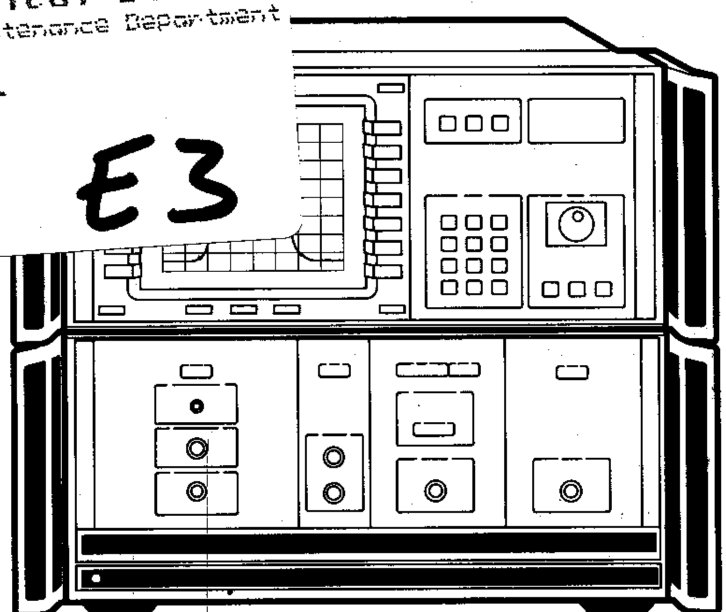
# Operating Guide

# HP 70000XL SCALAR/SPECTRUM ANALYZER SYSTEM



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## Printing History

Each new edition of this manual incorporates all material updated since the previous edition. Change sheets may be issued between editions, allowing you to correct or insert information in the current edition.

The part number of this manual changes only when a new edition is published. Minor corrections or additions may be made as the manual is reprinted between editions.

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## How to Use This Manual

*If you have not configured your spectrum analyzer/tracking generator system,* turn to the "Installation" section in the *HP 70900A Local Oscillator Installation and Verification Manual.* The installation and verification manual describes analyzer preparation and verification and tells you what to do if something goes wrong. The HP 70000XL Scalar/Spectrum Analyzer ships fully configured.

*If you are not familiar with your spectrum analyzer/tracking generator system,* turn to the *HP 70000 Modular Spectrum Analyzer Operation Manual.* The operation manual describes analyzer features and tells you how to make spectrum analyzer and tracking generator measurements. Consult the operation manual whenever you have a question about standard spectrum analyzer/tracking generator use.

*If you are ready to use the HP 70000XL Scalar Personality capability of your spectrum analyzer/tracking generator system,* turn to Chapter 1, "HP 70000XL Description" in this manual. This section describes the required hardware and key scalar and signal analysis features of the scalar analysis personality. The following sections start with a general overview followed by examples of typical scalar measurements using the HP 70000XL Scalar Personality.

The standard HP 70000 modular spectrum analyzer and tracking generator functions found under the [MENU] hardkey are documented in the following manuals:

> *HP 70000 Modular Spectrum Analyzer Operation Manual* (HP Part Number 5958-4233)
> *HP 70000 Modular Spectrum Analyzer Language Reference Manual* (HP Part Number 5958-6467)

## Notation Conventions in this Manual

The HP 70206A display features fourteen **softkeys** (special function keys): seven at the the left edge of the display and seven at the right. A softkey executes a function defined by firmware or software. The name of the function appears on the display next to the activating key.

This manual uses the following conventions:

| | |
|---|---|
| KEY | A boxed uppercase key-name in this small bold font represents a key physically located on the instrument. This is commonly referred to as a **hardkey.** |
| Firmkey | A boxed word in a plain font and an uppercase first letter indicates a top-level softkey, referred to as a **firmkey.** A firmkey accesses a related sub-menu of softkeys. For example, pressing MENU causes firmkey labels to appear on the left side of the display and the related softkey labels to appear on the right. |
| softkey | A boxed word in a plain font and all lowercase letters indicates a softkey key that accesses a subset menu of softkeys. |
| SOFTKEY | A boxed word in a plain font and all uppercase letters indicates a softkey that executes its function. |
| CRT Text | Unboxed text in this simple font indicates text that appears on a CRT. |

NOTES:

# Contents

# 1

# System Description

This chapter describes the hardware configuration and the feature set of the HP 70000XL Scalar/Spectrum Analyzer systems.

## System Components

HP 70000XL systems consist of the HP 70000XL Scalar/Spectrum Analyzers, related software, and accessories. The following lists identify analyzer components and software. (The *HP 70900A Local Oscillator Installation and Verification Manual* lists the electrical specifications of the HP 70000XL systems.)

### HP 71100XL Scalar/Spectrum Analyzer System

| | |
|---|---|
| HP 70001A | Mainframe |
| HP 70206A | System Graphics Display |
| HP 70900A | Local Oscillator |
| HP 70902A | IF Section, (Res BW 10 Hz–300 kHz) |
| HP 70904A | RF Section, (100 Hz–2.9 GHz) |
| HP 70300A | Tracking Generator, (20 Hz–2.9 GHz) |
| 70900-60121 | HP 70000XL Personality Kit |

The following standard options are available for the HP 71100XL Scalar/Spectrum Analyzer:

| | |
|---|---|
| Option 003 | add HP 70310A Precision Frequency Reference |
| Option 004 | add HP 70903A IF Section, (Res BW 100 kHz–3 MHz) |
| Option 006 | delete HP 70904A, add HP 70905A RF Section, (50 kHz–22 GHz) |
| Option 007 | delete HP 70904A, add HP 70906A RF Section, (50 kHz–26.5 GHz) |
| Option 008 | delete HP 70904A, add HP 70908A RF section, (100 Hz–22 GHz) |

The standard HP 71100XL system occupies six of the eight slots available in an HP 70001A Mainframe. A second mainframe is required for a system that includes Options 008 and 003 and 004.

### HP 71201XL Scalar/Spectrum Analyzer System

| | |
|---|---|
| HP 70001A | Mainframe |
| HP 70206A | System Graphics Display |
| HP 70900A | Local Oscillator |
| HP 70902A | IF Section, (Res BW 10 Hz–300 kHz) |
| HP 70905B | RF Section, (50 kHz–22 GHz) |
| HP 70600A | Preselector Module, (0–22 GHz) |
| HP 70301A | Tracking Generator, (2.7–18 GHz) |

| | |
|---|---|
| 70900-60121 | HP 70000XL Personality Kit |

The following standard options are available for the HP 71201XL Scalar/Spectrum Analyzer:

| | |
|---|---|
| Option 001 | delete HP 70905B/70600A, add 70906B/ HP 70601A |
| Option 003 | add HP 70310A Precision Frequency Reference |
| Option 004 | add HP 70903A IF Section, (Res BW 100 kHz–3 MHz) |
| Option 009 | add HP 70300A RF Tracking Generator, (20 Hz–2.9 GHz) |

The standard HP 71201XL system occupies all eight slots available in an HP 70001A Mainframe. A second mainframe is required for a system that includes Option 003, 004, or 009.

## HP 71210XL Scalar/Spectrum Analyzer System

| | |
|---|---|
| HP 70001A | Mainframe |
| HP 70206A | System Graphics Display |
| HP 70900A | Local Oscillator |
| HP 70902A | IF Section, (Res BW 10 Hz–300 kHz) |
| HP 70908A | RF Section, (100 Hz–22 GHz) |
| HP 70301A | Tracking Generator, (2.7–18 GHz) |
| 70900-60121 | HP 70000XL Personality Kit |

The following standard options are available for the HP 71210XL Scalar/Spectrum Analyzer:

| | |
|---|---|
| Option 003 | add HP 70310A Precision Frequency Reference |
| Option 004 | add HP 70903A IF Section, (Res BW 100 kHz–3 MHz) |
| Option 009 | add HP 70300A Tracking Generator, (20 Hz–2.9 GHz) |

The standard HP 70210XL system occupies all eight slots available in an HP 70001A Mainframe. A second mainframe is required for a system that includes Option 003, 004, or 009.

## Accessories

The following accessories enhance HP 70000XL measurement capability.

| | |
|---|---|
| HP 2225A ThinkJet Printer | Provides quick hardcopy outputs. |
| HP 7440A ColorPro Plotter | Provides high-quality color plots. |
| HP 8447 Series Amplifiers (100 kH–1.3 GHz) | Increases sensitivity by greater than 15 dB, or increases the tracking generator output power to greater than +10 dBm. |
| HP 8347A Amplifier (100 kHz–3 GHz) | Increases output power of the tracking generator to greater than +15 dBm for higher dynamic range. The higher power output provided by the HP 8347A can minimize sweep time by allowing measurements in wider IF bandwidths. |
| HP 8349A Microwave Amplifier (2–20 GHz) | Increases output power of the tracking generator to +20 dBm for higher dynamic range. |
| HP 773D, HP 774D, 775D, 776D, and 777D Directional Couplers | Provides high directivity from 40 dB to 30 dB depending on frequency range. |

| | |
|---|---|
| HP 85044A Transmission Reflection Test Set | Simplifies setup requirements for transmission and reflection measurements from 300 kHz to 3 GHz. The HP 85044A contains a power splitter, a directional bridge ( >30 dB directivity), and a 70 dB step attenuator. Option H10 deletes the 70 dB attenuator and the power splitter. |
| | In coaxial systems, opens and shorts establish measurement planes of known reflection and magnitude. Table 1-1 lists recommended opens, shorts, and adapters for use with the HP 85044A Test Set. |

**Table 1-1. Accessories for the HP 85044A Test Set**

| |
|---|
| HP 11524A APC-7 to Type N (f) adapter |
| HP 11534A APC-7 to SMA (f) adapter |
| HP 11512A N (m) short |
| HP 0960-0055 SMA (m) short |

## Firmware and Personality

The HP 70000XL operator interface consists of firmware and a downloaded software **personality.** The firmware for the HP 70000XL resides in the HP 70900A Local Oscillator (LO) module (the system master). HP 70900A Local Oscillator firmware must be dated *880901* (YYMMDD) or later. The LO firmware version appears on the display during the power-on sequence and after the following key sequence: [MENU], [misc], [more], [service], [ROM VERSION].

The HP 70000XL Scalar Personality is a **DLP** (downloadable program) that resides in the HP 70900A Local Oscillator non-volatile storage memory. Personality software provides a set of softkey functions that implement a particular application. The HP 70000XL personality is scalar and signal analysis measurement.

**Note**

Chapter 7 provides help if you need to re-load a personality that has been erased from RAM, or if you need to re-store a personality after its softkeys have been accidently erased from the screen.

## HP 70000XL Feature Set

The HP 70000XL personality provides a dual measurement mode: **scalar analysis** and **spectrum analysis.** The scalar analysis mode optimizes the HP 70000XL user interface for scalar measurements and provides a set of functions that simplifies typical transmission and reflection measurements. The signal analysis mode provides two high-level routines for analyzing signal distortion. The following summarizes key features of the scalar and signal modes.

### Scalar Analysis Mode

- The **150 dB Display** function provides a full 150 dB display range to view high-rejection measurements.
- **Guided Calibration** routines prompt you through either a transmission or an open/short average calibration.
- **Multiple CAL Traces** allow storage of two sets of transmission and two sets of reflection calibration traces in non-volatile memory.
- **Markers** allows trace-to-reference level, marker-to-center frequency, or delta markers-to-start/stop frequencies. Resolution of frequency and amplitude measurements, both absolute and relative, are 1 Hz and 0.01 dB, respectively.
- **Autoscale** automatically sets the reference level and the amplitude scale to optimize the initial amplitude response on the display.
- The **Golden Device** mode allows storage of a reference device along with upper and lower test limits. The golden device becomes the basis for pass/fail testing.
- User-defined **Limit Lines** increase throughput of pass/fail testing by giving an audible *beep* when test limits are exceeded.
- The **Dual Display** mode allows active tuning of passband ripple while simultaneously sampling stop-band rejection.
- **Device Bandwidth** and **Shape Factor** functions ease characterization of filter bandwidth, shape factor, and Q.

### Signal Analysis Mode

- The **Spur Search** routine reduces the time spent locating and characterizing unknown signals. You can specify parameters such as frequency range, spur specification, analyzer sensitivity, and guard band. The specified search parameters determine an estimated search time.
- The **Total Harmonic Distortion** routine returns the frequency and amplitude of the fundamental, second and third harmonics, and the total harmonic distortion in percent.

# 2

# General Overview of the System Interface

## Introduction

This operating guide will help you use the HP 70000XL Scalar/Spectrum Analyzer System to perform transmission, reflection, harmonic distortion, and spur search measurements. It assumes previous experience in network and signal analysis techniques; therefore, the emphasis is on basic measurement sequences rather than measurement theory. Appendix B provides a treatment of scalar network measurement errors.

The scalar mode menu structure (see Appendix A) is similar to the firmkey/softkey structure of the standard HP 70000 Modular Measurement System menu keys. There are three menus in the HP 70000 system: [USER], [MENU], and [DISPLAY]. A status indicator in the lower right corner of the CRT indicates the selected menu.

## Definitions of Keys on the HP 70206A

The HP 70206A System Graphics Display features **hardkeys** and **softkeys.** A hardkey has a single function, which is printed on the key or on the panel. The function of a softkey depends on software or firmware definitions; the function label appears on the display, next to the physical key. A softkey that is at the highest menu level and calls a sub-menu of softkeys is a **firmkey.** Refer to "Manual Terms and Conventions" (page v) for key representations and descriptions.

Hardkeys include data entry keys and system keys. System hardkeys are [LOCAL], [PRINT], [PLOT], [IP], [←], [USER], [MENU], and [DISPLAY]. The following list describes three of the system hardkeys.

[USER] Pressing this key accesses firmkeys and softkeys defined by the HP 70000XL Personality. This operating guide describes the functions of all softkeys accessed by the USER hardkey.

[MENU] Module configuration determines functionality of the HP 70000 Modular Measurement System.

Pressing [MENU] presents a set of **firmkeys** representing the functionality of the configured system. The firmkeys access the standard operating functions of a particular system configuration. Pressing [MENU] also provides access to standard spectrum analyzer, tracking generator, or other system module functions as documented in the *HP 70000 Modular Spectrum Analyzer Operation Manual.*

[DISPLAY] Pressing this key allows access to display functions associated with the HP 70206A display. The standard display functions are documented in the *HP70206A System Graphic Display Operation Manual* and the *HP 70000 Modular Spectrum Analyzer Operation Manual.*

## Instrument Preset

Pressing the green instrument-preset hardkey, [I-P], displays the standard [MENU] firmkeys and sets the analyzer to the power-on state described in Table 2-1.

**Table 2-1. Instrument State after an [I-P]**

| | |
|---|---|
| STIMULUS RESPONSE | Stimulus Response mode OFF<br>Source power OFF |
| AMPLITUDE | Ref level = 0 dBm<br>log scale = 10 dB/DIV |
| FREQUENCY | Full span of tracking generator |
| COUPLED FUNCTIONS | Attenuator AUTO<br>Sweep time AUTO<br>Bandwidths AUTO |
| DISPLAY | Markers OFF<br>Display line/threshold OFF<br>Trace A ON |

## HP 70000XL User Interface

The HP 70000XL user interface consists of two measurement modes—scalar analysis and signal analysis. The scalar analysis mode includes functions dedicated to transmission and reflection measurements; signal analysis mode includes functions dedicated to harmonic and spurious measurements. Pressing [USER] on the HP 70000XL system display presents the top-level menu shown in Figure 2-1.

