5, Trunk = 25+17+3.5=45.5, Bridger = 25+15+3.5=43.5, LE = 26+12+3.5=41.5

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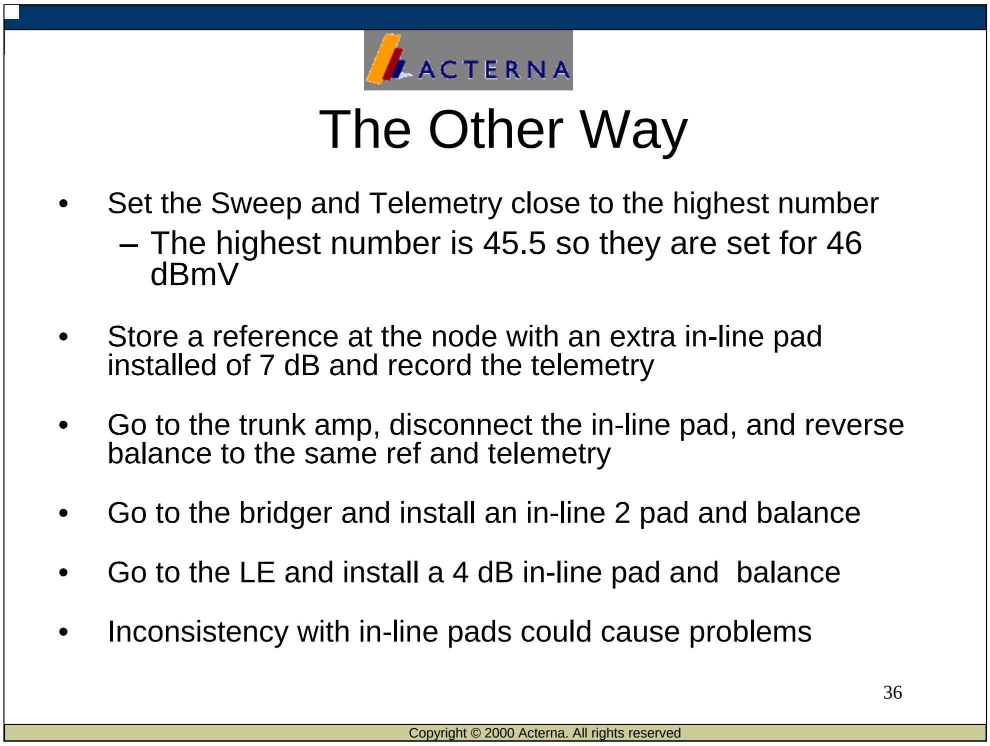
•Another way people are reverse balancing is listed next. Suppose you have a Node with 20 dB test points and a recommended in of 15 dBmV and a Trunk amp with 25 dB TPs and recommended in of 17 dBmV. The Bridger amp with 25 dB TPs has a recommended in of 15 because you are balancing constant inputs of 10 dBmV to the hybrid and the internal loss from the test point to the hybrid is 5 dB vs 7 dB like the trunk amp. There is also an LE with a 26 dB tap for injection and a recommended in of 12 dBmV.

•After adding all the numbers and the extra loss from the summation network (splitter) used in reverse balancing, the total generator output would be:

•Node = 20+15+3.5=38.5, Trunk = 25+17+3.5=45.5, Bridger = 25+15+3.5=43.5, LE = 26+12+3.5=41.5



The Other Way

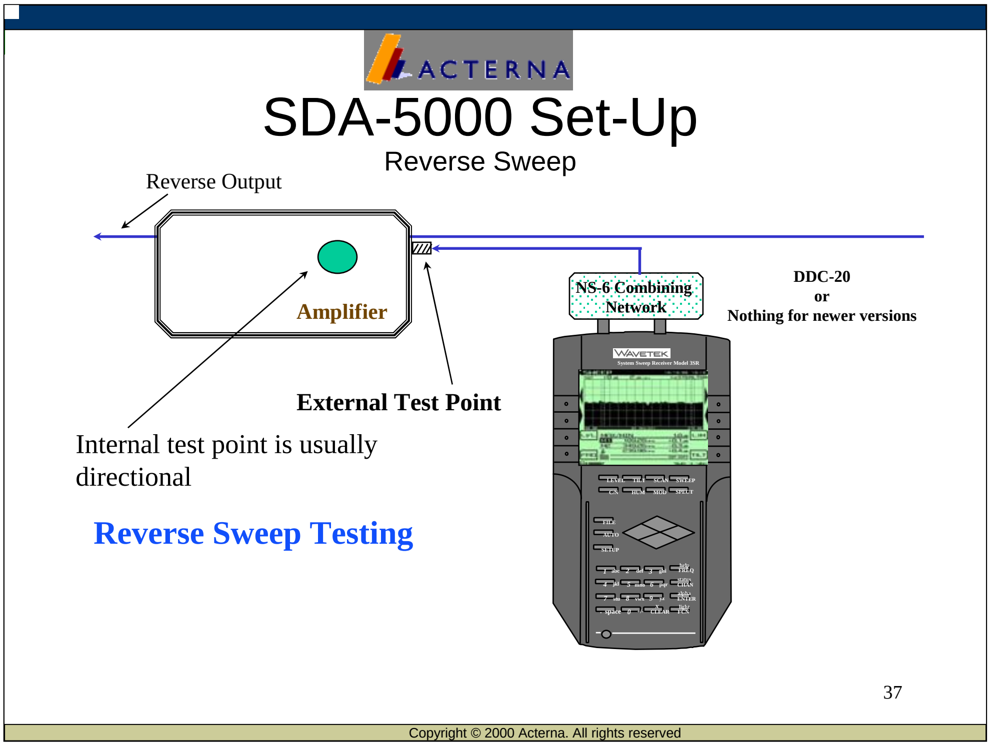
- Set the Sweep and Telemetry close to the highest number
  - The highest number is 45.5 so they are set for 46 dBmV
- Store a reference at the node with an extra in-line pad installed of 7 dB and record the telemetry
- Go to the trunk amp, disconnect the in-line pad, and reverse balance to the same ref and telemetry
- Go to the bridger and install an in-line 2 pad and balance
- Go to the LE and install a 4 dB in-line pad and balance
- Inconsistency with in-line pads could cause problems

•Find the highest number and set the Sweep and Telemetry close to this. For instance, the highest number is 45.5 so they are set for 46 dBmV.

•Store a reference at the node with an extra in-line pad installed of 7 dB. This will automatically knock down the sweep and telemetry level without having to change the generator output and the associated problems with doing that. Store a reference and record the telemetry.

•Go to the trunk amp, disconnect the in-line pad, and reverse balance to the same ref and telemetry. Go to the bridger amp and install an in-line 2 pad. Balance to the same telemetry and ref. Go to the LE and install a 4 dB in-line pad. Balance back to the same ref of 0 and telemetry that was recorded when the ref was stored.

