SYSTEM SWEEP USE AND DOCUMENTATION

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Broadband frequency-response testing, also known as sweep testing, has long been recognized as being the most accurate and comprehensive overall test for broadband systems such as CATV. One glance at the sweep response provides a clear picture of overall system performance. This makes system sweeping an ideal answer to "Proof-of-Performance" testing, which requires verifying in-channel flatness from headend to subscriber drop. Additionally, system sweeping can be a quick and efficient method for system alignment and balancing.

The sweep testing concept has been well proven on the bench in manufacturing test as well as in repair and alignment of broadband system components. The problem has been in moving system sweeping into the field.

It is possible to use bench techniques in the field to perform individual channel frequency response testing. However, this requires the system to turn off each channel in turn for testing. This becomes tedious and time consuming for the higher channel counts of today's systems. Also, with more 24-hour channels today, there's the problem of program interruption for testing.

To address field needs, test equipment manufacturers have developed a number of complete-band sweeping systems. These do provide full-channel coverage quickly and efficiently. However, they can also cause significant interference with channel programming. Some instruments do address the interference problem, but they usually do so at the expense of resolution and setup ease. Moreover, the physical bulk of many sweep receivers makes them difficult to handle in the field.

The exception is the new 2721/2722 Non-Interfering Sweep System from Tektronix. The receiver is light, compact, and easy to use in the field (Figure 1). Just as importantly, the transmitter's sweep pulses are synchronized with the video signal's vertical blanking to eliminate picture interference. Along with this, sweep trace normalization and digital storage allow relative responses between any two system points to be displayed directly.

Other integrated features include a Signal Level Meter (SLM), AC/DC voltmeter, temperature probe, and RS-232C interfacing. The RS-232C interface provides communication between the 2721/2722 sweep transmitter and receiver units while being programmed for the specific

CATV system application. The interface also allows stored data and waveforms to be output to a printer or, using the PC Download Software, downloaded to a personal computer. Response histories stored on computer disk or PC memory can then be called up and compared on screen (Figure 2) for quick evaluation of system performance trends.

The best way to understand the use and benefits of the 2721/2722 features is to look at some basic applications. This begins with basic sweep system set up. With the system set up, some basic system alignment and troubleshooting applications can be explored. Documentation of system sweep performance will also be covered.

Figure 1. The light and compact 2722 Sweep Receiver with its high visibility display brings a new level of efficiency and capability to in-service CATV system testing.
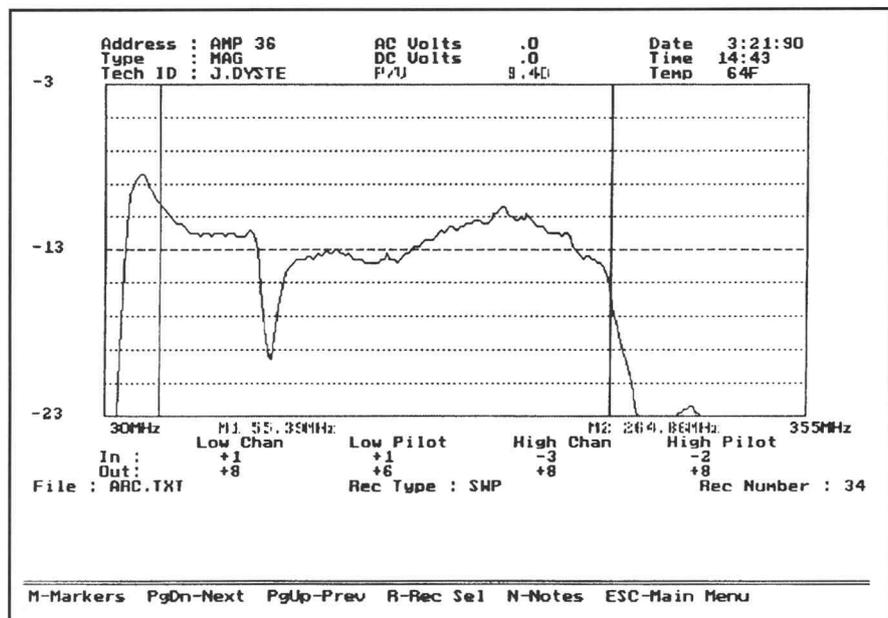
Figure 2. Digitally stored responses can be downloaded from the receiver to a personal computer, allowing quick on-screen comparison with response histories. Waveforms stored in the receiver can also be output directly to a printer or to an optional built-in chart recorder.

Basic Set Up Concepts

There are three major stages in setting up the 2721/2722 Non-Interfering Sweep System —

- 2721 Sweep Transmitter programming
- 2721 Transmitter connection to the broadband system headend
- 2722 Receiver calibration and normalization

Sweep Transmitter Programming. Before response testing can be done, the 2721 Sweep Transmitter must be programmed for your particular CATV system configuration. Programming is done by connecting the 2722 receiver to the 2721 transmitter with the supplied RS-232C cable. The receiver's keypad and menu system is then used to enter CATV system configuration data. This includes information about the system channels to be tested, the scrambling used, the number of test points per channel, the sweep telemetry pilot frequency, and other system characteristics.

Typically, initial programming is done before 2721 transmitter installation in the CATV system. However, re-programming of the installed sweep transmitter can be done at any time to account for changes in the CATV system. This would be necessary, for example, when channels are added to the system. Such re-programming is done by reconnecting the 2722 receiver to the 2721 via the RS-232C interface and keying in the changes.

2721 Transmitter Connection. The 2721 Sweep Transmitter is connected to the CATV system in the manner shown in Figure 3. Notice that the 2721 has two connections to the system headend. The connection closest to the headend samples the CATV system carriers for sweep system synchronization. The second connection is for sweep insertion and mixing with the system carriers.

It is important to use high-quality directional couplers for sweep insertion. Directionality of the couplers should be as high as possible. At the same time, coupler attenuation needs to be as low as possible to allow sufficient sweep signal strength. Couplers with these attributes will ensure a good 75 Ω impedance match for the inserted sweep and will minimize sweep signal reflections to the headend origin. Also, the cables used for sweep system setup should all be of high quality and as short as possible for practical installation.

It is also important to note the direction of the coupler used at the sweep insertion point (refer to Figure 3). The coupler is connected in the trunk backwards, allowing it to mix the 2721 Sweep Transmitter output with the outgoing carriers. Additionally, external attenuators are used in the insertion line. This is done to adjust the transmitter's +45 dBmV output so that the sweep level is 5 dB lower than the average carrier level after sweep and carrier mixing.

The 2722 Sweep Receiver is initially connected at the headend, too. This can be at the output test point of the first downstream amplifier if that amplifier is at the headend. If there isn't an amplifier at the headend, the receiver is connected at the headend output test point via a directional coupler as shown in Figure 3. After sweep system calibration and normalization, the 2722 is moved to downstream amplifier test points for actual frequency response testing.

Calibration and Normalization. With the receiver connected at the headend test point or amplifier, the headend un-normalized trace can be observed (Figure 4). After verifying sufficient sweep amplitude and the required peak-to-valley levels for calibration, the procedure can be executed from the receiver's utility menu.
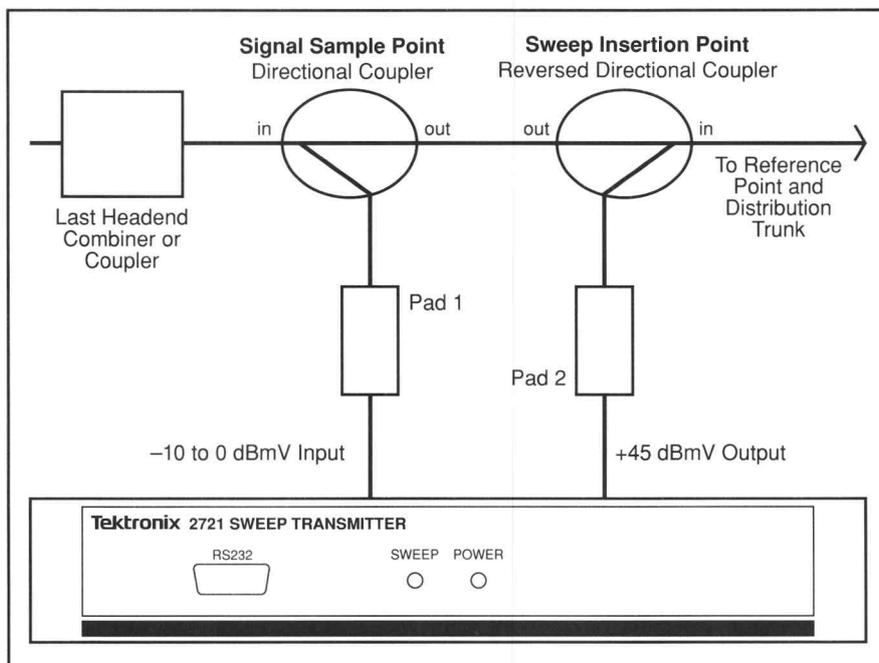
Figure 3. The 2721 Transmitter is connected at the CATV system headend. After calibration and normalization, the 2722 receiver is moved downstream to other points for response testing.
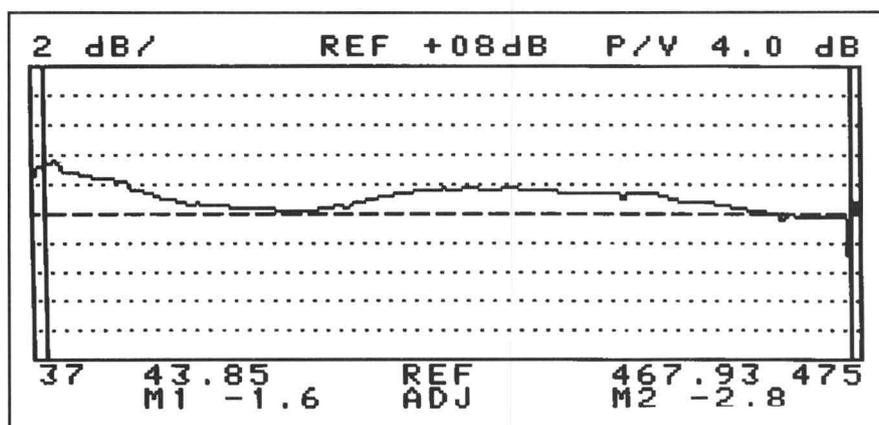
Figure 4. The un-normalized headend trace should be checked to make sure it has a mid-screen level and a low peak-to-valley level.

The automatic calibration procedure includes sweep normalization. Normalization is a technique that allows the flatness variations of the sweep transmitter and receiver to be automatically corrected on the viewed trace. This is done by using the sweep system's microprocessor to subtract out any flatness variations of the sweep instruments and their setup. The result is a flat reference trace such as shown in Figure 5.

The normalized reference trace is stored in the receiver's memory (Figure 6), and subsequent measurements are made with respect to this stored reference. As a result, only the unflatness of the system being tested is measured.

Using a normalized reference eliminates one of the key shortcomings of traditional system frequency-response testing. This key shortcoming is the amplitude variations across frequency of the sweep equipment itself. Previously, compensating for test system variations during field measurements has required substantial mental agility and more than one grease pencil mark on the display screen. But now, with sweep normalization, sweep testing is greatly simplified. For example, to duplicate the headend response at subsequent trunk stations or field test points, simply adjust the system response until it appears as a straight line.

Reference traces other than the headend trace can also be stored as additional references for key system points. Consider, for example, the case where the headend calibration did not include the first trunk amplifier in the cascade. You can view the output of the first trunk amplifier in the field, align the amplifier for the correct output, then store this trace as a reference. This allows a one-for-one comparison of the desired output versus the actual output at each amplifier station in the cascade.