**Note**

Since DLPs implement the HP 70000XL user interface, you can preset softkeys with [key control], [PRESET USER] or by selecting [FIRMKYS on/off]. To recall the DLPs, toggle firmkeys ON and press [Misc], [key control], [RECALL USER], 900.

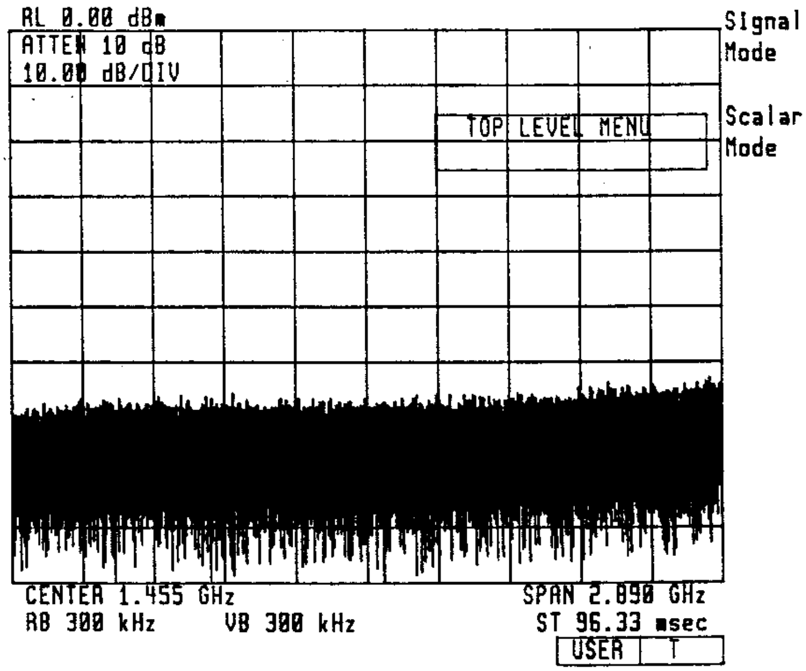


**Figure 2-1. Top Level Menu**

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**Note**

If the display does not look like Figure 2-1 after pressing the USER hardkey, press EXIT Signal or EXIT Scalar on the bottom left corner to re-enter the top level menu. Exiting and re-entering the signal or scalar mode will preset the measurement mode to the proper initial state. For more information on the preset condition, refer to Table 3-1 in Chapter 3.

---

## Invoking Signal Analysis Mode

To invoke the signal analysis mode, press USER then Signal Mode. If Scalar Mode appears, press EXIT Scalar then press Signal Mode again (see Figure 2–2). Signal mode contains harmonic distortion and spurious search measurement routines. Harmnc Distn and Spur Search are examples of firmkeys, as Figure 2–2 shows. Chapter 6 provides measurement examples using these routines.

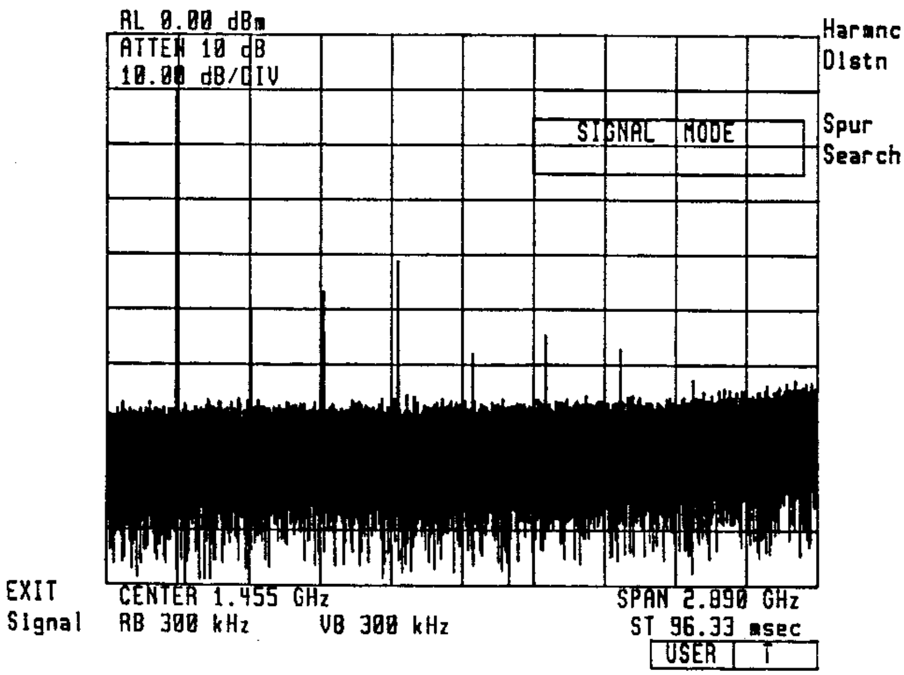



Figure 2-2. Signal Mode Menu

## Invoking Scalar Analysis Mode

To invoke the scalar analysis mode, press USER then Scalar Mode. If the signal mode appears, press EXIT Signal then press Scalar Mode again (see Figure 2-3).

The scalar mode firmkeys appears on the left side of the display. Pressing any firmkey accesses a related sub-menu on the right side. An underscore on the firmkey indicates that it is active.

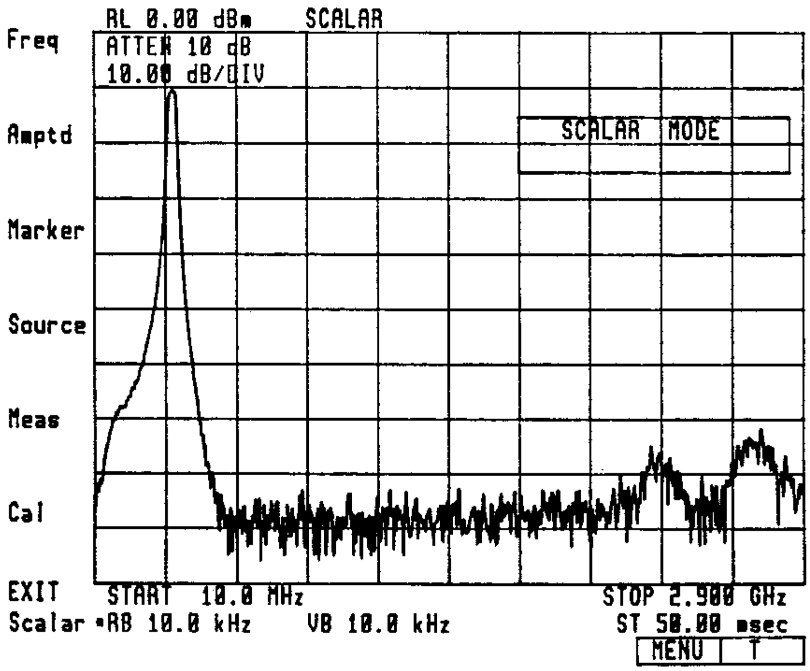



**Figure 2-3. Scalar Firmkeys**

The scalar mode interface is optimized for transmission/reflection measurements. Its functions include the following features:

- Guided calibration routines with multiple trace storage for both transmission and reflection measurements.
- A dual display mode to monitor two independent frequency and amplitude ranges.
- A 150 dB display mode for viewing high rejection devices.
- Independent upper and lower limit-lines for pass/fail testing.
- A "golden device" mode to allow a convenient way to do production testing.
- A powerful and convenient set of markers for general measurements.
- Filter functions for measuring bandwidth, shape factor, and filter Q.

NOTES:

# 3

# Scalar Mode Overview

Scalar mode consists of seven firmkeys. Four facilitate general test setups and measurements. Two others, `Meas` and `Cal`, provide additional measurement capabilities and calibration, respectively. The seventh is an EXIT firmkey. This chapter describes the first four firmkeys, Chapter 4 describes `Meas`, and Chapter 5 describes `Cal`. This chapter includes two simple filter-measuring examples.

## Setup and Measurement Firmkeys

Four firmkeys, `Freq`, `Amptd`, `Marker`, and `Source`, access functions that set up scalar measurements (refer to Figure 3-1).

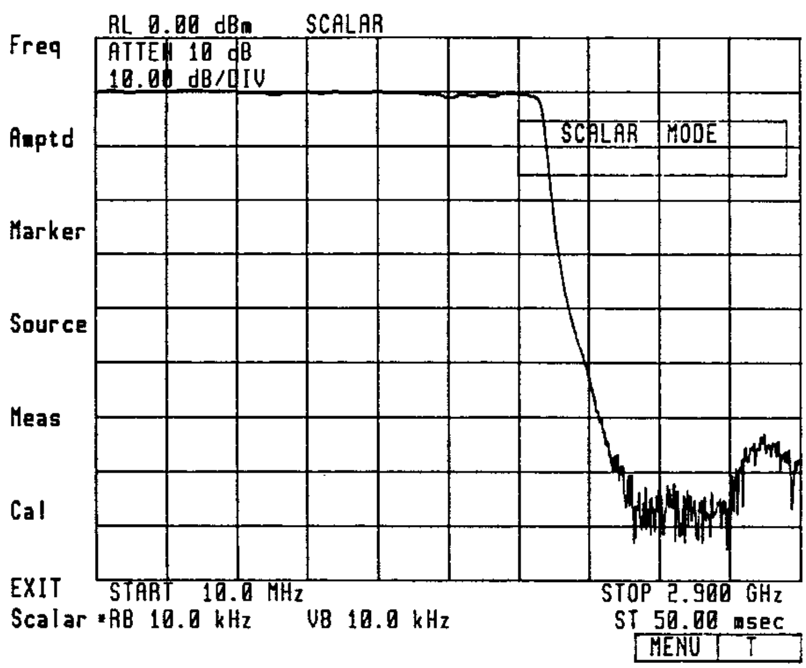



**Figure 3-1. Setup Firmkeys**

## Frequency Firmkey

Pressing [Freq] provides access to softkeys that adjust frequency-related parameters. The following set of softkeys will then appear on the right side of the display:

| | |
|---|---|
| START | Set start frequency. |
| STOP | Set stop frequency. |
| CENTER | Set center frequency. |
| SPAN | Set frequency span. |
| FULL SPAN | Set full span of tracking generator. |
| CW | Set CW (continuous wave) frequency. |
| SCALAR PRESET | Preset the instrument for scalar operation. |

## Amplitude Firmkey

Pressing [Amptd] provides access to softkeys that adjust amplitude-related parameters. The following set of softkeys will then appear on the right side of the display:

| | |
|---|---|
| REF LVL | Set the power or reference level to the top line of display. |
| REF LVL POSN | Set the position of the reference level. |
| LOG dB/DIV | Set the log scale in dB per division. |
| ATTEN | Set spectrum analyzer's input attenuator. |
| DSP LIN | Set a display line. |
| RES BW | Set the analyzer's resolution bandwidth. |
| AUTO SCALE | Automatically sets optimum reference level and log scale. |

## Marker Firmkey

Pressing [Marker] provides access to softkeys that set marker functions. The following set of softkeys will then appear on the right-side of the display:

| | |
|---|---|
| MKR NRM | Activate single marker mode. |
| DELTA | Activate delta marker mode. |
| HIGHEST PEAK | Active marker to the highest peak. |
| MINIMUM POINT | Active marker to minimum point. |
| Δ --> SPAN | Sets frequency span from lower frequency marker to higher frequency marker. |
| --> REF | Active marker to reference level. |
| --> CF | Active marker to center frequency. |

## Source Firmkey

Pressing [Source] provides access to softkeys that control the tracking generator and also sweep times. The following set of softkeys will then appear on the right side of the display:

| | |
|---|---|
| [SRC PWR] | Activate and adjust source power. |
| [PWR SWP]* | Activate and adjust power sweep. |
| [ALC NRM] | Activate normal internal ALC (automatic level control) detector for frequencies greater than or less than 10 MHz. |
| [ALC ALT]* | Activate alternate ALC detector. Used for frequencies below 10 MHz. |
| [SWPTIME] | Adjust analyzer sweep time. |
| [CONT SWEEP] | Select continuous or single sweep. |
| [SINGLE SWEEP] | Execute a single sweep. |

* Applicable only on the HP 71100XL.

## Scalar Preset State

Two different preset states set up the system for scalar measurements. [Scalar Mode], from the top-level menu, sets the highest level preset; [SCALAR PRESET] sets the lower level. Table 3-1 shows preset conditions.

**Table 3-1. System Settings for the Two Preset States**

| Settings | [Scalar Mode] | [SCALAR PRESET] |
|---|---|---|
| Instrument Preset [I-P] | X | – |
| Display Scalar Firmkeys | X | X |
| Initialize DLP Variables | X | – |
| Display XL Version Date | X | – |
| STIM RESP MODE | X | X |
| Reference Level 0 dBm | X | X |
| Log Scale 10 dB/Div | X | X |
| Resolution BW 10 kHz | X | X |
| Continuous Sweep | X | X |
| Functions Auto-Coupled | X | – |
| Markers OFF | X | X |
| SCALAR Message | X | X |
| Source Power ON | X | X |

## Sweep Time

The sweep time of the HP 70000XL analyzer is automatically adjusted to provide accurate measurements in the signal mode and in the scalar mode. The STM RSP (stimulus response) function under [MENU], [State], and [track gen] controls the sweep time mode for signal mode or scalar mode.

In the signal mode, the sweep time equation is optimized for measuring discrete signals. It must sweep slowly enough to allow the resolution bandwidth filter to charge to its peak value, thereby ensuring accurate amplitude and frequency measurements. The STM RSP mode is turned `Off` for the signal mode.

In the scalar mode, the sweep time is faster, since scalar measurements are typically made on devices which have gradual amplitude versus frequency transition. High Q devices, which have sharp amplitude versus frequency transitions, may require a slower sweep rate to ensure accurate measurements. To adjust sweep time manually, press [Source] then [SWEEP TIME]. To ensure a correct sweep rate for a particular scalar measurement, adjust the sweep time of the analyzer until the displayed measurement response no longer changes in amplitude.

# Filter Measurement Examples

The following examples are intended to give the first-time user of the HP 70000XL analyzer a general understanding of the scalar mode menu layout. Additional information about [Freq], [Amptd], [Marker], and [Source] can be found in the *HP 70000 Modular Spectrum Analyzer Operation Manual.*

Chapter 4 in this manual describes system calibration, and Chapter 5 describes the functions under [Meas]. After initial power-up, press [USER] to enter the HP 70000XL Personality. Press [Scalar Mode] to select the scalar personality. When the HP 70000XL analyzer is in the scalar mode, a highlighted `SCALAR` message appears above the top graticule line.