•The one caveat to this is the inconsistency with in-line pads. One more variable is added to the equation!



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SDA-5000 Set-Up

Reverse Sweep

Reverse Output

Amplifier

External Test Point

Internal test point is usually directional

NS-6 Combining Network

DDC-20
or
Nothing for newer versions

Reverse Sweep Testing

- Reverse Telemetry Level: Add loss of NS-6 and test point.

- The NS-6 or DDC-20 is necessary for version 8.5 or earlier. A summation network for return path sweeping is not necessary for versions 9.x or later.

- Typically use the highest level: + 40 dBmV or 50 dBmV.

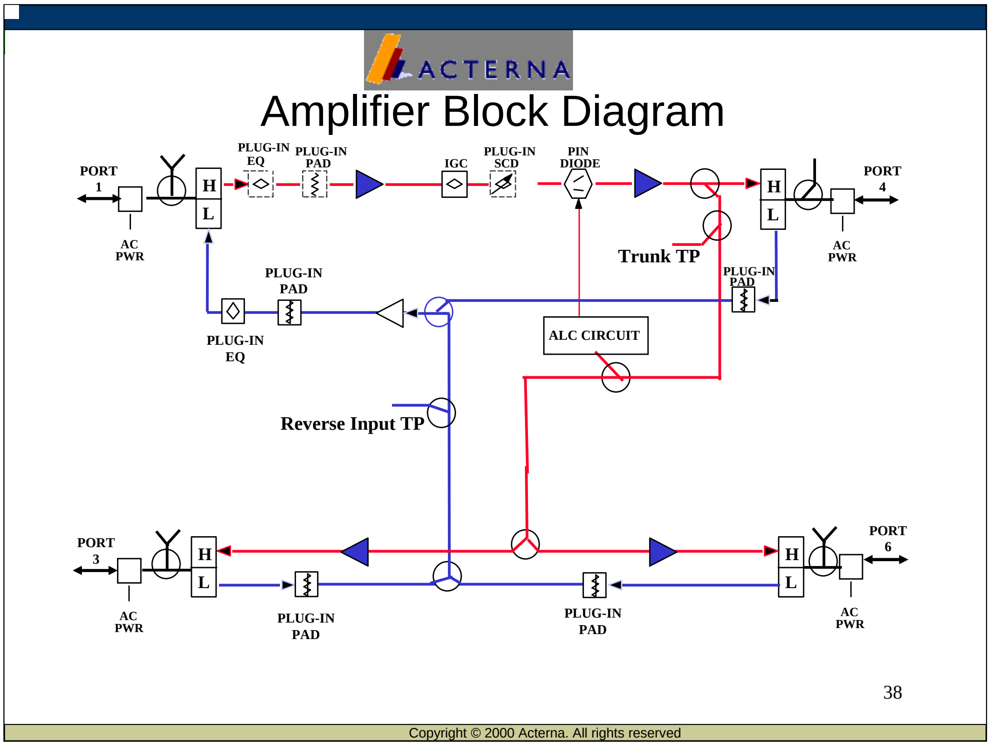
- Reverse Insertion Level: The same as above, + 50 dBmV.

- Reverse Telemetry Frequency: Set at the 3ST unit, between 5 & 40 MHz.

- Be sure “Reverse Sweep” is enabled at 3ST.

- The reverse sweep plan must be made on the 3ST, it cannot be done on the 3SRV.

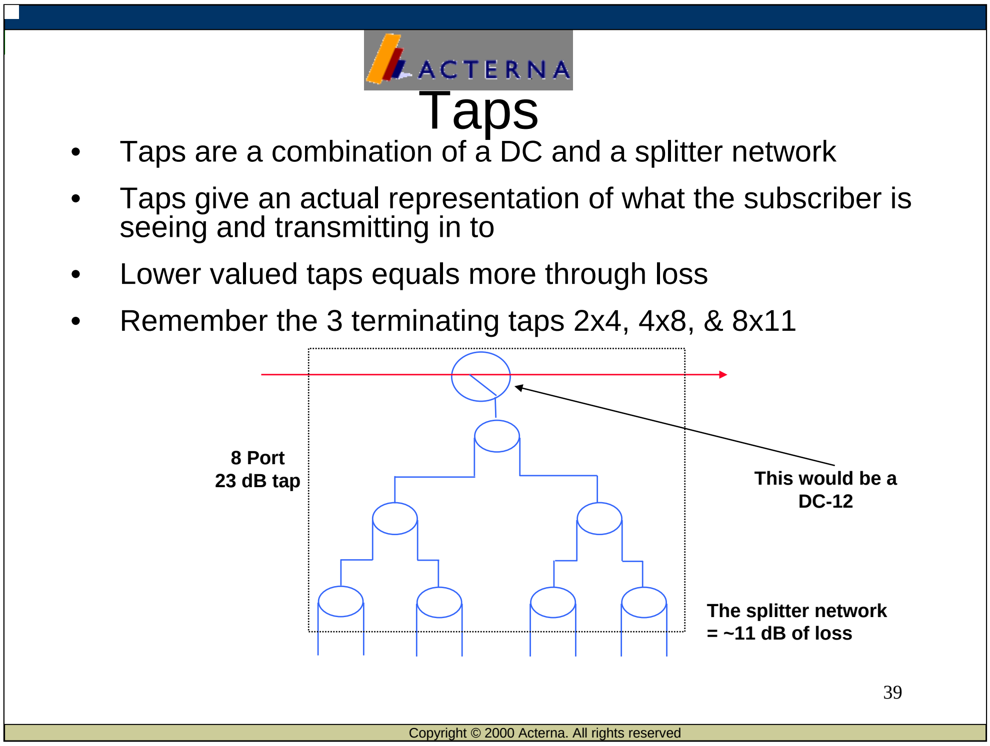
- Add test point loss to “Compensation”, and loss of the NS-6.



Amplifier Block Diagram

- A thorough understanding of block diagrams and schematics is necessary to properly balance and sweep amplifiers. In the above diagram the most logical choice for reverse sweep injection would be the port 4 forward output test point. It is on the outside of the diplex filter, which allows reverse signal to take the low side towards the hybrid. It is also directional which eliminates reflected signal from causing standing waves.

- The test point labeled Reverse Input is a reading test point, not an injection test point.



Taps

- Taps are a combination of a DC and a splitter network
- Taps give an actual representation of what the subscriber is seeing and transmitting in to
- Lower valued taps equals more through loss
- Remember the 3 terminating taps 2x4, 4x8, & 8x11

8 Port
23 dB tap

This would be a
DC-12

The splitter network
= ~11 dB of loss

- A “tap” is a combination of splitters and a directional coupler.

- A tap with 4 dB of loss is a “terminating” tap, or a splitter. It does not have any signal after splitting to be carried over.