When an additional reference is stored in the 2722 Sweep Receiver, all of the test point's parameters are also stored. This includes reverse tilt if used on the line, the specific cable used for the test, and information on any test probe used. All of these factors now become common with use of that reference trace. This relieves you from complicated trace interpretations and allows precise performance verification at any point along the cascade.

Basic Amplifier Alignment

With a normalized reference stored in the 2722 Sweep Receiver, you can begin actual sweep testing and system alignment procedures. A built in sequence of test procedures simplifies standard day-to-day alignments. These procedures are accessed via the 2722's menu screens and include the following items —

- **SETUP** provides a screen for entering test station parameters for later data archiving.
- **MEASURE INPUTS** reads and stores the four user selected frequencies on the station's input test point.
- **VOLTMETER** reads and stores the raw 60 VAC power and the station's 24 VDC power.
- **SWEEP** displays the frequency sweep used in aligning the station for best flatness.
- **SIGNAL LEVEL METER** (SLM) monitors and stores all the carrier levels.
- **QC** (Quick Check) provides a final check of the station's operation.
- **ARCHIVE** stores the station's setup data, measured voltages, and sweep response trace.
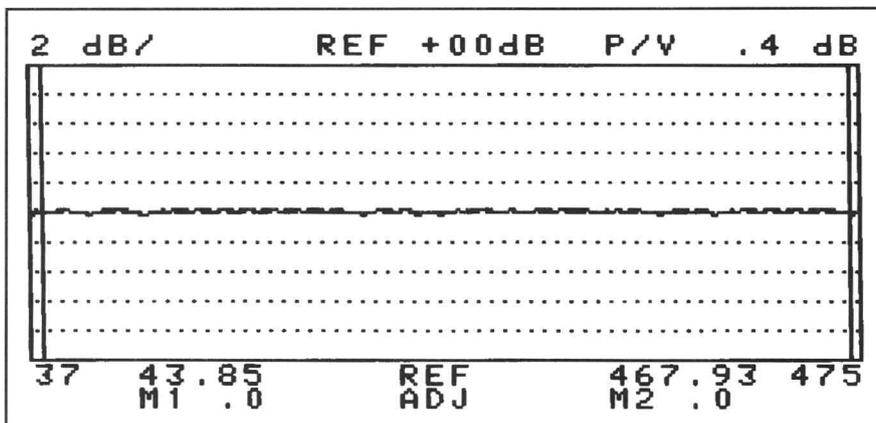
Figure 5. Calibration and normalization removes test system variations from the sweep as well as any reverse tilt used on the line. This leaves a flat headend sweep trace for use as an unambiguous measurement reference.
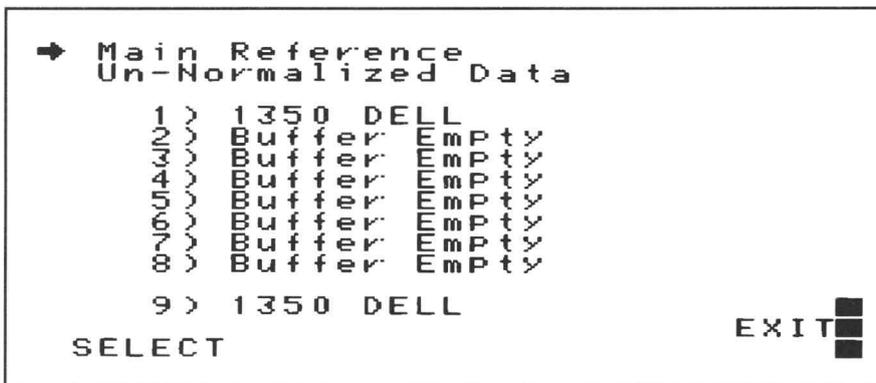
Figure 6. The 2722's DISPLAY menu allows selection from up to 8 references stored in memory, in addition to the Main Reference. An additional reference, number 9, is automatically stored as a new reference trace whenever a sweep waveform is Archived into the 2722's memory.

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The SETUP menu is shown in Figure 7. This screen allows you to make entries that identify and characterize the station being aligned. These entries are archived with the sweep waveform at the end of alignment.

It is important to update the SETUP Address entry at each station or test since this is the name that the test data will be stored under. Failing to do this will result in multiple archived records with the same Address.

Also, it's important to enter any probe loss data. The probe loss entry provides a numeric offset to SLM screen readings to compensate for probe or test point losses.

While the primary goal is sweep testing and alignment of the station, it is wise to use the MEASURE INPUTS and VOLTMETER functions first. Doing so makes sure that a full set of current station information is stored with the sweep response data.

After taking care of the SETUP menu and measurement preliminaries, you can switch to the main sweep screen for alignment of the amplifier. A typical amplifier response is shown in Figure 8.

Remember, the viewed amplifier response is relative to a normalized reference. Variations due to the sweep system have been removed. This means that all the variations seen in Figure 8 are due directly to the amplifier itself (and associated passive components). So the goal in amplifier alignment is to make the sweep trace in Figure 8 look as flat as possible. This could include adjusting or even changing the station's input equalizer, making interstage adjustments, or monitoring for loose connectors, poor grounds, and so forth.

However, before doing any alignment, it's wise to check the station's input response (Figure 9). You don't want to waste time trying to correct flatness or level errors that are actually occurring upstream from the amplifier.

Since the input level will typically be low, you'll probably need to use the PRE AMP function in the UTILITY menu when checking input response. This PRE AMP function increases the received sweep level by 22 dB so that low input levels can be monitored. The reference level shown on the sweep screen is automatically adjusted when the PRE AMP is in use.

Storing the input sweep data can be a valuable addition to your test data. This can be especially important when building test history archives on a personal computer. To store the input data, simply use the ARCHIVE key in the QC menu. When you do this, consider adding the notation "INPUT" to either the address line or NOTES field before storing the input waveform. This will allow you to quickly go through data base files and distinguish stored input waveforms from references and other test waveforms.
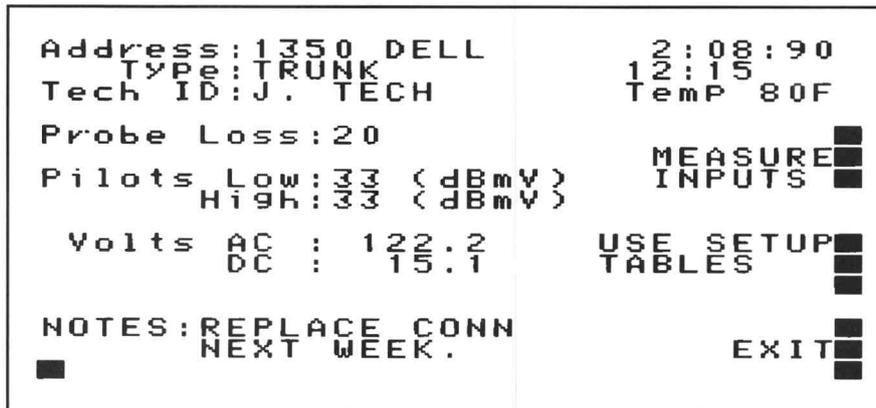
Figure 7. The SETUP menu screen provides a means of keeping track of pertinent information regarding a test station.
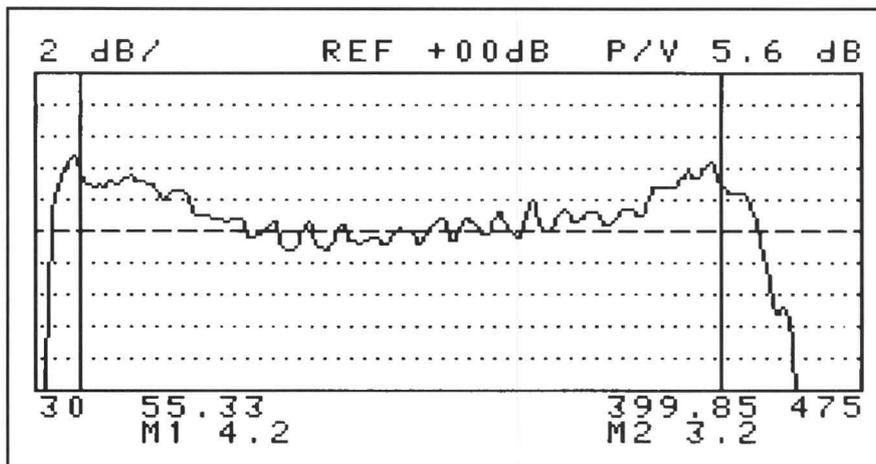
Figure 8. A typical amplifier response as seen on the Main Sweep screen. All the variations are due to the amplifier since the sweep trace is relative to a normalized reference.
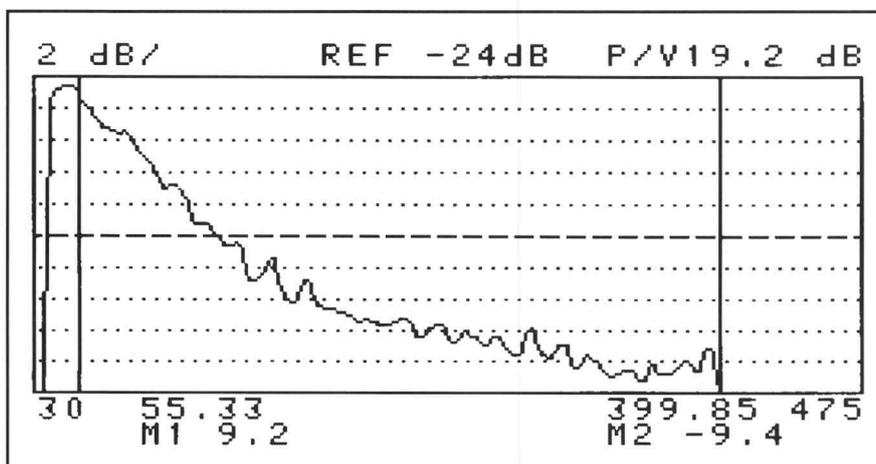
Figure 9. A typical amplifier input response. Notice that, except for reverse tilt, the input response closely matches the output in Figure 8.

Using the amplitude-calibrated sweep of the 2721/2722 allows very precise monitoring and setup of the station's output. Often, this can be done with better accuracy and resolution than monitoring carriers alone. Certainly, the alignment is far easier since the frequency response is adjusted to a flat line at center screen.

However, you may still want to use the SIGNAL LEVEL METER function to check carrier levels. The SLM function displays all of the carrier amplitudes of the system in the manner shown in Figure 10. A measurement marker, shown as a full-screen vertical line in Figure 10, can be moved to any channel for readouts of the channel's visual carrier frequency (bottom right of display) and visual and aural carrier levels (top of display).

Just as the sweep record can be stored with the ARCHIVE softkey, the SLM display and measurements can be stored using the STORE softkey. This separate SLM record also includes all of the data stored in the SETUP screen.

As a final check before leaving the amplifier station, you should run the Quick Check (QC). QC monitors the amplitudes of the four specified frequencies (usually two pilots and the high and low channel frequencies), checks the peak-to-valley reading from the sweep screen, and displays the AC and DC voltages read earlier. This provides a good overall summary of station operation before closing up and going to the next station. You use the ARCHIVE function on the QC menu to store the current sweep waveform and Setup screen data into one of the 50 memory locations in the 2722 Sweep Receiver.

Troubleshooting for Best System Flatness

When troubleshooting system problems, response traces offer nearly instantaneous recognition of problems and quick isolation of problem locations. For example, the sweep in Figure 11 clearly has a response problem which is commonly referred to as "suckout."

The problem illustrated in Figure 11 was noticed on the output of Amplifier 18 in the cascade. The question now is: Does Amplifier 18 have a suckout problem, or does the problem exist somewhere upstream?
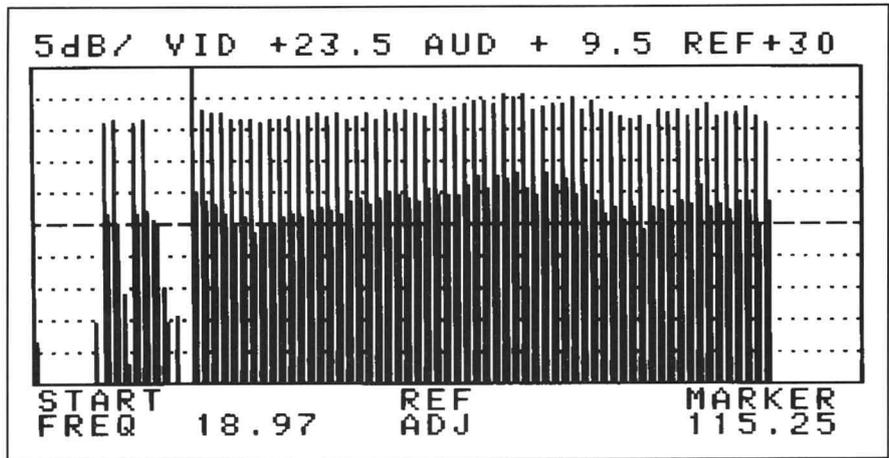
Figure 10. The Signal Level Meter display, in this case of a 65-channel system, provides the additional capability of checking system carrier levels.
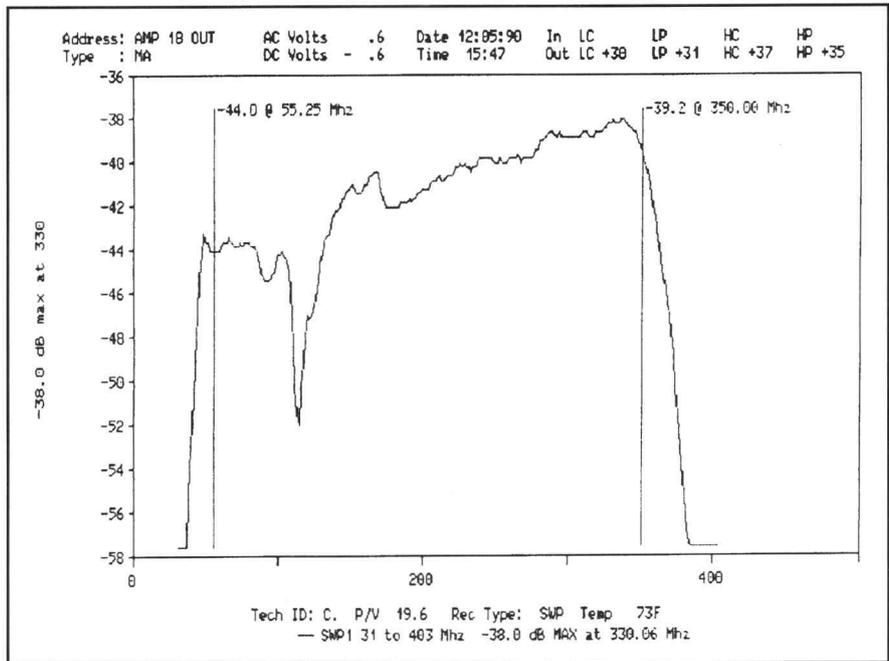
Figure 11. The sweep response at the output of Amplifier 18 clearly shows a "suckout" problem. The question now is: Does the problem also exist at the input of Amplifier 18?

Address: AMP 18 IN   AC Volts   .6   Date 12:05:90   In LC   LP   HC   HP
Type : NA   DC Volts - .6   Time 16:38   Out LC -7   LP -6   HC -16   HP -15

-38.6 @ 55.25 Mhz   -51.9 @ 350.00 Mhz

Tech ID: C. P/V 21.8 Rec Type: SWP Temp 68F
— SWP1 31 to 403 Mhz -37.8 dB MAX at 44.13 Mhz
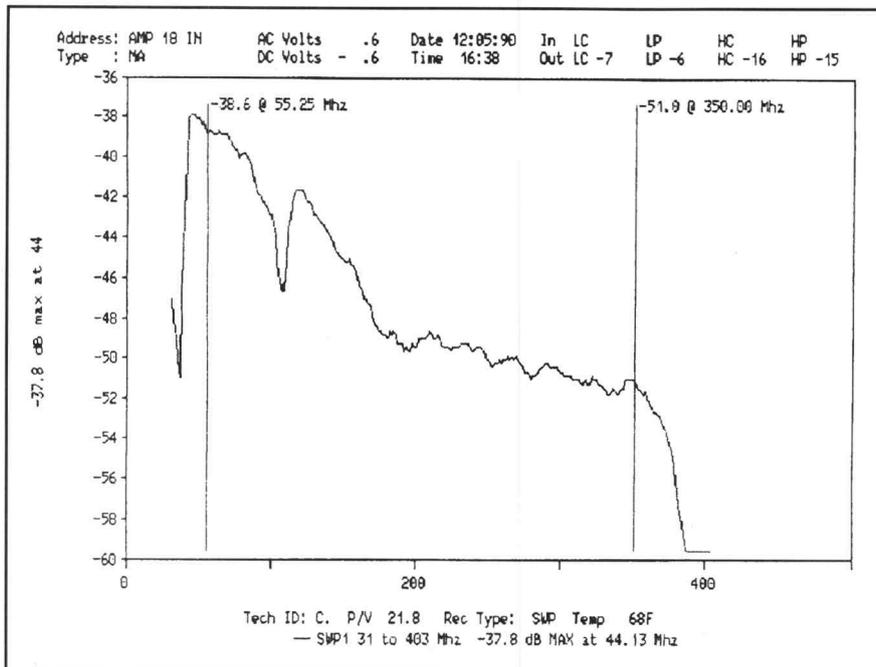
Figure 12. The same suckout problem exists at Amplifier 18's input. That means the problem is not in Amplifier 18, but must originate from somewhere upstream.

Address: AMP 12 OUT   AC Volts   .6   Date 12:05:90   In LC   LP   HC   HP
Type : NA   DC Volts - .6   Time 17:18   Out LC +2   LP +2   HC +7   HP +6

-27.8 @ 55.25 Mhz   -25.8 @ 350.00 Mhz

Tech ID: C. P/V 14.4 Rec Type: SWP Temp 68F
— SWP1 31 to 403 Mhz -25.8 dB MAX at 347.56 Mhz
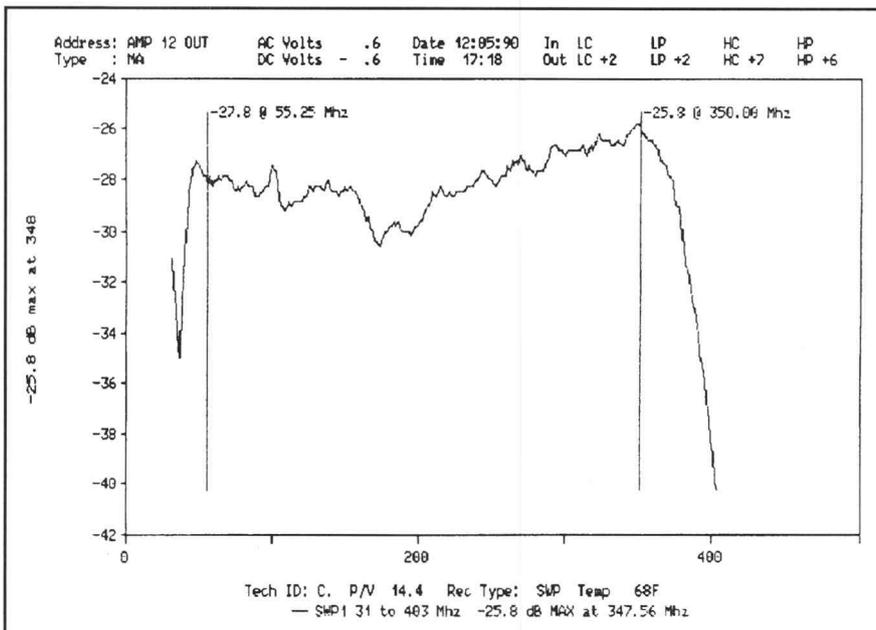
Figure 13. The suckout problem is not seen on the output of Amplifier 12. Moving forward from there, the problem was isolated to Amplifier 15, which had a loose motherboard.

Looking at the response trace at Amplifier 18's input provides a quick answer. As shown in Figure 12, the suckout also exists at the input. So the problem must be originating somewhere upstream from Amplifier 18.

But where?

By using the "divide-by-two" troubleshooting technique, the suckout problem can be quickly isolated. A quick check of Amplifier 12 shows no problem at the output (Figure 13).

So, dividing by two, we move to Amplifier 15, which shows the suckout on the output but not on the input. The problem was ultimately isolated to a loose motherboard in amplifier 15.

The point is that by quick looks at input/output response traces, you can quickly spot problems and determine whether they exist at the current station or some previous station. If the problem isn't at the current station, move halfway back up the line and check for the problem, then move halfway again until the problem is isolated to the specific station.

Response sweeps offer an equally effective tool for a variety of other system troubleshooting, repair, and optimization applications. These include equalizer network tuning, compensating for amplifier signature characteristics, and locating mismatches or return loss problems.

Equalizer Networks. Making major corrections to defective or malfunctioning amplifier stations is a fairly obvious use of calibrated system sweep equipment. But the system is just as valuable for making minor adjustments to improve overall system performance.

For example, replacing an input equalizer board is relatively easy. But verifying the results of such a step can be very time consuming without the use of a calibrated sweep system.

Monitoring the sweep response of the station as the equalizer is replaced or updated provides rapid confirmation of the station's performance. This also allows you to quickly spot and deal with response difficulties that are often inherent in the equalizer board itself. In newer amplifier stations with built-in equalizer trim networks, fine tuning can be done while watching the response curve for overall band operation and the effects of network trimming.

Amplifier Signature Characteristics. Most amplifiers exhibit excellent flatness. Most amplifiers also have minor irregularities that are peculiar to the specific amplifier model. These irregularities tend to be frequency-specific "signatures" that occur because the amplifiers are of the same design, manufactured with like components, and are equally spaced in the field. As a result, in a cascade composed of a specific type of amplifier, these signature variations will build up.

For example, a 0.25 dB variation appears insignificant in a single station. But when that variation is a signature and it adds across 10 to 20 amplifiers, the amplitude of the added signatures becomes a serious concern.

With the Tektronix 2721/2722 System Sweep, signature characteristics can be automatically compensated for in trace normalization. You simply store a reference trace that includes the signature characteristic. Then, as the cascade is aligned to the reference, the signature is removed by adjusting to the normalized reference sweep. The normalized reference sweep is flat, and it's always a matter of adjusting subsequent stations so that their sweeps are as flat as possible, too.

Return Loss Problems. The standard broadband coax distribution system has a nominal 75 Ω impedance. All too often, though, the actual coax cable used has an impedance closer to 72 Ω. Additionally, slight variations are caused by the impedance matching attempts of input/output networks at each amplifier station. The combination of all broadband components in a standard system — cables, connectors, splices, passive devices, and active devices — contribute to varying characteristic impedances in the system as well.

Good engineering practice dictates verification of cable and component parameters prior to system installation. This should include frequency response testing for overall transmission line characteristics and return loss. The goal is to ensure the overall match of the cable to the 75 Ω components used in the field. This quality testing needn't end at the warehouse or test bench either.

Careful use of an amplitude-calibrated system sweep can identify serious mismatches on an operating line. Moreover, this can be done with the CATV system in-service and without having to disconnect or separate the various system components.

As an experiment, you can easily observe a mismatch by reversing the connection of the directional coupler used for 2721 sweep signal insertion. When this coupler is correctly used, it is actually reversed from normal connection (see Figure 3). That is, the coupler output port should face upstream toward the headend source. This is done to facilitate sweep insertion and mixing with the system carriers. In this

configuration, the raw, un-normalized sweep observed on the 2722 receiver should be relatively smooth. The minor variations that do exist will be for variations in cables, sweep amplitude, and other components. These variations should appear random and should not exceed three or four decibels.

If the sweep insertion coupler is reversed so that its input faces the headend source, the coupler acts as a tap instead of a mixer. As a tap, the majority of the sweep transmitter energy is now directed back to the headend racks. A portion of this energy will be reflected back through the directional coupler causing standing waves that can be observed at the headend test point.

Figure 14 shows an example of such standing waves. Notice that the sweep variations appear as humps that occur in a regular, periodic fashion. Such standing waves can be the result of a defective or incorrectly installed directional coupler. They can also be caused by mismatches or return loss problems at any point in the CATV system.
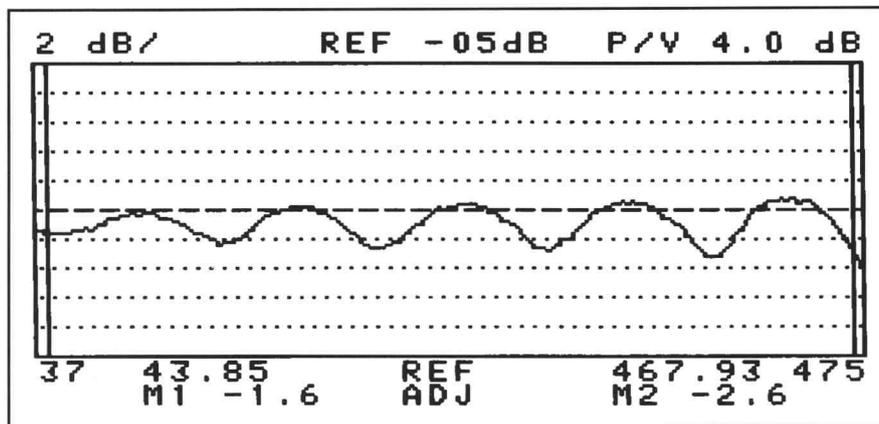
Figure 14. An example of standing waves caused by an improperly installed directional coupler at the headend sweep insertion point.

To catch such reflection problems, you need to carefully observe swept responses when monitoring any active line. The response trace should be smooth overall across the frequency band of interest. While sharp suckouts are obvious indications of problems, you also need to be aware of more subtle variations across the trace, especially those with the regular periodic appearance that indicates mismatches in the line.

When such subtle variations are observed, they are typically seen first at the station's output test point. This might suggest that the mismatch is downstream from the test point and is causing signal reflections to be added to the test point result. But that is not always the case. In fact, experience dictates that the input of the amplifier should be checked immediately. A mismatch that has occurred upstream from the amplifier can be transmitted directly through the amplifier — being amplified and equalized — and show up on the output test point.

Locating mismatches — or the source of any other problem for that matter — may require more than a few measurements made throughout the system. These measurements can be made quickly and easily with the 2721/2722 System Sweep. But more than that, the observations can be made without interrupting or interfering with subscriber services. This is because of the 2721's non-interfering method of sweep synchronization with and insertion into the vertical interval of the video signal.

Documenting System Sweep Performance

Imagine being on a pole observing the sweep trace at the output of an amplifier. You notice a small glitch in the sweep. Then you begin to wonder — was that glitch on the sweep at the last amplifier that you looked at? Maybe it wasn't. But then again, maybe it was and it was just too small to catch your attention.

The only way to resolve such uncertainties is to look at the trace from the last amplifier. Without some form of documentation, that means unhooking the sweep receiver and going back to that other amplifier for another look. But, if you've been using the digital trace storage feature of the 2722 Sweep Receiver, you don't need to go back to that other amplifier. Just call its stored sweep up from memory and see if that mystery glitch was indeed there.

Digital storage of traces is the most immediately useful documentation feature of the 2722. Because of the amount of internal storage available — up to 50 records — it's a good idea to store the sweeps at each station for later use or archiving.

Beyond its internal storage features, the 2722 Sweep Receiver also offers other equally useful documentation features. These include use of an optional internal printer, downloading to an external printer, and downloading to a personal computer for analysis and long-term archiving.

But, before using any of these features, it's wise to establish some general archiving practices. These practices, which can significantly improve the overall value of archived records, include —

- Determine unique and specific nomenclatures for the SETUP data fields. For example, consistently use AMPLIFIER 15, AMP 15, or possibly a map location of the station being monitored. A consistent labeling scheme simplifies use of archived records in a database and can dramatically improve record search efficiencies.

- Decide whether both Input and Output levels (using the SLM function and storage) will be included in the stored records. Frequently these carrier level records can be an additional tool for later analysis or more extensive system logging.

- Decide whether both Input and Output sweep traces are to be stored routinely. Also, make sure that your SETUP labeling system differentiates Input and Output records — e.g., AMP 15 IN and AMP 15 OUT.

- Select a basic format for the NOTES field. You can assign the equalizer value to this area or routinely identify the use of special modules or power supply conditions. These notes can be a ready reference for future line work.

Once the basic decisions have been made about what to store and how to label records, you can begin your archiving program. The following discussion provides guidance and suggestions for this.

Downloading to the Internal Printer. Any trace or screen display can be output on the 2722 receiver's optional YT-1 Printer. This includes both SLM and Sweep screens as well as the SETUP and QC data screens. Also, active traces can be output to the YT-1 Printer during sweep testing or stored traces can be output at a later time.

Making a hard copy of the screen is done by first bringing up the screen display to be printed. Then simply press the print button on the YT-1 Printer. Be sure to close the small access door on the printer before tearing off the last print. This ensures that the paper will continue to feed smoothly from the front of the printer.

The built-in printer can be an indispensable aid for optimum CATV system maintenance. For example, you can download traces to the printer while at a station and store the printouts in the amplifier cover. Though the paper used in the YT-1 is thermal, and may darken over time in extreme heat, this can provide a convenient performance record for other technicians checking the station at a later date. These printouts also provide a convenient means of leaving service notes such as, ''replace splice on next visit.''

Using an External Printer. Records stored in the 2722 can be downloaded to an Epson FX compatible serial port printer. Simply connect the printer to the 2722's DB-9 connector with an RS-232C serial cable. Then use the 2722's UTILity menu to access PRINT ARCHIVE then PRINT RECORD or PRINT ALL RECORDS. PRINT RECORD sends the currently selected record to the printer, and PRINT ALL RECORDS downloads the entire 2722 record memory to the printer.

A significant advantage to using an external printer is that the screen data is included on the hardcopy. This results in a complete record of the station for use with standard maintenance records. A further convenience is that the form designed for this printout covers the top half of the 8.5×11 computer paper, leaving the bottom half for additional notes or inclusion of the SLM display (see Figure 15).


```
Address:ST.31                    1:24:90
     Type:XR2                   12:03
Tech ID:JIM SMITH               Temp 77F

AC Volts           :0
DC Volts           :0

        Low   Low   High  High
        Chan  Pilot Chan  Pilot    P/V
In :
Out: +39   +34   +36   +42       5.2
```

```
2  dB/          REF  +06dB   P/V  5.2  dB
```

```
31   47.97          REF      310.93   421
     M1 4.6         ADJ      M2  -.6
```

```
Address:ST.31                    1:24:90
     Type:XR2                   12:57
Tech ID:JIM SMITH               Temp 80F

AC Volts           :0
DC Volts           :0

        Low   Low   High  High
        Chan  Pilot Chan  Pilot
SLM: +38   +34   +37   +42
```

```
5dB/  VID - 2.8  AUD - 2.2  REF+56
```

```
START               REF          MARKER
FREQ   18.97        ADJ          49.25
```

Figure 15. Using an external printer allows both the sweep and SLM displays for a station to be archived on a single piece of 8.5×11 paper.

10

```
        Address : AMP A104        AC Volts   60.4        Date    3:07:90
        Type    : TEXSCAN         DC Volts   25.1        Time    11:12
+4      Tech ID : G.STETSON       P/U        11.20       Temp    20C




-6  ----------------------------------------------------------------------




-16
        37MHz      M1 55.78MHz                  M2 448.39MHz      474MHz
                 Low Chan      Low Pilot    High Chan    High Pilot
        In :
        Out:        +2            +2            +8           +7
        File : ARC.TXT          Rec Type : SWP          Rec Number : 9


    F1-M1 Dn    F2-M1 Up    F3-M2 Dn    F4-M2 Up    ESC-Disp Menu
```
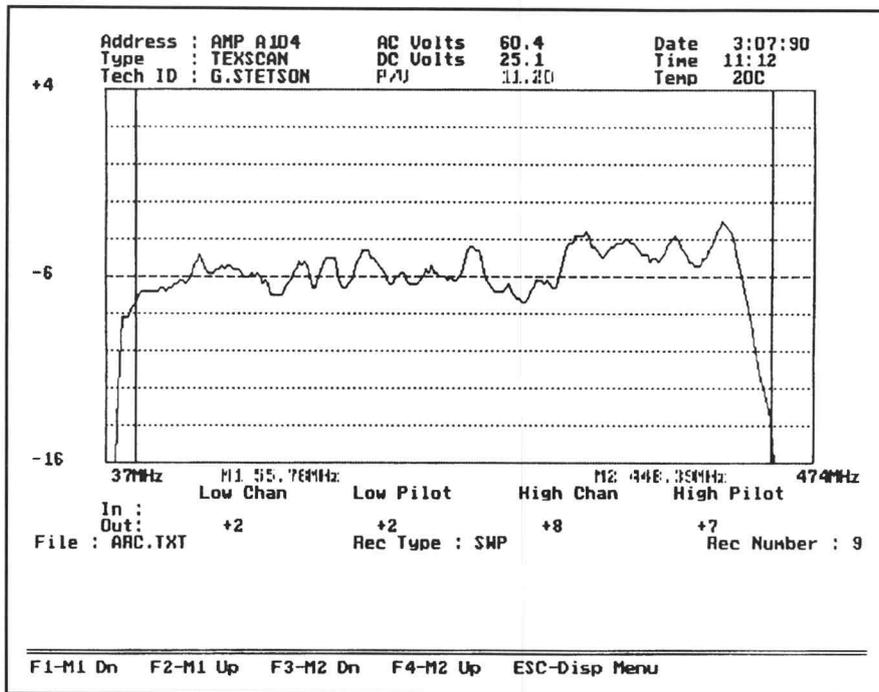
Figure 16. Example of a sweep display from the PCARC portion of the PC Download Software. PCARC also provides measurement markers on the display for on-screen analysis.

Downloading to a PC. The most efficient method of archiving 2722 records is to store them as files on an MS-DOS formatted disk. This is done by connecting the 2722 to a PC with an RS-232C cable and using the 2722's Download function along with the PC Download Software.

The DOWNLOAD TO PC command on the 2722's PRINT ARCHIVE menu selects the download function. This automatically transfers the archived records to the PC.

From the PC side, the PC Download Software package allows menu-driven control of the process. This includes selection of the Comm port to be used and file names for downloaded records. This software also provides random selection of records for viewing and active markers for extracting measurement data from the displayed records (see Figure 16). Permanent copies of the PC Download Software displays can be made on paper using the PC's printer and a background printing utility such as PIZAZZ.

Archived files can also be converted to a standard ASCII text format. This allows the files to be imported into other analysis programs such as Lotus 1-2-3 and dBASE.

A sample Lotus template could use macro commands to provide automated analysis of PC archived 2722 records which could include —

- **Sort Function** to sort the order of records by specific fields
- **Extract** for selecting records for display by one or more of the record's fields
- **Charting** to reproduce the original waveform using the Lotus charting capability.

This, of course, is only a glimpse of the analysis and documentation potential available from PC archived records. To access this potential, you need to first acquire and store sweep and SLM records with the Tektronix 2721/2722 Non-Interfering Sweep System. Not only does this allow you to immediately see and correct problems in the field, but the archived records allow you to spot and correct trends before many problems even occur.

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