## Example 1: Measuring Passband Center Frequency

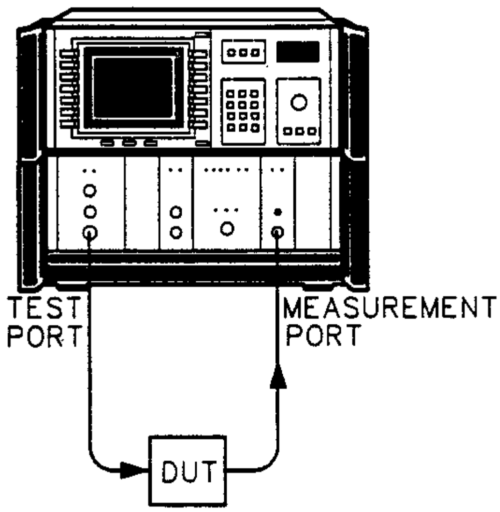



**Figure 3-2. Transmission Measurement Set-up**

In scalar mode, the HP 70000XL sweeps the full tracking-generator frequency band with source power set to −10 dBm. To control source power, press `Source`, `SRC PWR`, then set the power level with data entry keys. A light next to the tracking generator output connector indicates active source power.

There are at least two ways to measure passband center frequency with the HP 70000XL. The first way, described step by step below, is a very general approach and is a good way to learn about the `Marker` functions. Another way, which is faster but requires more system knowledge, uses the `device bw` function under the `Meas` firmkey (covered in Chapter 5). We recommend you learn the following general approach first to familiarize yourself with the scalar mode interface.

1. Press Freq to access the **Freq** functions.
2. Press CENTER and adjust the passband to the center frequency. Press SPAN and adjust the span to view the passband.
3. Press Marker, MKR NRM On to turn on the normal marker. Use the knob to adjust the marker to the center of the passband. The approximate filter passband center frequency is read directly from the screen (see Figure 3-3).

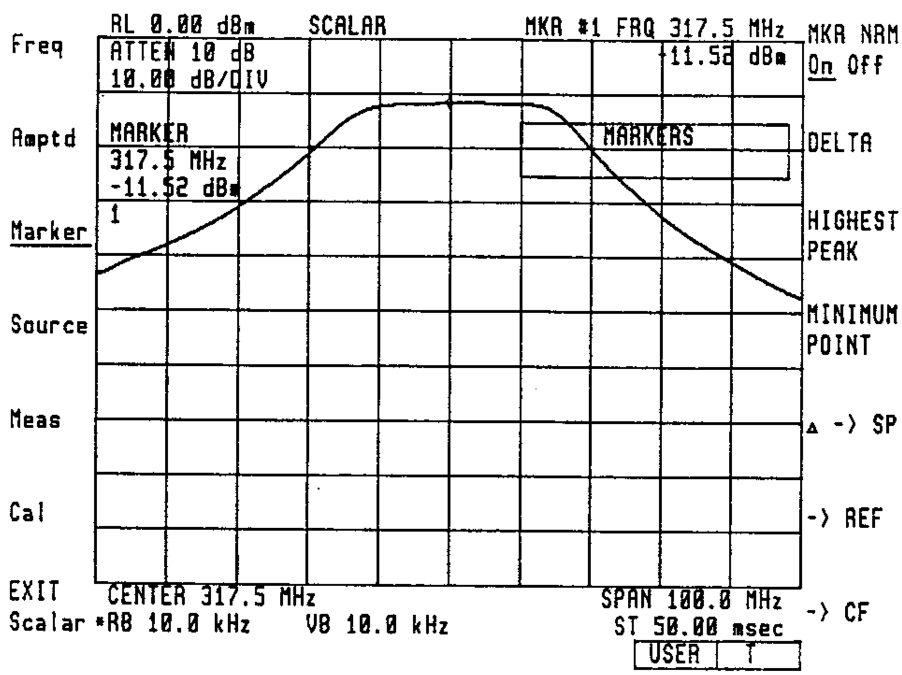



**Figure 3-3. Using Marker to Determine Approximate Passband Frequency**

## Example 2: Measuring Filter Rejection

This example is a continuation of Example 1.

1. Press Freq, FULL SPAN to look at the full band.
2. Press STOP and adjust the stop frequency to a convenient frequency.
3. Press Marker, HIGHEST PEAK to set the marker at the peak of the filter.
4. Press DELTA and adjust the second marker to measure rejection along the filter stopband.

Filter rejection is read from the active function area (see Figure 3-4).

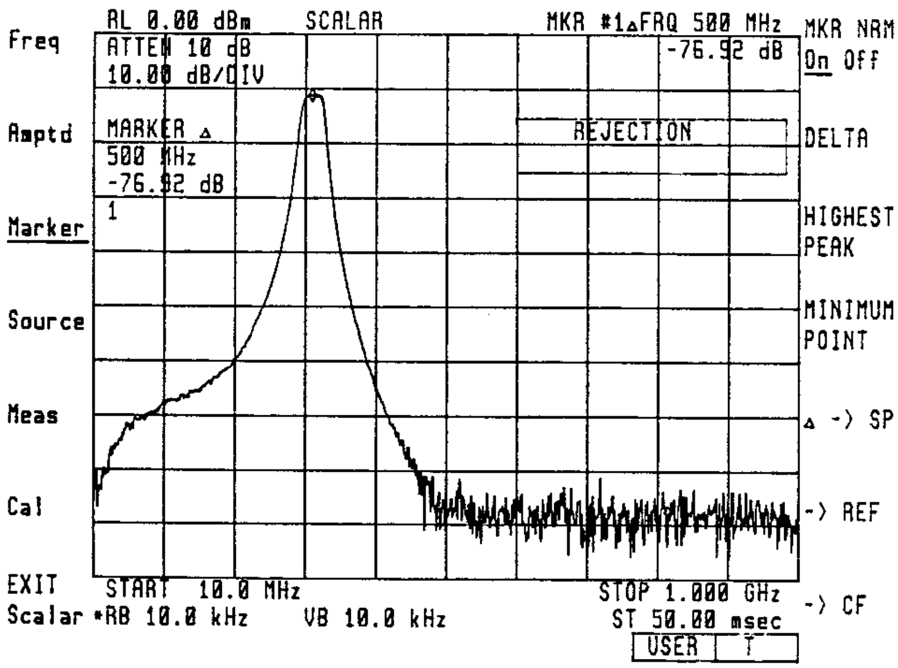



**Figure 3-4. Filter Rejection**

NOTES:

# 4

# Calibration

Spectrum-analyzer/tracking-generator systems measure the magnitude response of the device under test (DUT) relative to the magnitude response of a known reference. In a typical measurement sequence, the reference is established at the measurement plane (the point at which the test device will be connected) and the reference response is stored. The DUT is then connected and the analyzer displays the magnitude difference between the reference and the test device.

For transmission measurements, the reference standard is the system itself. Therefore, a **straight through** or **thru** measurement (no DUT between source and receiver) removes frequency-response uncertainty from total measurement uncertainty.

Reflection measurements typically use reference standards with known reflection coefficients (such as **opens** and/or **shorts**). Using either an open or a short allows us to remove system frequency-response uncertainty. The HP 70000XL analyzer uses an **open/short average** calibration technique. In addition to frequency response errors, this technique removes errors due to directivity and source match, thus reducing uncertainty in the measurement.

## Calibration Keys

Pressing the `Cal` firmkey activates the calibration menu on the right side of the display (refer to Figure 4-1).

[cal thru] Initiates the transmission calibration. The sub-menu includes [STORE THRU 1] and [STORE THRU 2] to allow non-volatile storage of calibration trace. An [ABORT] key returns to the [Cal] menu.

[thru on/off] When toggled `ON`, you can recall one of two available transmission calibration traces with [RECALL THRU 1] or [RECALL THRU 2]. When toggled `OFF`, the calibration trace is no longer applied to the measurement. [ABORT] returns to the [Cal] menu.

[cal opn/sht] Initiates the open/short average calibration routine. The sub-menu includes [STORE OP/SH 1] and [STORE OP/SH 2] to allow non-volatile memory storage of calibration trace. [ABORT] returns to the [Cal] menu.

[opn/sht on/off] When `ON`, user can recall one of two available reflection calibration traces with [RECALL OP/SH 1] or [RECALL OP/SH 2]. When toggled to `OFF`, the calibration trace is no longer applied to the measurement. [ABORT] returns to the [Cal] menu.

CAL MSG ON/OFF — Enables the SCALAR UNCAL'D message to blink whenever the instrument's start/stop frequencies do not match the calibration frequencies.

TRACKING PEAK — Automatically adjusts the tracking generator frequency to the peak of the spectrum analyzer's resolution bandwidth response. Required only for resolution bandwidths less than 1 kHz.

TRACKING ADJUST — Allows manual adjustment of tracking generator frequency to the peak of the spectrum analyzer's resolution bandwidth.

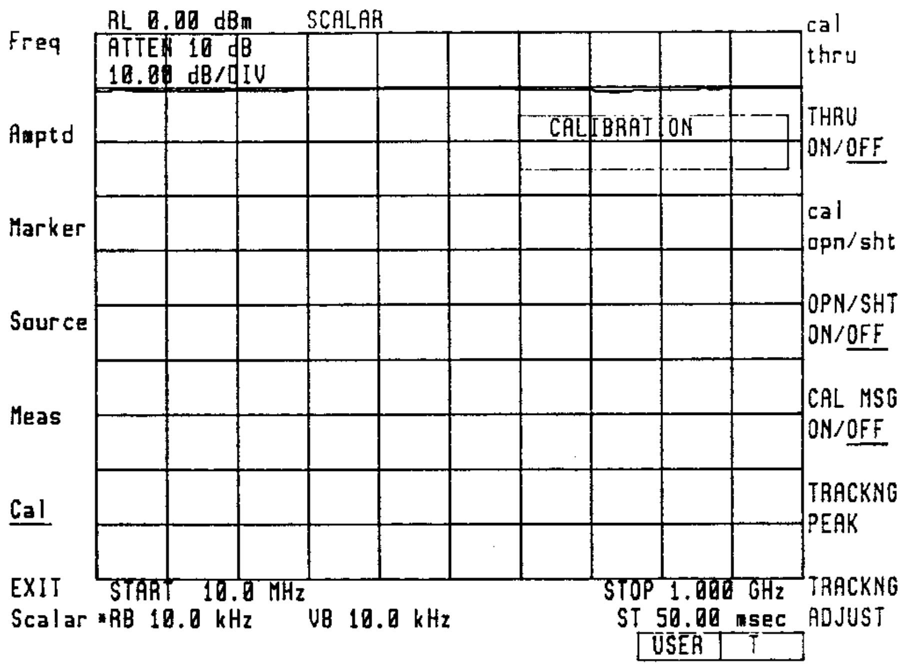



**Figure 4-1. Calibration Menu**

Prompts provide instructions that minimize calibration errors. The HP 71100XL allows you to store two unique transmission (**thru**) calibrations and two unique reflection (**open/short**) calibrations in non-volatile trace memory. Stored calibration information has full 12-bit amplitude resolution. Because of the high amplitude resolution, you can change settings for scale factor, reference level, and reference level position without recalibrating. When calibration traces are active, the reference level unit is in dB (relative) instead of dBm (absolute).

## Calibration Indicators

This section discusses some HP 70000XL analyzer messages that warn of certain calibration conditions.

An UNCOR (uncorrected) message appearing in the upper-right quadrant of the display indicates an uncalibrated spectrum analyzer or disabled [cal enable] factors. To calibrate the spectrum analyzer, connect the 300 MHz calibrator signal from the HP 70900A Local Oscillator to the RF input and press [MENU], [Amptd], and [CAL ALL].

An UNCAL (uncalibrated) message appearing in the upper-right quadrant of the display indicates that the spectrum analyzer is sweeping too fast for a specific setting. Typically, this occurs when you use analyzer functions in a manual mode. To remove the UNCAL message, return sweep time to AUTO by pressing the SWPTIME softkey or you can press [I-P].

The SCALAR message above the top graticule line indicates that the HP 70000XL analyzer is in the scalar (rather than signal) mode. In the scalar mode, a faster sweep time is used because the majority of devices in stimulus-response measurements have bandwidths that are greater than the instrument's bandwidth. For devices with sharp frequency transitions (for example, high-Q devices), it is recommended that the sweep time be increased manually until the maximum amplitude response is displayed.

The SCALAR UNCAL'D message warns you that the transmission or reflection calibration data is not valid for the current frequency setting of the instrument. Pressing [CAL MSG ON] arms the SCALAR UNCAL'D message. When the calibration message is armed the overall sweep cycle is slightly increased. Pressing [CAL MSG OFF] disarms the calibration message and the sweep cycle is restored to normal. If the message SCALAR UNCAL'D appears on the lower-left corner of the screen you may either recalibrate or set the frequency parameters back to the *exact,* original settings.

---

**Note**

*To achieve best accuracy,* calibrate the system with the same adapters and cables that will be used during the measurement. Also, do not change the power level or spectrum analyzer resolution bandwidth or attenuator settings after normalization. Doing so will result in measurement errors because after the changes the reference trace will not represent the frequency response of the system. If you must change settings between calibration and measurement, recalibrate at the new settings.

*To ensure good repeatability,* the connecting ports for the DUT must be clean, in good condition, and properly tightened. If the test setup is not electrically stable during repeated connections, the frequency response of the test setup will not be removed and errors may result.

---

## Transmission Calibration

The thru is the calibration standard for transmission measurements. Ideally, a thru calibration is achieved simply by connecting the output of the source (test port) to the input of the receiver (measurement port). Since the insertion loss between the test port and measurement port (Figure 4–2) should approach 0 dB, a *thru* provides a convenient reference point. The source and receiver connectors must match those of the DUT. For a more thorough understanding of measurement accuracy, see Appendix B, "Scalar Measurement Accuracy."

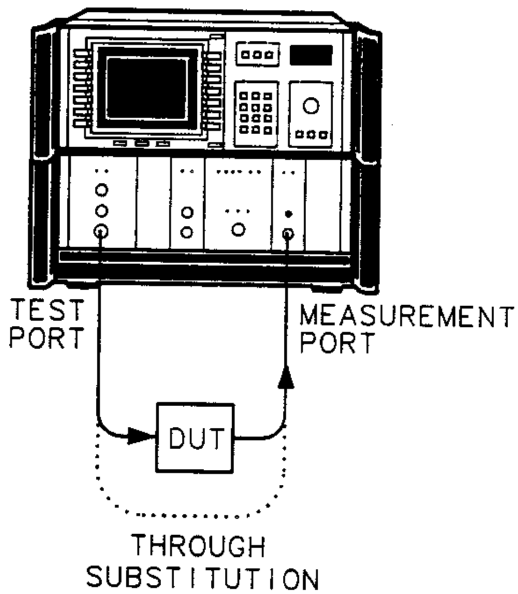



**Figure 4-2. Transmission Normalization**

To perform a thru calibration, follow these steps:

1. Connect the DUT and find required start/stop frequencies and overall instrument settings. If the measurement requires a narrow resolution bandwidth (less than 1 kHz), press TRACKING PEAK to peak the source.
2. Press Cal to access the calibration menu, then cal thru to begin a thru calibration. The prompt Connect THRU, Store when ready instructs you to connect the thru and press the STORE THRU 1 key. Pressing ABORT will bring you back to the main menu.
3. Replace the DUT and connect the test and measurement ports together (see Figure 4-2). If this is not possible because of connector differences, use a high-quality adapter.
4. Press STORE THRU 1. While the calibration information is being read into trace memory, the message READING IN CAL TRACE is on the screen. When the read process is complete, the message Function executed appears.