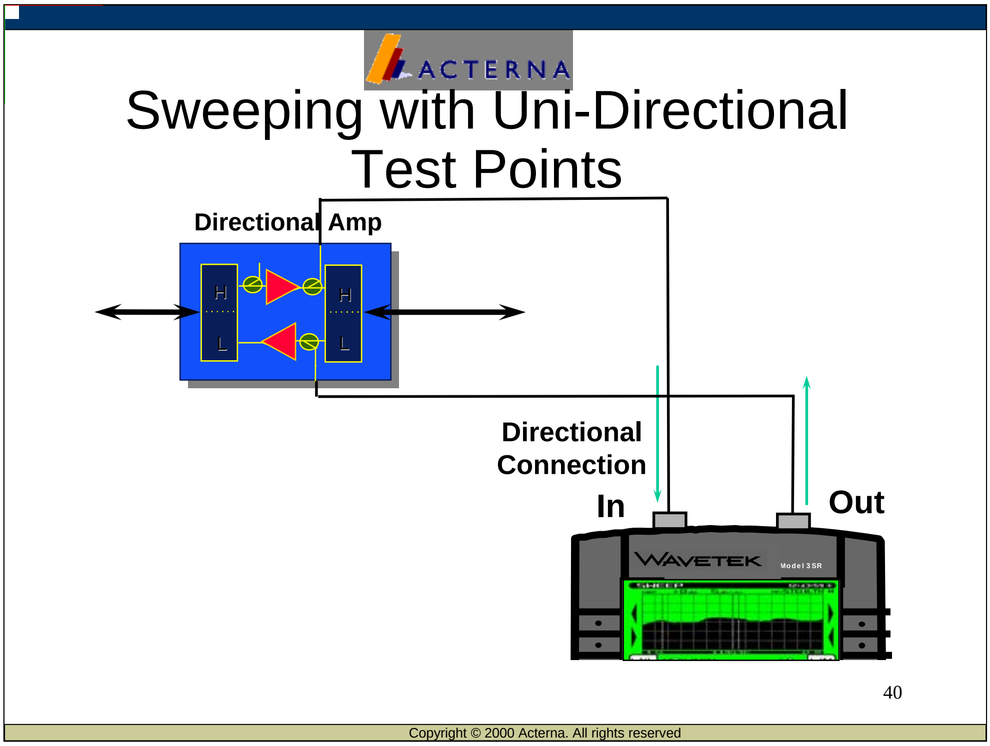
- An 8 dB tap is comprised of two splitters, one leg of the splitter feeding through, the other leg feeding another splitter.

- The next jump is to an 11 dB tap, this uses a DC-8 and a 2-way splitter. As tap values increase, the through loss decreases.

- Taps are typically selected for the through loss, and for the subscriber requirements.

- A tap is a passive device, but may be an indirect contributor to the noise of a system. This is due to the ingress from loose or bad connectors, and cracked or corroded wiring.

- Be careful with push-on fittings on tap ports.



Sweeping with Uni-Directional Test Points

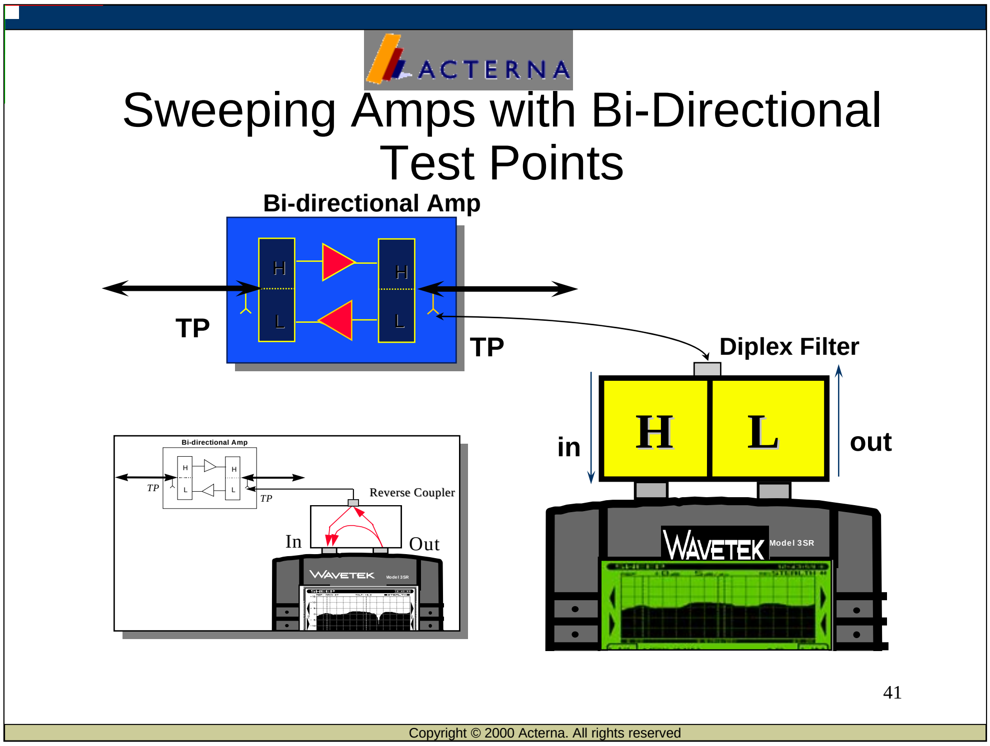
Directional Amp

Directional Connection

In

Out

- If your amplifier has directional test points you will need two directional couplers to allow transmitting on the reverse path and receiving the forward path.



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Sweeping Amps with Bi-Directional Test Points

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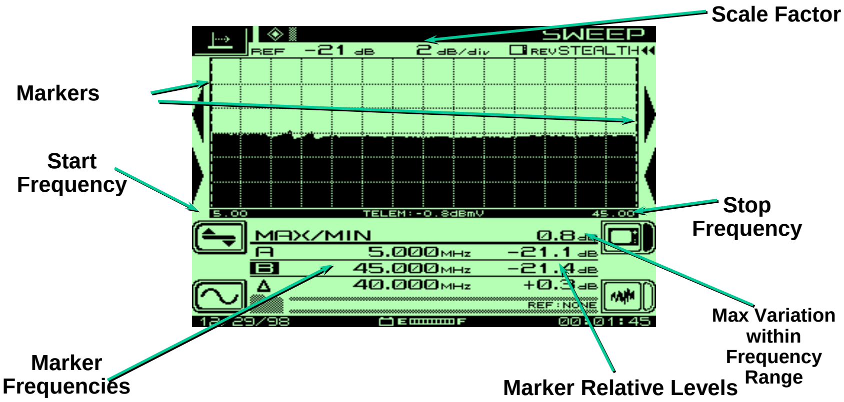
- The most common type of amplifier test point is a bi-directional test point or a directional test point on the outside of the diplex filter. For this application we include a reverse coupler that allows you to transmit, receive, and sample your own signal. You should use this coupler only for sweeping and not for measuring levels unless it is calibrated.

- For a test point to be directional, it must be in series with the circuit. Test probes will always be in a parallel circuit unless the circuit is temporarily disconnected and the probe is placed in series. High impedance test probes will create a better match because they only pick off a small sample of the signal. If I use an intentional impedance mismatch, it will cause CPD and other distortions to be reflected back towards the source. This can help in troubleshooting when also instantaneous viewing the noise floor in the Headend or Hub site.

SDA Reverse Sweep Display



Scale Factor

Markers

Start Frequency

Stop Frequency

Max Variation within Frequency Range

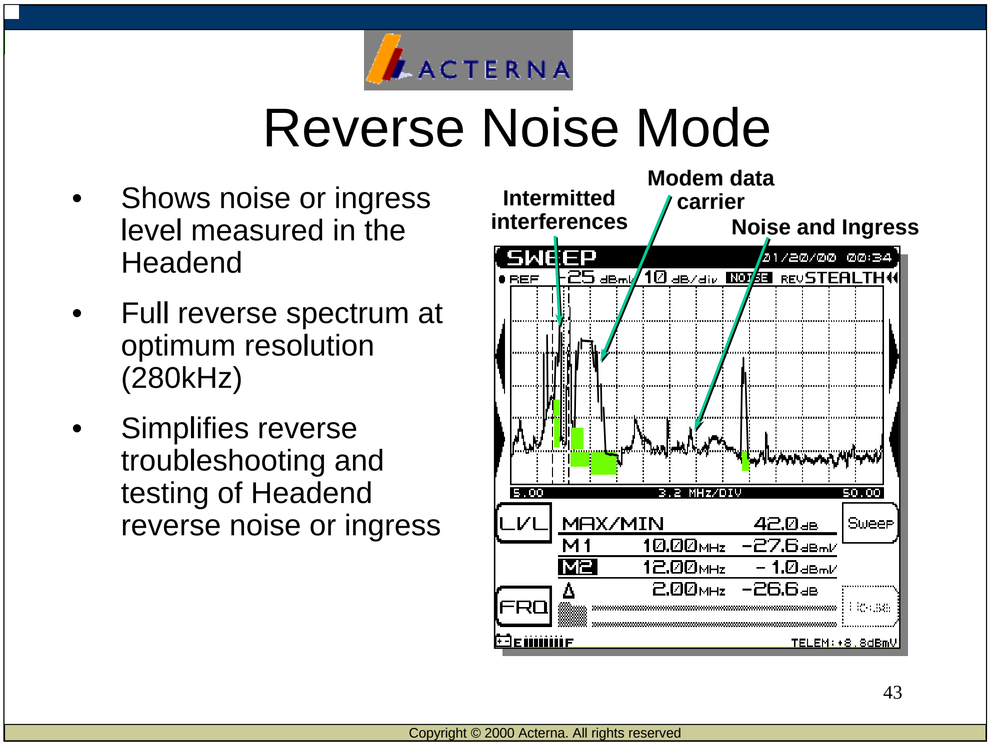
Marker Frequencies

Marker Relative Levels

```
SWEEP
REF  -21 dB   2 dB/div   REVSTEALTH
5.00          TELEM:-0.8dBmV          45.00
MAX/MIN                               0.8dB
A         5.000MHz                 -21.1 dB
B        45.000MHz                 -21.4 dB
Δ        40.000MHz                  +0.3 dB
                                   REF:NONE
12/29/98      E          F         00:01:45
```

- Note: the “max/min” displays the peak-to-valley between the markers. The delta displays the difference in level and frequency at the markers.

- Notice the dB/div is wrong. It should be 2 dB/div for sweep viewing.



Reverse Noise Mode

- Shows noise or ingress level measured in the Headend
- Full reverse spectrum at optimum resolution (280kHz)
- Simplifies reverse troubleshooting and testing of Headend reverse noise or ingress

Intermitted interferences

Modem data carrier

Noise and Ingress

•This mode is very beneficial because you can see the noise that accumulates in the headend without having to actually be there.

•This eliminates extra resources such as personnel in the headend and communication devices. This also cuts down on inefficient usage of time and errors due to misinformation and different interpretations of the display.

•By switching between the noise mode and a local spectrum analyzer mode, one can identify the source of interference or ingress and track it down more proficiently.

•Remember, the noise mode is a display of all the cumulative noise that is being injected into the headend unit. The more node receivers feeding into the 3ST or 3HRV the more difficult to narrow down the search.

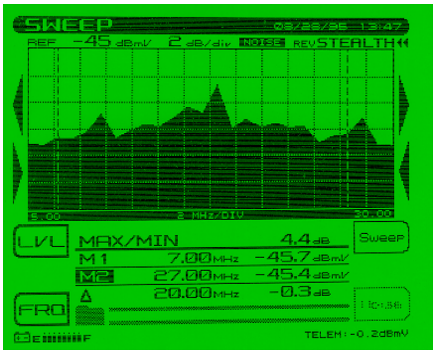
•Also remember that the local viewing must be done with a cable on the field unit “in” port and reading from a reverse reading test point not a tap or forward output test point.

•This ingress shouldn’t show up in the sweep if the channel plan is setup properly and the ingress is low enough in amplitude.

•It’s better to view the noise mode with 10 dB/div so that you don’t over react when you see noise spikes that seem high.

Old Reverse Noise Display

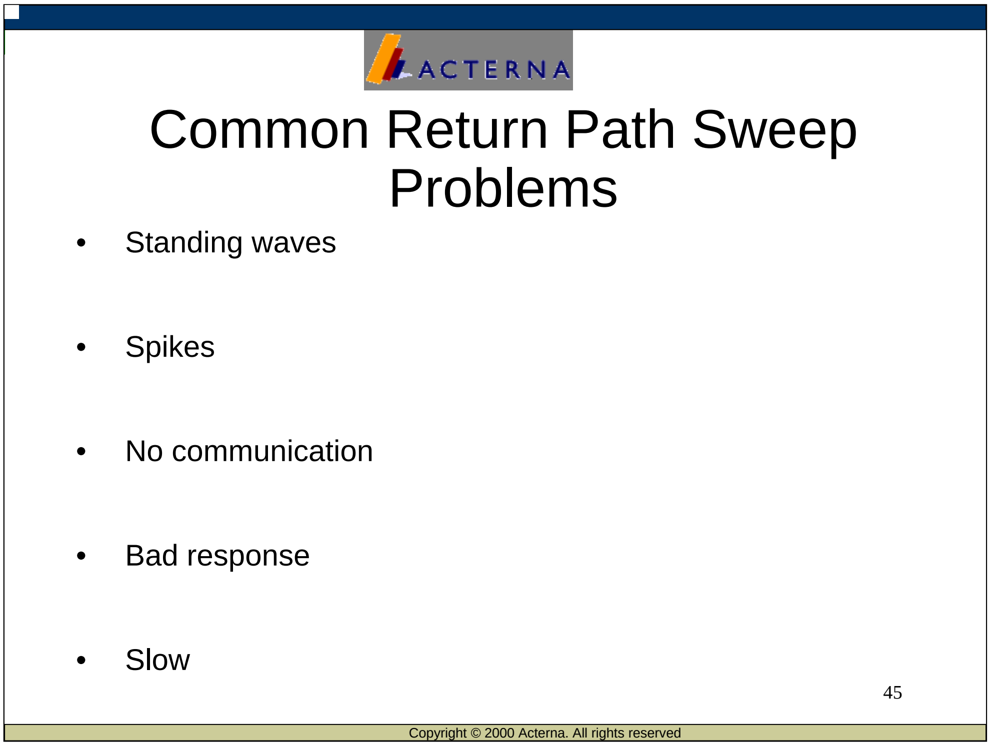
- Noise display resolution prior to version 9.3 and on 3HRV
- Resolution is determined by the return channel plan



MAX/MIN 4.4 dB
M1 7.00 MHz -45.7 dBmV
M2 27.00 MHz -45.4 dBmV
Δ 20.00 MHz -0.3 dB
TELEM: -0.2dBmV

•This screen leaves a lot to be desired. It doesn't resemble a spectrum analyzer display and can be hard to interpret.

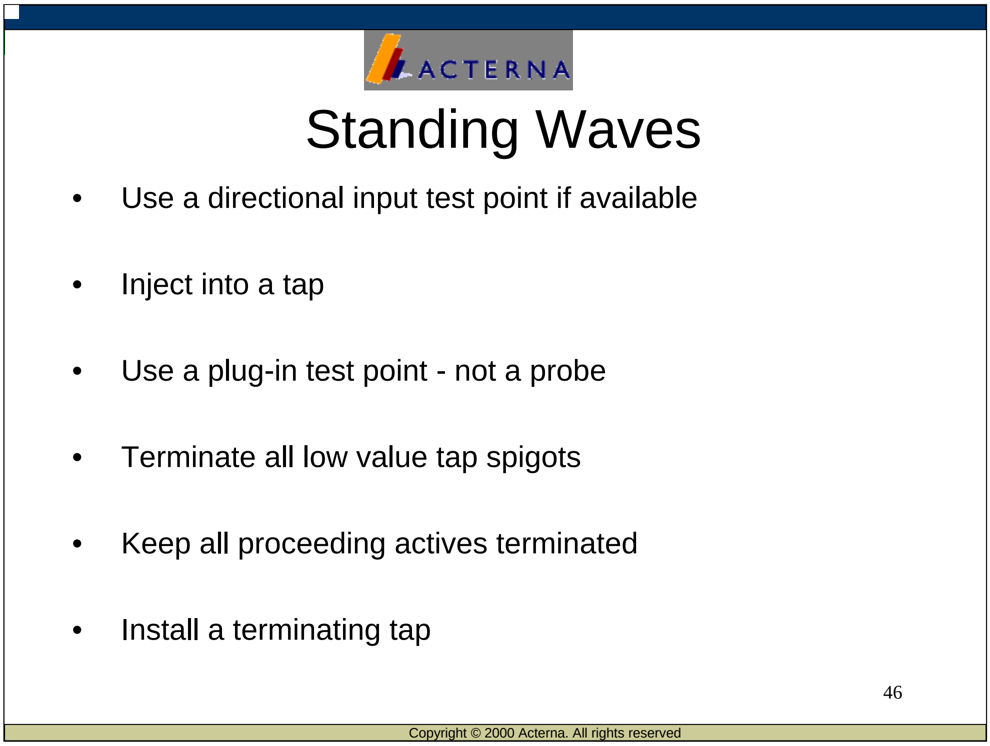
•You could make a channel plan with sweep points every 250 kHz, but it would slow down the sweep refresh and more than likely cause an unstable trace because of interference.



Common Return Path Sweep Problems

- Standing waves
- Spikes
- No communication
- Bad response
- Slow

- This is an outline of “Murphy’s Law” for sweeping.



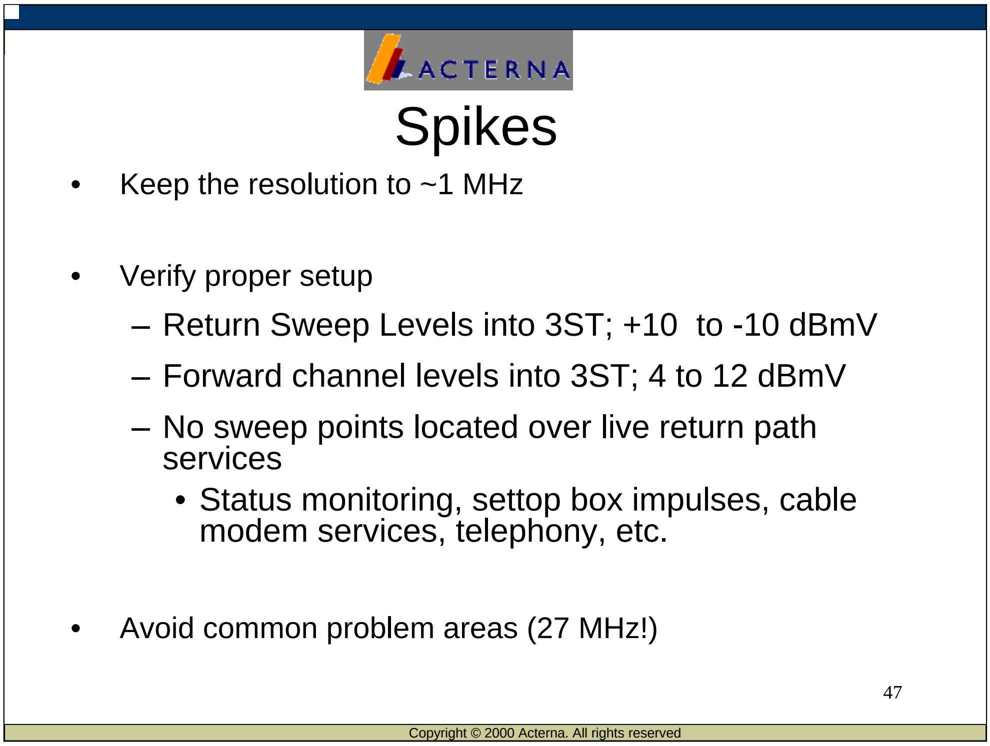
Standing Waves

- Use a directional input test point if available
- Inject into a tap
- Use a plug-in test point - not a probe
- Terminate all low value tap spigots
- Keep all proceeding actives terminated
- Install a terminating tap

•By injecting into a tap or directional test point, you eliminate the signal from traveling downstream instead of purely upstream where it's supposed to go.

•If you must use a bi-directional test point, you could get standing waves from seemingly minor imperfections. It could even be unterminated taps or splitters in peoples' houses that are a few thousand feet away.

•The low cable loss at lower frequencies allows reflected signal to travel back without much attenuation.



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Spikes

- Keep the resolution to ~1 MHz
- Verify proper setup
  - Return Sweep Levels into 3ST; +10 to -10 dBmV
  - Forward channel levels into 3ST; 4 to 12 dBmV
  - No sweep points located over live return path services
    - Status monitoring, settop box impulses, cable modem services, telephony, etc.
- Avoid common problem areas (27 MHz!)

- Keep the resolution to ~1 MHz for reverse sweep. This lowers the probability of inadvertent, overlapping sweep points and transients.

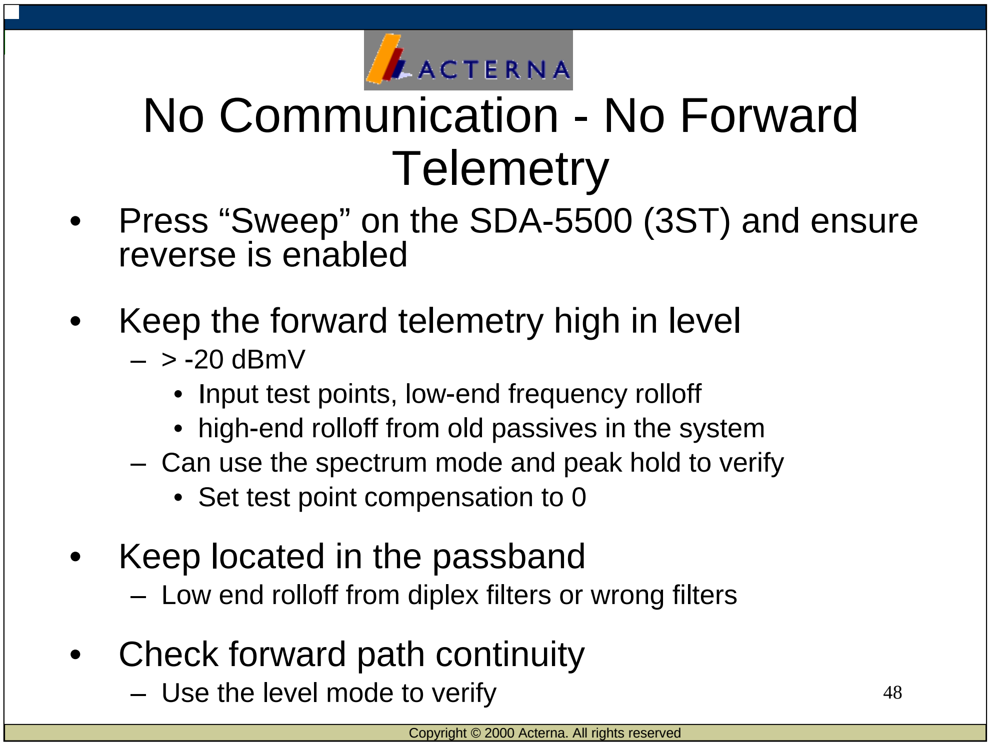
- A sweep point every 1 MHz is sufficient in most situations for reverse sweeping. It also creates a faster sweep update and less memory requirements.

- Some systems will place sweep points every 250 kHz in the frequency band where they will actually run modems and telephony.

- The recommended input to the headend unit is 0 dBmV ± 2, but it will work between 10 and -10 dBmV depending on the aggregate noise floor.

- Forward levels too high into the 3ST will cause intermods that affect the forward and reverse sweep and noise mode. 6 dBmV ± 2 is the “sweet” spot.

- One of the biggest problems in the reverse is CB and Ham radio.

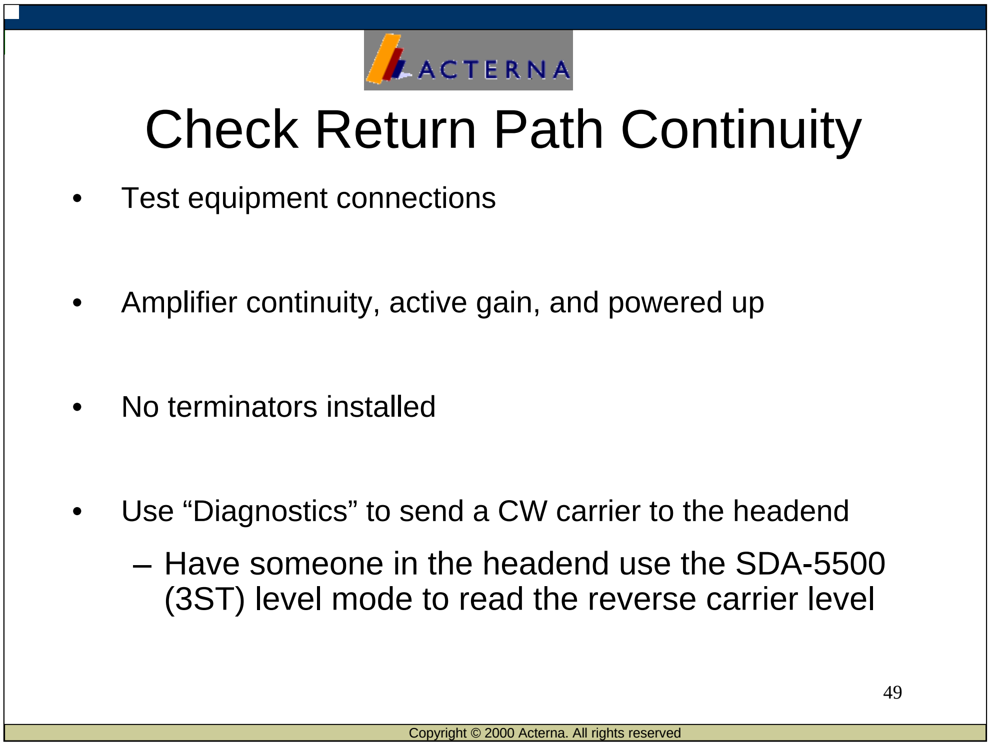


No Communication - No Forward Telemetry

- Press “Sweep” on the SDA-5500 (3ST) and ensure reverse is enabled
- Keep the forward telemetry high in level
  - > -20 dBmV
    - Input test points, low-end frequency rolloff
    - high-end rolloff from old passives in the system
  - Can use the spectrum mode and peak hold to verify
    - Set test point compensation to 0
- Keep located in the passband
  - Low end rolloff from diplex filters or wrong filters
- Check forward path continuity
  - Use the level mode to verify

- Use the level mode to check continuity.

- Use the Spectrum mode to tune to the telemetry frequency and see the actual level. Set test point compensation to 0 because it does affect your readings.



Check Return Path Continuity

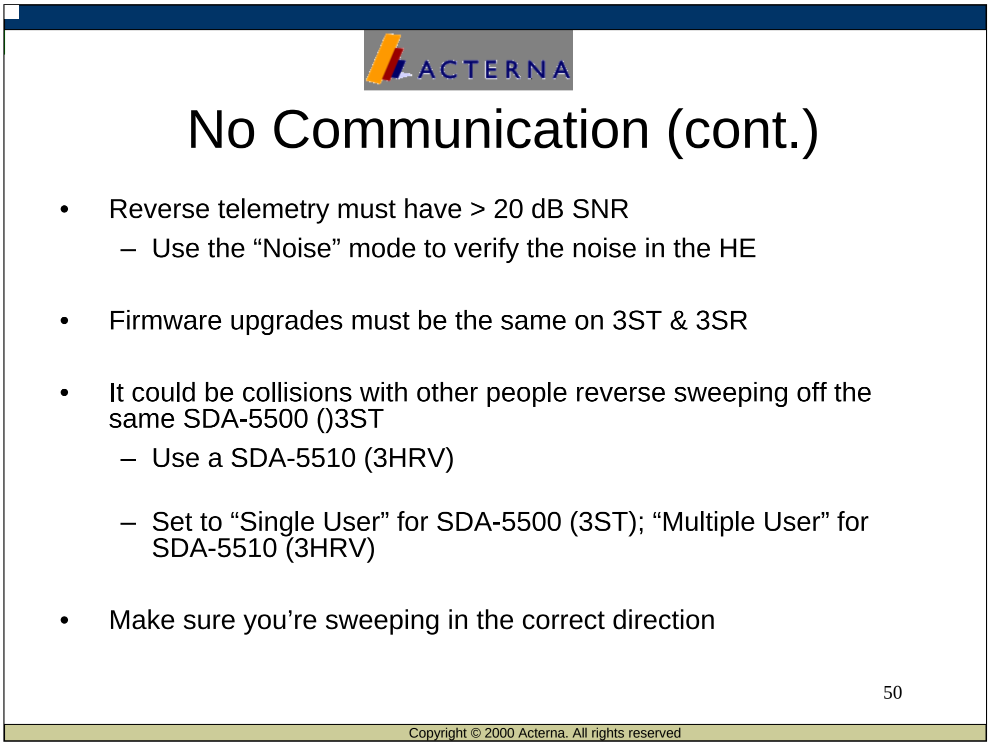
- Test equipment connections
- Amplifier continuity, active gain, and powered up
- No terminators installed
- Use “Diagnostics” to send a CW carrier to the headend
  - Have someone in the headend use the SDA-5500 (3ST) level mode to read the reverse carrier level

•Check return path continuity. Verify test equipment connections, amplifier continuity, active gain, and that no terminators are installed.

•Look at the noise floor level on the reverse input and compare with the reverse output. It should be higher by the amount of gain of the amplifier, but not necessarily. The noise reading could be affected by the test equipment noise floor.

•It may be warranted to inject a carrier and read the output to verify continuity. Use "Diagnostics" to send a CW carrier to the headend. Have someone in the headend use the 3ST “Level” mode to read the reverse carrier level.

•Be sure to put it back in “Sweep” mode when finished!



No Communication (cont.)

- Reverse telemetry must have > 20 dB SNR
  - Use the “Noise” mode to verify the noise in the HE
- Firmware upgrades must be the same on 3ST & 3SR
- It could be collisions with other people reverse sweeping off the same SDA-5500 ()3ST
  - Use a SDA-5510 (3HRV)
  - Set to “Single User” for SDA-5500 (3ST); “Multiple User” for SDA-5510 (3HRV)
- Make sure you’re sweeping in the correct direction

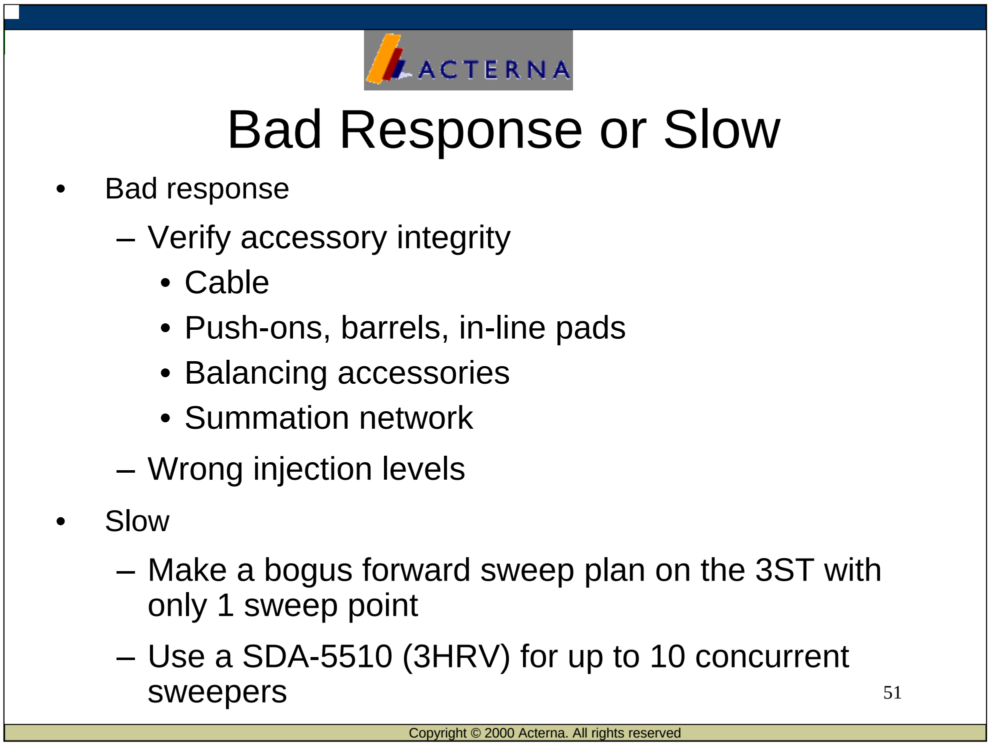
•To calculate the S/N for the reverse, find the telemetry level at the headend read on the field unit while sweeping, activate the "Noise" mode and move the marker to the same frequency. Record the difference.

•Note: The number of node returns is limited for the Stealth reverse setup because the reverse telemetry signal needs to have > 20 dB S/N. Probably less than 40 nodes should be combined into the headend unit.

•This may also influence where you place the telemetry. Stay away from 5-15 MHz because of the inherent noisy nature of this passband. Stay away from 27 MHz because of CB ingress and any multiple of 6 MHz because of common path distortions (CPD).

•Stealth firmware version 9.3 is the latest. StealthTrak version 1.2 is the latest and fully compatible with version 9.3. Stealth firmware 8.5 and 9.3 are not compatible and will yield inaccurate sweep measurement results.

•Verify the instrument is sweeping in the correct direction. Press the left diamond key and look in the upper right corner of the field unit display.



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Bad Response or Slow

- Bad response
  - Verify accessory integrity
    - Cable
    - Push-ons, barrels, in-line pads
    - Balancing accessories
    - Summation network
  - Wrong injection levels
- Slow
  - Make a bogus forward sweep plan on the 3ST with only 1 sweep point
  - Use a SDA-5510 (3HRV) for up to 10 concurrent sweepers

- Verify accessories are operating correctly such as cable, push-ons, DDC-20, pads, etc.

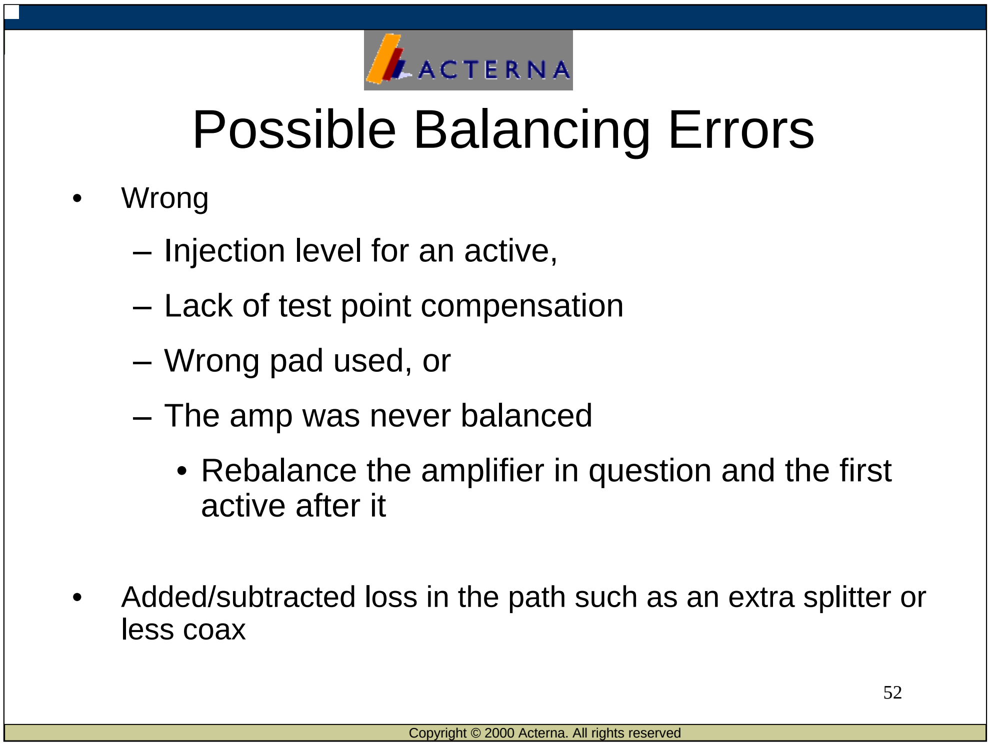
- Low sweep points may get confused with the noise floor, especially from the total noise funneling. This could cause the "grassy" effect on the sweep display. Increase the sweep insertion level on the field unit to verify.

- High forward levels into the meter can cause severe intermodulation that can affect the reverse sweep.

- Note: Sweep and telemetry levels >15 dB above the recommended input could cause return laser clipping and erroneous balancing and sweep traces. This depends upon the type of laser and return hybrids used.

- Make a bogus forward sweep plan on the Tx with only 1 sweep point. By sweeping the forward faster, the reverse will also be faster, but forward sweep will not be usable.

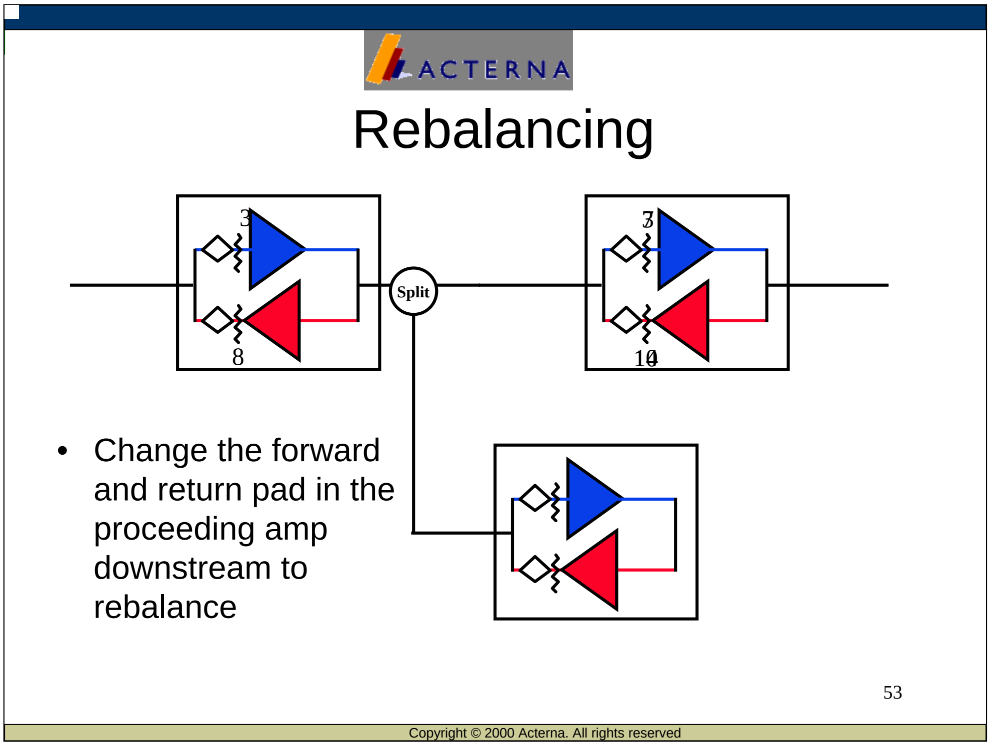
- Use a 3HRV for up to 10 concurrent sweepers. This will decrease the probability of collisions with other sweepers off the same device. It also eliminates the chance of forward level overload because forward channels are not inserted in the 3HRV.



Possible Balancing Errors

- Wrong
  - – Injection level for an active,
  - – Lack of test point compensation
  - – Wrong pad used, or
  - – The amp was never balanced
    - Rebalance the amplifier in question and the first active after it
- Added/subtracted loss in the path such as an extra splitter or less coax

- Hypothetical situations.



Rebalancing

- Change the forward and return pad in the proceeding amp downstream to rebalance

- Because forward unity gain is achieved by balancing an active's gain for the losses before it, the amplifier downstream would be rebalanced if more loss was introduced before it.

- Because reverse unity gain is achieved by balancing an active's gain for the losses after it, the amplifier downstream would be rebalanced if more loss was introduced after it.

NOTES: