ACTERNA

Maintaining the Frequency Response of the HFC Forward Path

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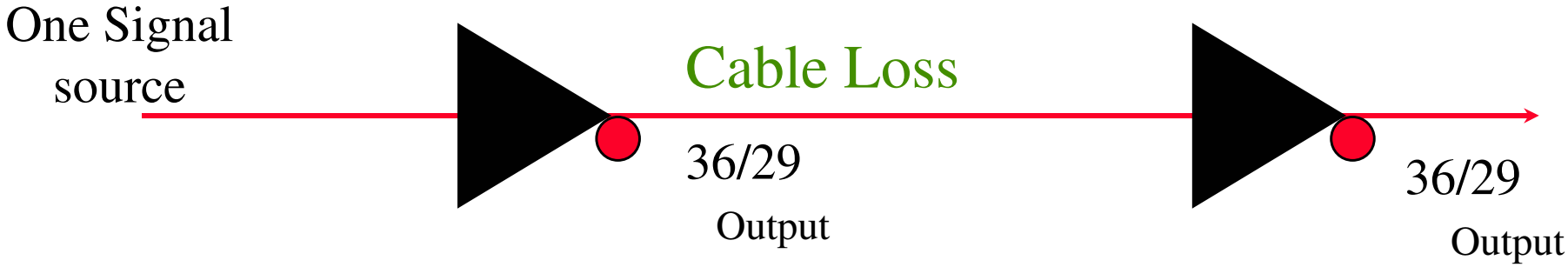
Unity Gain

- Balance each amp for system spec.s
  - Usually the same signal output level and tilt
- We're really balancing for inputs because we condition the signal before the preamp
- The amp compensates for the losses preceding it
- Unity gain: gain offsets the losses
  - What goes into the cable comes out of the next amp

Forward Balancing

- Tilted outputs to compensate for the cable after
- Technically, once the system is balanced it is totally transparent between the subscriber and Headend
  - Except for distortions, noise, ingress,….
- Unity gain is not achieved when trunk outputs feed an LE at higher outputs or when we derate LEs

Forward Alignment: Unity Gain @ Output

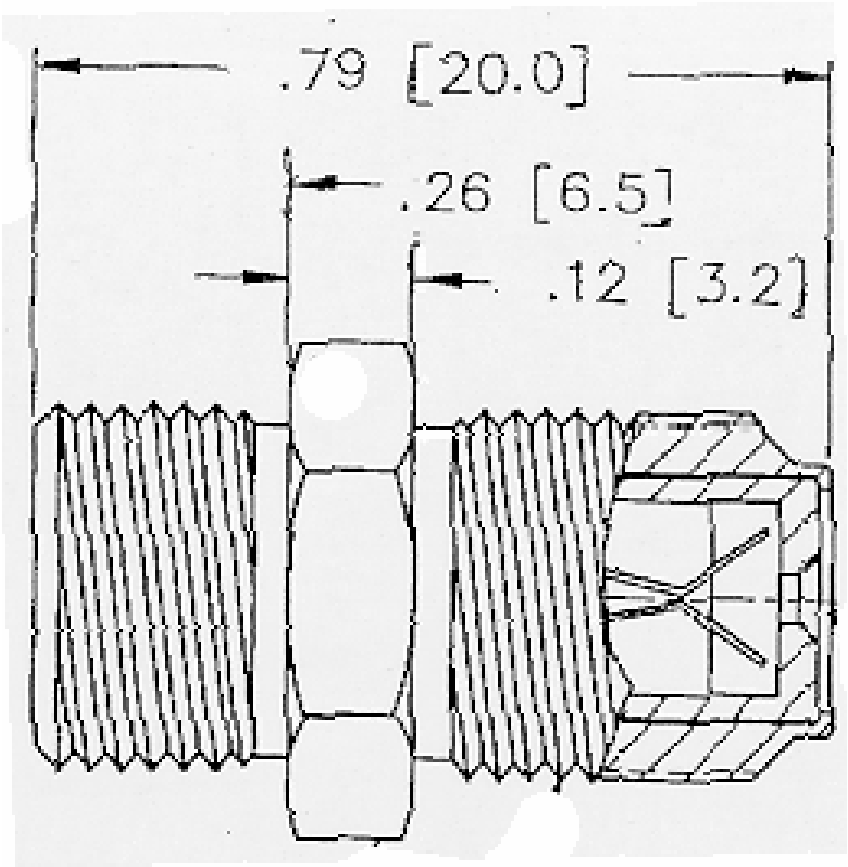


Balancing Equipment

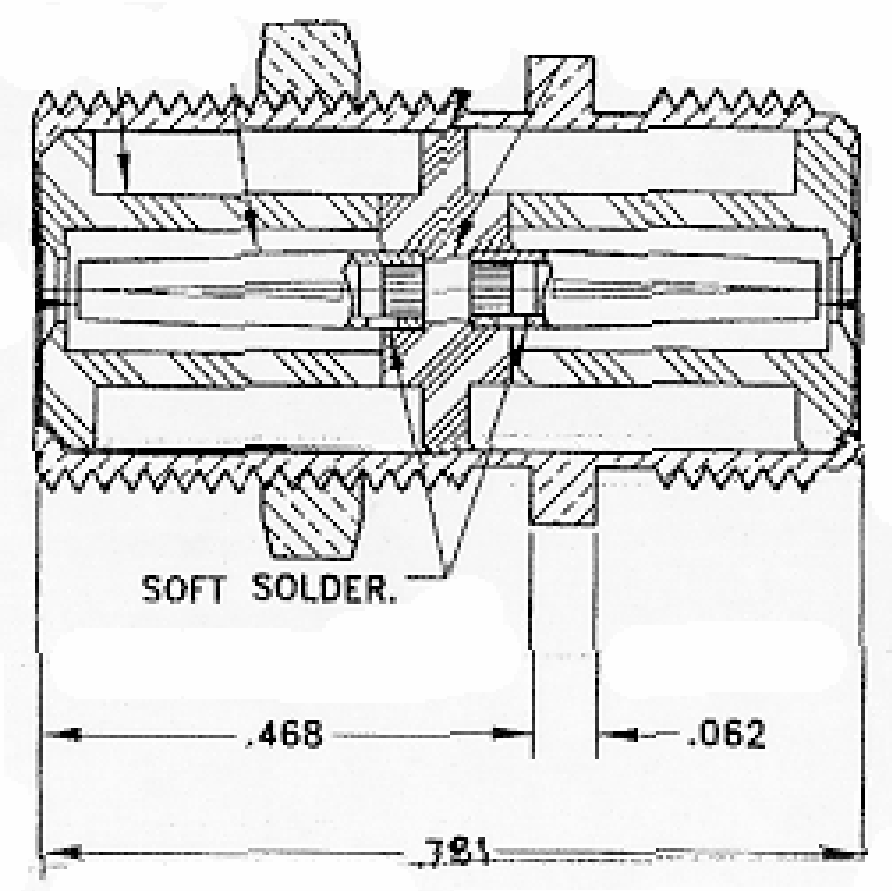
- Pads, a complete selection of values
- EQs and CSs
- SLM, fully charged!
- Test leads
  - Not too long or too short
  - No shorts
  - Proper connectors and crimping
  - Not crushed or kinked
  - No faulty push-ons or poor VSWR F-81s (barrels)

Types of F-81s

Standard



Precision



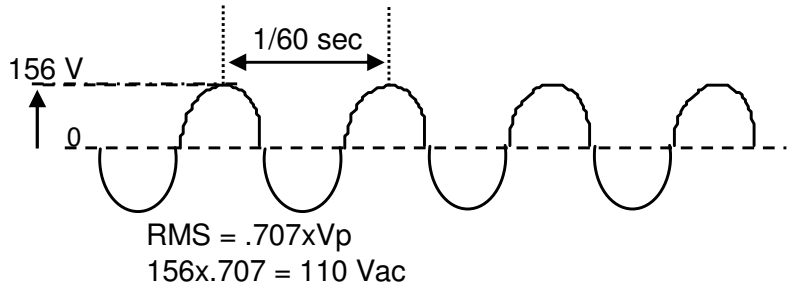
Construction Equipment

- Fiber or cable
- Shrink tubing
- Connectors
- All necessary splicing tools that would be used in construction
  - Small repairs will be made as the plant is swept

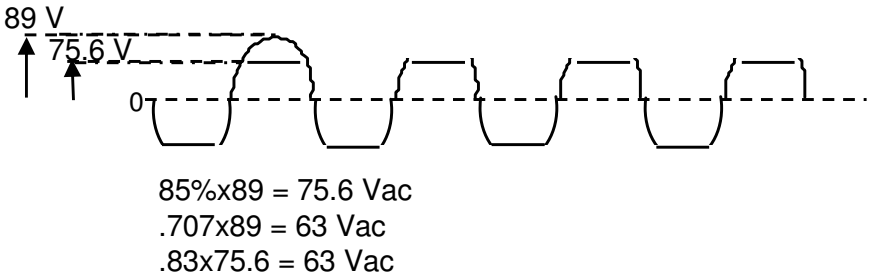
Cable Plant Spares

- Variety of taps for faceplate replacement
- Variety of MLPs (Main Line Passives)
  - Splitters
  - DCs
  - Power Inserters
- Active devices
  - Modules for all amplifier types (Nodes, Trunks, LEs)
  - Housings

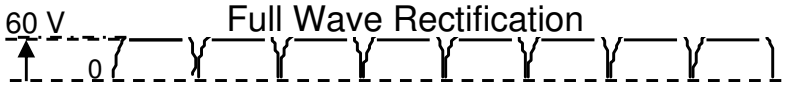
CATV Powering Scenario



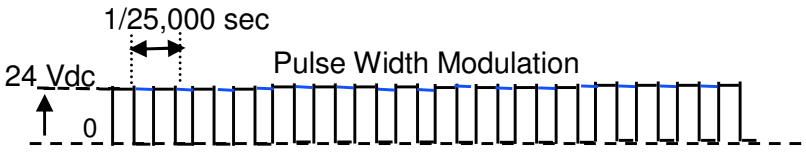
Line Power



Main Line Power



"Raw" dc



24 Vdc/B+

Check Power Before Balancing or Sweeping

- AC input (use True-RMS meter for accuracy)
- Raw DC (if equipped)
- B+ (usually 24 Vdc, but not always!)
- Ripple <15 mVac (use ac-coupled meter)
  - Hum problems if > 15 mVac on the dc test point
- Also do some preliminary maintenance (PM)
  - Check seizure screws
  - Check module hold-down screws

SLM Balancing

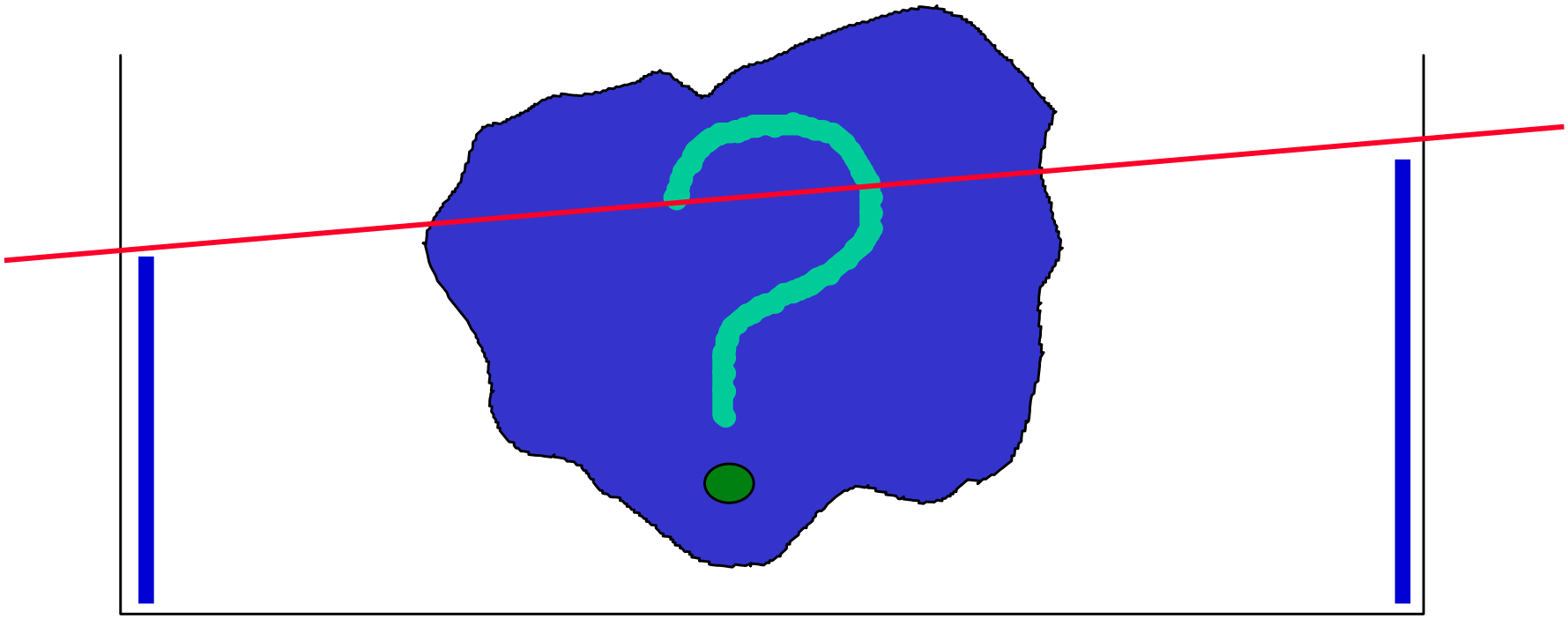
- Use a directional TP least susceptible to reflections
  - -20, -25 , or -30 dB for most equipment
- Consult maps before balancing
  - Use TombStone for new builds
  - Note discrepancies; may indicate problems
- Assure the ALC is off (if equipped)
- Install system design accessories
  - Interstage Eqs, pads, and feedermakers
- System design outputs are for 70 degrees, balance with temperature correction otherwise

SLM Balancing (Cont.)

- Use “Tilt” mode to select correct EQ or CS
- Observe high frequency and use “Tilt” or “Level” mode to select the correct pad
- No “tweeky” in a lot of amplifiers
- Verify all active ports have proper levels
- Change RF module, if it has failed
- Housing changes and major construction should be done by the appropriate personnel

Why Sweep?

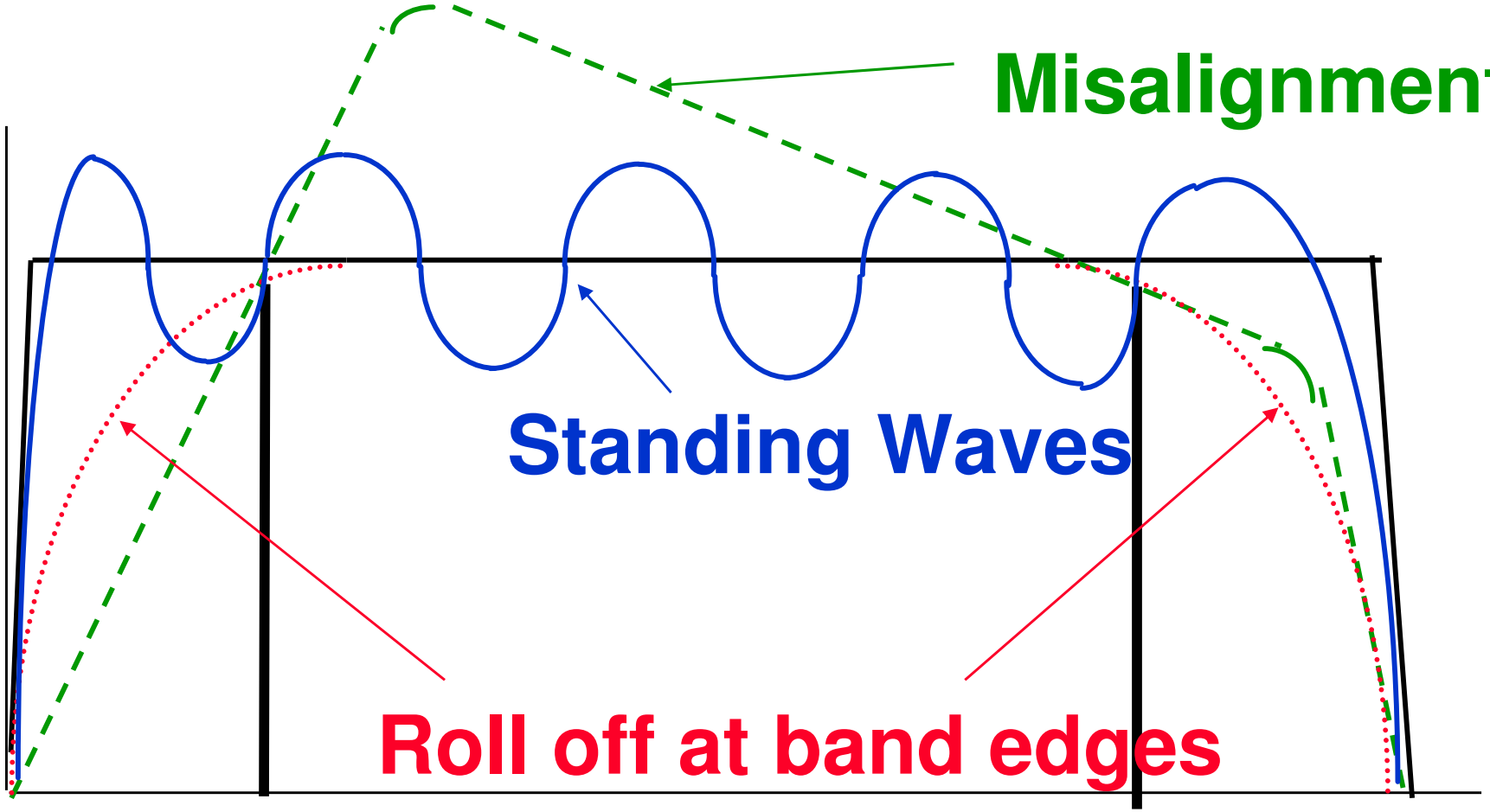
Bandedge Balancing



55.25MHz

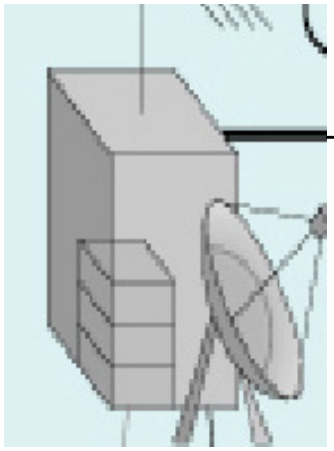
745.25MHz

Sweep Finds Problems That Signal Level Measurements Miss



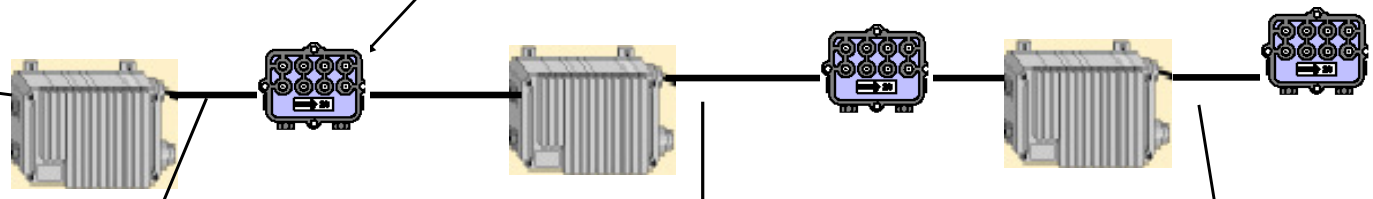
Balancing Amplifiers

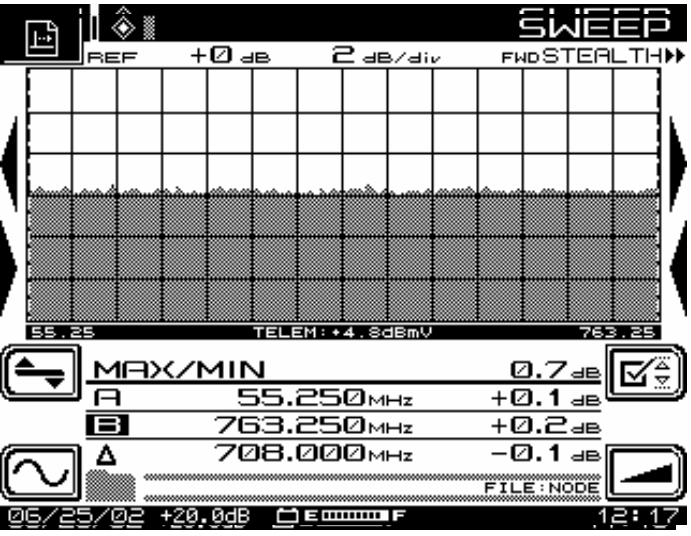
Balancing amplifiers using tilt

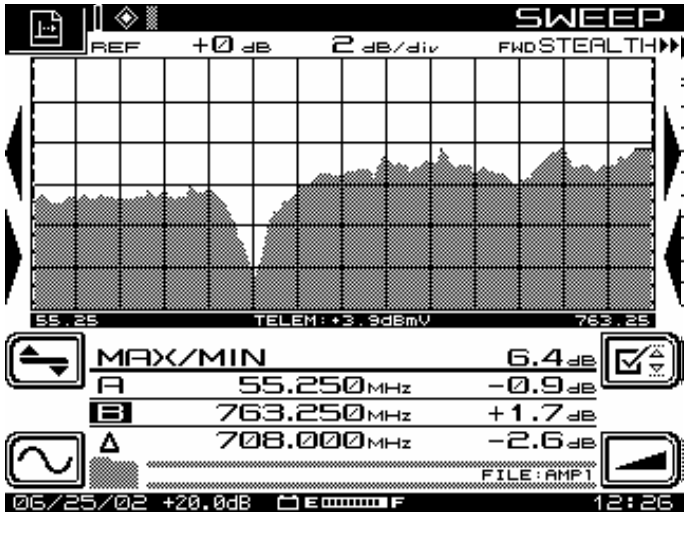


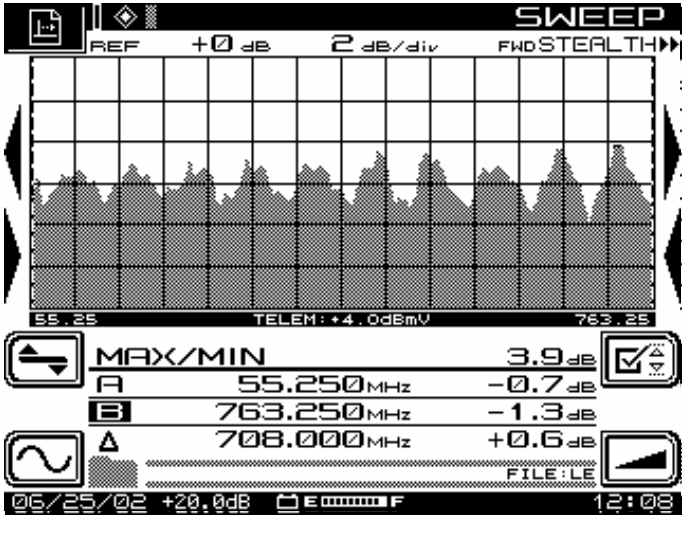
No Termination

Lose Face Plate, or crack cable shield









Why Sweep?

- If “BandEdges” are used, system problems may not be observed
- Bandedge balancing only verifies the amp is operational
- Proper levels ensure good C/N and distortion performance
- Accurate testing permits proper amplifier adjustments
  - Gain, slope, & frequency response
- This helps alleviate problems such as:
  - Poor picture quality
  - Slow data throughput
  - Customer complaints

Sweep Vs Signal Level Meter Measurements

- The Stealth sweep allows a reference to be stored eliminating the effect of headed level drift
  - But, not unstable carriers
- Sweep systems can measure in unused frequencies
- Most important during:
  - Construction of new plant and system overbuilding
  - Verifying inactive plant or just certain legs
    - Theoretically, one could balance the RF actives before a node is actually activated - “Unity Gain”
- Sweep systems are more accurate and faster

Sweep Verifies Construction Quality

- Sweep can find craftsmanship or component problems that aren't revealed with other tests
- Damaged cable
- Poor connectorization
- Amplifier RF response throughout its frequency range
  - Gain
  - Slope
- Loose seizure screws, module hardware, …….

Sweep Finds Damage Caused by Aging or Environmental Factors

- Water migration in coaxial cable and passives
- Damage due to repetitive vibration
  - Trains, trucks, etc.
- Connectors loosened by temp contraction/ expansion
- Damage due to:
  - Fire
  - Bullet holes
  - Malicious mischief
- Helps find problems before they develop into an outage

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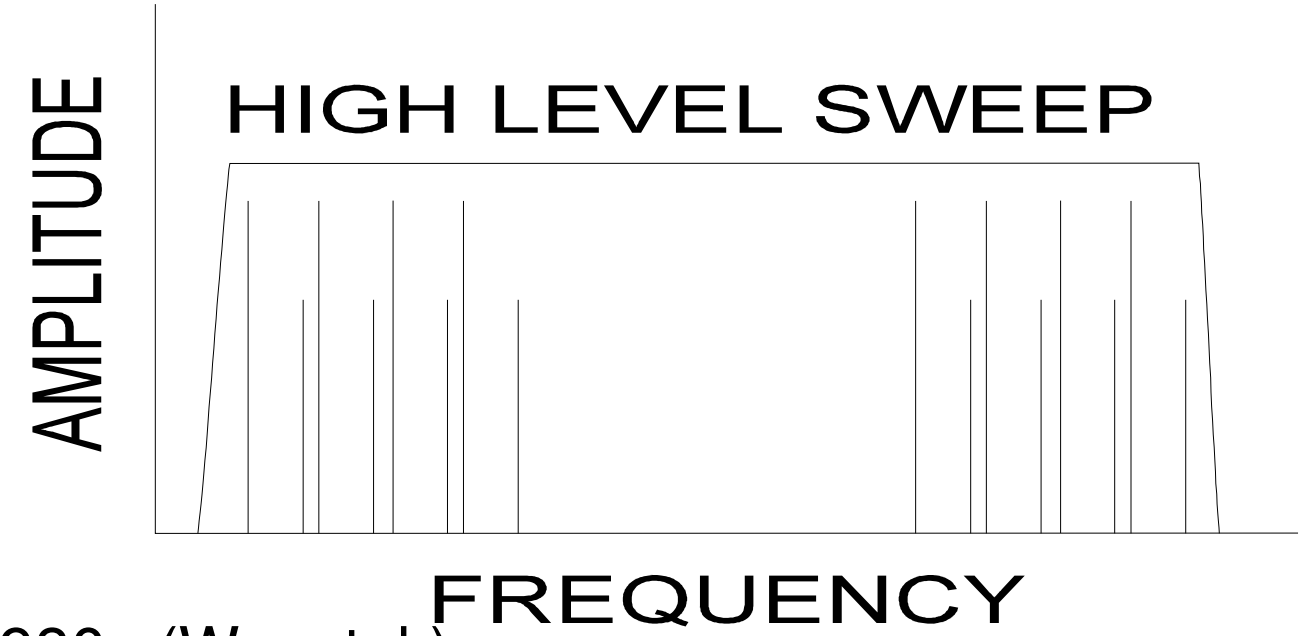
Sweep Methods

- Low Level Sweep
- High Level Sweep
- Guard Band Method
- Vertical Blanking Method
- Sweepless Sweep
- Stealth Combination Sweep

Low Level Sweep

- Late 1970s analog analyzer (Avantek)
- Channel loading and long amp cascade caused poor resolution, hard to see sweep
- Sweep rate in msec
- Confusion with system noise
- Potential interference (continuous sweep)

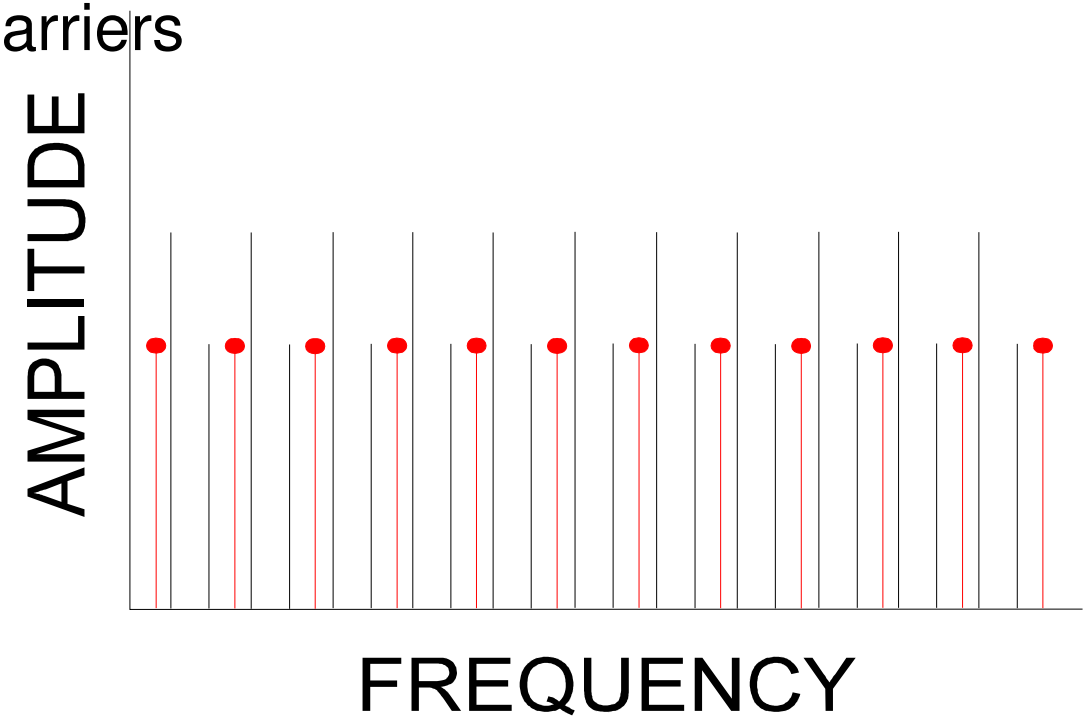
High Level Sweep



- Mid 1980s (Wavetek)
- High resolution
- Easier to see, but produces “interference” in the picture
- Sweep rate in µsec
- Equipment is heavy

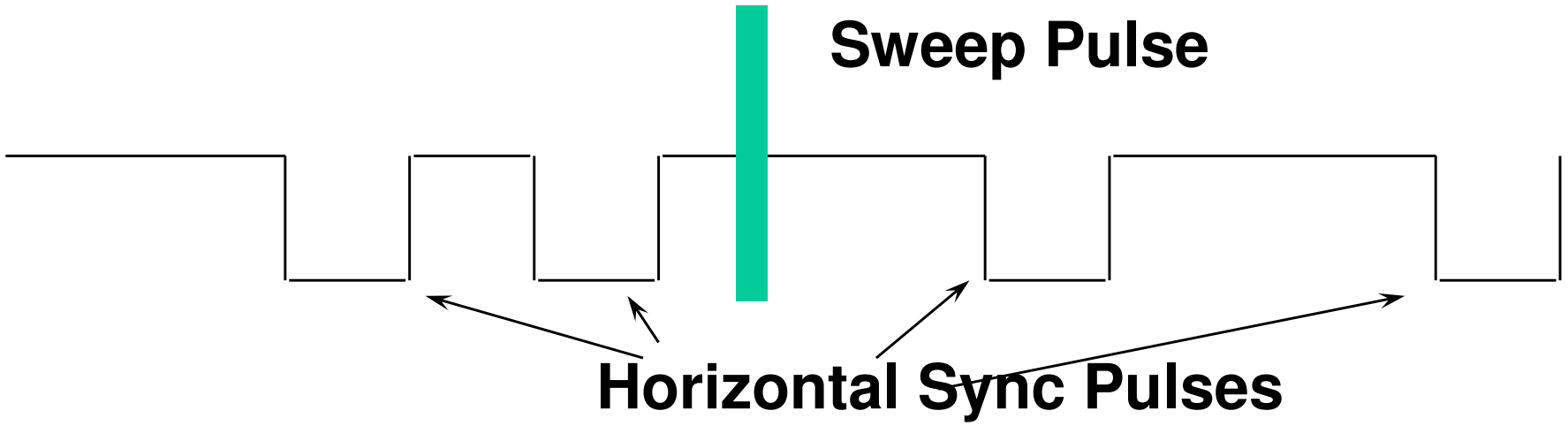
Guard Band Method

- Inject sweep between video and audio carriers
- Initial setup is critical and time consuming
- Interference with digital carriers
- Late 1980s
- Minimal Interference
- Sweep rate in µsec
- Relatively expensive



Vertical Blanking Method

- Late 1980s, totally non-interfering
- Inserted during vertical blanking interval
- Expensive transmitter (all signals routed through)
- Has difficulty with some scrambled channels
- Not compatible with digital TV-carriers (QAM)
- Blank spectrum not tested
- Slower sweep update (4 sec)



“Sweepless” Sweep Method

- Late 1980s
- Compares headend levels to system test point levels
- Totally non-interfering (no sweep injection signal)
- Relatively inexpensive (no headend unit)
- Normal level variations in headed signals cause loss of valid reference information
- Blank spectrum not tested
- If the noise floor is used as a reference for the empty areas, it will be unstable

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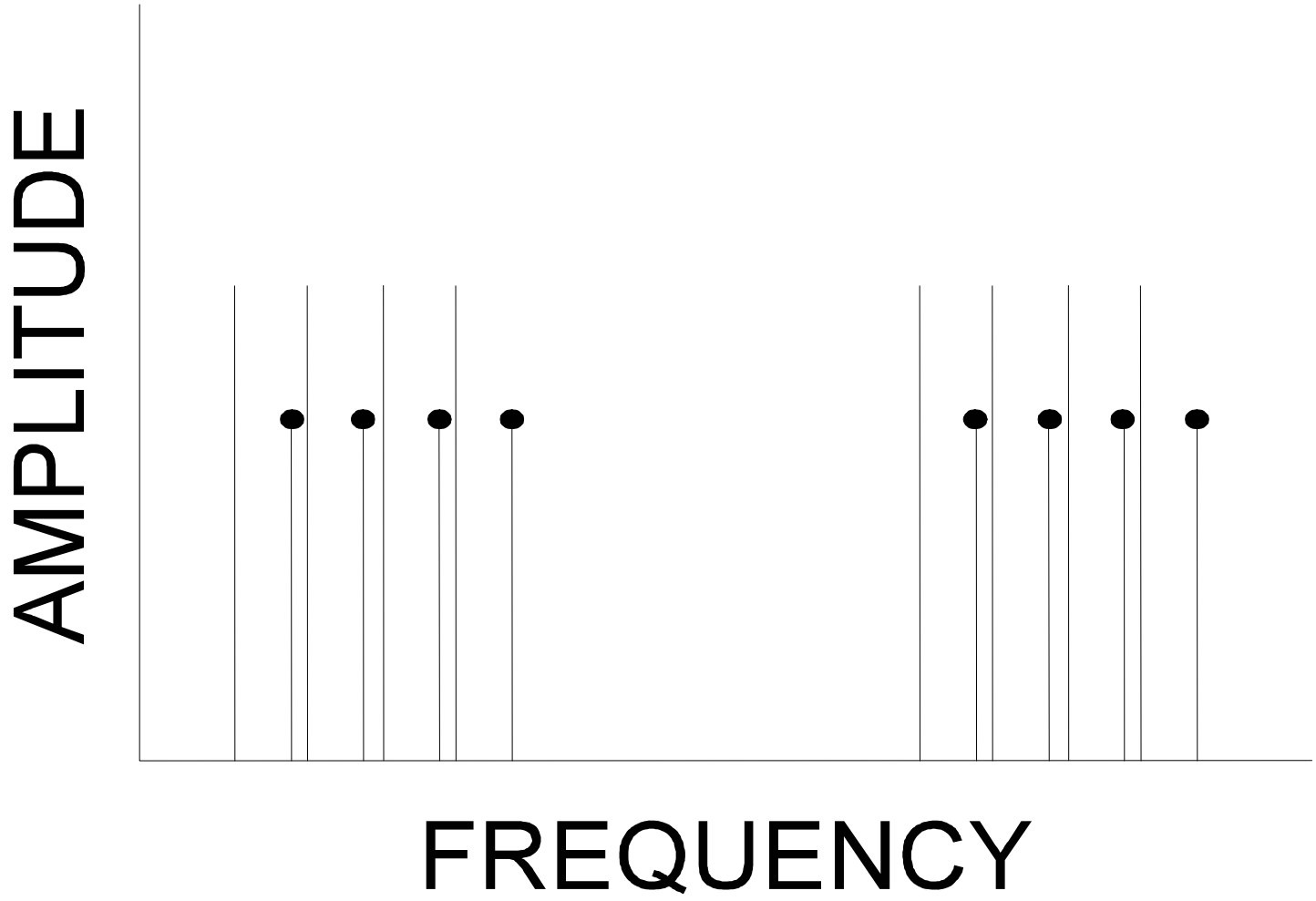
‘Sweepless’ Sweep

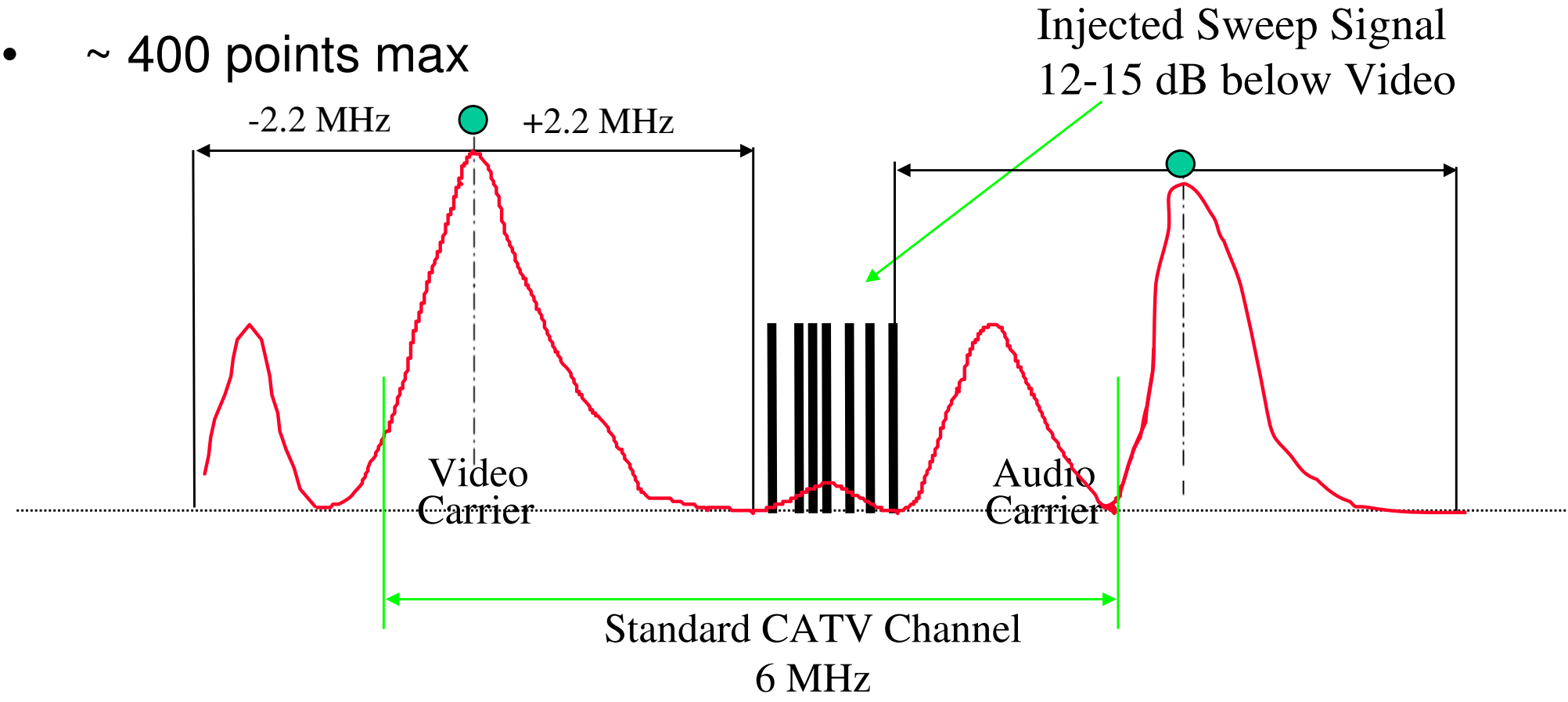


Sweep Gear Manufacturers

- WWG Stealth
- CaLan/Agilent(HP) 1777/1776, 3010R/H
- Avantron
- Trilithic
- Tektronix

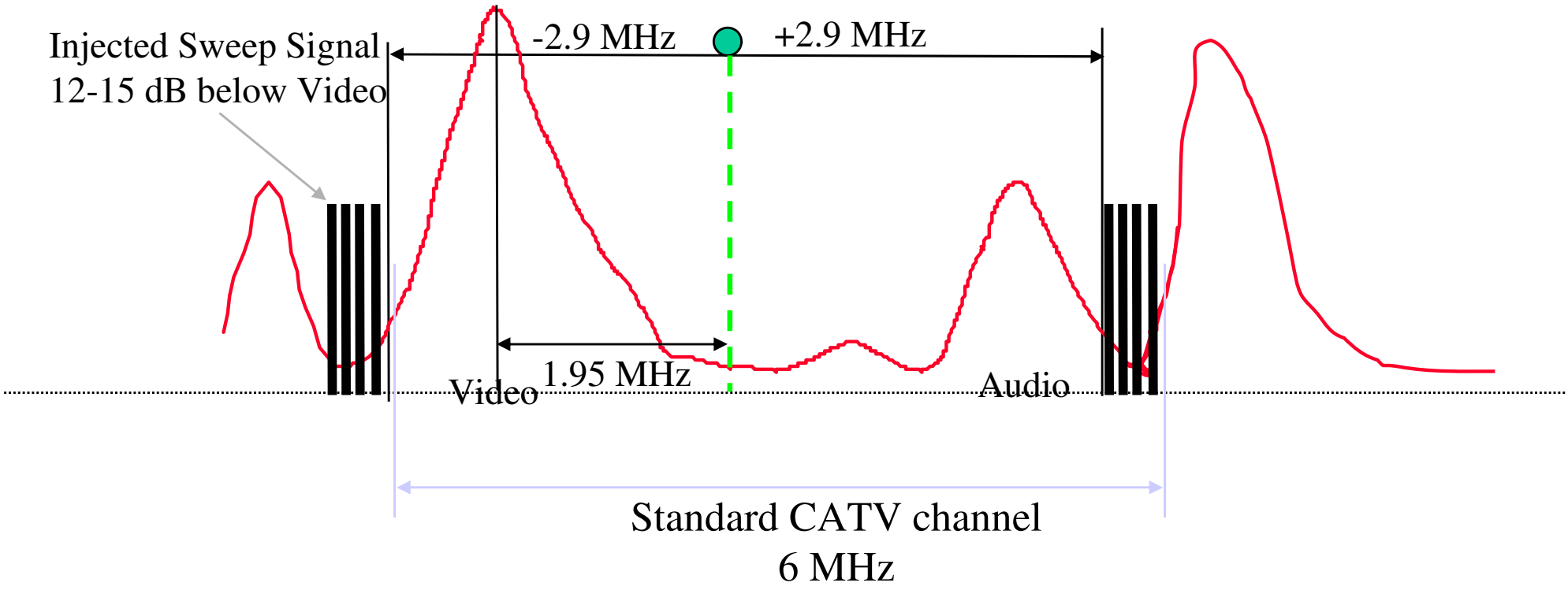
CaLan System Sweep

- 2.2 MHz Guardbands around the video carrier
- Dwell time of 1 (100µs)
- ~ 400 points max



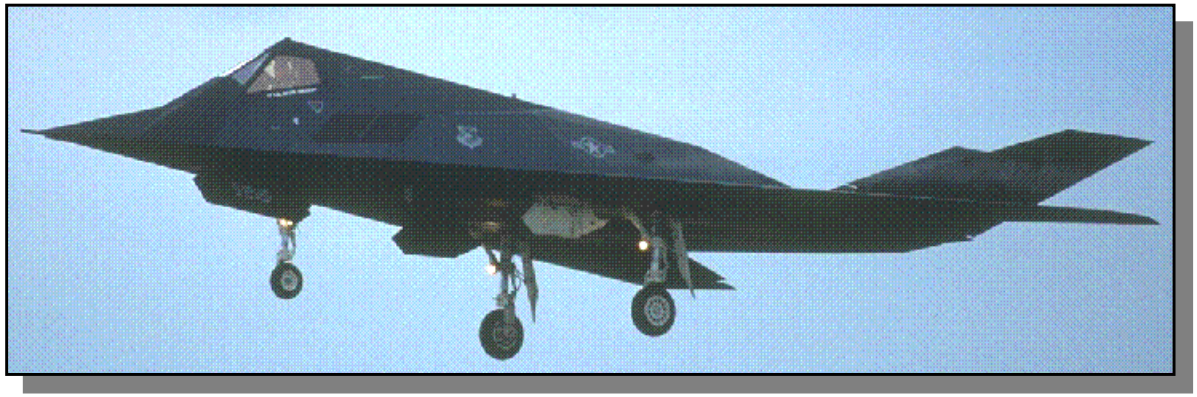
CaLan Setup - Phantom Sweep

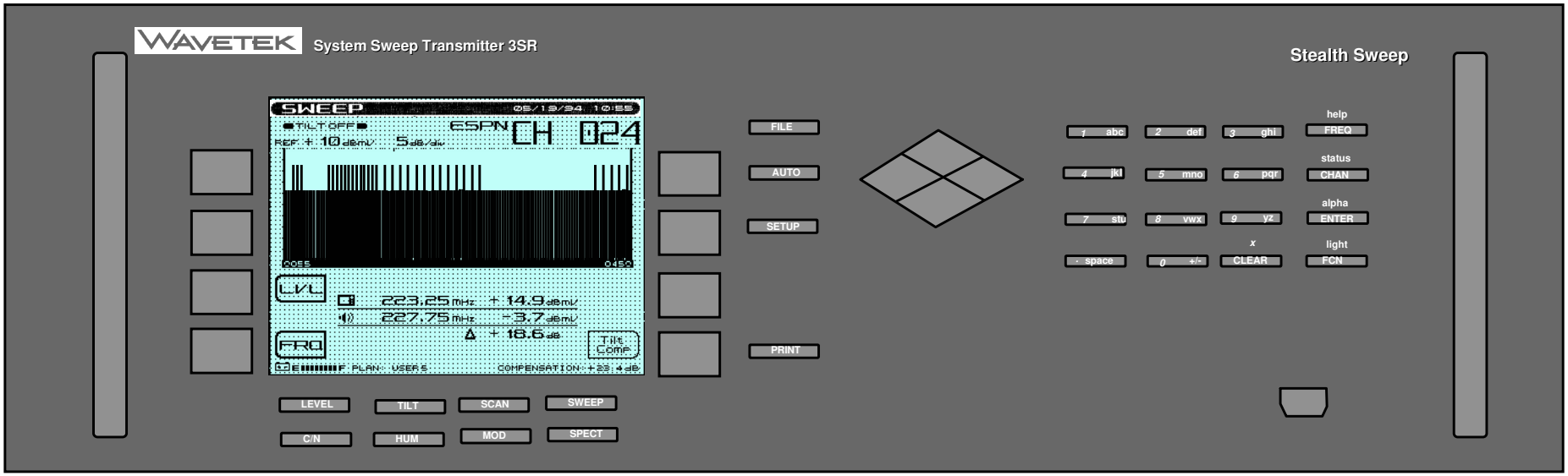
- A Phantom sweep point at 1.95 MHz above the corresponding video channel with a dwell time of 0
- 2.9 MHz guardbands around the phantom carrier



Why Call it Stealth?

- Both “Stealths” are invisible on the “screen”



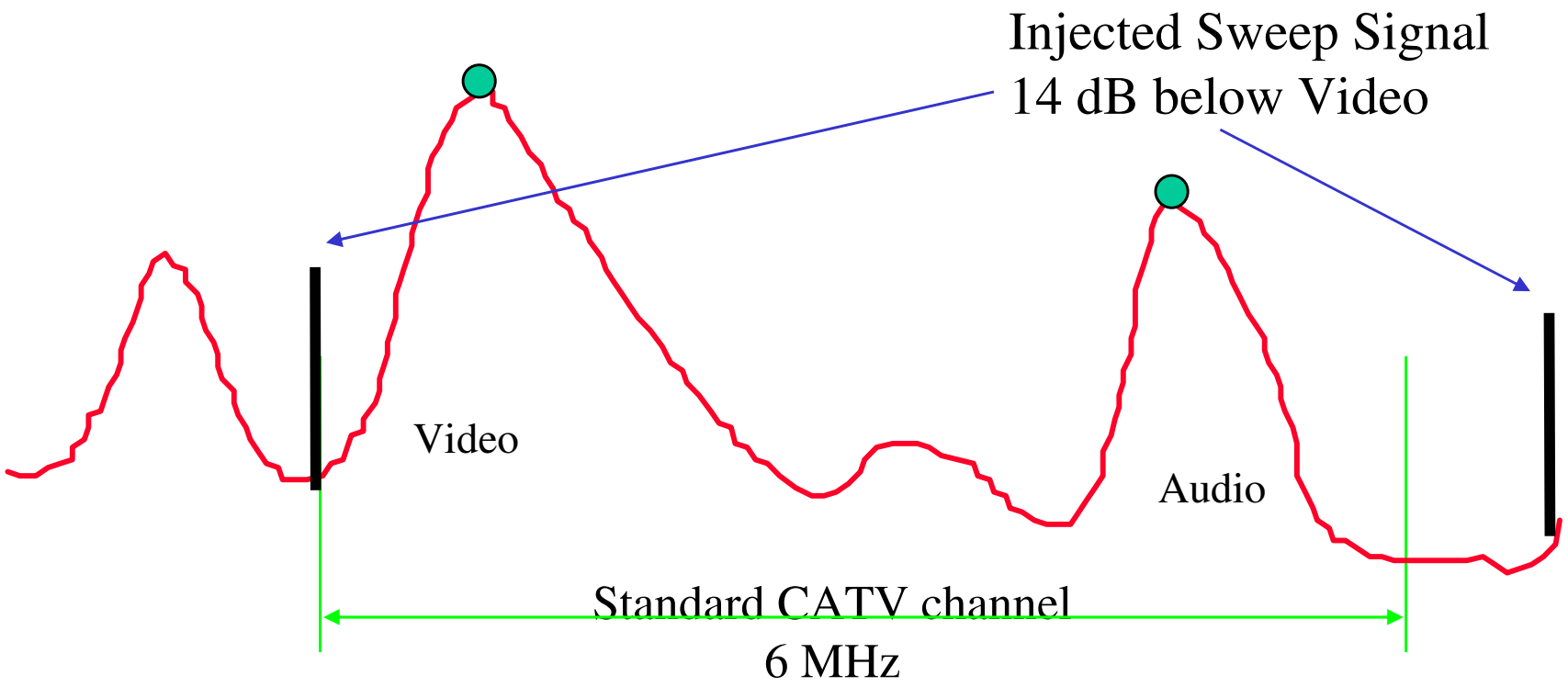


The “Stealth” System Sweep

- Non-Interfering
- Fast (approximately 1 second for 200 data points)
- Stable (continuously refreshed headend reference)
- 1 GHz range
- Scrambled TV, Digital Video, Digital Radio and Data Signal compatible
- The most efficient solution for return-path measurements

Standard Acterna Setup

- Can monitor Video and Audio at 4 ms dwell time or place a sweep point in the lower sideband
- Place sweep points where ever at 2.8 ms dwell



Dwell Times

- 158 ms = Digital, Scrambled, & Telemetry
- 2.8 ms = Sweep Point & Single channel
- 4 ms = Video & Dual

- Example
  - 100 scrambled channels; all used as sweep reference points
  - 158 ms*100 = 15.8 seconds to update the sweep trace!

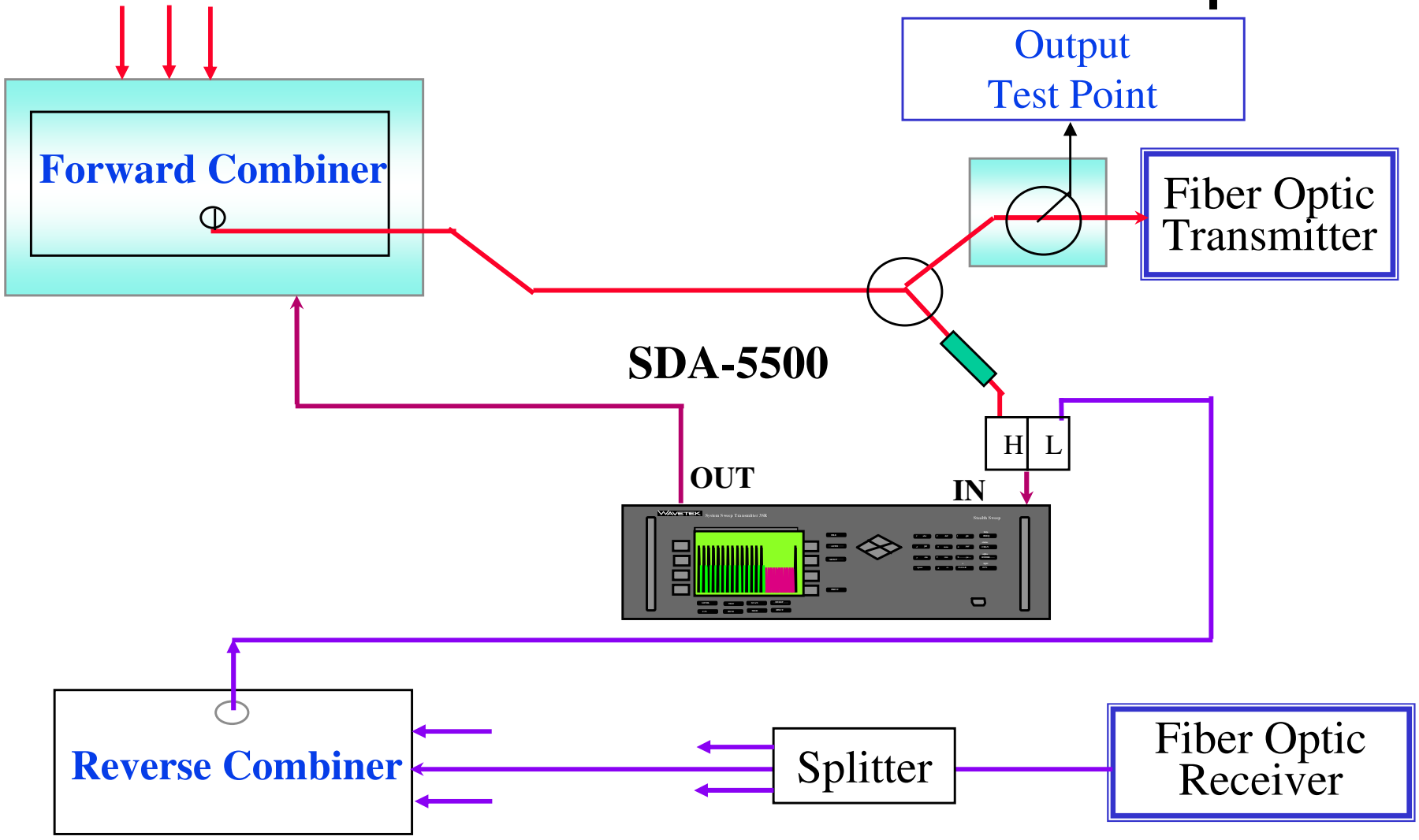
Dwell Time Comparison

- SDA
  - 158 ms = Telemetry
  - 10 ms = Digital
  - 24 ms = Scramble
- WWG:
  - 158 ms = Digital, Scrambled, & Telemetry
  - 2.8 ms = Sweep Point & Single channel
  - 4 ms = Video & Dual
- CaLan
  - 0 = no reading of this channel
  - 1 = 100 us standard CATV
  - 2 = 4 ms stereo audio
  - 3 = 24 ms scrambled channels

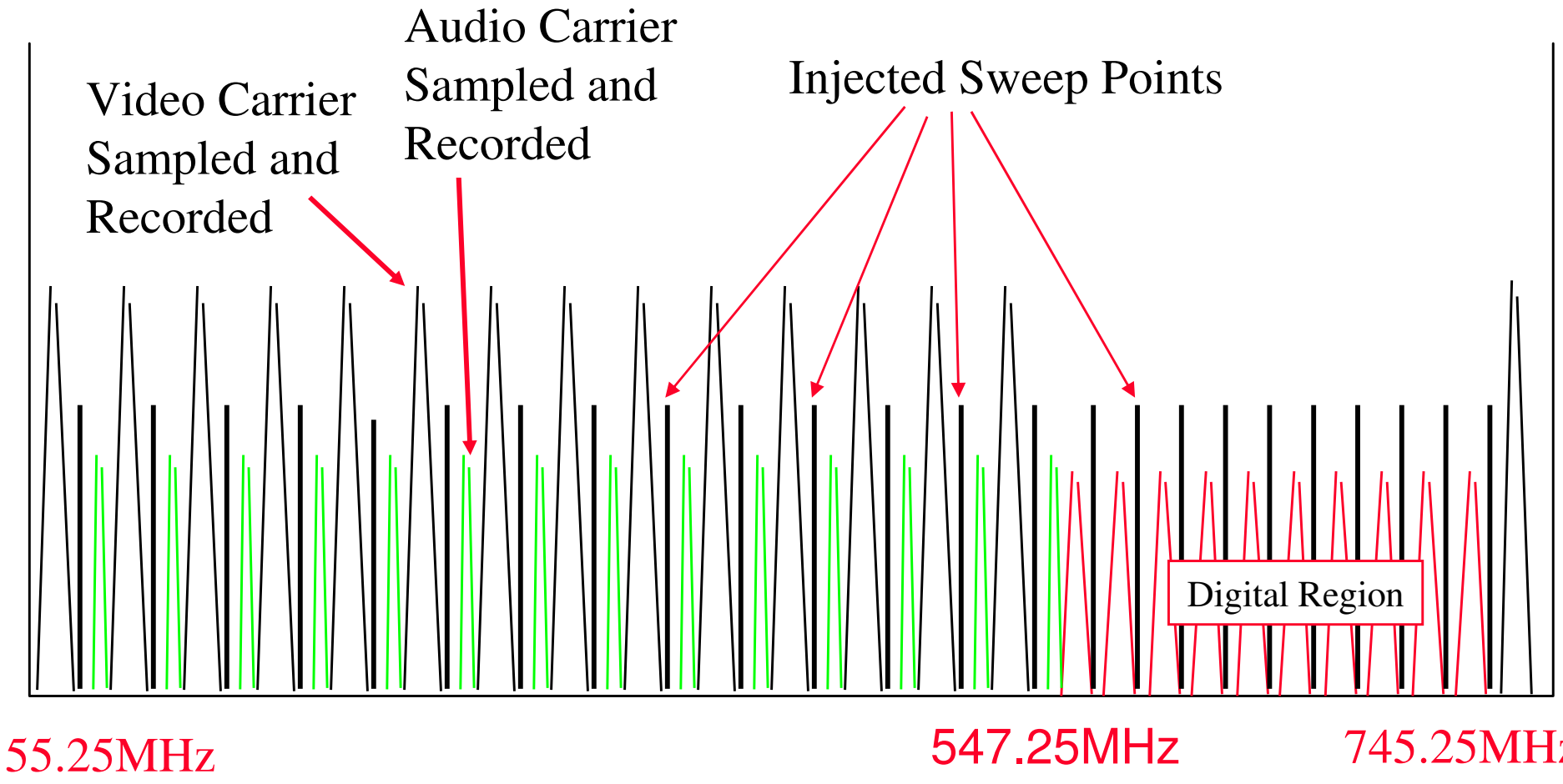
ACTERNA Sweep Choices

- The default setup/channel plan is the safest setup for a non-intrusive sweep
  - Measure actual carriers on the system
  - Place sweep points in unused bandwidth
- The fastest sweep places a sweep point in the lower sideband and doesn't sweep the active carriers
  - Placement and amplitude of sweep points is critical because of interference to adjacent carriers
  - ~ 1.1 MHz below the video carrier frequency
- 2.8 ms*100 = .28 s to update!

Stealth “SDA-5500” Set-Up

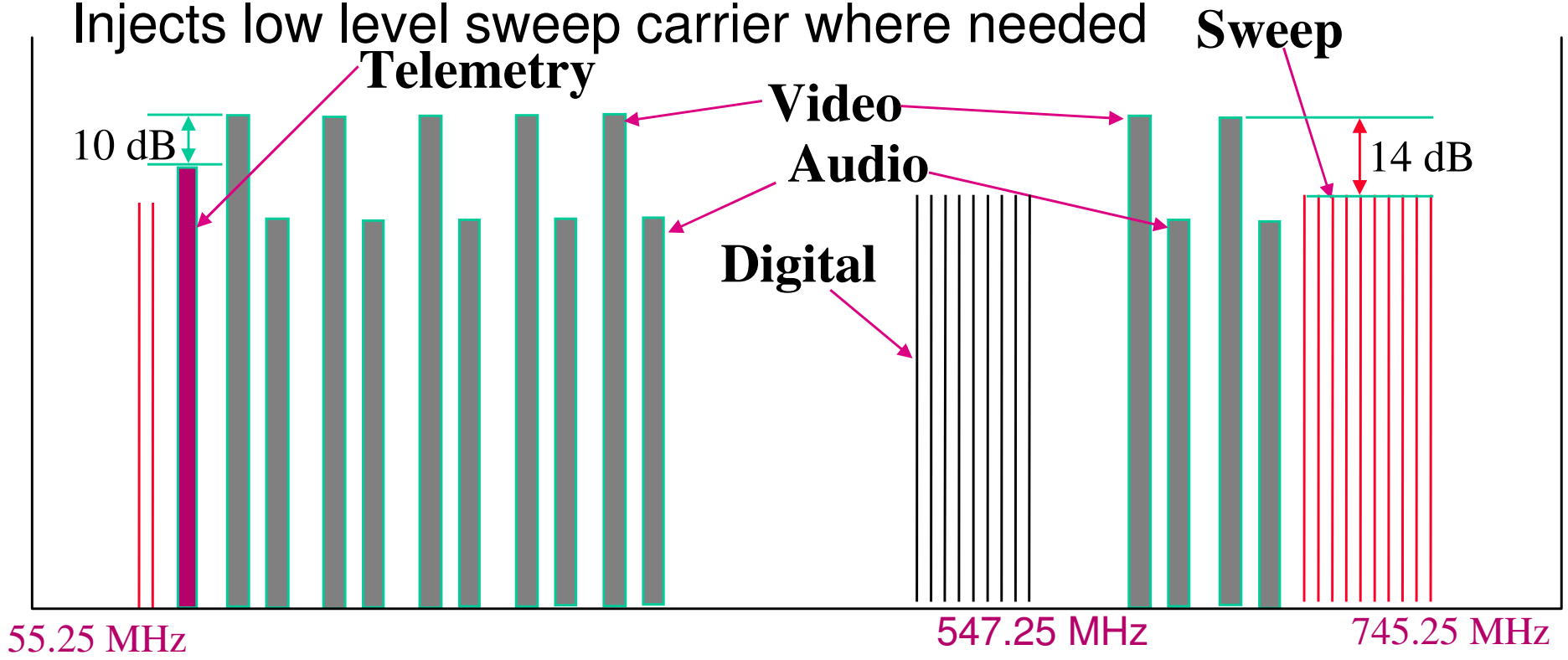


Injected Sweep Pulses



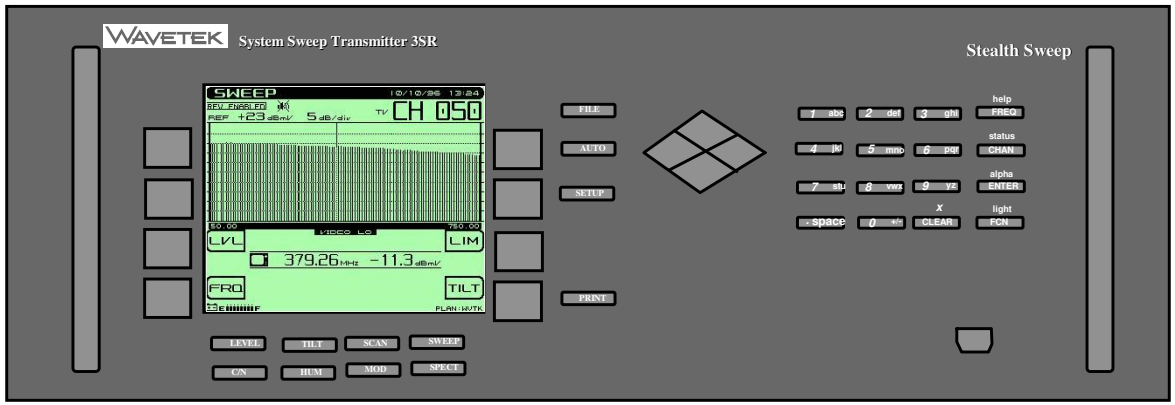
Stealth Sweep Insertion

- All functions of handheld unit
- Full measurement capability in the headend
- Injects low level sweep carrier where needed



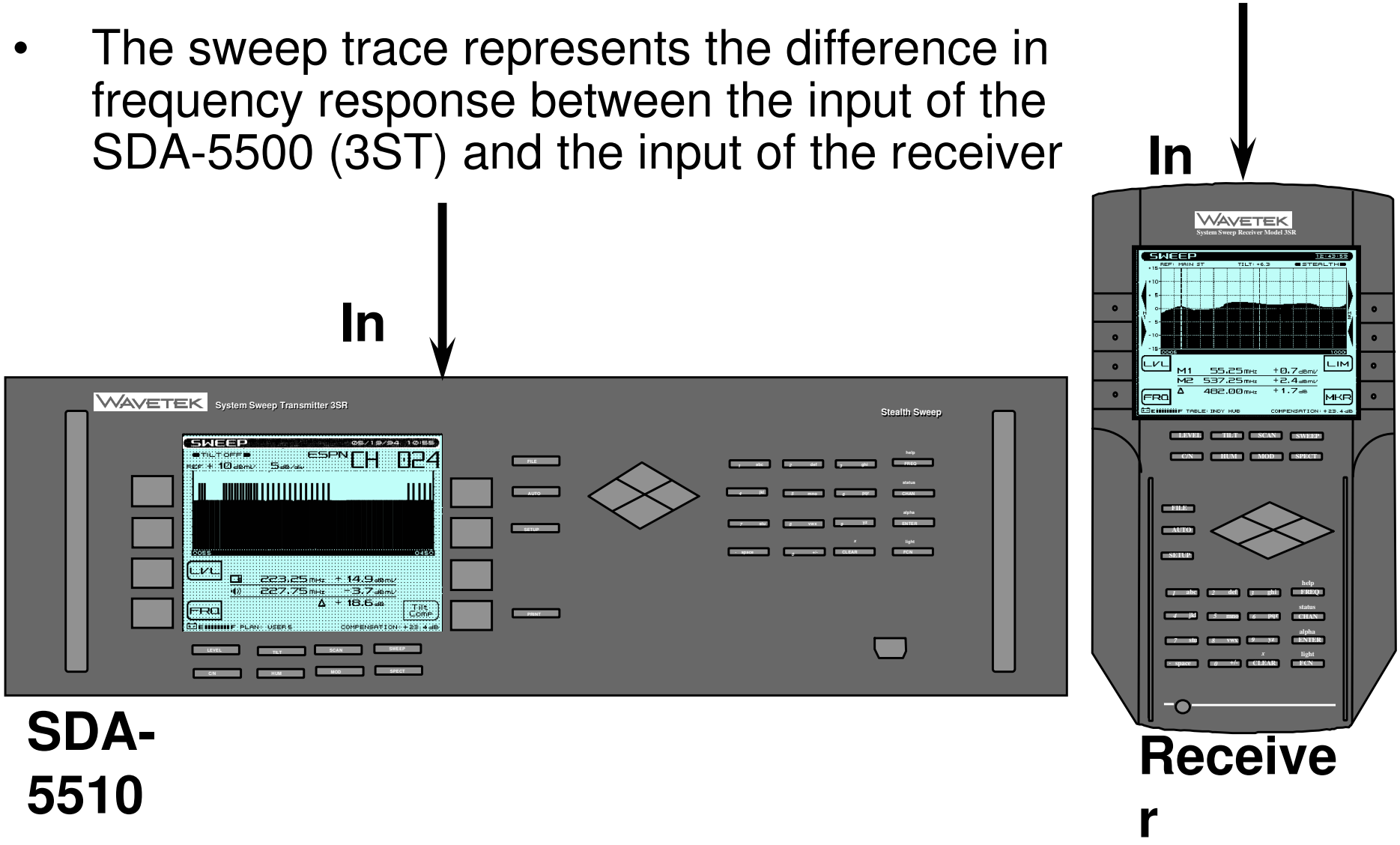
Stealth System Sweep Transmitter SDA-5500(3ST)

- Sweep transmitter and headend monitor
- Constantly monitors video, audio, and digital carriers plus sweep insertion points
- Transmits any level variations to the SDA-5500 on a telemetry carrier to update the reference
  - Keeps receiver up to date on headend levels



Results

- The sweep trace represents the difference in frequency response between the input of the SDA-5500 (3ST) and the input of the receiver



SDA-5500 (3ST) Setup

- Video carriers into SDA-5500 (3ST): 4 to 12 dBmV (6 ± 2 is better)
- Sweep insertion pulses set approximately 14 to 16 dB below video
- Telemetry level set 10 dB below video
  - FSK modulation ~ 100 kHz wide
  - ~ 1 MHz needed
- Ensure no sweep points are built within 6 MHz either side of the ALC frequency
  - Could cause a problem with the ALC in certain amps
- After building a channel plan, it's downloaded to the field unit via the serial cable provided by ACTERNA

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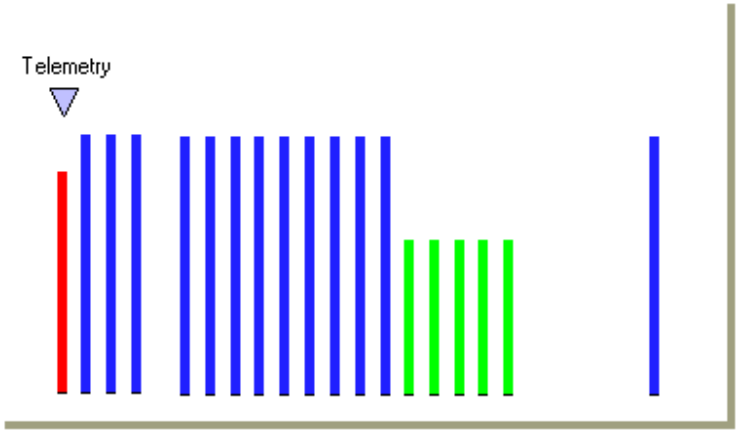
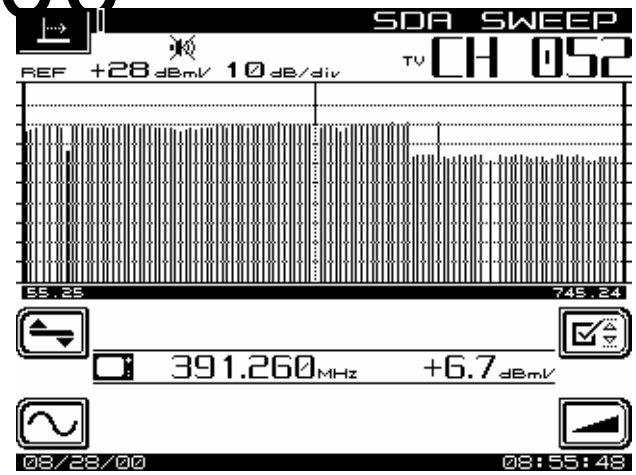
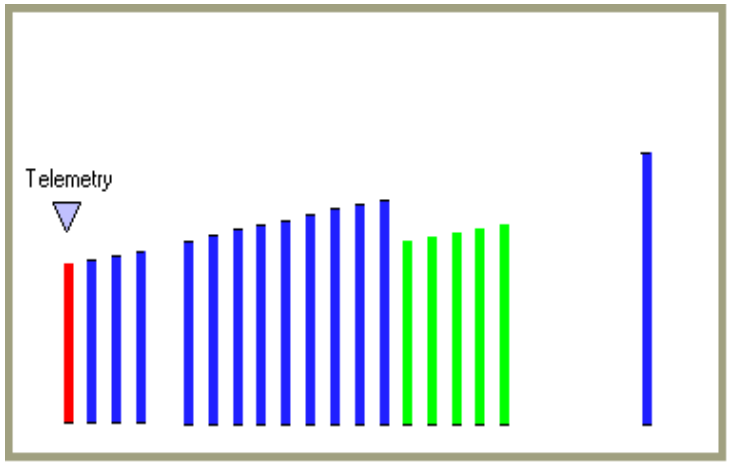
Maintaining the Frequency Response of the HFC Forward Path

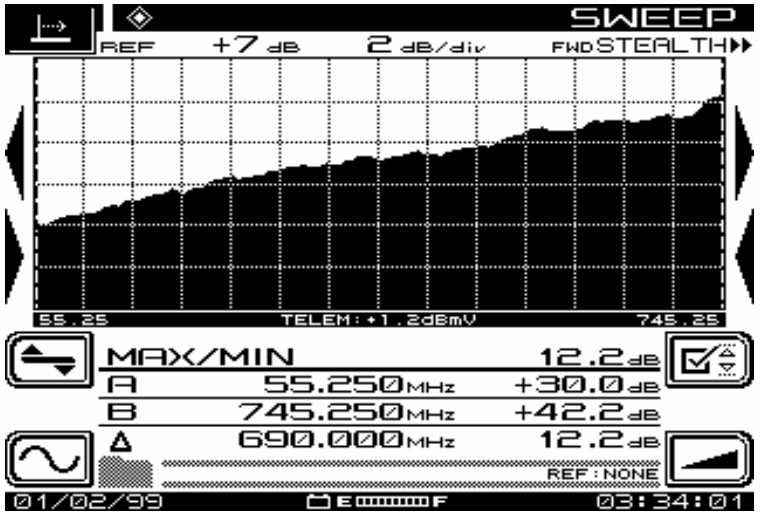
SDA 5500





SDA 5000





SDA-5500 & SDA-5000 Setup & Spec.s

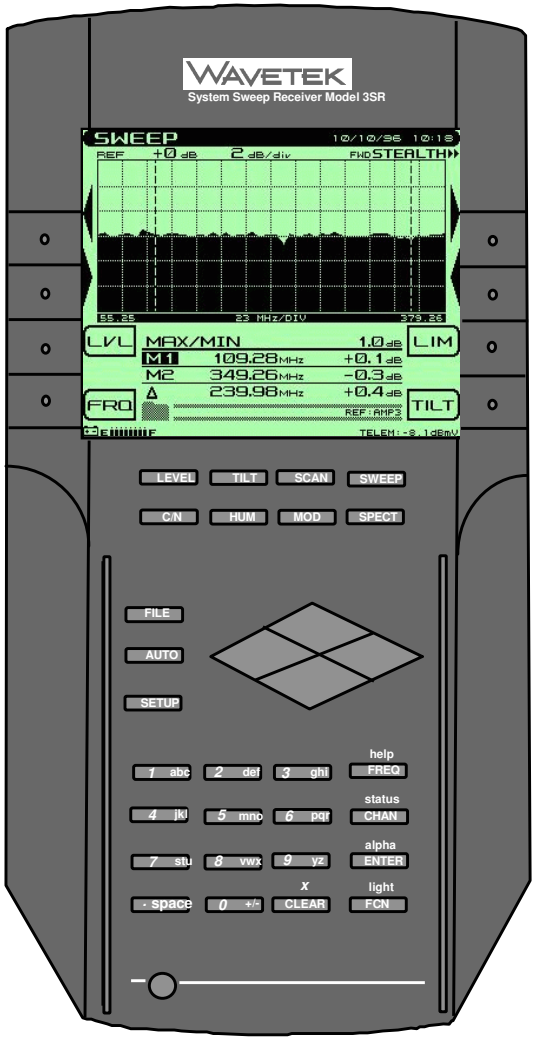
- Null modem would work on a regular RS-232 cable
- Ensure same Baud rate
- Tx downloads the plan you've built, but "sweep points" don't show up in the SDA-5000 channel plan
- Telemetry Level must be > -20 dBmV to guarantee communication
- It could overload with > 20 dBmV/channel input for a completely loaded analog system
- You can sweep without downloading the channel plan, but other measurement modes won't operate correctly

Stealth Sweep Receivers

- Handheld instruments
- Lightweight, ~ 5 lbs
- High resolution LCD display viewable in direct sunlight
- Wide operating temp. 4° to 120°F
- Water resistant rubber front panel
- SAM4040 can be upgraded to 3SR
- 3SR can be upgraded to SDA-5000

Stealth Receiver Battery Stats

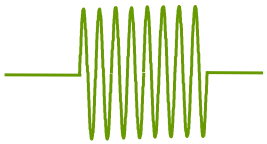
- Field replaceable battery
  - Nicad 3 to 6 hours normal operation
  - Nickel metal hydride (double)
- Optional cigarette lighter adapter for Nicad
- Optional 4 or 6 bay battery charger
- DC/AC protected (200Vp-p / 60Hz)



Sweeping within a Digital Channel is Discouraged

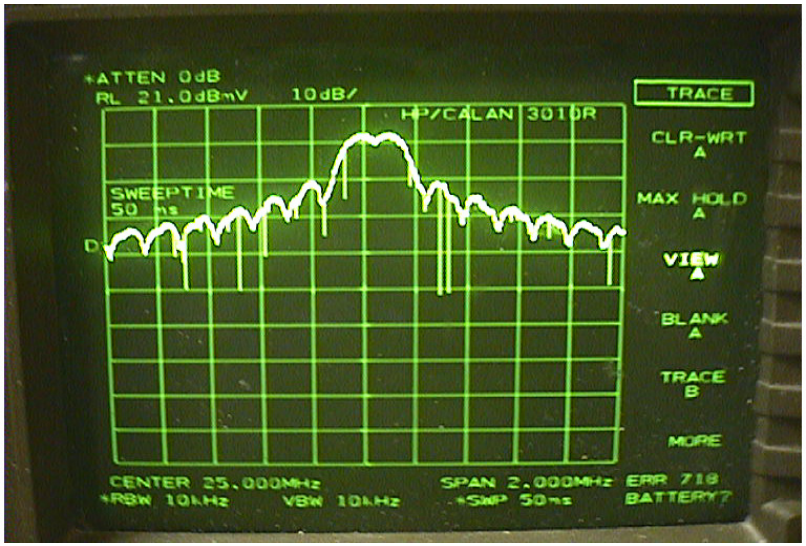
- Sweep pulses are like noise and when added to the noise and ingress already on the system may overload the Forward Error Correction capabilities
- May slow down data rate due to resends during high traffic
- The digital carrier will interfere with the sweep causing an unstable trace
- It's much better to insert narrow sweep pulses in the guard bands

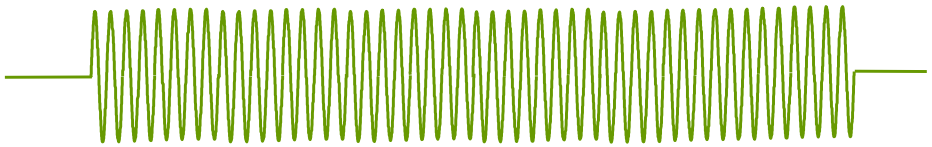
Pulse Width Determines Spectral Footprint



5 µs = >800 kHz footprint

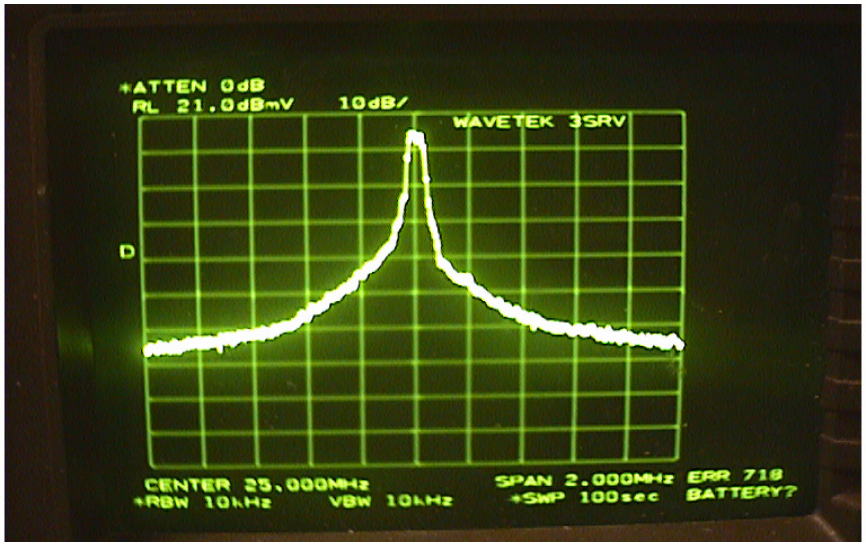
Competing System



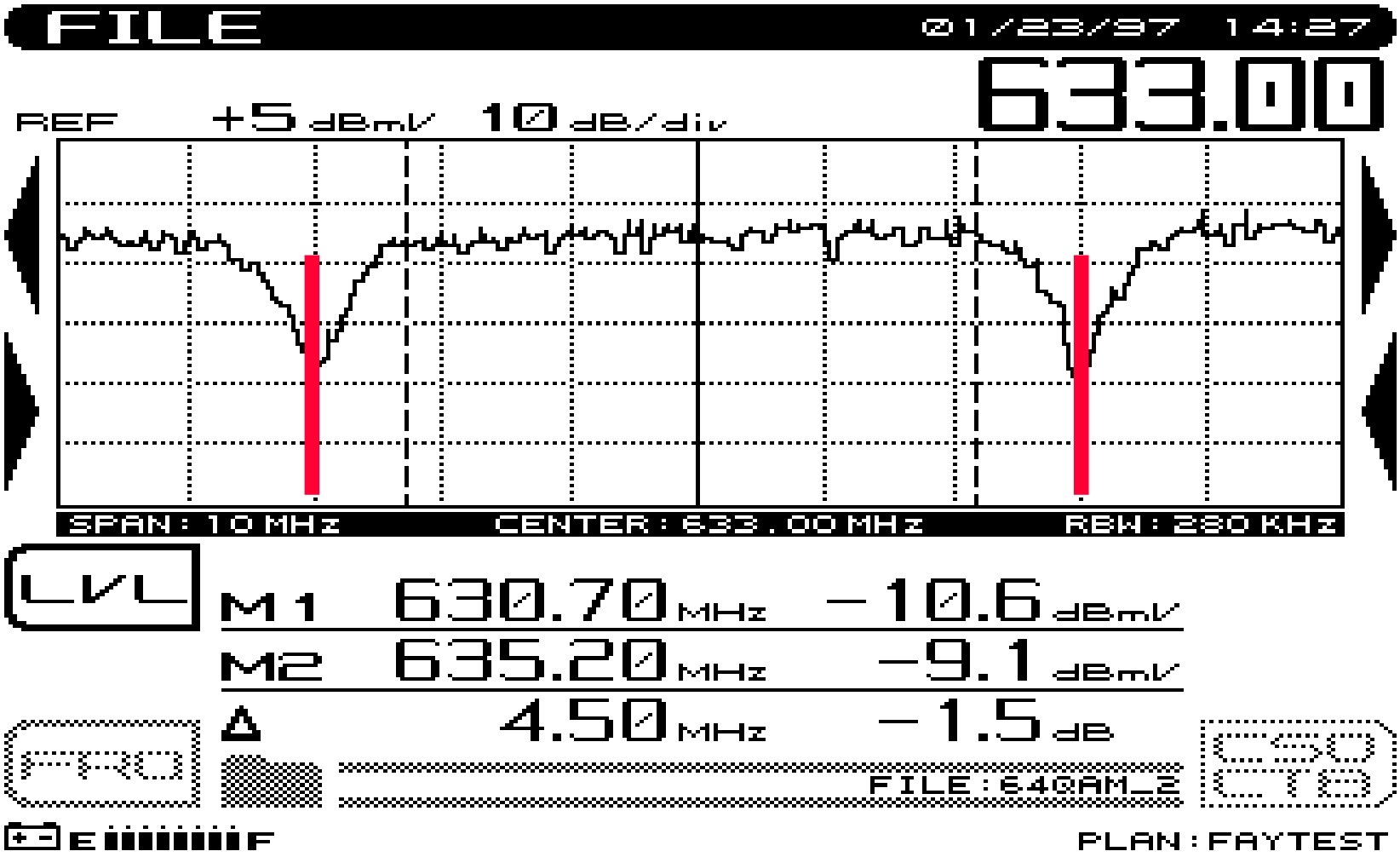


2.5 ms = 100 kHz footprint

WWG Stealth



64 QAM Guard Bands



Digital Concerns

- If there are guardbands, it would be good to place sweep points in these guardbands
- For digital video there may be limited guardbands
  - May have to measure at a 158 ms dwell time
- Forward digital channels don't have the luxury of retransmitting bits like high speed data on the return
  - Forward Error Correct (FEC) can mask some loss of bits, but may lose dynamic range prematurely

Initial Setup Requirements

- Ensure Headend is perfectly flat and stable!
  - Correct video carrier levels
  - Correct V-A delta
  - Correct video modulation depth (1Vp-p or 87.5%)

- Obtain the MOST UP-TO-DATE MAPS of the system
  - Maps will be used to verify plant construction
  - The Sweep is the last detailed check of the system
  - Remember, YOU are the final QC!

Build Channel Plan

- Set the channel table to reflect the system channel plan (NCTA most common)
- Edit for sync suppressed channels in the channel plan by selecting “scrambled” for the carrier type on the Stealth
- It may be necessary to not sweep the FM band (88-108 MHz) or just avoid certain frequencies

Before You Leave the Headend

- Obtain a flat reference
  - The “flat” reference may be used to measure the frequency response of passive devices (taps, etc.) especially end-of-line taps
- Be sure the SDA-5500 (3ST) is in the sweep mode and the reverse is enabled
- **Remember, you’re sweep traces are only as good as your reference!**

Connection to the System

- Setup a reading test point in the Headend in advance
- Make sure that the unused ports on the DCs are terminated properly
- Any future channel changes must be accounted for on the channel plan in the transmitter
- It may be necessary to not sweep unstable areas in the spectrum
  - FM band (88-108 MHz)
  - Strong off-air channels

Referencing in the System

- A “tilted” reference should be taken only after the reference point has been checked for proper levels
- Must sweep until “wait” indicator disappears before storing reference (4 sweeps)
- Reference points can be
  - AM fiber node (HFC systems)
  - 1st amp in cascade (conventional tree-branch)
  - Use directional TP least susceptible to reflections
- Tilt compensation is used for amplifier outputs that are different than the reference output tilt

Tilt Compensation

- Acterna built-in tilt correction allows the user to add in the correct tilt to flatten the response
- The highest tilt channel programmed in the channel plan is the affected point and the lowest is the pivot point
- A mathematical calculation is used to flatten the response
- The only other option is longer test leads to attenuate the high end or use cable simulators
  - This adds another unknown to our response

Sweep Procedure

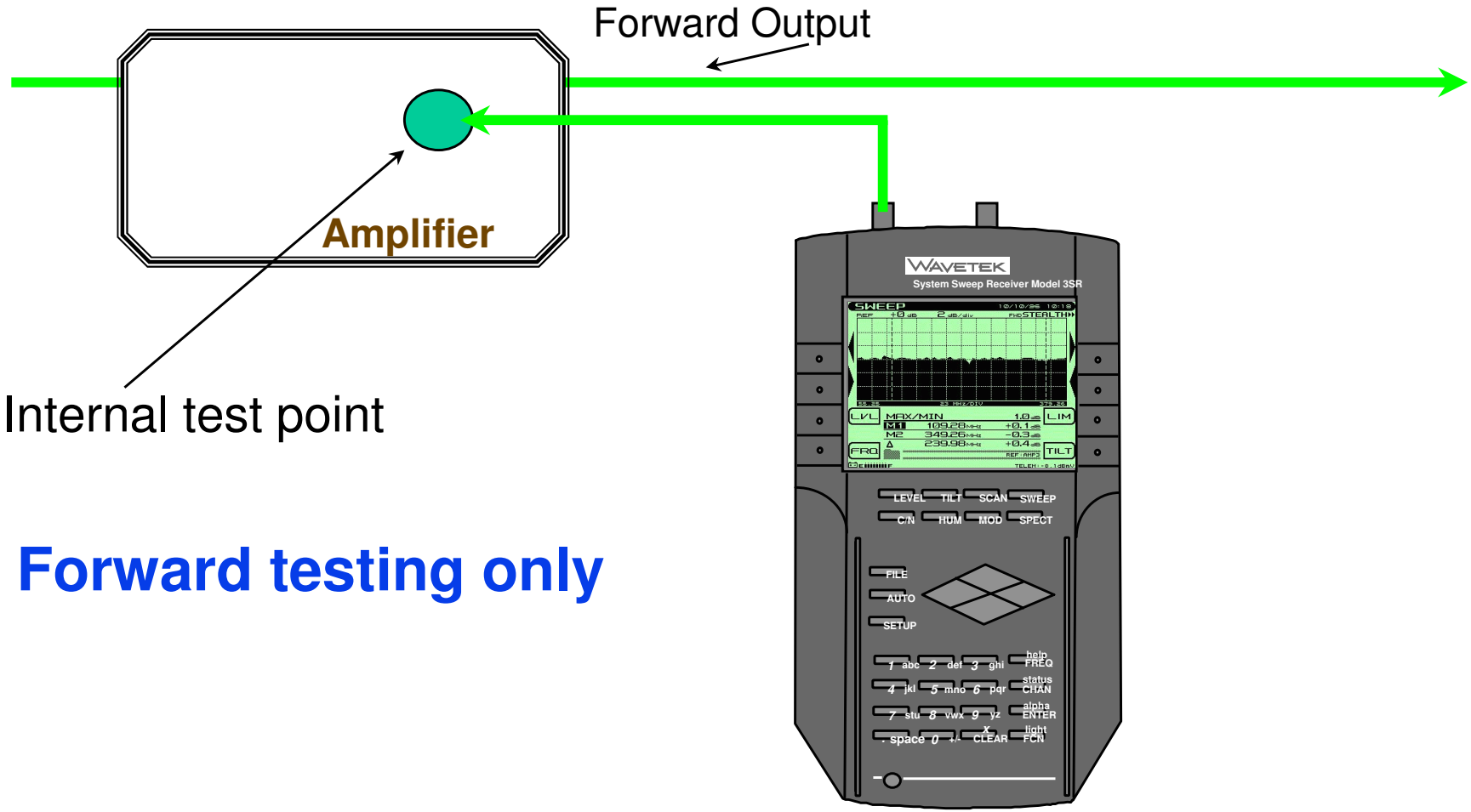
- Begin at the Fiber node for HFC systems then sweep the distribution
- Sweep all active ports
- Store a record of all test points that were swept in the sweep receiver
  - Acterna Storage system = StealthWare
- Acterna stored traces are a stored database of points
- These traces can be manipulated later to change dB/div, markers, tilt compensation, etc.
- Harder to cheat though!

Verify Correct Installation

- Check for legs spliced to wrong locations
- Check for correct passives, pole location, tap values, etc.
- Make any changes that are simple and that can be done quickly
- Record any discrepancies and changes on the system maps
  - Your record may be the final check on the system

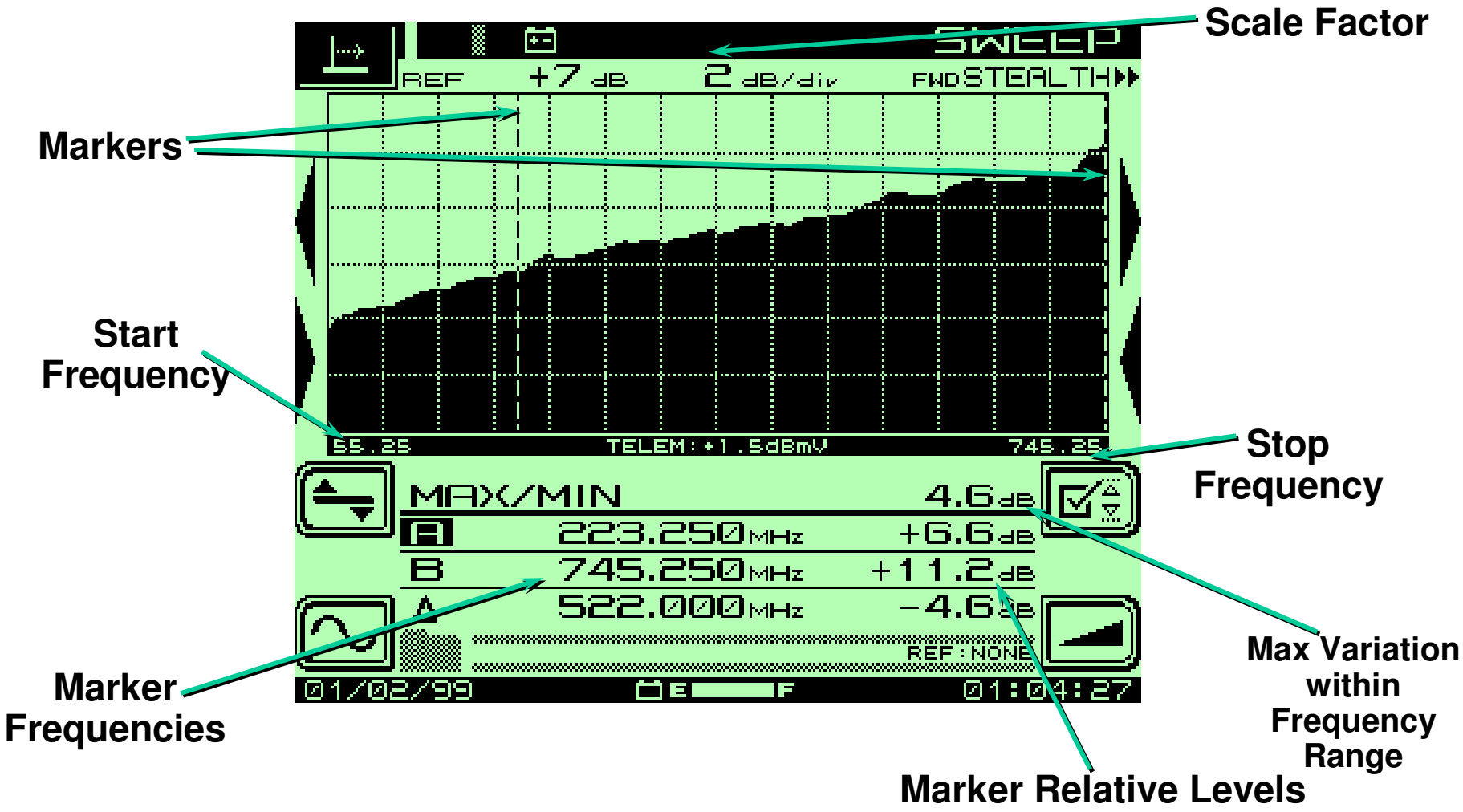
SDA-5000 Set-Up

Forward Tilt & Sweep

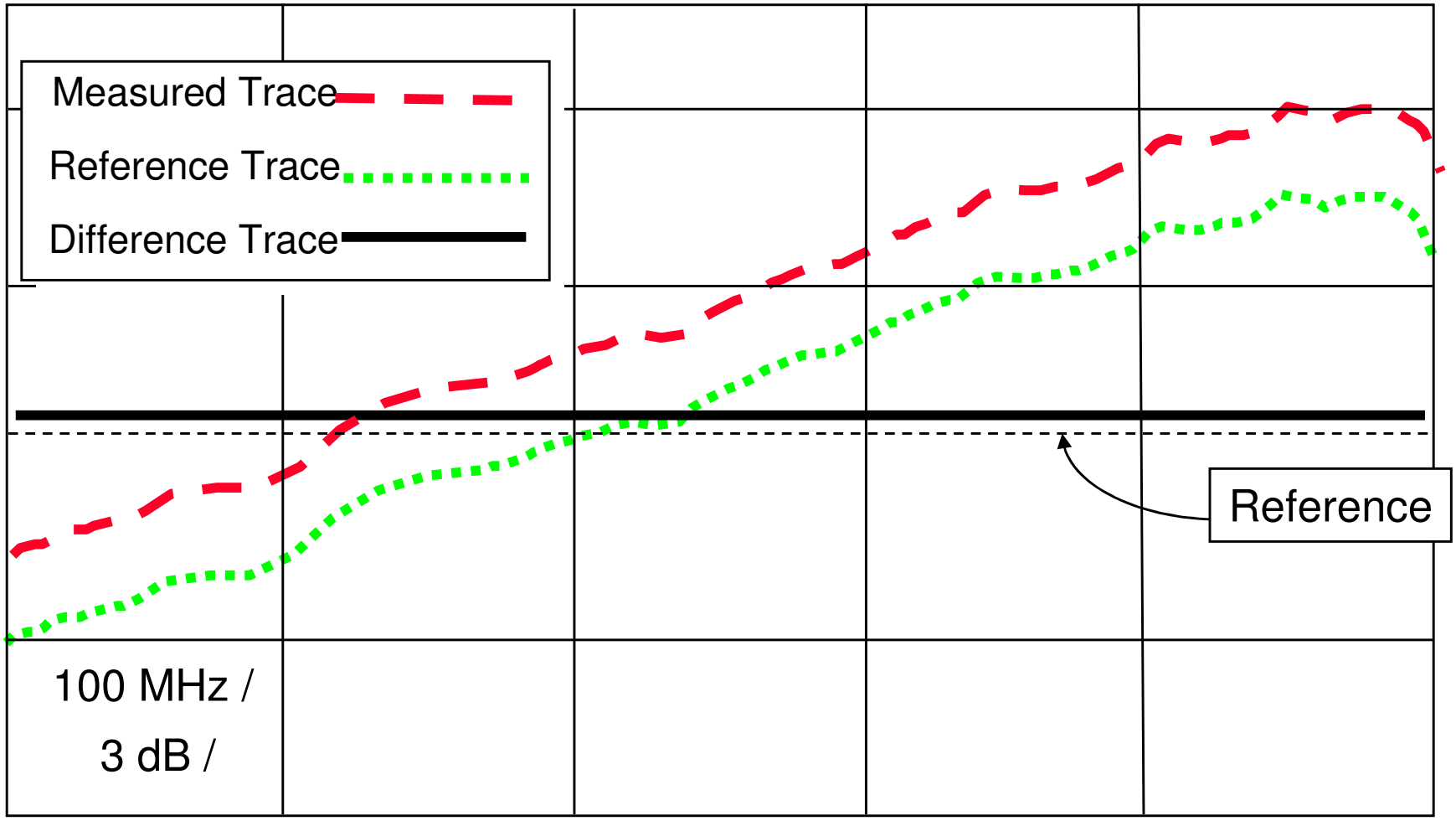


Forward testing only

Stealth Sweep Display

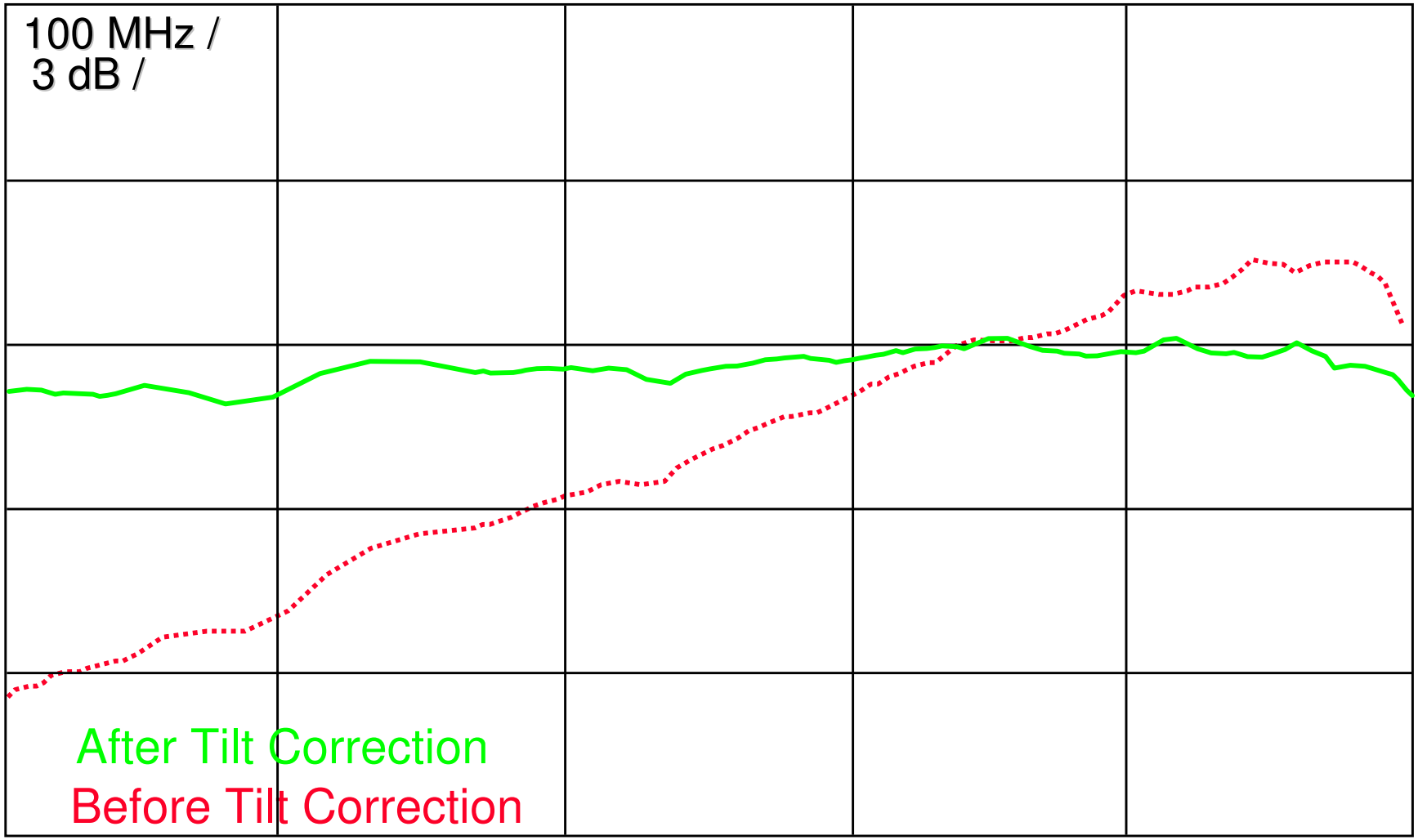


Normalization



- Combining the Reference and the Measured signal

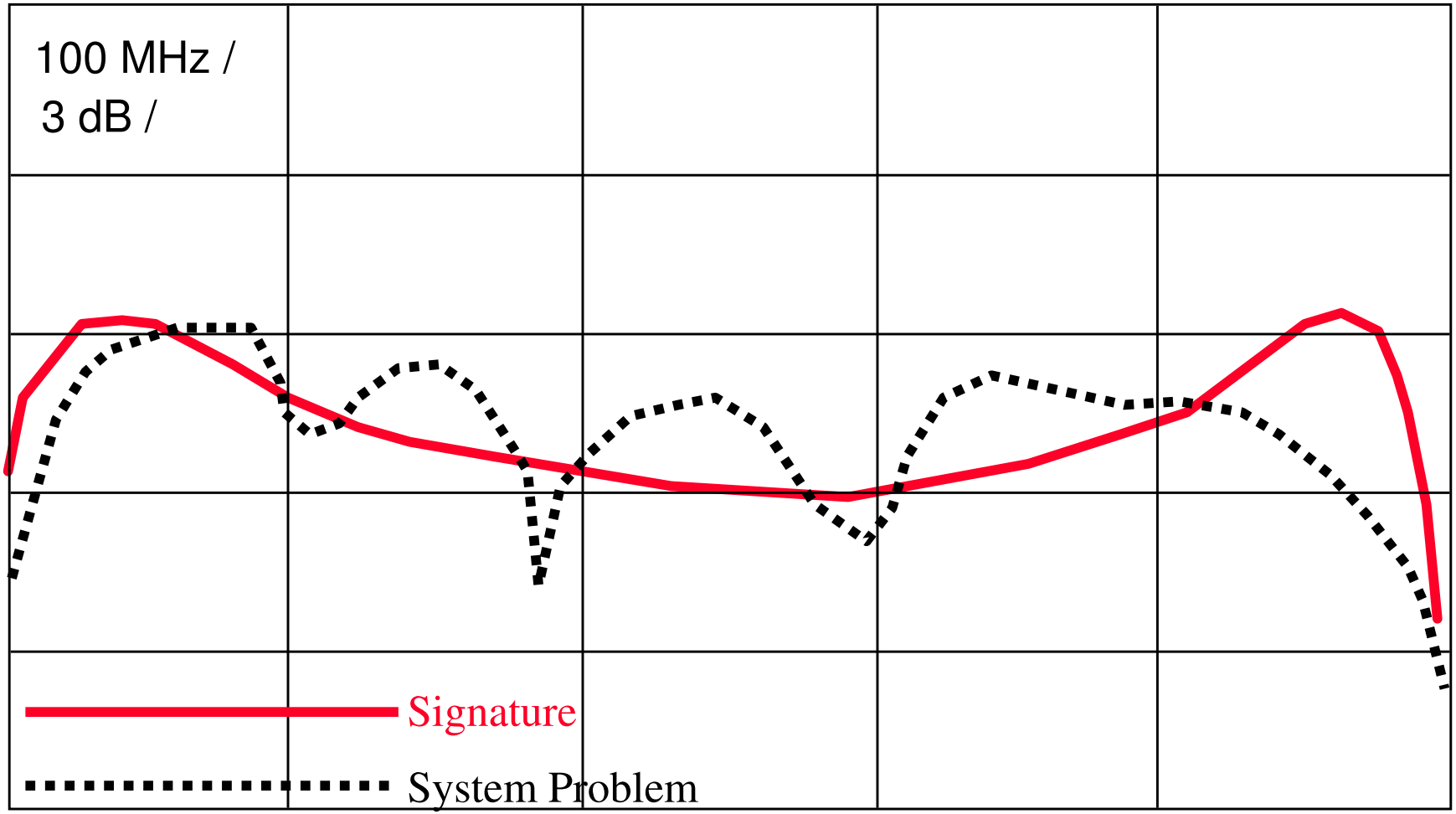
Peak/Valley Measurement



System Signature

- Signature of the amp is actually the signature of the technician who aligned the amp
- Old amplifiers had tighter spec.s from the manufacturers and they only went to 450 MHz or so
- 750 MHz is harder to keep within a certain spec., but cascades are shorter
- Some nodes start with a 2 or 3 dB P-V!, but we usually reference this out
- Do not confuse system problems with signature, especially if viewing from a resistive test point
- Fix all system problems prior to signature correction

System Problem Vs. Signature



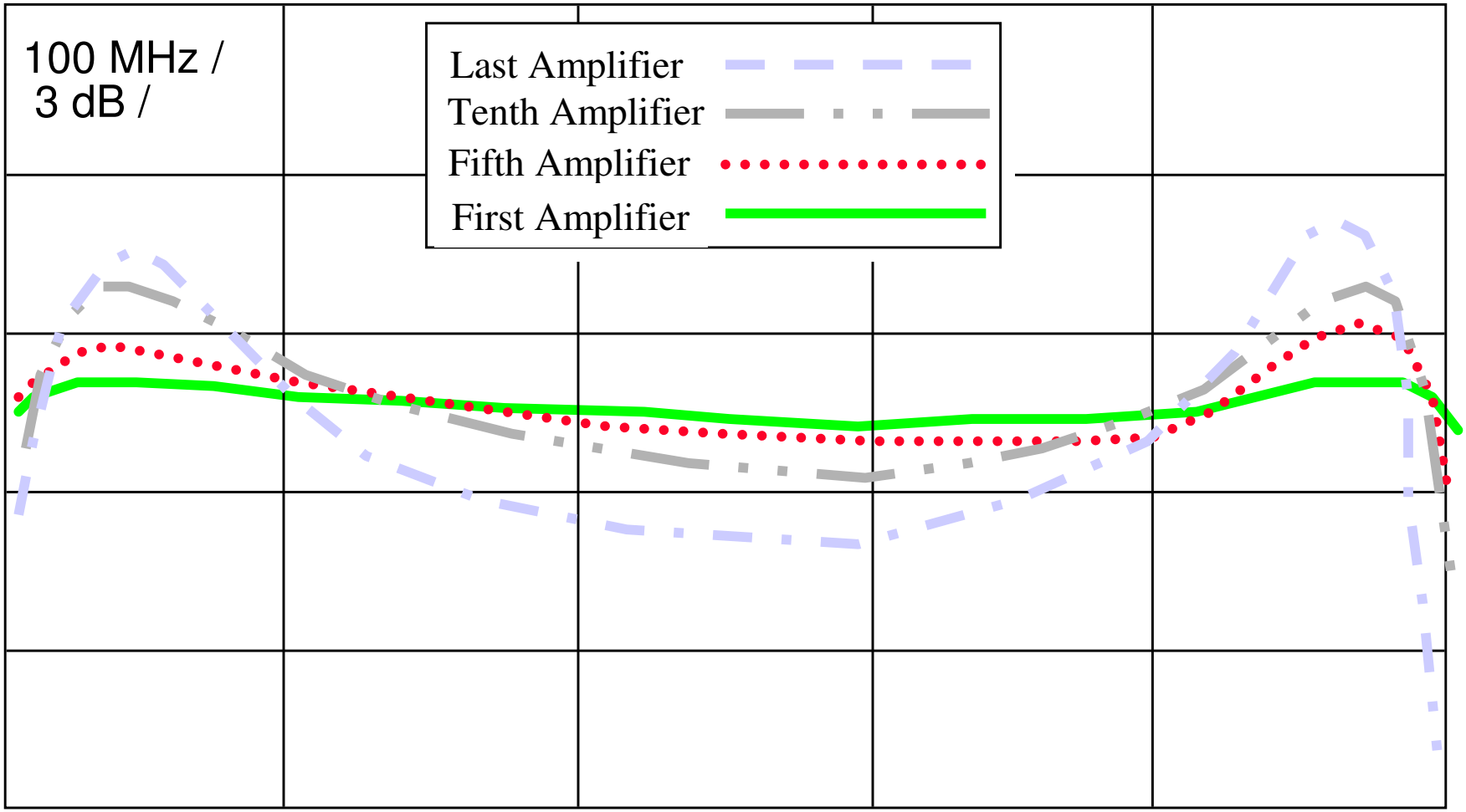
Peak-to-valley Spec.S

- N/10 + 1 was then, this is now,
  - Old cascades were 50 amps deep, (50/10 + 1 = 6 dB)
- Some systems use N/10 + 3 or a variation of this
- N/10 is only .1 per amp, more realistic would be .5 or .3 per amp, which would be N/2 or N/3
- For that matter why even have a P-V spec per amp when it may be sufficient just to have an end-of-line spec
- We have customer premise equipment with requirements and FCC regulations to abide by such as:
  - 3 dB between adjacent carriers
  - 12 dB between any 2 carriers for a 500 MHz system
    - This may warrant a “raw” sweep

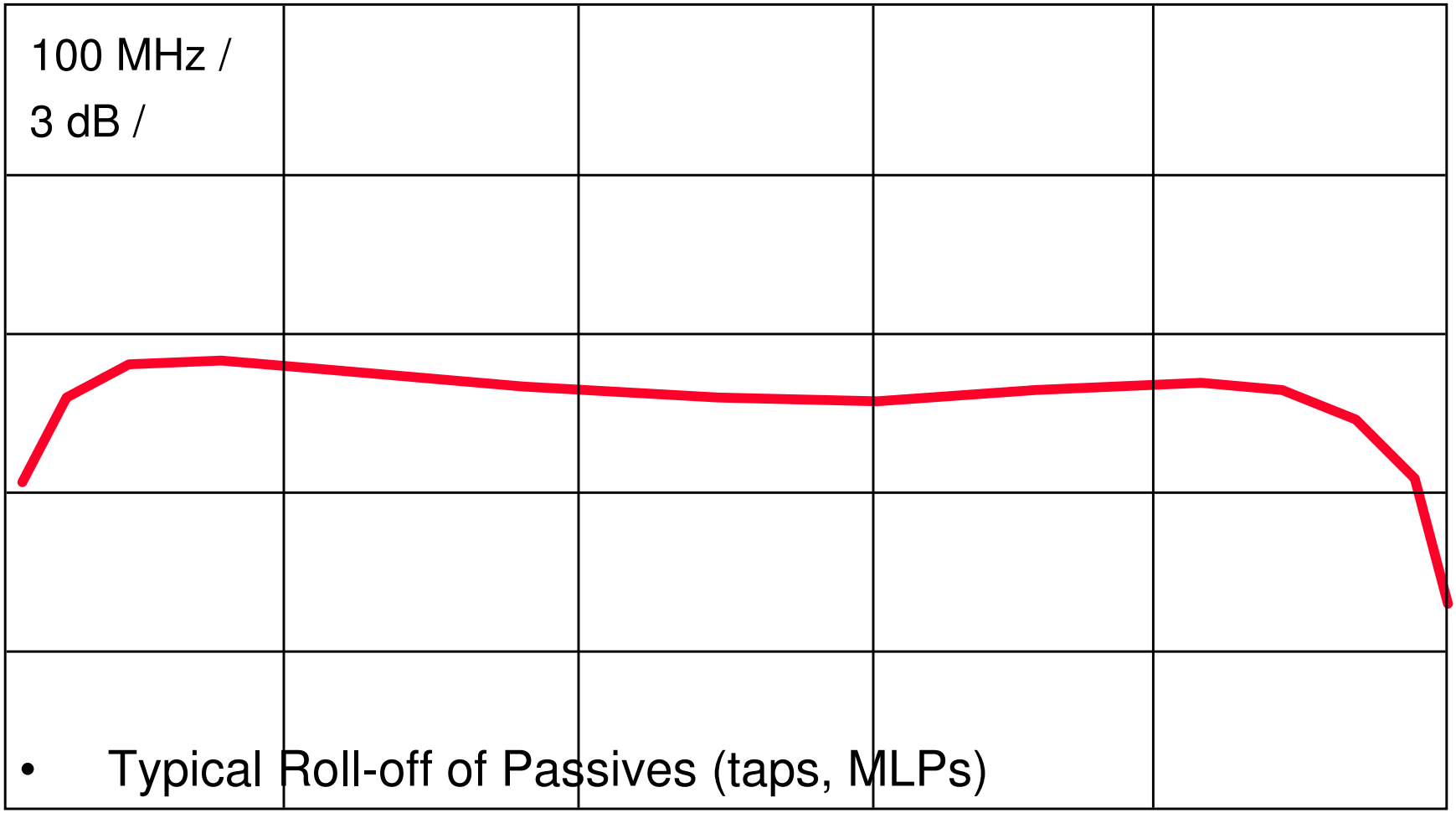
Signature Correction Boards

- Understand the negatives of correction boards (bode, mop-up, trim, etc.)
  - Masking system problems
  - Spacing considerations
  - Placement limitations
  - Performance influence
  - Response Q
  - Cost
- Use only when required for passing your specifications

Active Signature

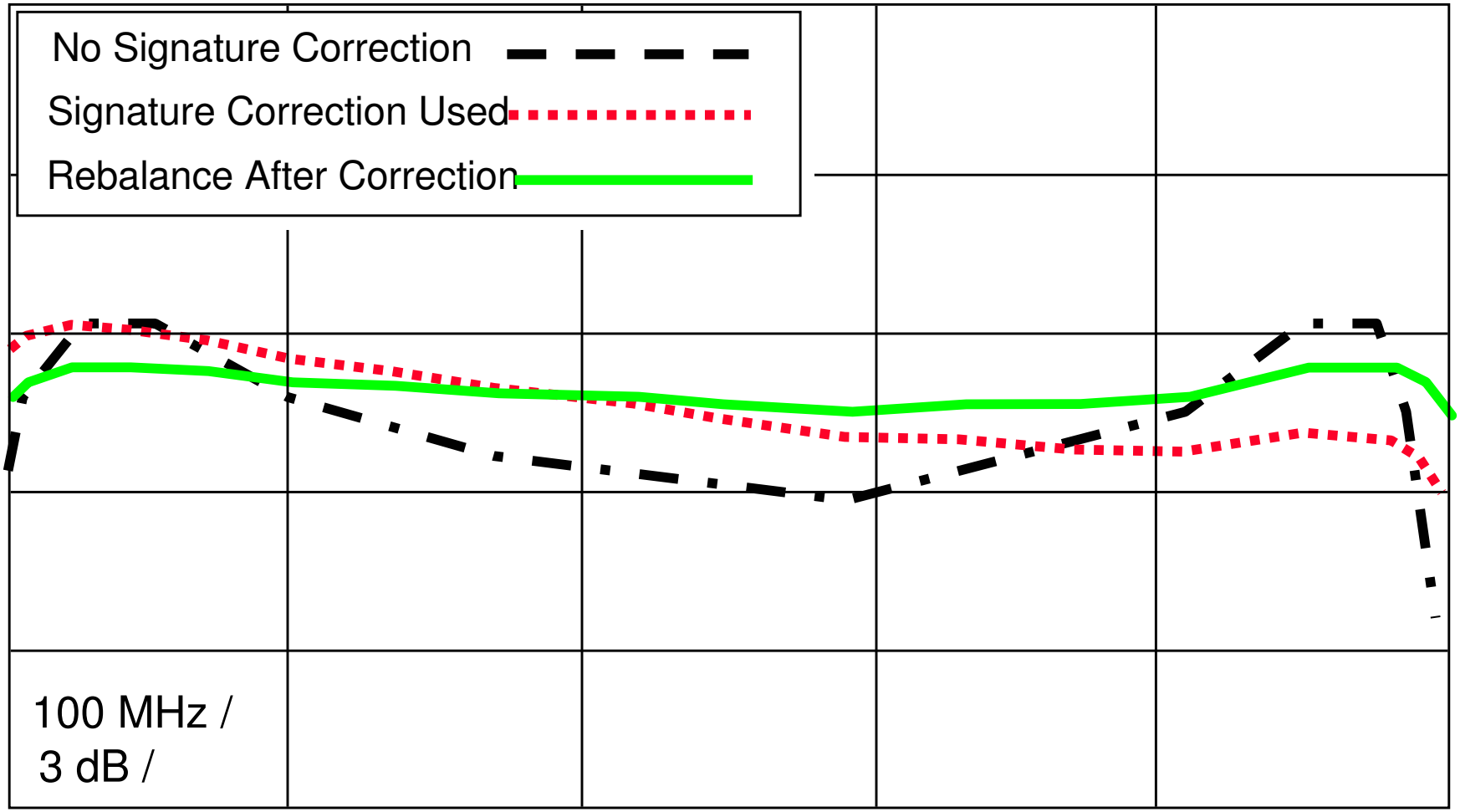


Passive Signature

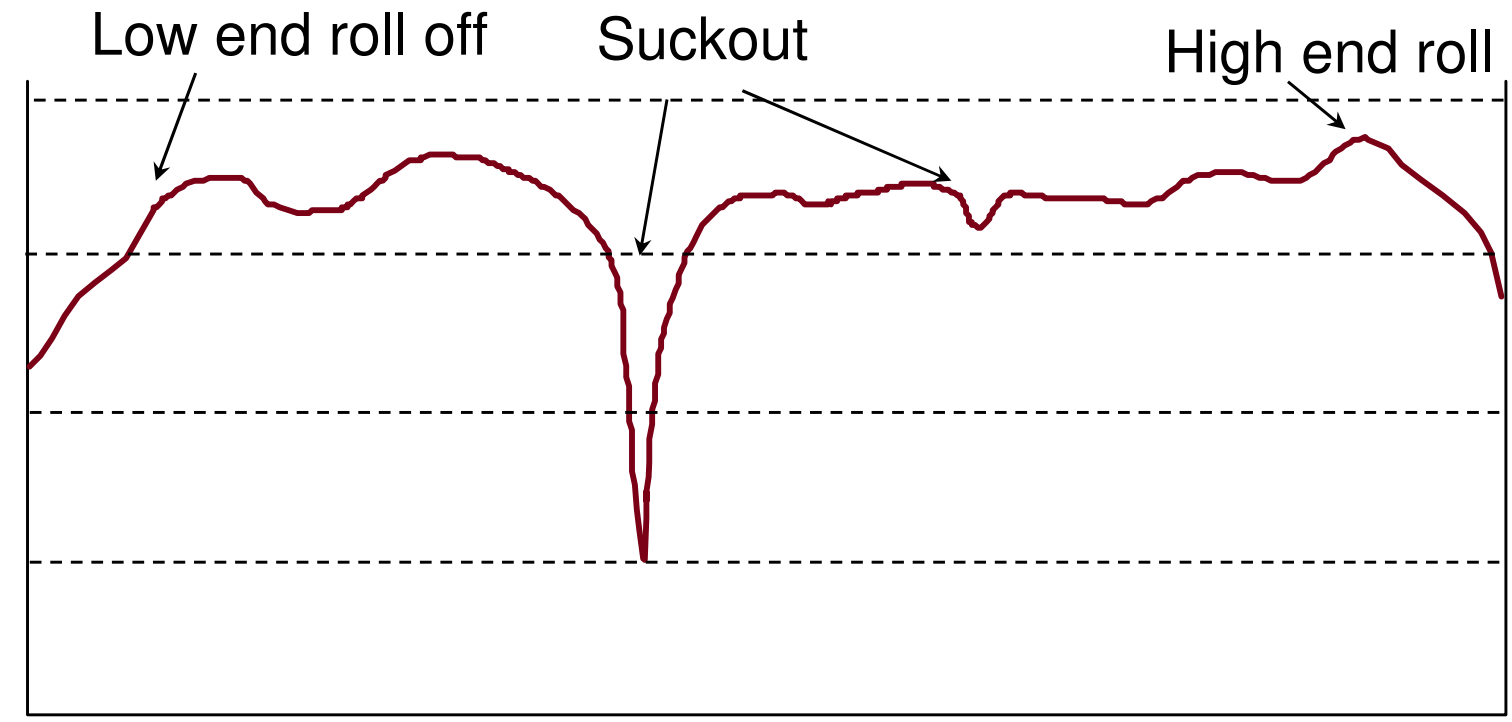


- Typical Roll-off of Passives (taps, MLPs)

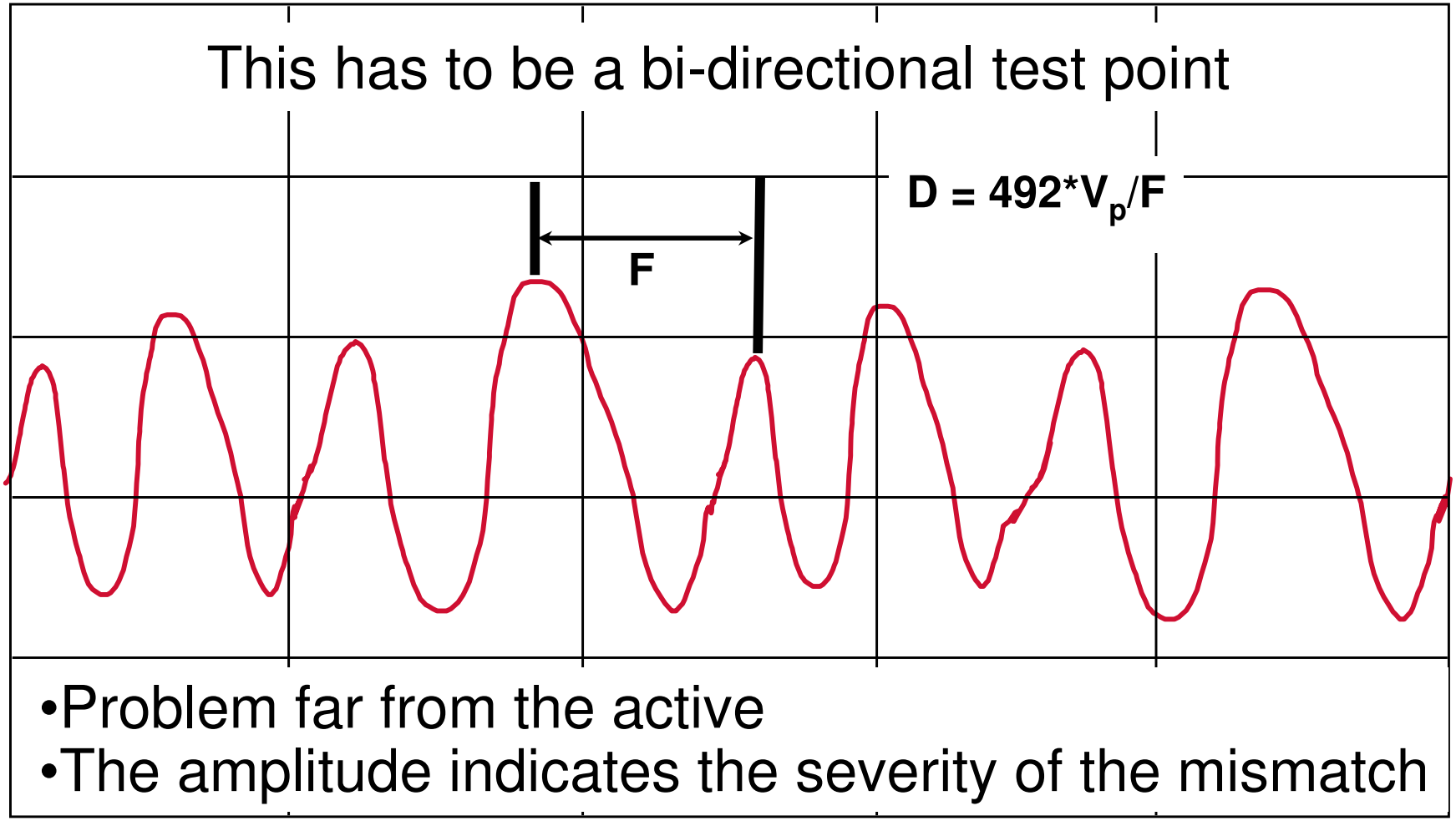
Adjusting System Signature



System Problems



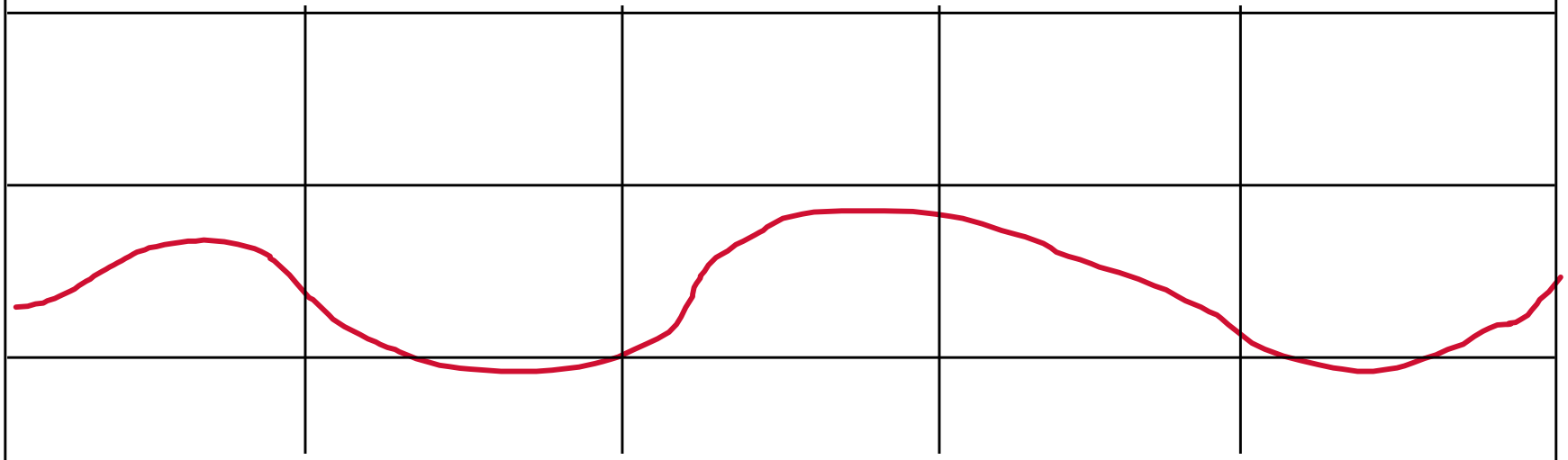
Troubleshooting the Sweep



- Problem far from the active
- The amplitude indicates the severity of the mismatch

Troubleshooting the Sweep

If the technician mistakes this for signature, the SCB will be used to fix something that isn't there



- Problem close to the active
- Could even be a reflection between the test point and test equipment

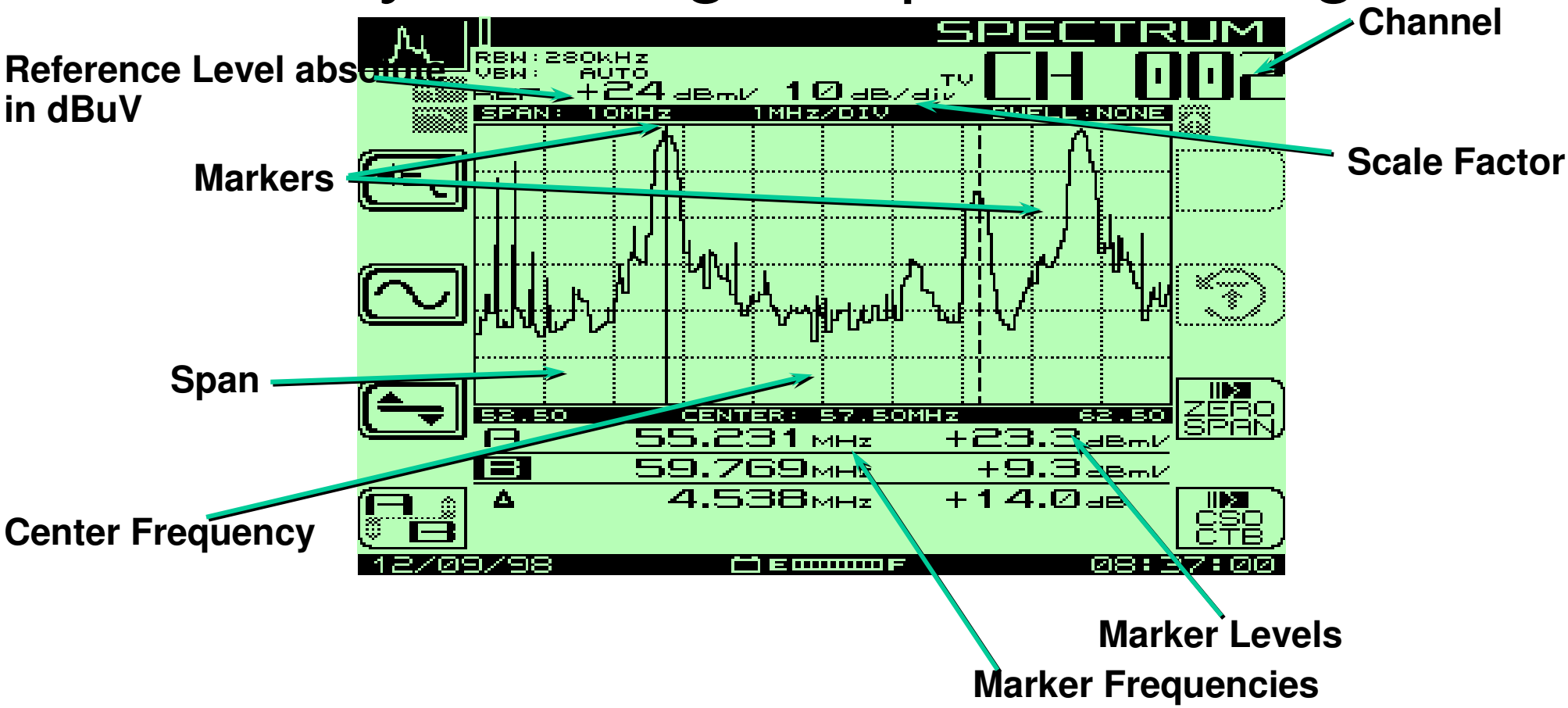
Stealth Firmware Version “9.3”

- You can upgrade yourself
- You need:
  - Stealth firmware version 9.3 upgrade file (*. mot)
    - http://www.acterna.com/usa/products/stealthware/93download.html
  - StealthWare version 7.1
    - Download upgrade file from:http://www.acterna.com/shared/products/stealthware/stealthware.htm
  - Upgrade code (send customer service a fax or e-mail)
    - Depends on instrument serial number

SDA-5000 Firmware Version “2.8”

- You can upgrade yourself
- Download upgrade file from:
  - http://www.acterna.com/products/sda5000/sdainstructions.html
  - StealthWare version 7.0
    - Download upgrade file from:
    - http://www.acterna.com/shared/products/stealthware/stealthware.htm
- All available today

3 Times Faster Spectrum Analyzer for Easy Viewing of Spurs and Ingress



- Real Dynamic Range: 60 dB
- Span: 50, 20, 10, 5 and 3 MHz

Sweep Documentation

- Keep Track of Your System
- Legal Requirements (FCC)
- Housekeeping and Historical Data

StealthWare

- Windows data collection and management package
- Trend analysis
  - Location
  - Time
  - Temperature
  - Channel
- Stores and displays Stealth screens
- Cut and paste to word processor or spreadsheet

Common Forward Path Sweep Problems

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

ACTERNA

Standing Waves

- Use a directional output test point if available
- Read from a tap
- Verify accessories are good
  - Test leads
  - Connectors
  - F-81s
- It could be a reflection between the test equipment and test point
  - Use an in-line pad to verify
- Use a plug-in test point - not a probe

ACTERNA

Test Probes

- Will always be bi-directional unless they are in series with the circuit
- Higher loss probes provide less of an impedance mismatch, but lower levels
- F-to-Housing adapters cause severe standing waves because of;
  - Bad grounding
  - RF power splitting
  - Impedance mismatch
- Be careful with in-line pads while probing seizure screws
  - Not usually dc blocked

Spikes

- Keep the resolution to ~ 6 MHz
- Verify proper setup
  - Forward channel levels into SDA-5500 (3ST); 6 $\pm$ 2 dBmV
  - Return Sweep Levels into SDA-550(3ST); 0 $\pm$ 2 dBmV
  - Channel types
  - Overlapping channels and sweep points
- Avoid common problem areas
  - FM
  - Strong off-air pick up, …….

No Communication - No Telemetry

- Verify the same frequency on the SDA-5500 (3ST) and SDA-5000 (3SR)
- Keep it high in level
  - > -20 dBmV
  - Input test points
  - Low end frequency rolloff
  - Old passives in the system
- Keep located in the passband
  - Low end rolloff from diplex filters
- Can use the spectrum mode to verify
  - No TP compensation

No Communication (Cont.)

- Check path continuity
  - Test equipment connections
  - Amplifier continuity
  - Active gain
  - Powered up
  - No terminators installed
  - Use the level mode to verify
- Firmware upgrades must be the same on the 3ST & the 3SR
- Press “Sweep” on the 3ST
- Make sure you’re in FWD Sweep and not reverse

Bad Response

- Verify accessories are operating correctly
  - Cable
  - Push-ons
  - In-line pads
  - Balancing accessories
- Low sweep points may get confused with noise floor
  - This could cause the “grassy” effect
  - Increase sweep insertion level
- High level RF can cause intermods that affect the sweep
- Use “Stealth” sweep instead of “Sweepless” sweep

Faster Forward Path Sweep

- Place sweep points in the lower sideband of the adjacent video channel
  - ~1.0 MHz below
  - Use StealthWare to build
- Do not monitor the video and audio, especially of scrambled channels
  - Leave them enabled, but don't sweep them
- Disable the Return Sweep
- Disable the Return Path Ingress Broadcast