The thru trace is stored in one of two available trace registers.

The message NORMALIZE THRU 1: ON identifies the current calibration data. Note that the reference level is read in dB relative to the calibration trace as opposed to dBm (absolute) prior to calibration.

## Calibration for Devices with Gain

Calibrating for active devices, such as amplifiers, is very similar to calibrating for passive devices. The only difference is that the amplifier has gain (instead of loss) and will display a trace *above*, rather than *below*, the reference level. So, in order to see the gain response, you must adjust the REF LVL POSN towards the center of the CRT, since gain response will typically be above the reference level. The automatically coupled input attenuator ensures that the spectrum analyzer response does not compress as you change reference level or reference level position.

When measuring devices which have gain, it is important to ensure that the device is not operating beyond its compression point (saturation). To check for possible saturation, press Source, SRC PWR, then change the power level going into the amplifier. (The source power is adjustable over 80 dB range.) If the power change drives the amplifier into saturation, you will see a *clipped* trace at the upper power range.

Once you adjust frequency range, amplitude range, and source power levels, you can follow the same transmission calibration steps as described above. Figure 4-3 shows an amplifier gain/bandwidth measurement.

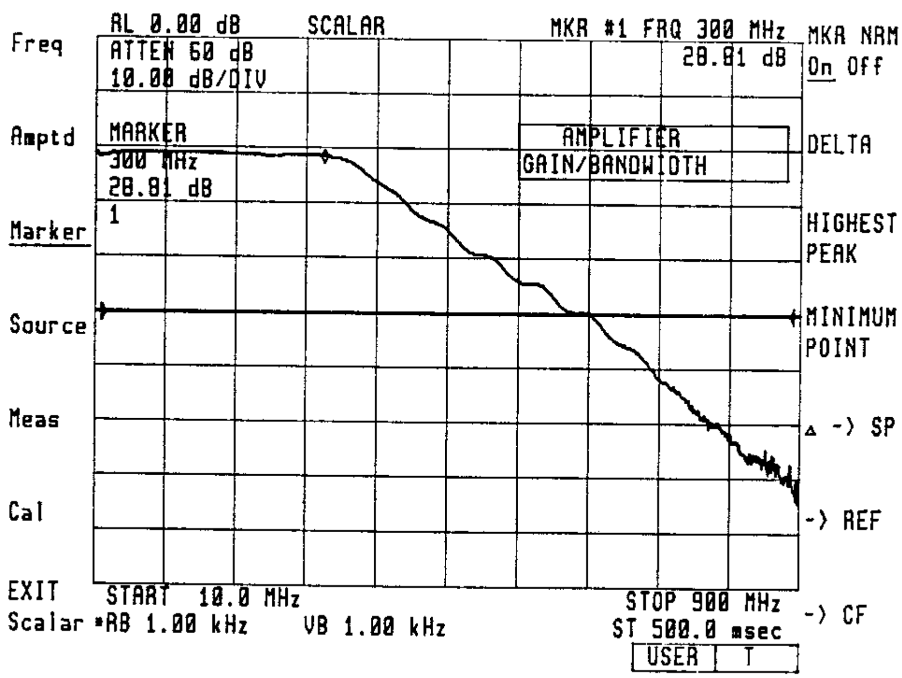



**Figure 4-3. Calibration for Devices with Gain**

## Reflection Calibration

Typically, the calibration standard for reflection measurements is a short circuit connected at the reference plane (the point at which the test device will be connected—see Figure 4–4). A short circuit has a reflection coefficient of 1 (0 dB return loss); it thus reflects all incident power and provides a convenient 0 dB reference.

**Note** If possible, use a coupler or bridge with the correct test port connector for both calibrating and measuring. Any adapter between the test port and DUT degrades coupler/bridge directivity and system source match. Ideally, you should use the same adapter for the calibration and the measurement. Refer to Appendix B for a discussion of measurement accuracy.

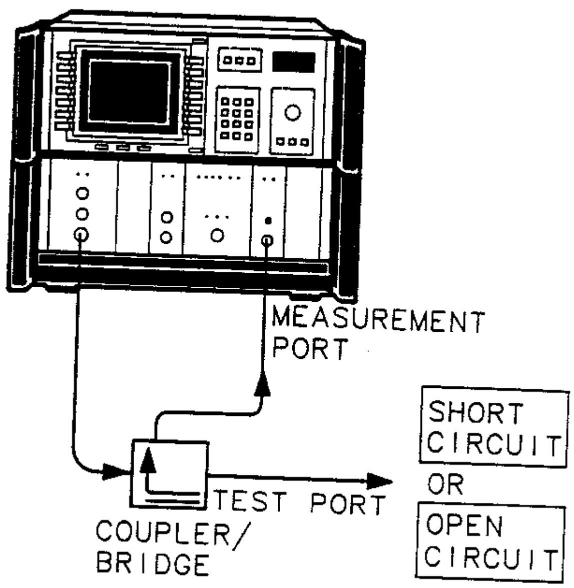



**Figure 4–4. Reflection Measurement Open/Short Calibration**

Although a short circuit is commonly used for reflection calibration, using only a short can cause errors in the calibration trace. These errors are due to directivity errors in the coupler/bridge and mismatch errors in the source. The result of these errors is that the calibration trace does not represent the actual 0 dB return loss signal.

A better way to do reflection calibration is to use a technique called **open/short average**. The calibration errors due to the sum of directivity and source match can be removed by averaging a short and an open circuit response. Although the reflection from an open circuit is 180 degrees out of phase with the short, the errors due to the sum of directivity and source match do not change phase when the load is changed from an open to a short. Hence, by averaging the response of a short with an open, the effects of directivity error and source match error are cancelled to produce a more accurate reflection calibration.

The following procedure demonstrates how to do an open/short average calibration:

1. Connect the DUT and set the required start and stop frequencies and overall instrument settings. If the measurement requires a narrow resolution bandwidth (less than 1 kHz), press TRACKING PEAK to peak the source.
2. Press cal opn/sht. The prompt Connect OPEN, Store when ready instructs you remove the DUT and leave the test port open.
3. Press STORE OPEN. When complete, the message Function executed appears. (If you unintentionally entered the cal opn/sht menu, press ABORT to return to the main menu.
4. Next, the prompt Connect SHORT, Store when ready instructs you to connect a short to the test port.)
5. Press STORE SHORT. When the data storage is complete, the message Function executed appears.
6. Press STORE OP/SH1. The averaged open/short calibration trace is stored in one of two available trace registers. The message NORMALIZE REFL 1: ON appears on the screen to let you know which calibration trace is active.

# 5

## Scalar Measurements

Pressing Meas gives you access to high-level measurement routines that reduce the time it takes to make typical transmission and reflection measurements. The following softkeys become available: `limit lines`, `golden device`, `dual display`, `150 dB display`, `shape factor`, `device bw` and SCALAR PRESET (see Figure 5-1). This chapter describes these functions and provides a measurement example of each.

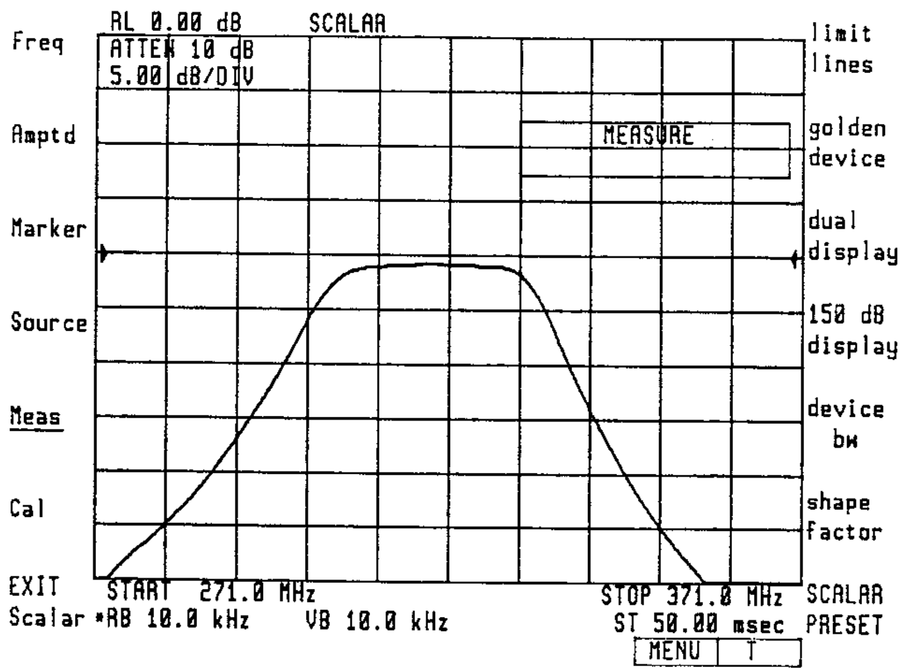



**Figure 5-1. Measurement Softkeys**

**Note**

If you want a hardcopy record of an example measurement, attach a printer or plotter to the HP-IB (Hewlett-Packard Interface Bus) connector of the HP 70206A display. Press DISPLAY, `define hardcopy` then define the output device.

## Limit Lines

Limit lines allow limit testing of measurement data. A limit line is a series of segments defining the upper or lower test limit or specification. Typically, the segments connect end to end, but a **point** feature allows gaps in the line.

Segment by segment, you draw the required limit line. For each segment, you first **select a segment,** which is initially represented by a high-intensity marker. Next you specify segment **type** (slope, flat, or point), then you position the marker by specifying its **frequency value** and/or **amplitude value.** As the marker moves, it draws a segment line.

Segment data (segment number and three parameters) are displayed in table form with a highlighted cursor to indicate the selected segment and parameter. Refer to Figure 5-2 (cursor not shown on illustration).

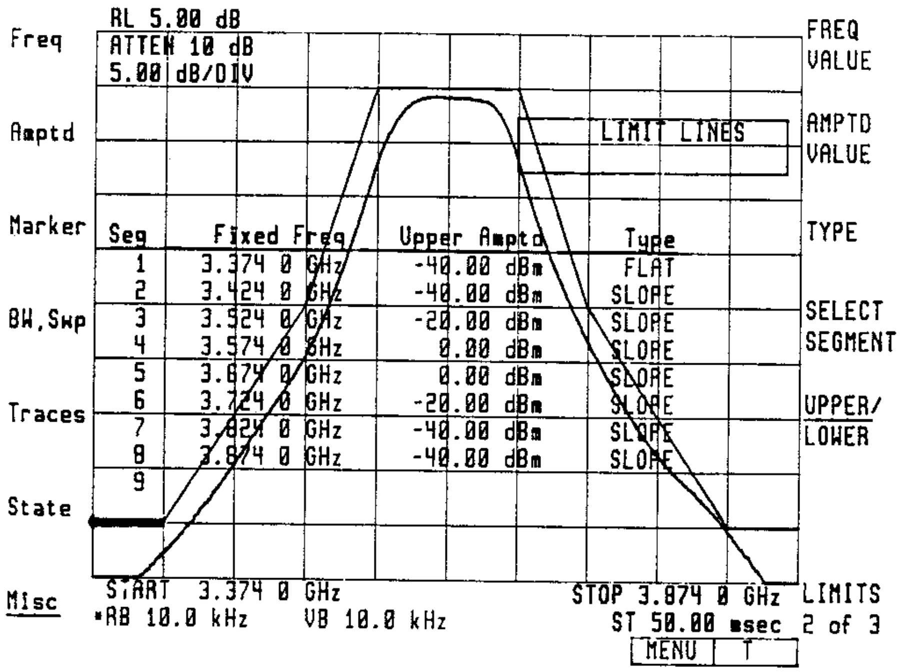



**Figure 5-2. Limit Lines**

You can specify two independent limit-lines, upper and lower. Each can have a total of 20 segments. The table will display 11 sets of parameters before the data begins to scroll. Arrows indicate the presence of more segments above or below the table. The program sorts the segments by frequency, so you can create segments in any order. To modify previously entered parameters, repeatedly press `SELECT SEGMENT` until the cursor is on the desired line in the table.

Toggling `LIMITS On Off` to `ON` enables the limit-line testing function. A trace `FAIL`s if it violates a limit line at any point. If you enable the beeper by pressing `BEEPER On Off`, a beep will sound for each failed trace.

The program stores the limit lines as a pair, LIMIT_HI and LIMIT_LO. Any change to the limit lines, to frequency span, or to center frequency causes recalculation of all trace data points. LIMIT_HI and LIMIT_LO are present only while LIMITS On Off is ON. Toggling to OFF disposes of the two traces unless you save them.

For more information about limit lines, refer to the *HP 70000 Modular Spectrum Analyzer Operation Manual.*

## Golden Device

The golden device softkey function allows use of a reference device, sometimes referred to as a *golden device* or standard, to establish a set of limit lines. Once the trace response of the reference device is stored, you can enter an upper and lower limit line that is relative to the reference trace. These upper and lower limit lines then become the test limits for other devices.

## Example: Creating Test Limits for a "Golden Device"

1. Press **Freq** and set the start/stop test range.
2. Press **Amptd** and set the desired reference level and log scale.
3. Press **golden device**. The trace for the golden device will be stored as a reference trace for the setting of limit lines.
4. Press **UPPER LIMIT** and enter an upper limit in dB. Press **ACCEPT VALUE**.
5. Press **LOWER LIMIT** and enter a lower limit in dB. Press **ACCEPT VALUE** (Figure 5-3).
6. Press **BEEP ON/OFF** to toggle the beeper ON.
7. Press **TEST ON/OFF** to toggle the test mode ON. A PASS or FAIL message indicates that the test mode is on.
8. Insert a device to test. If the test device exceeds the upper or lower limits established by the golden device, a FAIL message will be displayed and the beeper will sound.
9. Press **EXIT Golden** to exit back to the **Meas** menu.

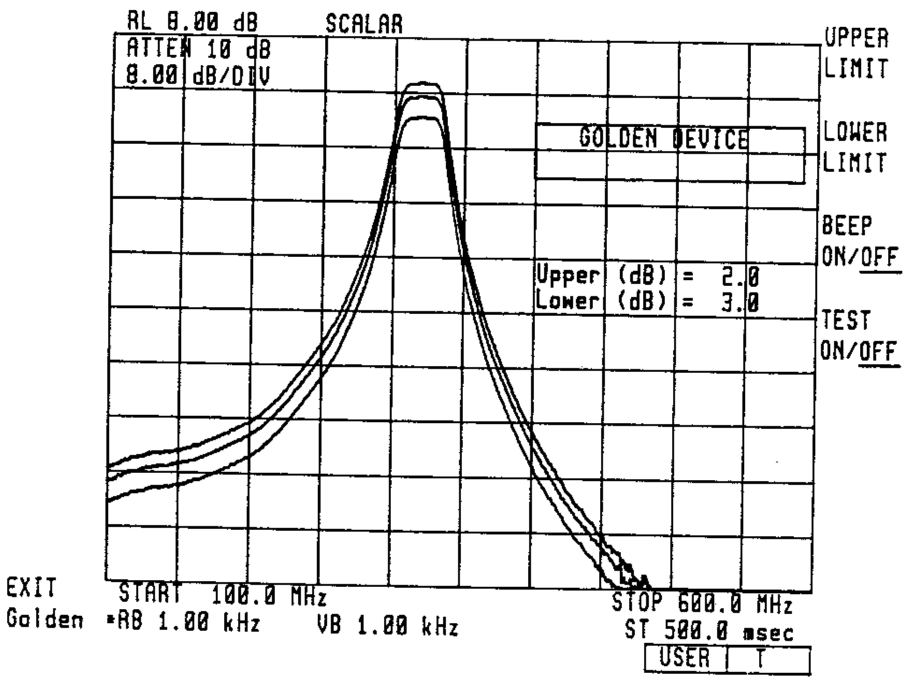



**Figure 5-3. Measurement Softkeys**

## Dual Display

The `dual display` softkey lets you set up and monitor two displays, ACTIVE and SAMPLE, with independent frequency and amplitude ranges. The ACTIVE display is intended to monitor the major frequency and amplitude range of interest while the SAMPLE display is intended to monitor a secondary frequency and amplitude range. Frequency, reference level, log scale, and calibration data are all accessible in the SAMPLE display.

Often, adjusting a single filter characteristic (such as ripple) can adversely affect other filter characteristics (such as shape factor, or stop-band rejection). To optimize the filter's overall performance, it is desirable to monitor a filter's passband range while simultaneously monitoring the rejection band. The **dual display** mode allows you to adjust filter ripple (typically in a narrow frequency range with high resolution amplitude scale) while simultaneously monitoring the rejection band (typically in a wide frequency range with lower resolution amplitude scale). The following is a description of the ACTIVE and SAMPLE display.

ACTIVE: The ACTIVE display (bottom window) contains the same instrument settings as the regular, single-window display. Use the real-time ACTIVE window to display the primary measurement. Markers and Limit Lines are not available in either the ACTIVE or SAMPLE display.

SAMPLE: Start/stop frequency, reference level, log scale, and calibration data are set using `setup sample`. The SAMPLE trace update rate is defined by the `SWEEP RATIO` setting. Use the SAMPLE window to display a secondary measurement area in a sample mode.

## Example: Adjusting Filter Ripple and Rejection

1. Press `Freq` and `Amptd` to adjust the frequency span and amplitude required to view the passband ripple.
2. Press `dual display` to access the dual display menu.
3. Press `setup sample`. Use the control knob, step keys, or entry keys to set the start and stop frequencies to view the filter rejection of the sample trace. Press `ACCEPT VALUE` after *each* entry (see Figure 5-4).
4. Press `EXIT SETUP` to bring you back to the `DUAL DISPLAY` menu.
5. Press `SWEEP RATIO`, 5, `ENTER`. The active trace (showing passband ripple) will now be swept five times before the sample trace (showing rejection) is swept. (Note that the default SWEEP RATIO is 10. Minimum allowable value is 1.)
6. Press `MEASURE` to display an ACTIVE and a SAMPLE window (Figure 5-5).
7. Press `EXIT DualDsp` to exit back to the `Meas` menu.

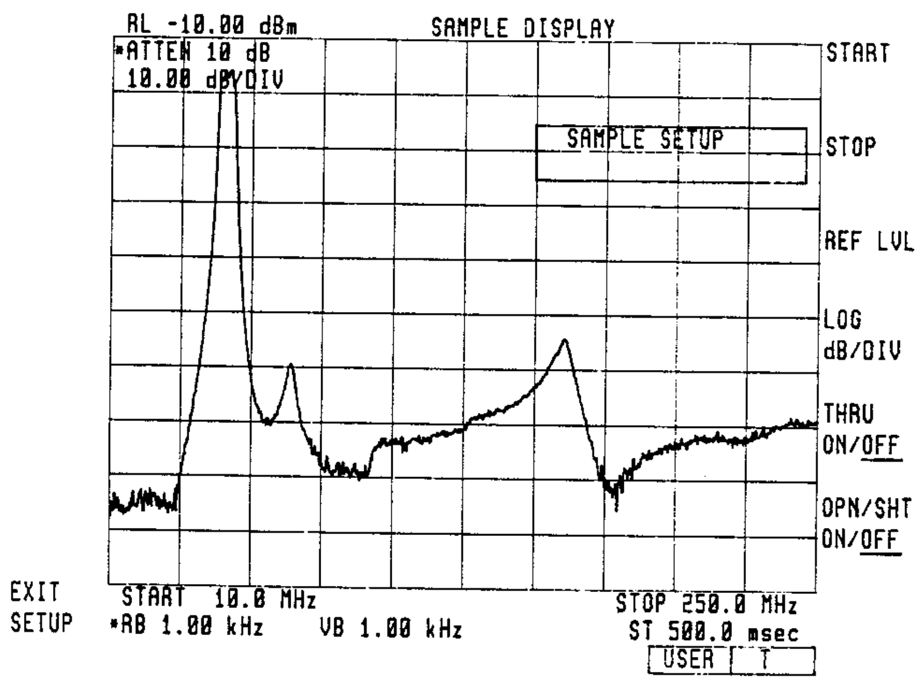



**Figure 5-4. Setup Sample Menu**

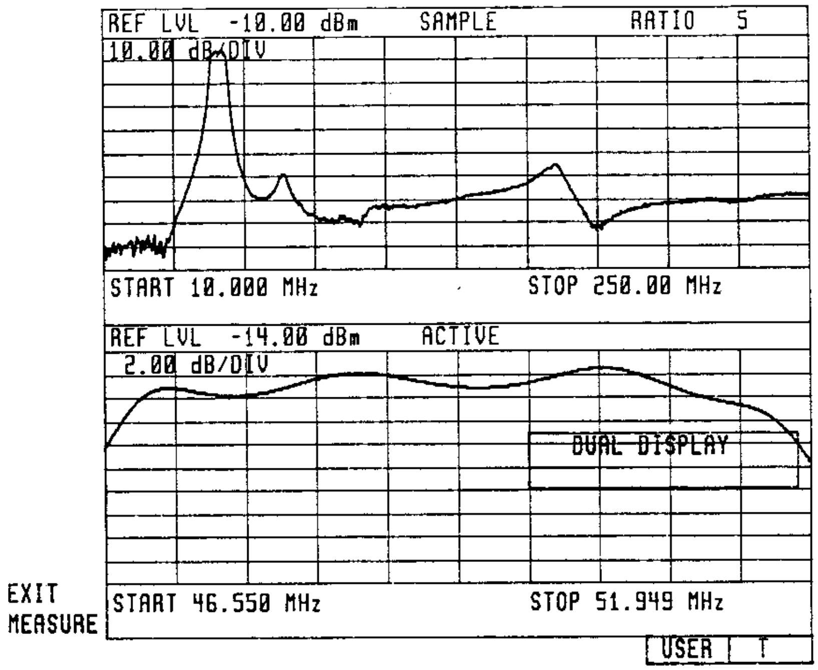



**Figure 5-5. Dual Displays of Different Frequency Ranges**

## 150 dB Display

The 150 dB display softkey automatically combines a high amplitude measurement with a high sensitivity measurement and then graphs the result in a 150 dB display range. Since the logarithmic range of the display is 90 dB, measurements which exceed a 90 dB log range are generally made with two sequential sweeps. In the 150 dB display mode, the first sweep measures the top 75 dB range and the second sweep measures the bottom 75 dB range. These two traces are then *spliced* together to form a single static display that shows a full 150 dB measurement range.

The 150 dB display softkey function automatically performs a tracking adjustment for resolution bandwidths less than 1 kHz, and automatically places markers on the maximum and minimum points of the measured response. From the sub-menu, you can select resolution bandwidths (which affect sensitivity and therefore the dynamic range), and you can tune a marker to read rejection ratio at different frequencies.

The 150 dB display capability is useful when making high dynamic range measurements. Measuring devices which have high stopband rejection require a system that can measure amd display over a wide dynamic range.

**Caution** The MAXIMUM input power is +30 dBm (1 watt) regardless of input attenuator setting.

## Example: Measuring Filter Rejection

1. Press Freq and adjust the frequency range to measure the filter's stopband rejection.
2. Press 150 dB DISPLAY. The 150 dB DISPLAY sub-menu appears.
3. Press RES BW and set the resolution bandwidth for desired sensitivity.
4. Press MEASURE. The routine first completes a *tracking adjust* (if required) to ensure proper frequency alignment of the tracking generator to the spectrum analyzer. Two sweeps are taken over different amplitude ranges. The trace information is then spliced together and displayed in 15 dB/division log scale. Note that two markers are positioned on the trace—one at the *highest peak* and the other at the *minimum peak.* Stop-band rejection may be read directly (Figure 5–6).
5. Press DELTA MARKER if the delta marker requires readjustment. Note that marker number-one is automatically positioned at the peak response of the trace.
6. Press ACCEPT VALUE to enter the delta marker position.
7. If a printer or plotter is attached, press PRINT or PLOT to get a hardcopy record of the measurement.
8. Press Exit 150 dB to return to the standard display.

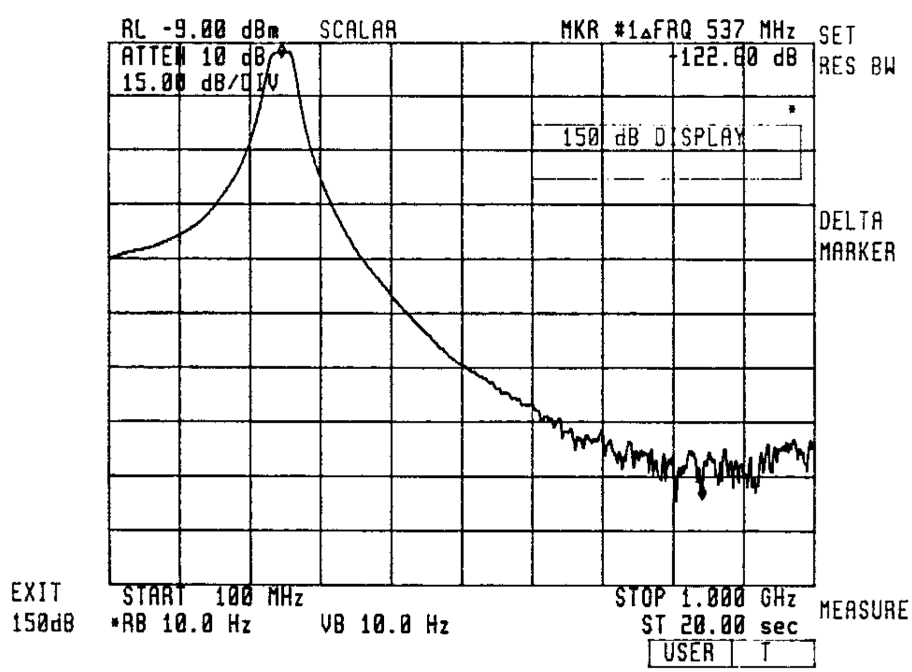



**Figure 5-6. Stop-Band Rejection in 15 dB/Division Display**

## Device BW

The **device bw** softkey allows measurement of filter bandwidth. The default bandwidth is 3 dB, but you may specify other bandwidths. The 3 dB points (or other user-specified points) are referenced from the highest peak of the passband response.

In addition to the bandwidth measurement, **device bw** also allows measurement of a bandpass filter's center frequency and Q. Filter Q is defined as the center frequency divided by the 3 dB bandwidth.

### Example: Measuring Filter Passband

1. Press [Cal] to calibrate the analyzer for a *thru* measurement (Refer to Chapter 4).
2. Press [Meas]. The Scalar Analysis Measurement menu appears.
3. Press [device bw]. The prompt `ENTER MARKER BANDWIDTH (dB) --- >` appears.
4. Press **3**, [ENTER] to set and measure the 3 dB bandwidth. The routine will place a marker at the highest peak of the trace and set a left and a right marker 3 dB below the peak. The filter's Marker Bandwidth is calculated from the 3 dB marker position then displayed.

   The center frequency of the filter passband (not the peak frequency) and the Q of the filter are calculated and displayed (Figure 5-7).

**Note**

The **marker bw** softkey function under [MENU] can be used to set a marker reference other than the highest peak of the trace. **Marker bw** can also be used to measure the 3 dB cut-off frequency of a low-pass or high-pass filter.

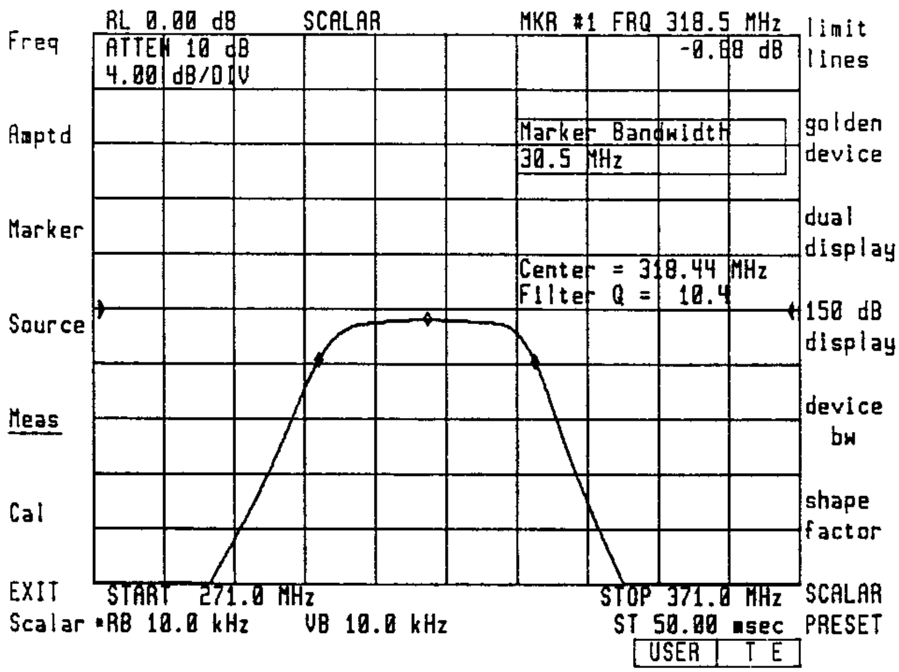



**Figure 5-7. 3-dB Bandwidth using DEVICE BW**

## Shape Factor

The shape factor softkey allows measurement of bandpass filter's shape factor. Shape factor is generally defined as the ratio of the 60 dB bandwidth to the 3 dB bandwidth. You can enter different upper and lower marker bandwidths for shape factor.

Shape factor provides an indication of a filter's rejection capability by quantitatively describing how quickly the filter makes the transition from the passband to the stop band. A filter with a numerically small shape factor would have a steeply sloped roll-off. A filter with a large shape factor would have a more gradual roll-off and therefore less rejection close to the filter's 3 dB passband.

## Example: Measuring Filter Shape Factor

1. Press Meas.
2. Press shape factor. The prompt ENTER UPPER BANDWIDTH (dB) appears.
3. Press **3**, ENTER to enter the upper bandwidth as the 3-dB bandwidth relative to the highest peak of the displayed response. The prompt ENTER LOWER BANDWIDTH (dB) appears.
4. Press **60**, ENTER to enter the lower bandwidth as the 60-dB bandwidth relative to the highest peak of the displayed response. The 60 dB : 3 dB shape factor now appears on the screen (Figure 5–8).

**Note**

If the marker amplitude results in a bandwidth that exceeds the current span, an error message **PARAMETER OUT-OF-RANGE** will be displayed. Enter a smaller marker amplitude or increase the frequency span and re-measure.

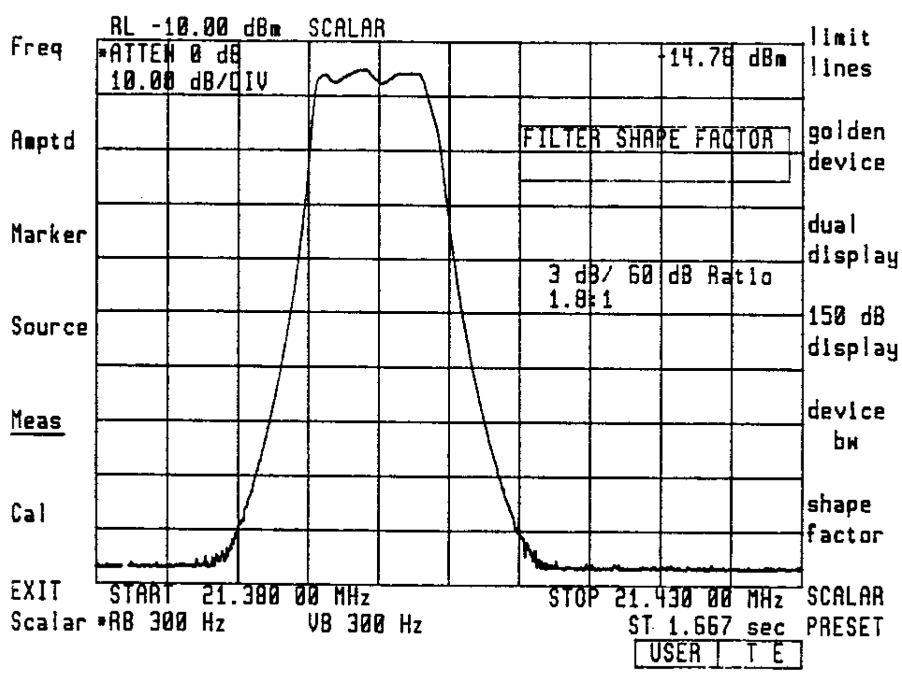



Figure 5-8. Filter Shape Factor

## Scalar Preset

The SCALAR PRESET softkey presets the system to the scalar analysis operating mode. It affects the reference level, log scale, and couple functions; frequency settings are not affected. The sweep time algorithm is preset for the scalar mode and messages are cleared from the display (see Table 3-1).

## Reflection Measurements

*Reflection Test Setup*—For typical reflection measurements, connect the DUT to the *test* port of the HP 85044A Test Set or to the *load* port of a directional bridge or coupler. The tracking generator output connects to the *RF input* port of the HP 85044A Test Set or to the *source* port of the directional bridge or coupler. Finally, connect the spectrum analyzer RF INPUT to the *reflected* port of the test set, bridge, or coupler (Figure 4-3). If adapters are required, use the same adapter for both calibration and measurement. Be sure to terminate the second port of a two port device.

All the capabilities described previously (except for the `shape factor` and `device bw` softkey functions) can be used for reflection measurements.

**Note**

For reflection measurements, it is particularly important to use high quality test port adapters. The quality of the adapter directly affects the system source match and the directivity of the measurement (see Appendix B, *Scalar Measurement Accuracy*).

The following example illustrates a typical return loss measurement on an isolator.

## Example: Measuring Return Loss

1. Connect the DUT and a bridge or a coupler for a reflection measurement. Terminate all other DUT ports.
2. Press Freq and adjust the start/stop frequency for the DUT.
3. Press Amptd, AUTO SCALE to scale the amplitude range.
4. Press Cal, cal opn/sht. The calibration routine will prompt you for each step. Remove the DUT and leave the test port open.
5. Press STORE OPEN to store the open. Connect a short.
6. Press STORE SHORT.
7. Press STORE OP/SH 1 to store the open/short average calibration in storage register 1. The system is now calibrated for a reflection measurement. Reconnect the DUT.
8. Press Marker, MKR NRM ON to activate the marker. Since the reference level is normalized to 0 dB due to the open/short average calibration, the marker reads return loss directly in dB (Figure 5-9). Return loss is defined as

$$-20 \times \log(\rho), \quad \text{where } \rho = \text{reflection coefficient.}$$

$$\text{VSWR} = \frac{1+\rho}{1-\rho}$$

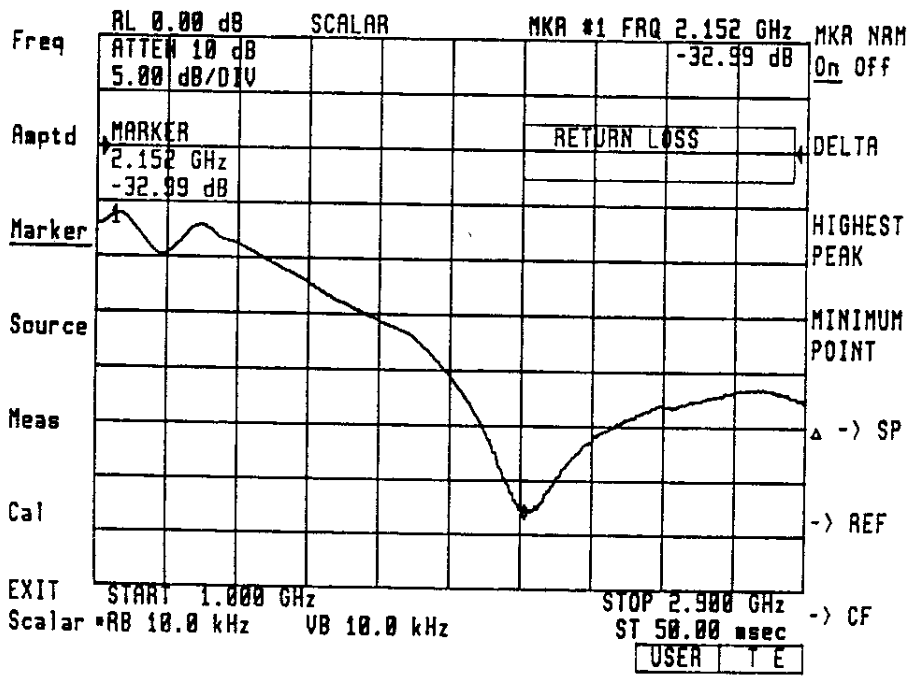



**Figure 5-9. Reflection Measurement - Return Loss**

# 6

# Signal Mode

This chapter discusses the Harmonic Distortion and the Spur Search routines found under the `Signal Mode` firmkey. These routines can be used over the full frequency range of the RF section that is configured into the HP 70000XL.

## Harmonic Distortion

The Harmonic Distortion routine measures the fundamental, second, and third order distortion products of the DUT and computes the total harmonic distortion. The routine prompts you to enter the fundamental frequency of the test signal. As long as the specified frequency is within ±5% of the actual frequency, the routine will capture and measure the signal. The Harmonic Distortion routine assumes that the third harmonic of the fundamental is within the frequency range of the spectrum analyzer and that all signals are at least 10 dB above the noise floor.

## Example: Measuring the Calibrator Signal

1. Press EXIT Scalar. The top level menu appears.
2. Connect the 300 MHz calibrator signal (from the HP 70900A module) to the RF INPUT of the spectrum analyzer.
3. Press Signal Mode. The Signal Analysis menu appears (Figure 2-2).
4. Press Harmnc Distn. The routine prompts you to enter the center frequency of the signal under test.
5. Enter **300** MHz, ACCEPT VALUE. The routine measures and displays the fundamental, second, and third harmonics of the source. The total harmonic distortion, in percent, is calculated as the square root of the *sum* of the squares of the second and third harmonic distortion components (Figure 6-1).

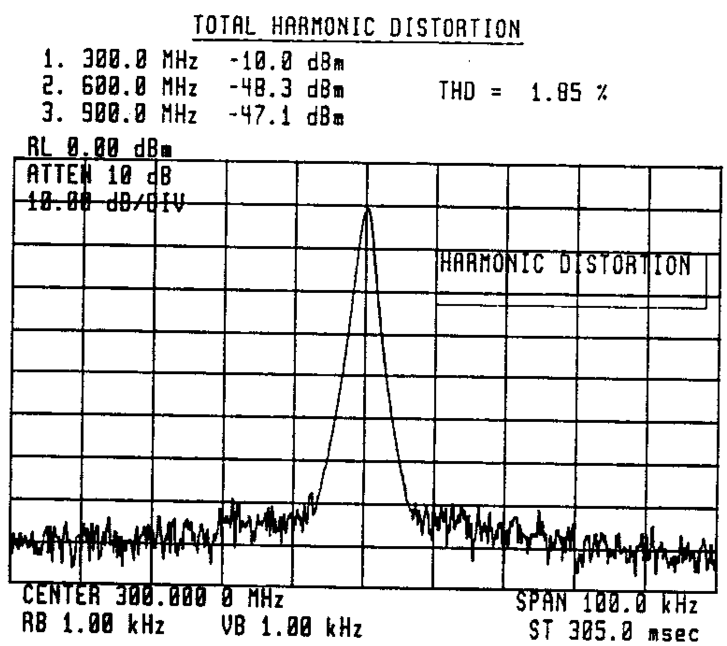



**Figure 6-1. Total Harmonic Distortion of a 300 MHz Signal**

## Spur Search

Spurious emissions, or spurs, are unwanted signal components produced by a device under test. Devices tested for such emissions include oscillators, mixers, magnetrons, land/mobile radios, cable TV systems, radar systems, and signal generators. Testing for spurs is a major concern of component, system, and instrumentation manufacturers. The consequences of spurs can be severe—for example, spurs produced by a mis-adjusted transmitter can cause interference on adjacent communication channels. Another example, spurs on the local oscillator of a receiver can result in false responses or can mask real ones.

The Spur Search routine will search a specified frequency range for signals over a user-specified spur specification. After you enter the measurement parameters (frequency range, spur specification, guard band) and spectrum analyzer sensitivity specification, the routine will calculate the total estimated time required for the spur search. If the estimated time is too long, the user can specify different parameters to minimize measurement time.

The estimated time calculation is based on the following conditions:

1. Frequency range
2. Spur specification
3. Guard band
4. Analyzer sensitivity

A narrower frequency range, lower spur specification, and smaller guard band will result in faster measurements. A spectrum analyzer with high sensitivity (low noise figure) will also produce faster measurements.

### Example: Calibrator Signal as the Source Under Test

1. Press `Spur Search`. The routine re-formats the display, locates the carrier, then calculates estimated sweep time based on default measurement and analyzer specifications. The routine pauses to allow you enter measurement and analyzer parameters.
2. Press `Find Spurs` to make the measurement. All spurs over the frequency range of interest and above the measurement threshold (determined by the spur specification plus guard band) are listed in order of increasing frequency (Figure 6-2).

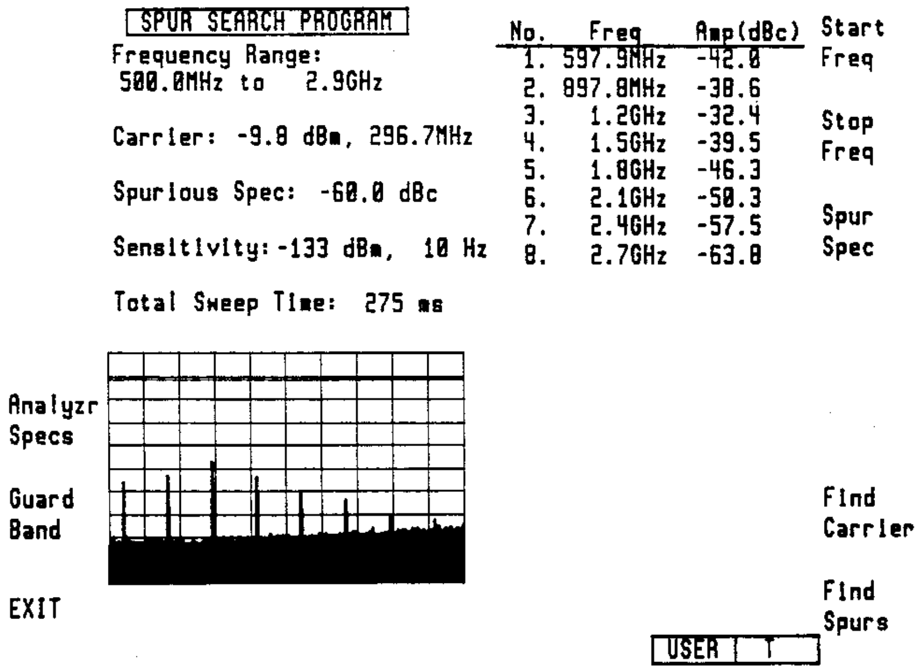



**Figure 6-2. Spurs Exceeding User Spec are Listed**

**Note**

The program defines a signal as a spur if, and only if, the signal is both above the threshold (Threshold = Carrier Amptd – Spur Spec – Guard Band) and meets the *peak excursion* criteria of 3 dB (that is, a signal must both rise and fall by 3 dB before being identified as a peak).

The above set of steps illustrates how the spur search routine works for the default set of search conditions. The following steps show you how to set up your own measurement parameters.

1. Press `Start Freq` then enter the start frequency from which you would like to search for spurious signals.
2. Press `Stop Freq` then inter the stop frequency for your particular measurement. Note that `Start Freq` and `Stop Freq` define the range over which the analyzer searches for spurs—the *carrier* may be outside this frequency range.
3. Press `Spur Spec` then enter (via the entry keys) your spurious specification (in dBc).
4. Press `Guard Band` then enter the appropriate guard band for the measurement. Conservatively, the guard band should equal the sum (in dB) of the following spectrum analyzer specifications: peak-to-peak display flatness, peak-to-peak band switching uncertainty, peak-to-peak attenuator switching uncertainty, log scale fidelity, IF gain uncertainty, amplitude correction uncertainty, IF alignment, and noise.
5. Press `Analyzr Specs` then enter the appropriate sensitivity specification of your spectrum analyzer over the frequency range of interest.

6. Press ACCEPT VALUE then enter the resolution bandwidth for which the sensitivity specification applies.
7. Press ACCEPT VALUE. (For example, the HP 71210A microwave spectrum analyzer has a sensitivity specification of −133 dBm in a 10 Hz resolution bandwidth over its entire microwave range of 2.7– 22 GHz.)
8. Press Find Carrier to locate the carrier of interest. The program assumes that the largest signal found across the entire frequency range of the analyzer is the carrier of interest. Note that the calculator mode of the program calculates the estimated sweep time for your particular measurement parameters. This same calculator mode function is useful for determining the difference in measurement times due to changes in test equipment and measurement parameters.
9. Press FIND SPURS to execute the Spurious Search routine and list spurs which exceed your specification.

NOTES:

# 7

# Personality Installation

This chapter describes the contents of the retrofit kit, how to recall the personality firmkey, and how to load the HP 70000XL Scalar Personality. It tells how to load the personality into either a system you have configured or to an existing system in which the personality was erased from memory.

## What Is a Personality?

A **personality** is a downloadable program consisting of measurement routines especially useful to a particular application. A **downloadable program** (DLP) is a software routine written with an external computer and **downloaded** (stored) into the instrument's non-volatile RAM. Once downloaded, the DLP can be executed, at the press of a softkey, without an external computer.The HP 70000XL Personality is an example of a DLP that provides a scalar analysis interface along with a number of unique measurement routines. If the HP 70000XL Personality is accidentally erased, it can be reloaded into the instrument using the procedure described in this chapter.

If other DLPs need to be run, you can unprotect and dispose the scalar personality with the following sequence: `PROTECT ALL, OFF`, `DISPOSE ALL`. The scalar personality requires most of the HP 70900A RAM, so we recommend that you do not load other DLPs while the scalar personality is loaded.

**Note**

You can erase the HP 70000XL softkeys with `key control`, `PRESET USER` or by selecting `FIRMKYS on/off`. To recall the DLPs, toggle firmkeys `ON` and press `Misc`, `key control`, `RECALL USER`, **900.** The HP 70000XL keys are saved in USER KEY register 900.

## Retrofit Kit Information

Hardware configurations of the HP 70000XL systems is described in Chapter 1. Current users of the HP 70000 spectrum analyzers with HP 70300A or HP 70301A tracking generators can upgrade their systems to a HP 70000XL by installing the required 70900A firmware and loading the scalar analysis personality. The scalar analysis personality is available as a retrofit kit under HP Part Number 70900-60121. Additionally, the scalar analysis personality requires the HP 70900A LO firmware with a revision date of 880901 (YYMMDD) or later.The firmware is available as model HP 70900A Option K91.

### Retrofit Kit Parts List

- Operating Guide 70900-90128
- DLP disk (3.5 inch) 70900-10033
- DLP disk (5.25 inch) 70900-10034

## Reloading the Personality

The following steps describe how to load the HP 70000XL Personality:

Equipment required:

- HP series 200 or 300 controller (with BASIC 3.0, 4.0, or 5.0 Operating System)
- Disc drive with 3.5 or 5.25 inch floppy media.
- HP-IB cable to connect from computer to instrument.
- HP 7100XL Scalar Personality (HP Part Number 70900-60121)

Connect the HP 70001A mainframe to the controller via the HP-IB cable. After booting BASIC on the computer, insert the disc with the personality into the disc drive. Do a catalog (CAT) to find the name of the DLP file. Load the DLP from the controller—for example, type `LOAD "XL_REV_A1"`, [RETURN]. This loads the scalar personality DLP into the computer memory. After the program is loaded, type `RUN`, [RETURN] or [ENTER]. This starts the process of *downloading* the scalar personality into the HP 70000 system. The downloading process will unprotect and dispose any existing DLPs in memory. Special data files that reside on the disk will be loaded into user keys 900 through 906. During the downloading process, the computer screen should be listing the various programs that are being loaded into the instrument. Once the run light from the computer is off, the personality should be resident in the instrument. Press [USER] and the [Signal Mode] and [Scalar Mode] should appear.

**Note**

If the HP 70900A firmware date is earlier than 880901, the personality will not load into the system.

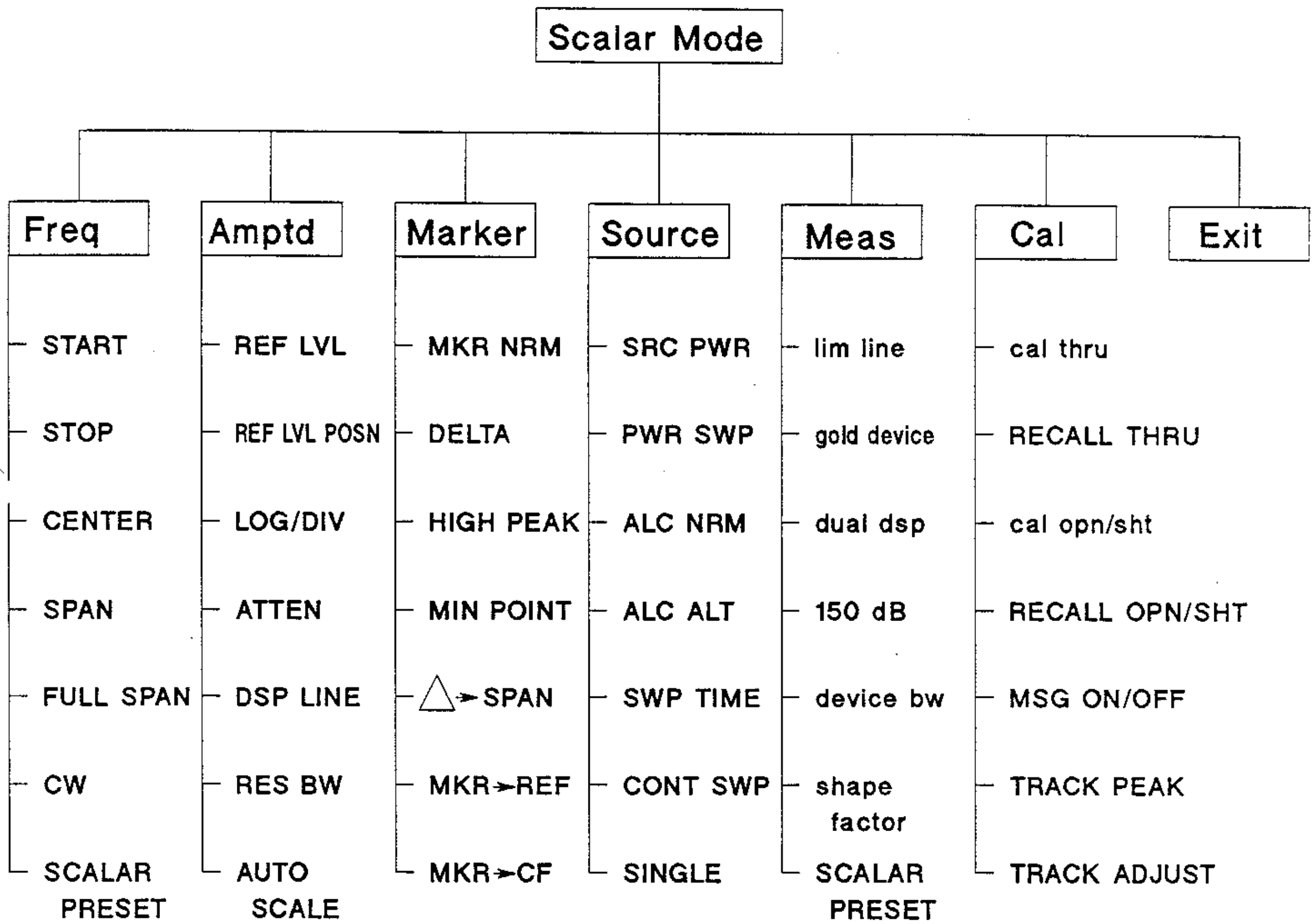
## Service

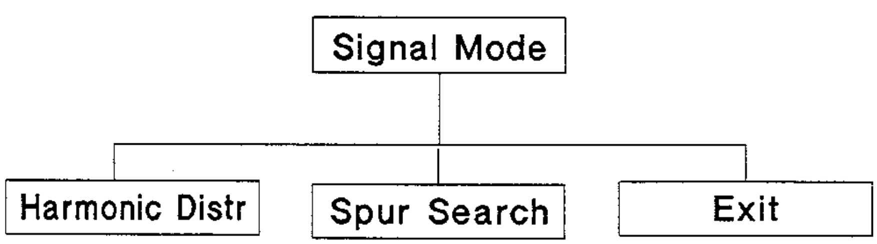
If you want to run the service-diagnostics DLP (DOWN_DIAG), you must dispose the HP 70000XL Personality before loading the diagnostics. After running the diagnostics, reload the scalar personality. Running the scalar personality automatically unprotects and disposes other DLPs.

NOTES:

# A

## Menu Structure



NOTES:

# B

# Scalar Measurement Accuracy

## Transmission Measurement Uncertainty

Transmission measurement uncertainty is composed primarily of relative amplitude accuracy (flatness, display fidelity) and the external circuit mismatch.

Normalization removes the flatness uncertainties. And display fidelity in the HP 70000XL is very good—better ±0.1 dB/dB but not more than a maximum of ±0.5 dB over a 90 dB range. The major causes of transmission measurement uncertainties, then, result from external mismatch among source, receiver, and DUT. These external mismatch uncertainties arise at calibration and measurement.

### Basic Calculation Review

You should be familiar with the relationships among reflection coefficient ($\Gamma$), standing wave ratio (VSWR), and return loss:
$\Gamma = \rho\angle\theta$, $\quad \text{VSWR} = \frac{1+\rho}{1-\rho}$, $\quad \rho = \frac{\text{VSWR}-1}{\text{VSWR}+1}$, $\quad$ Return Loss $= -20\log\rho$.

**Maximum mismatch error** in dB is expressed by

$$\text{MME} = 20\log(1 \pm \rho_1\rho_2),$$

*where* $\rho_1$ and $\rho_2$ are the scalar reflection coefficients at the points of connection.

**Note** The HP Reflectometer Calculator (HP Part Number 5952-0948) makes it easy to determine equivalents among $\rho$, VSWR, and return loss.

Reflection coefficient is a vector (complex) quantity. In a scalar system like the HP 70000XL, we cannot measure phase of a particular $\Gamma$ and then account for it in our error analysis and correct for it in the measurement. We can, however, ignore phase, determine **worst case** caused by interaction of two reflection coefficients (two $\rho$'s), then know that actual measurement error is between zero and worst case. Worst case is the same as MME in the above expression.

In the following example, all results are maximum possible errors. We want to calculate the maximum mismatch error of a filter measurement at its 3 dB point. The final error window will combine the MME at calibration and the MME at measurement. Assume a source with $\rho_s = 0.2$ (or 1.5 VSWR) and a receiver with a $\rho_r = 0.13$ (or 1.3 VSWR). Given these two $\rho$'s, our MME equation yields a possible calibration (*thru* measurement) error window of **±0.23 dB.**

Now we must calculate possible errors with the DUT inserted between the source and receiver. The source $\rho_s$ will interact with the DUT input $\rho_{d1}$; the receiver $\rho_r$ will interact with the DUT output $\rho_{d2}$. Therefore, we must calculate two MME's, then add them together to arrive at the measurement error window.

At the 3 dB point the filter reflects half of the input power, so reflection coefficients $\rho_{d1}$ and $\rho_{d2}$ equal 0.707 (or 5.8 VSWR). Our MME equation yields the input and output mismatch errors, respectively: +1.15/−1.3 dB and + 0.76/−0.84 dB. We now add these error windows to get the MME at measurement (+1.91/−2.14 dB):

$$1.15 + 0.76 = \mathbf{+1.91} \text{ dB, and} - 1.3 + (-0.84) = \mathbf{-2.14} \text{ dB.}$$

To get the total uncertainty of the measurement, we subtract the negative measurement number from the positive calibration number, and we subtract the positive measurement number from the negative calibration number (We subtract because measurement error was the denominator of a linear equation before converting to dB.):

$$+.23 - (-2.14) = \mathbf{+2.37} \text{ dB, and} - .23 - (+1.91) = \mathbf{-2.14} \text{ dB.}$$

Thus, for our 3 dB point filter measurement, our MME is +2.37/−2.14 dB—we might measure anything from 0.86 to 5.37 dB.

The error can be worse if hardware constraints necessitate additional cables and/or adapters between source and/or receiver and the DUT. The source is at the end of its cable/adapter; the receiver input is at the end of its cable/adapter, so we must consider the mismatches at these points rather than at the panel connectors. Effective mismatch becomes worse.

To determine effective mismatches, multiply the VSWR values. For example, if the *lossless* cables and adapters each have VSWR's of 1.1, the source VSWR becomes

$$1.5 \times 1.1 \times 1.1 = 1.8 \text{ (or } 0.29\rho)$$

and the receiver VSWR becomes

$$1.3 \times 1.1 \times 1.1 = 1.57 \text{ (or } 0.22\rho).$$

With these numbers, the maximum mismatch errors at calibration and at DUT input/output at measurement are +0.54/−0.58, +1.6/−2.0, and +1.27/−1.5 dB, respectively.

**Note**

When the DUT is a low-loss device, we must also account for the interaction between source and receiver when the DUT is connected. We ignore this interaction at the 3 dB point of our filter, because it would add only about 0.2 dB.

Also, we assume that the DUT input and output connectors are the same type, opposite sex. If not, you must insert an adapter at calibration, then remove it when you insert the DUT. The adapter's effect on uncertainty is small, thus it is not included here.

## Enhancing Transmission Measurement Accuracy

### Attenuators (Pads)

The simplest way to improve the situation is to place well-matched fixed attenuators (with DUT compatible connectors) at the source output and at the receiver input. Connect the attenuators at the ends of the cables/adapters discussed above, *not* at the tracking generator and analyzer panel connectors.

For example, given 10 dB pads with $\rho$'s of 0.05 (or 1.1 VSWR), the source and receiver reflection coefficients (assuming the above cables and adapters) become 0.078 (or 1.17 VSWR) and 0.071 (or 1.16 VSWR) respectively. The maximum calibration, input, and output mismatch errors then become $\pm0.05$, $+0.48/-0.5$, $+0.43/-0.44$ dB, respectively—dramatic improvements.

If we need accurate measurement of points farther down the filter skirts, e.g. the 6, 10, 20 dB points, the reflection coefficient of the filter approaches unity (infinite VSWR). In such cases our 10 dB pads may not give us enough isolation, leaving us with errors in excess of 1 dB. Fortunately, the HP 70000XL has plenty of dynamic range, so we can often afford to throw some of it away for the sake of accuracy. Using 20 dB pads totally masks source and receiver mismatches, for all practical purposes, and leaves just the $\rho$'s of the pads themselves.

### Directional Coupler/Detector

Another way to improve source match, with essentially no loss of power, is to use a directional coupler/detector in an external leveling loop. In this case the output of the coupler becomes the output of the source. The effective source match in this case becomes

$$\rho_{source} = \sqrt{d^2 + (0.75 \times \rho_c)^2}$$

*where* $d$ = coupler directivity,
$\rho_c$ = coupler main line reflection coefficient.

For a coupler with 30 dB directivity (equivalent to 0.03 $\rho$) and 0.07 $\rho$ (1.15 VSWR), source mismatch becomes 0.06 $\rho$ (or 1.13 VSWR), a little better than we achieved using the 10 dB pad above.

### Two-Resistor Splitter

Instead of a coupler, we could use a two-resistor splitter in the leveling loop. Such a splitter has no resistors in the input arm and a series 50-ohm resistor in each of the output arms. The leveling detector connects to one of the resistive arms. The output connector on the other resistive arm becomes the effective source port at which we measure source mismatch. The leveling action makes the junction of the input and output arms a virtual RF ground. As a result, the source mismatch is dependent upon the quality of the resistor in the output arm. For example, the HP 11667A has an equivalent source VSWR of 1.1 from dc to 4 GHz, 1.2 up to 8 GHz, and 1.33 up to 18 GHz. Note the wide frequency range of the splitter—a significant advantage over a coupler. In terms of source power, the splitter does cost 6 dB, which is more than a coupler but less than a pad.

## Reflection Measurement Uncertainties

Instrumentation contributes the same uncertainties to reflection measurements as indicated above for transmission measurements. In this section, we shall focus on the uncertainties caused by the external circuit. However, there is more than just mismatch to consider. The error expression for reflection is

$$\Delta\rho = A + B\rho_d + C\rho_d^2,$$

*where* $\Delta\rho$ = measurement uncertainty,
$A$ = directivity of the coupler or bridge,
$B$ = calibration error and frequency response,
$C$ = source mismatch, and
$\rho_d$ = reflection coefficient of the DUT.

The coefficients in the above expression are linear terms, but coupler or bridge directivity is usually expressed in dB, as is frequency response, and source mismatch is often expressed in VSWR, so all of these must be converted to linear values. In addition, measurement results from reflectometer systems such as the HP 70000XL are in dB of return loss, and it is common to express uncertainty in dB:

$$\text{Uncertainty} = 20\log(1 \pm \Delta\rho).$$

The HP Reflectometer Calculator (HP Part Number 5952-0948) makes it easy to determine equivalents among $\rho$, VSWR, and return loss.

### The A Term

Let's look at the A term in the error expression first. If the measurement port of a directional coupler or bridge is terminated with a perfect load, there should be no signal at the detector port because there is no reflection from the load. (In this case the spectrum analyzer of the HP 70000XL is the detector.) However, since no coupler or bridge is perfect, there is always some signal at the detector port. The level of this signal is a measure of the directivity of the coupler or bridge and is generally expressed in dB. For example, if we put a perfect load on our coupler and measure a 30 dB return loss, that really means that our coupler has 30 dB directivity.

The directivity signal is thus a constant signal at the detector port that adds vectorially to the desired reflection signal that we wish to measure, producing an error in the measurement. To produce an error of no more than 1 dB, the directivity signal must be at least 20 dB below the signal to be measured. In other words, the directivity of the coupler or bridge must be at least 20 dB better than the return loss of the device to be measured. If we were testing devices with return losses of about 10 dB (1.92 VSWR), we would need a coupler or bridge with 30 dB directivity for no more than 1 dB of error just due to directivity.

The error expression tells us that the B and C terms become small as the match of the DUT improves. So directivity of the coupler or bridge becomes the limiting factor when measuring high-return-loss devices. Unless we take extra-ordinary steps in the measurement process that are beyond the scope of this discussion, the only thing that we can do to improve measurement results is to use a better coupler or bridge.

*A word of caution*—Use a coupler/bridge with a test-port connector that matches the DUT. Any adapters have their own reflections and degrade the directivity of the coupler/bridge.

For example, a perfect coupler with an adapter having a 1.065 VSWR (30 dB return loss, 0.032 $\rho$) has an effective directivity of 30 dB. A coupler with 30 dB directivity would have an effective directivity ranging anywhere from infinity to 24 dB, depending upon the phase of the reflection from the adapter relative to that of the directivity signal of the coupler itself.

## The C Term

Next, let's look at the source match term, C. As far as the DUT is concerned, the source port is the measurement port of the coupler or bridge, i.e. the port to which the DUT is attached. Any reflection from the DUT (the signal that we wish to measure) flows back toward the source, and, unless the match of the source is perfect, a part of this signal is re-reflected back toward the DUT. The DUT reflects part of this re-reflected signal just as it did part of the original signal. If $\rho_d$ is the reflection of the DUT and C is the reflection coefficient of the source, then a first-order approximation of the measured signal $\rho_m$ is

$$\rho_m = \rho_d \times C \times \rho_d = C\rho_d^2.$$

This term becomes important when measuring devices with high reflection coefficients (low return losses). For example, we might want to measure the 6 dB return-loss points. In this case reflection coefficient is 0.5, so $\rho_d{}^2$ is 0.25. For a good measurement, then, we need to minimize the mismatch of the source. When using a coupler for reflection measurements, we usually use a dual coupler (two couplers in the same physical package) and use one of the couplers in a leveling loop. We can then calculate effective source match just as was done in the transmission discussion above. Using the same numbers as in the transmission example (0.06 $\rho$, 1.13 VSWR), the uncertainty in determining the 6 dB return loss point due to source mismatch is

$$\Delta\rho = 0.06 \times 0.25 = 0.015, \text{ or}$$

$$20\log(1 \pm \Delta\rho) = \pm 0.13 \text{ dB}.$$

Once again, it is best to use a coupler/bridge with a measurement port that matches the connector type of the DUT because an adapter degrades source match. We get effective source mismatch by multiplying source VSWR without the adapter by the VSWR of the adapter. Using the same adapter that we used above to determine effective directivity, we get a source mismatch of

$$\text{VSWR}_s \times \text{VSWR}_a = 1.13 \times 1.065 = 1.2 \text{ VSWR (or } 0.09\ \rho).$$

If we use a bridge, determination of source match is more complex. Fortunately, a bridge like the HP 85044A is a combination splitter/bridge, and the effective source mismatch is specified for the case in which the splitter is utilized in a leveling loop. The effective source match of the HP 85044A is 1.44 VSWR (0.18 $\rho$), and the uncertainty due to source mismatch only is

$$\Delta\rho = 0.18 \times 0.25 = 0.045, \text{ or}$$

$$20\log(1 \pm \Delta\rho) = +0.38/-0.40 \text{ dB}.$$

## The B Term

Finally, let's look at the B term. This term includes calibration uncertainty and frequency response (as well as instrument uncertainty, which we are ignoring in this discussion). As was the case in transmission, frequency response can be removed with trace arithmetic. The calibration uncertainty also can be removed with trace arithmetic, but we must take a few extra steps to insure that it is.

In a reflection measurement, we compare the signal reflected from a DUT to the signal incident upon the DUT. To get a measure of the incident signal, we connect a device that reflects all of the incident signal to the measurement port of our coupler or bridge and use this reflected signal as our reference that represents a reflection coefficient of unity (1.0). The usual calibration device is a short circuit.

If our system were perfect, we would indeed get an exact measure of the unity reflection from the short. However, from the above, we know that there are two other signals that add vectorially to the unity signal: a directivity signal and a multiple-reflection signal resulting from source mismatch. So the calibration uncertainty part of the B term is somewhere between zero and the algebraic sum of A and C, depending upon the phase angles of A and C relative to the unity (actually −1) reflection from the short. Since the HP 70000XL is a scalar system, it measures the absolute value of the combination:

$$|-1 + A + C|, \text{ or } +1 - A - C.$$

In most analyzer/tracking-generator systems, we must live with the calibration uncertainty because there is no provision for removing it.

The HP 70000XL allows us to use a second standard, an open, to eliminate A and C from the calibration trace. The reflection from an open is also unity, but in this case it is +1 because the reflected signal is in phase with the incident signal rather than 180 degrees out of phase as it is for the short (hence the −1). As is the case with the short, a calibration trace based on an open also includes A and C:

$$|+1 + A + C|$$

To eliminate A and C we can average the two calibration traces and end up with just the unity value that we wanted. Thus the two-step calibration process for the HP 70000XL: first calibrate with an open and store that trace; then replace the open with a short and recalibrate. The HP 70000XL automatically calculates the mean of the short and open calibrations and stores the result.

The stored open/short average also includes the inherent system frequency response, so we can eliminate the B term completely, and the error expression becomes

$$\Delta\rho = A + C\rho_d^2.$$

Still, coupler/bridge directivity (A) is critical for accurate measurement of well matched devices (high return loss, low VSWR or $\rho$), while source match (C) becomes the critical factor for low return-loss (high VSWR or $\rho$) measurements, e.g. the 3 dB point of our filter.

# C

# Simple Theory of Operation

A tracking generator is a signal source whose RF output signal follows (tracks) the tuned frequency of the spectrum analyzer.

The spectrum analyzer in the HP 70000XL is a swept-tuned, heterodyned receiver (see Figure C–1). The incoming signal at the RF input ($F_{sa}$) mixes with the local oscillator (LO) frequency ($F_{lo}$) to produce a sum and difference. If the difference equals the intermediate frequency ($F_{if}$), it is amplified, then sent to a video detector. After detection, the video signal is amplified and applied to the vertical deflection input of the CRT to produce an amplitude response on the display. A scan generator simultaneously drives the horizontal deflection input and the LO tuning input to synchronize the CRT's frequency axis with the RF input.

The tracking generator uses the spectrum analyzer's LO to produce an output signal. By mixing the analyzer's LO signal with an oscillator that is at the same frequency as the analyzer's IF, the tracking generator generates a signal that will exactly track the spectrum analyzer's tuned frequency. Since the spectrum analyzer's LO is also used by the tracking generator, the stability of the system is dependent on the stability of the spectrum analyzer's LO.

In equation form, if we make the oscillator frequency in the tracking generator ($F'_{if}$) and the IF in the spectrum analyzer ($F_{if}$) equal, then the output frequency of the tracking generator ($F_{tg}$) is equal to the tuned frequency of the spectrum analyzer ($F_{sa}$). Precise frequency tracking between the two instruments is achieved when the difference between $F_{if}$ and $F'_{if}$ equals zero. The automatic tracking-peak routine in the HP 70000XL ensures accurate tracking between the two instruments.

$$F_{if} = F'_{if}$$
$$F_{sa} = F_{lo} - F_{if}$$
$$F_{tg} = F_{lo} - F'_{if}$$

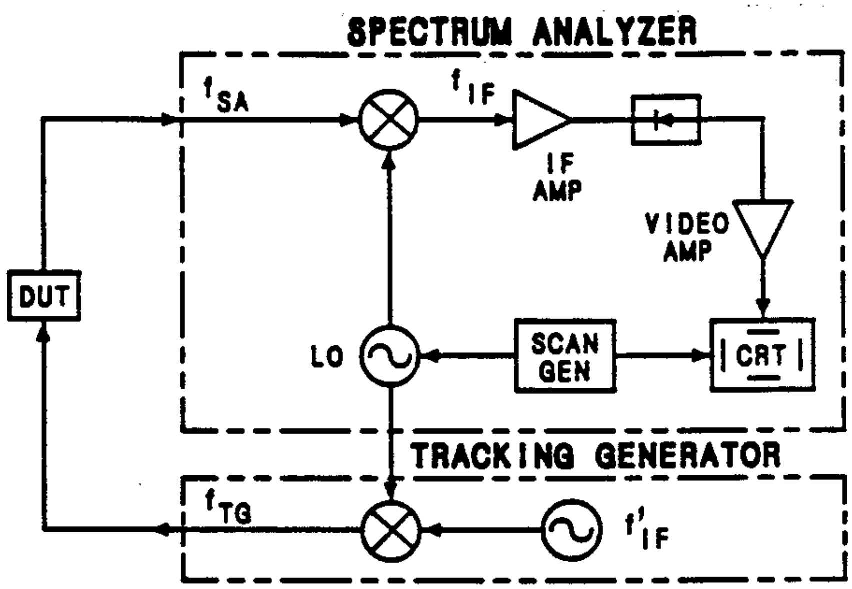



Figure C-1. Spectrum Analyzer/Tracking Generator Block Diagram

## Dynamic Range

A spectrum analyzer/tracking generator system, such as the HP 70000XL, has the capability of making very high dynamic-range measurements with fast, continuous sweeps.

- By design, the spectrum analyzer is precisely tuned to the frequency of the tracking generator, thereby avoiding any harmonic or spurious responses that limits dynamic range.
- The narrow 10 Hz resolution bandwidth filters allow high sensitivity which defines the lower limit of the measurement range.
- The maximum output power of the tracking generator defines the upper limit of the measurement range. Additional dynamic range may be achieved by using an external amplifier to further increase the output power of the tracking generator or improve the sensitivity of the receiver. (Maximum input power to spectrum analyzer must not exceed +30 dBm).

High dynamic range measurements relies on high quality cables and connectors. Cables and connectors with poor isolation will directly affect the dynamic range of the measurement.

# Glossary

`AUTO SCALE`
: Sets the reference level to position the peak response near the top of the screen and rescales the log display.

`CW`
: Prompts the user for center frequency, then sets the span to 0 Hz, thus setting a continuous wave (CW) output from the tracking generator.

`Cal`
: Firmkey which calls up the calibration softkeys.

carrier
: Fundamental frequency signal to which spurious signals are referenced.

data entry keys
: The numeric entry keys on the front panel of the HP 70000 system display.

`DEVICE BW`
: Prompts the user for device bandwidth, then sets a pair of markers x dB down from the peak of the amplitude response on screen.

DLP (downloadable program)
: A software program created external to a system then transferred into system memory. It executes in system memory without external computer control.

downloadable program
: (see DLP)

`DUAL DISPLAY`
: Re-formats the display to simultaneously show both active and sample traces.

DUT Device under test.

dynamic range
: Measurement range of the HP 70000XL (in dB), from maximum output power from tracking generator to the displayed average noise level at the spectrum analyzer.

firmkey
: The seven keys to the left of the display that are always present. A firmkey calls up to seven softkeys, which appear to the right of the display.

`FULL SPAN`
: Sets the full (largest) span of the tracking generator in the system.

golden device
: A device that establishes a reference to measure other devices against.

guardband
: A margin (usually in dB) added to a test specification to guard against measurement uncertainty.

hardkey
A single function key.

Harmnc Distn
Calculates the total harmonic distortion THD = $(b^2 + c^2)^{0.5}$ where a = fundamental, b = second harmonic, and c = third harmonic.

LIMIT LINES
Actively monitors pass/fail testing based on user defined test limits. Alerts the user if FAIL occurs.

normalization
The process of of displaying a measurement trace relative to a reference trace through trace subtraction. This term pertains to thru calibration.

150 dB DISPLAY
Splices two traces (offset by reference level) to display a response with high dynamic range.

open
An electrical open circuit used to establish a measurement plane for calibration of reflection measurements.

open/short averaging
The calibration technique used to attain the best reference for reflection measurements.

personality
A DLP that implements a specific application.

panning
A display function whereby both center frequency and span changes are updated in real-time, independent of sweep time, when the control knob is used.

Scalar Mode
One of two top level keys that allows access to the scalar analysis menu.

SCALAR PRESET
Initializes the control settings of the HP 70000XL to the scalar preset state.

sensitivity
A spectrum analyzer specification stating average noise level for a given bandwidth and frequency range.

SHAPE FACTOR
Prompts the user for both an upper and lower bandwidth (in dB relative to the peak response) then displays the ratio of lower bandwidth to upper bandwidth.

short
An electrical short circuit used to establish a measurement plane for calibration of reflection measurements.

Signal Mode
One of two top level keys which allows access to the signal analysis menu.

softkey
One of a set of keys called up by a firmkey.

Spur Spec
: Prompts the user for a spurious test specification.

Start Freq, Stop Freq
: Allow the user to set the start and stop frequencies.

straight through
: (see thru)

SWEEP RATIO
: The ratio between active sweeps to sample sweeps in the DUAL DISPLAY mode.

thru
: The calibration reference for transmission measurements.

TRACKING ADJUST
: Allows manual alignment of tracking generator output frequency to spectrum analyzer tuning frequency.

TRACKING PEAK
: Automatically aligns the tracking generator output frequency to the spectrum analyzer tuning frequency.

NOTES: