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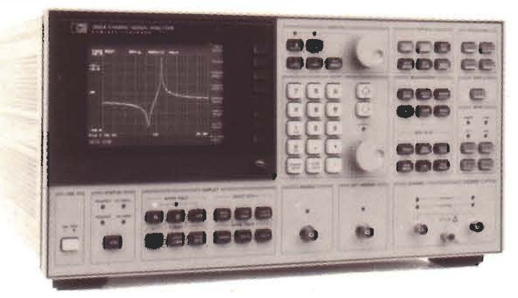
HEWLETT PACKARD

OPERATOR'S INTRODUCTION TO THE HP 3562A DYNAMIC SIGNAL ANALYZER

PRODUCT NOTE 3562A-1



Introduction

The Hewlett-Packard 3562A Dynamic Signal Analyzer represents a new standard in accuracy and versatility for dual-channel FFT analyzers. A full complement of measurement and analysis capabilities combined with outstanding specifications make the HP 3562A an invaluable tool for the test, analysis and design of dc-to-100 kHz electronic, electro-mechanical and mechanical systems.

This Product Note is an operator's introduction to the HP 3562A Dynamic Signal Analyzer. As an introduction, this note will explain the basic concepts and operation of the analyzer: detailed explanations are left to the HP 3562A Operating Manual. The body of the text is based on built-in Preset states and is designed to help you start making measurements quickly.

The information is organized as follows:

Chapter 1: General Operation. The HP 3562A is operated using front panel hardkeys and associated groups of softkeys. Chapter 1 defines the front panel concept and demonstrates a general set up sequence.

Chapters 2 through 4: Frequency Response Measurements. Wideband and narrowband meas urements are demonstrated for the Linear Resolution (Chapter 2), Log Resolution (Chapter 3) and Swept Sine (Chapter 4) measurement modes.

Chapter 5: Spectrum Analysis with Demodulation. Spectrum analysis with Linear Resolution FFT analysis and the HP 3562A demodulation capability is demonstrated.

Chapter 6: Waveform Analysis with Time Capture. Waveform analysis in the time and frequency domains is possible with the HP 3562A. Waveform capture and analysis is described.

Chapter 7: Data Collection with Time Throughput. The HP 3562A can sample and digitize analog signals and store the data directly to an external disc drive. Configuration of a throughput session and recall and analysis of data is demonstrated.

Chapters 8 through 10: Analysis Capabilities. A full range of data analysis functions are built into the HP 3562A. Waveform Math (Chapter 8), Curve Fitting (Chapter 9) and Frequency Response Synthesis (Chapter 10) are demonstrated.

Chapter 11: Auto Sequence Programming. Measurement and analysis functions can be automated by entering the necessary key strokes into an Auto Sequence program. Entry, operation and editing of an Auto Sequence program is demonstrated.

Chapter 12: Documentation of Results. Results can be thoroughly documented with mass storage or hardcopy; the operation of plotters and disc drives is described.

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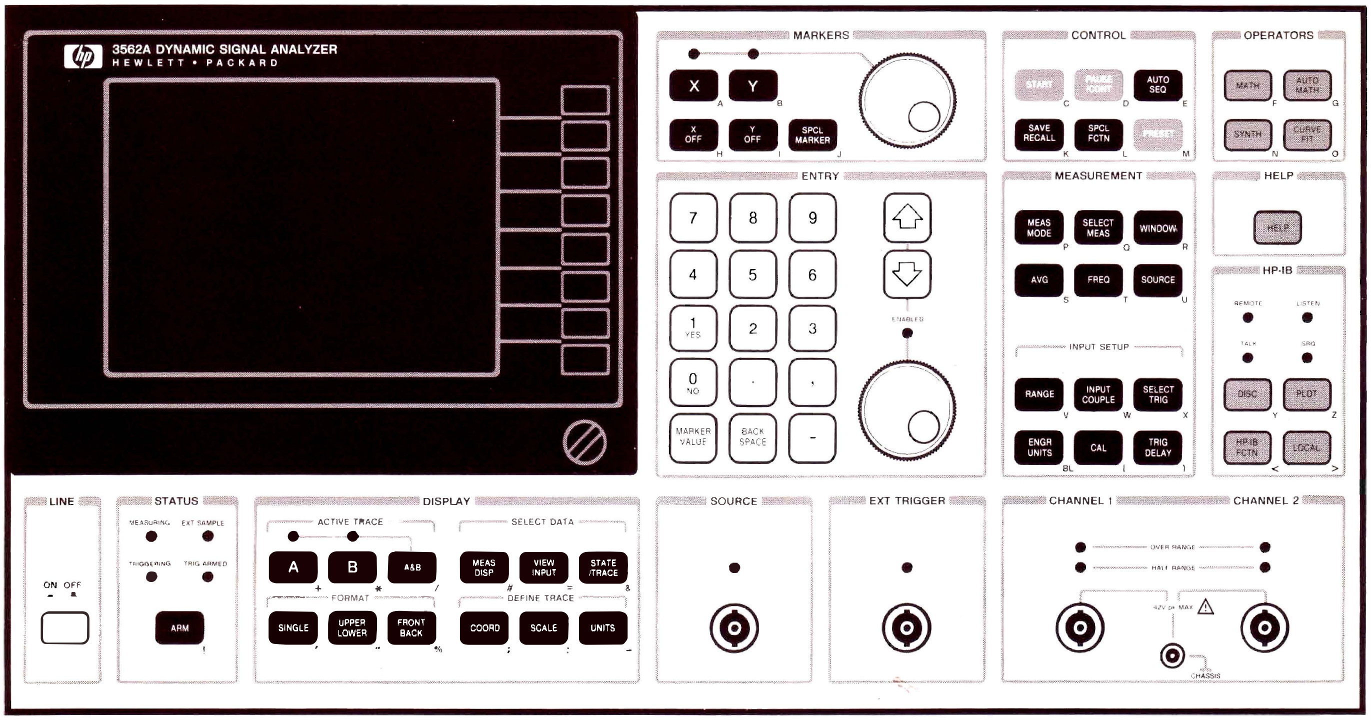
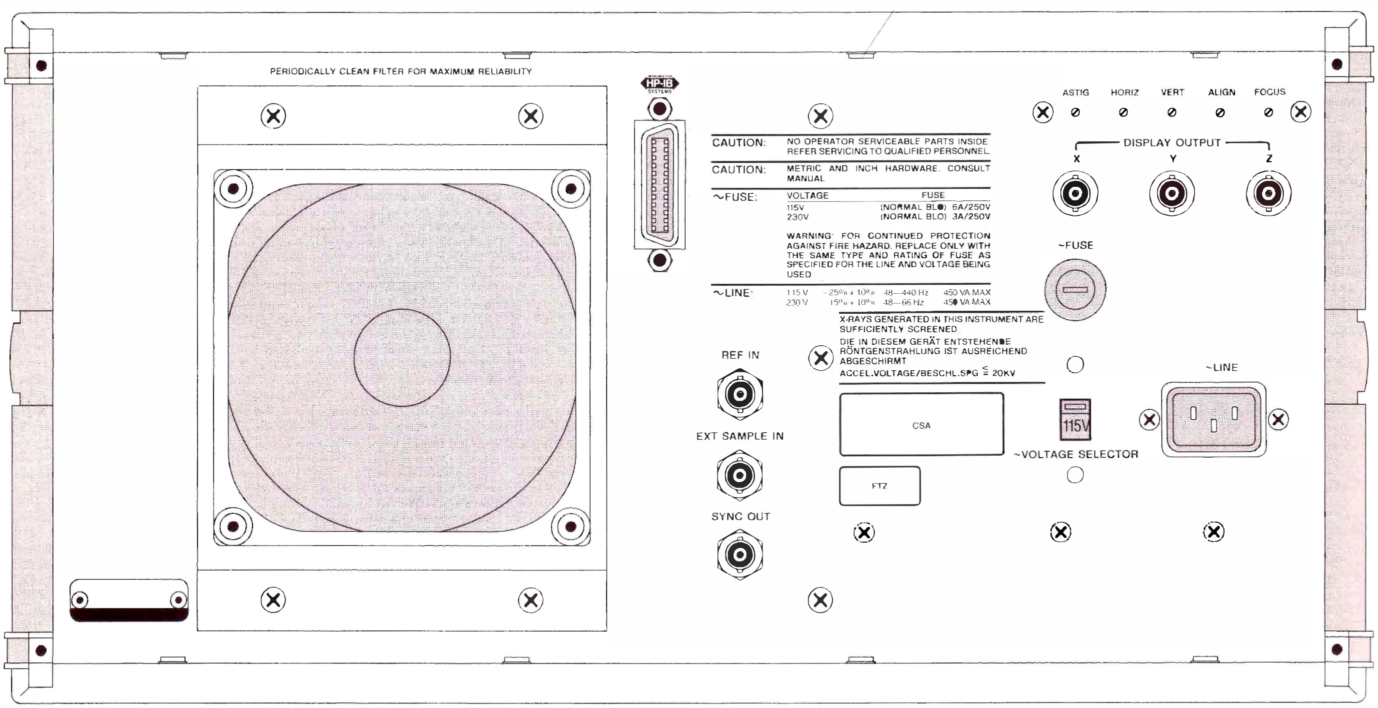


HP 3562A Front View



HP 3562A Rear View

Chapter 1:

General Operation

Measurement
Display
Entry
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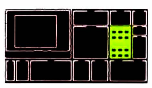
General Measurement Sequence

Introduction

Basic operation of the HP 3562A is performed through logically grouped front panel keys and a group of eight softkeys located to the right of the display. The front panel keys are grouped by function and can perform one of three operations: enable a direct action such as starting a measurement, enter data, or display a softkey menu. Softkeys also perform one of three functions: select a "1 of N" function such as measurement mode, define a parameter for data entry such as frequency span, and terminate the entry with the proper units such as "kHz" or "mHz."

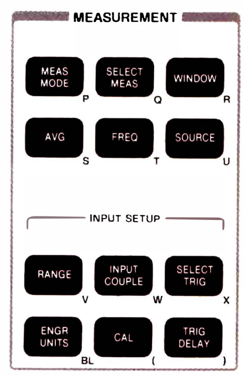
The following summaries are an introduction to the basic function of each front panel key group. These summaries are presented in the order that the key groups would typically be used when performing a measurement

Measurement

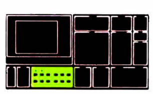


This group of keys is used to select the measurement mode and the measurement to be performed such as frequency response or power spectrum. All measurement parameters including frequency span and source level are selected in this group.

The bracketed group of keys is used to set up the input channels: ac or dc coupling, single-ended or differential operation and triggering parameters. Input ranges can be set manually or with autoranging.

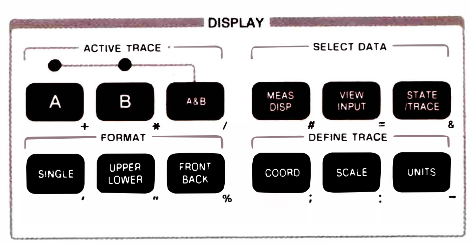


Display

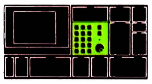


A wide choice of display formats and coordinates enhances the analysis of measurements. Magnitude can be displayed in dBV, dBm, volts or user-defined engineering units. Frequency can be displayed as hertz (Hz), log hertz, revolutions-per-minute (rpm) and orders (harmonics).

Depending on the measurement selected, several functions such as frequency response magnitude and phase, coherence, power spectrum, histogram and auto correlation can be displayed. Default, automatic and user-definable display scales ensure the presence of data on the screen.

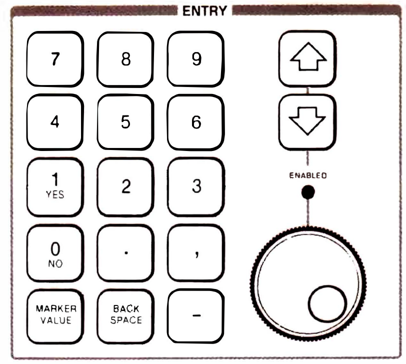


Entry

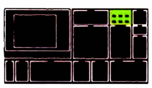


Discrete frequencies and levels can be entered using the numeric keypad. If the X-axis marker is active, the MARKER VALUE key enters the displayed marker frequency value for the active parameter.

The up/down arrow keys and the entry knob are also useful for fast entry of numerical parameters. For example, the knob makes it easy to scroll through the available frequency spans for rapid setup of zoom measurements; manual selection of input range is simplified with the arrow keys.



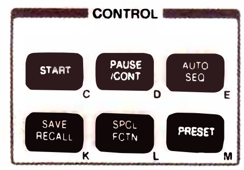
Control



The SAVE/RECALL and PRESET keys can help save time when setting up a test by putting the analyzer into a known condition. Five user-defined states can be saved locally; a menu of special preset states can be accessed with the green PRESET key. In any of the four measurement modes (Linear Resolution, Log Resolution, Swept Sine and Time Capture) pressing PRESET will return the analyzer to the preset for that mode.

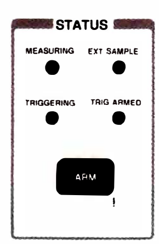
Once a measurement has been set up, the two yellow keys are used to start, pause and continue the test. If an averaged measurement is paused, the average count will resume where it was paused.

The built-in automation capability of the HP 3562A, Auto Sequence programming, is accessed through the AUTO SEQ key. Up to five separate programs can be stored in the analyzer at one time. A program can be started manually or automatically at a user-selected time—the internal clock is accessed with the special function (SPCL FCTN) key.

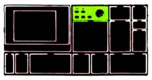


Status

The operating status of the analyzer is displayed by the LEDs in the Status group. Manually triggered measurements are initiated with the ARM key.

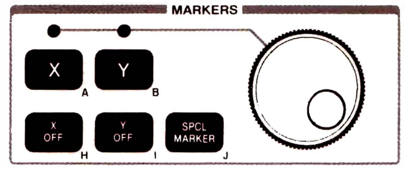


Markers

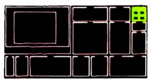


Analysis of on-screen data is simplified by the independent X- and Y-axis markers. Marker functions include single point and band cursor operation.

Special marker functions such as peak search, harmonic and sideband markers and slope readouts are time-saving aids for network and spectrum analysis.

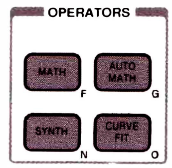


Operators

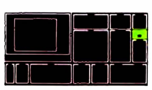


Advanced analysis of measurements is possible without transferring the data block to an external computer. Waveform Math provides a complete set of block operations including algebraic functions (+ , − , × , ÷), integration, differentiation, forward and inverse Fourier transforms, and more. Incoming data can be manipulated and displayed as it is taken using the AUTO MATH feature.

Laplace domain analysis is possible with the Curve Fit and Frequency Response Synthesis capabilities. A table of poles and zeroes can be extracted from a measured frequency response using the HP 3562A's advanced curve fitter. A model of a system can be transferred to a synthesis table from the Curve Fitter or entered manually in pole/zero, pole/residue or ratio of polynomials formats. Frequency response magnitude and phase can then be synthesized across a selected frequency span.

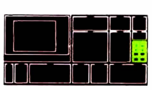


Help

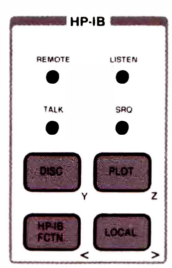


The Help key provides instant assistance to the user on the display of the HP 3562A. When used as a prefix for any key or softkey, the Help key will display a detailed description of the selected key or softkey.

HP-IB



For documentation of measurement or analysis results, the HP 3562A provides direct control of external HP-IB plotters and disc drives. The HP-IB address for the analyzer is set using the HP-IB Function menu.



General Measurement Sequence

The power of the HP 3562A makes it a very versatile yet easy to use network, spectrum and waveform analyzer. Full span (100 kHz) frequency response, spectrum and waveform measurements can be obtained quickly using the general sequence described here. This general sequence is the starting point for the measurements shown in Chapters 2 through 7; however, users should feel free to modify this procedure to suit their particular application.

1. Select Mode

Start by pressing the **MEAS MODE** *key and selecting a measurement mode: Linear Resolution, Log Resolution, Swept Sine or Time Capture.*

2. Preset

Press the green **PRESET** *key: the analyzer will be in a default condition, performing and displaying a measurement. To display the state table for the active mode, press the* **STATE/TRACE** *key. The Linear Resolution, Log Resolution and Swept Sine presets share the following characteristics:*

Frequency Span	*= 100 kHz (Time Capture is 5 kHz)*
Source Level	*= 0 V*
Input Range	*= Autorange up only (both channels)*
Averaging	*= Off*
Triggering	*= Free Run*

3. Set Up Source

For frequency response measurements, press the **SOURCE** *key to activate the Source menu. When the* **SOURCE LEVEL** *softkey is selected, the Entry knob, arrow keys and keypad are enabled for setting the output level. The signal type is chosen from one of the bracketed choices (available signal types depend on the active measurement mode).*

4. Select Averaging

If the random noise source is selected, measurement averaging should be activated. Press the **AVG** *(averaging) key: the* **ENABLED** *LED in the Entry group will turn on indicating that entry of the top menu item, number of averages, is active. Select the number of averages using the arrow keys, the entry knob, or the keypad. Select* **STABLE (MEAN)** *averaging.*

5. Connections

Connect the signal or device under test to the input BNC connectors (and the signal source if necessary). Press the **INPUT COUPLE** *key: proper input coupling and grounding can be selected from this menu.*

6. Set Input Ranging

Press the **RANGE** *key: select Autorange up for either or both channels, or adjust the ranges manually. When properly adjusted, the green* **HALF RANGE** *LEDs should be on and the red* **OVER RANGE** *LEDs should be off.*

7. Start

Press the yellow **START** *key to begin the measurement.*

8. Configure Display

Configure the display to view the desired information. As an aid to analysis and comparison, results can be displayed in three formats with a wide selection of coordinates. Examples of typical display configurations are shown throughout this note.

Chapter 2:

Frequency Response Measurements with Linear Resolution

Linear Resolution in the HP 3562A
The Linear Resolution Preset Measurement
High Resolution Zoom Measurement
Analysis via Display Selections
Internal Storage of Results

Introduction

Linear resolution is the measurement technique common to all fast-Fourier transform (FFT) based analyzers. Time data is sampled until a data buffer called the "time record" is filled with a fixed number of time samples. Once the time record is filled, the fast-Fourier transform of the record is computed and the frequency spectrum is displayed. For those unfamiliar with the operation of FFT-based analyzers, a good tutorial explanation is presented in Hewlett-Packard Application Note 243, "Fundamentals of Dynamic Signal Analysis"

Common applications of dual-channel FFT analyzers such as the HP 3562A include frequency response measurements of electronic networks and mechanical structures. Both of these applications can benefit from the measurement speed, resolution and versatility found in high-performance Dynamic Signal Analyzers.

Linear Resolution in the HP 3562A

The Linear Resolution mode in the HP 3562A provides 801 lines of frequency resolution per channel in single- or dual-channel operation. Resolution ranging from 125 Hz (100 kHz span) to 12.8 μHz (10.24 mHz span) can be obtained in baseband (0-start) mode. In zoom mode, resolution as narrow as 25.6 μHz (20.48 mHz span) can be obtained anywhere in the dc-to-100 kHz measurement range of the HP 3562A.

Given two high performance input channels and a built-in signal source, frequency response measurements are easy to implement with the HP 3562A. The remainder of this chapter is an introduction to frequency response measurements with the HP 3562A Linear Resolution mode. Baseband and zoom measurements on a low frequency electronic crystal resonator will be shown to demonstrate: (1) the general measurement sequence outlined at the end of Chapter 1, (2) quick configuration of a zoom measurement using the X-axis marker and the MARKER VALUE key and (3) a variety of informative display configurations.

The Linear Resolution Preset Measurement

Given an unknown network, a good starting point is a full span baseband frequency response measurement. This can be done very quickly with the general measurement procedure and the Linear Resolution preset:

1. Select Mode

At turn-on the HP 3562A is set for Linear Resolution operation. If the analyzer is on, press the **MEAS MODE** *key and select the* **LINEAR RES** *soft key.*

2. Preset

Press the green **PRESET** *key. The Linear Resolution setup state can be displayed, as shown in Figure 2-1, by pressing the* **STATE/TRACE** *key.*

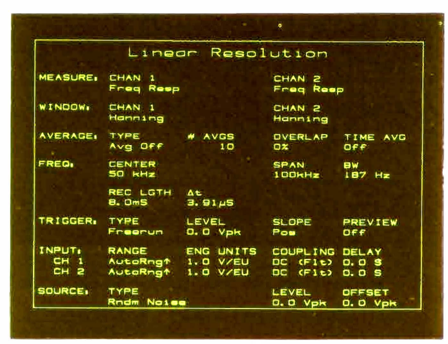


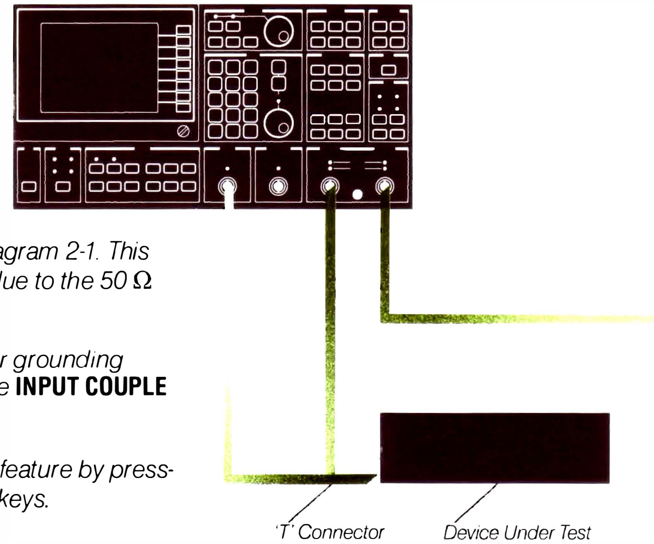
Figure 2-1

3. Set Source Level

Press the **SOURCE** *key, then select the* **SOURCE LEVEL** *softkey. The Entry group arrow keys, knob and keypad will be active: select the desired output level for the signal source. The random noise source is the default selection.*

4. Averaging

Press the **AVG** *key. The Entry group is active; select the number of averages to be taken. Since random noise will be used for this measurement, select* **STABLE (MEAN)** *averaging.*



5. Connect D.U.T. *Connect the device under test as shown in Diagram 2-1. This configuration is for high impedance networks due to the 50 Ω output impedance of the signal source.*

6. Input Coupling *If it is necessary to change the input coupling or grounding (summarized in the set up state table), press the* **INPUT COUPLE** *key to activate the required menu.*

7. Input Ranging *Press the* **RANGE** *key. Activate the autoranging feature by pressing the* **AUTO 1 RNG UP** *and* **AUTO 2 RNG UP** *softkeys.*

8. Select Data *Press the* **MEAS DISP** *key, then select the* **FREQ RESP** *(frequency response) softkey.*

9. Start *Press the yellow* **START** *key. The dc-to-100 kHz frequency response will be displayed automatically. Figure 2-2 shows the results for the low frequency crystal resonator.*

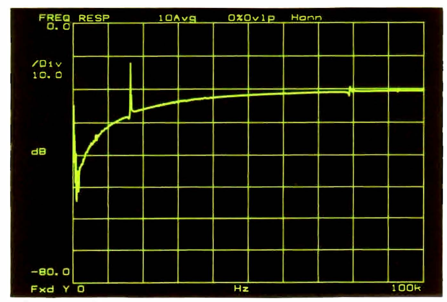


Figure 2-2

High Resolution Zoom Measurement

The full span measurement shows the location of the resonance but does not have sufficient resolution to show much detail. A zoom measurement makes it possible to concentrate the full 801 lines of resolution in a narrow band centered on the resonance. The X-axis marker combined with the Entry group **MARKER VALUE** key quickens and simplifies zoom measurement setup.

1. Activate Marker *To activate the X-axis marker, press the* **X** *key. The LED above the key will be illuminated indicating that the marker knob can be used to move the cursor. Position the marker on the resonant peak.*

2. Band Marker *In the X-marker softkey menu select* **HOLD X CENTER**. *This activates the "band marker" capability; turning the marker knob will adjust the width of the band while holding the center frequency constant. The crystal resonator response with the band cursor activated is shown in Figure 2-3.*

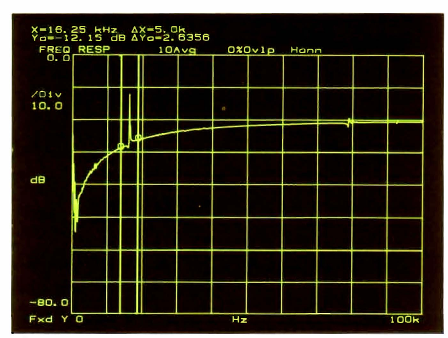


Figure 2-3

3. Set Center and Span *To set up the zoom measurement, the new center frequency and narrower span must be selected. Press the* **FREQ** *key. With the band marker set to the desired width, make the following selections:* **FREQ SPAN** *softkey and* **MARKER VALUE** *key (the center of the band marker will become the measurement center frequency; among the available zoom spans, the span equal to, or the next span greater than, the marker span will be entered as the measurement span).*

4. Start *Press the* **START** *key. The zoom measurement will be displayed. For better resolution, repeat the above process using the X-axis marker, or by numeric entry of a new frequency span. Figure 2-4 shows a zoom measurement of the crystal filter at a span of 800 Hz (1 Hz resolution).*

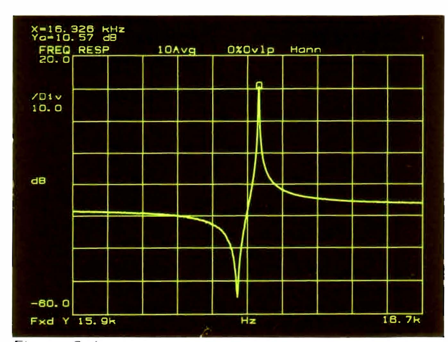


Figure 2-4

Analysis via Display Selections

While the frequency response magnitude display provides very useful information, thorough device characterization requires both magnitude and phase, perhaps with a logarithmic frequency scale. Additional information can be obtained from the impulse response and the coherence function.

When performing Linear Resolution frequency response measurements, the HP 3562A can display several functions with a variety of trace coordinates. Examples are shown using the results of the preceeding zoom measurement.

1. Impulse Response

To see the measurement choices available, press the **MEAS DISP** *(measurement display) key in the Display group. The active measurement will be displayed at the upper left of the trace graticule.* **FREQ RESP** *should be displayed. Select* **IMPLS RESP** *(impulse response) to observe the time domain response of the network.*

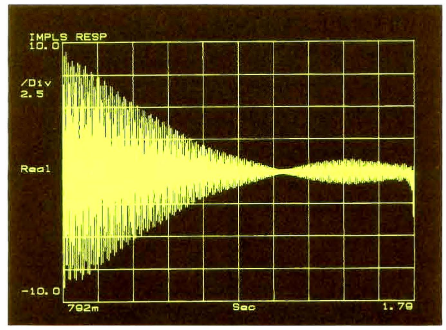


Figure 2-5

2. Split Screen Display

Refer back to the **DISPLAY** *group. Press the* **UPPER LOWER** *key to create a split screen display. Press the* **B** *key to activate the lower trace.*

3. Magnitude and Phase

Select the **FREQ RESP** *softkey. Press the* **COORD** *(coordinate) key. Several trace coordinates including phase and linear magnitude are available. The* **NEXT** *softkey displays the next level of coordinates which includes linear or logarithmic frequency axis. An example is shown in figure 2-6.*

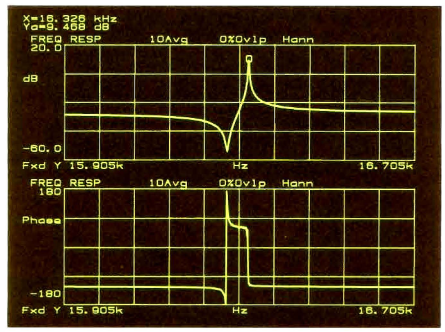


Figure 2-6

4. Coherence

Press the **MEAS DISP** *key, then select the* **COHER** *softkey to display the coherence function. The display should be similar to Figure 2-7*

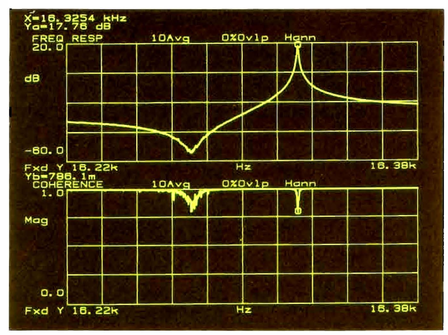


Figure 2-7

Internal Storage of Results

The frequency response and coherence function from this measurement will be used to demonstrate curve fitting in Chapter 9. To store these results:

1. Activate Trace

Press the **A** *key to activate trace A.*

2. Save Trace

Press the **SAVE RECALL** *key. Select the* **SAVE DATA #** *softkey, then the number* **1** *followed by the* **ENTER** *softkey. [Data register #1 has battery backup.]*

3. Activate Trace

Press the **B** *key to activate trace B.*

4. Save Trace

Select the **SAVE DATA #** *softkey, then the number* **2** *followed by the* **ENTER** *softkey. [Data register #2 does not have battery backup.]*

If you have a disc drive with your HP 3562A, refer to Chapter 12 for details regarding measurement storage on disc.

Chapter 3: Frequency Response Measurements with Logarithmic Resolution

Logarithmic Resolution in the HP 3562A
The Log Resolution Preset Measurement
Single Decade Measurement
Analysis via Display Selections

Introduction

Logarithmic resolution is a measurement technique which uses linear resolution FFT measurements to create results similar to a log swept sine test. Linear resolution points are combined, rather than redistributed, to produce frequency response or power spectrum measurements with a true logarithmic frequency scale.

The key contribution of this technique is the combination of fast, high resolution FFT analysis with the proportional resolution of a log sweep measurement. Further, when applied to broadband testing of mechanical or electronic resonances, the log resolution technique provides reduced measurement variance (compared to linear resolution) and can save significant test time (when compared to log sweep tests with equal resolution).

Logarithmic Resolution in the HP 3562A

The Log Resolution mode in the HP 3562A provides 80-point-per-decade resolution over one to five integer decades. Available start and stop frequencies and combinations thereof are shown in Table 3-1. Frequency response magnitude and phase can be measured using stationary (i.e., non-transient) stimuli such as random noise or fixed sine signals from the built-in signal source. Input and output power spectra can also be measured and observed. For complete analysis of results, measurements can be manipulated with the built-in Waveform Math and Curve Fitting capabilities.

The following sections of this chapter introduce the basics of frequency response measurements with the Log Resolution mode. The 3-decade preset measurement and a second 1-decade measurement, with averaging, will be shown.

Start Frequency (in Hz)	Stop Frequencies (in Hz)				
0.1	1	10	100	1k	10k
0.2	2	20	200	2k	20k
0.5	5	50	500	5k	50k
1	10	100	1k	10k	100k
2	20	200	2k	20k	
5	50	500	5k	50k	
10	100	1k	10k	100k	
20	200	2k	20k		
50	500	5k	50k		
100	1k	10k	100k		
200	2k	20k			
500	5k	50k			
1k	10k	100k			
2k	20k				
5k	50k				
10k	100k				

Table 3-1: Log Resolution Start and Stop Frequencies

The Log Resolution Preset Measurement

As is the case in the Linear Resolution mode, a full span frequency response measurement is the preset condition.

1. Select Mode *Press the* **MEAS MODE** *key and select the* **LOG RES** *softkey.*

2. Preset *Press the green* **PRESET** *key to select the log resolution preset measurement. The Log Resolution setup state can be displayed, as shown in Figure 3-1, by pressing the* **STATE/TRACE** *key.*

Figure 3-1

3. Set Source Level *Press the* **SOURCE** *key, then select the* **SOURCE LEVEL** *softkey. The* **ENTRY** *group keys and knob will be active for selection of the signal source output level. Note that random noise and fixed sine (stationary signals) are the only choices in this mode: select* **RANDOM NOISE**.

4. Averaging *Press the* **AVG** *key; use the* **ENTRY** *group to select the number of averages to be taken. Since random noise is the test signal, select* **STABLE(MEAN)** *averaging.*

5. Connect D.U.T. *Connect the device under test as shown in Diagram 3-1. Since the output impedance of the source is 50 Ω, this configuration should be used for high input impedance devices.*

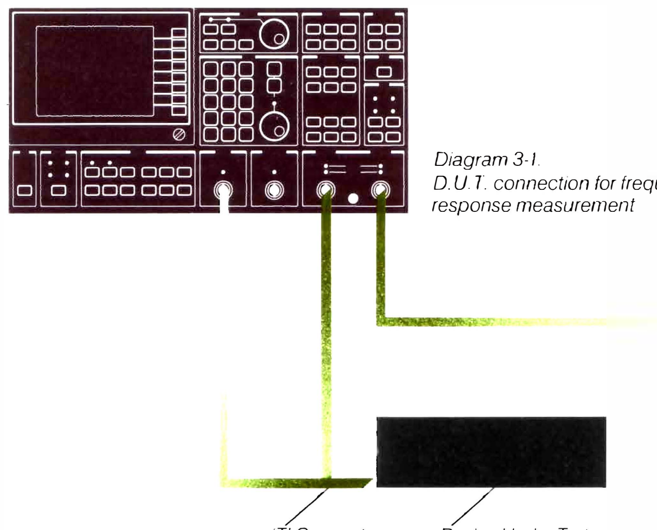


Diagram 3-1.
D.U.T. connection for frequency response measurement

6. Input Coupling *If it is necessary change the input coupling and grounding settings from the preset conditions, activate the* **INPUT COUPLE** *menu and enter the necessary changes.*

7. Input Ranging *Press the* **RANGE** *key. Activate input autoranging on both channels by pressing the* **AUTO 1 RNG UP** *and* **AUTO 2 RNG UP** *softkeys.*

8. Select Data *Press the* **MEAS DISP** *key, then select the* **FREQ RESP** *(frequency response) softkey.*

9. Start *Press the yellow* **START** *key. The 100 Hz-to-100 kHz frequency response will be displayed automatically. The result shown in Figure 3-2 is from the same crystal resonator used in the Linear Resolution example.*

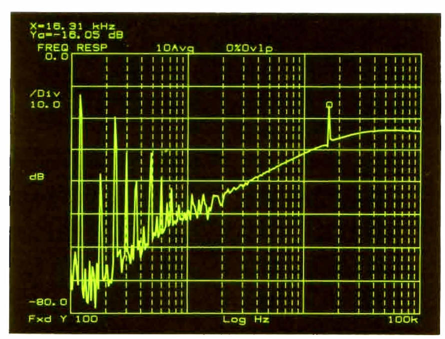


Figure 3-2

Single Decade Measurement

As mentioned previously, measurement spans of 1 to 5 decades can be selected in Log Resolution mode. To demonstrate entry of frequency parameters, a one decade measurement will be performed with the crystal resonator.

1. Set New Span

Press the **FREQ** *key to activate the frequency selection menu. The start frequency and measurement span can now be entered with the corresponding softkeys. For this measurement, start frequency was selected to be 5 kHz and the span was set to 1 decade. Refer back to Table 3-1 for a summary of the available start, stop and span values.*

2. Check Input Ranges

With the narrower frequency span, the input ranges may need to be changed due to the band-limited, constant-power noise source. Autoranging will handle this quickly.

3. Start

Press the yellow **START** *key. The results for the crystal resonator are shown in Figure 3-3.*

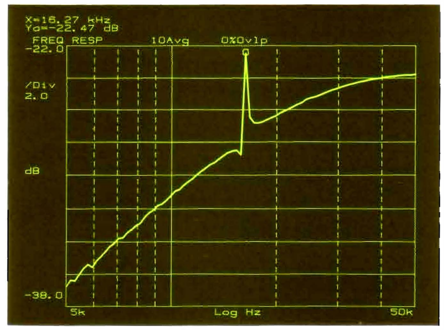


Figure 3-3

Analysis via Display Selections

In the Log Resolution mode the available measurement displays are: frequency response, coherence function, channel 1 power spectrum, channel 2 power spectrum and the cross power spectrum. Examples from the results of the preceding measurement are given to illustrate some of the available vertical trace coordinates.

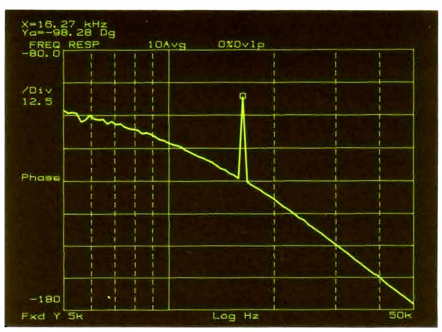


Figure 3-4: One-decade frequency response phase

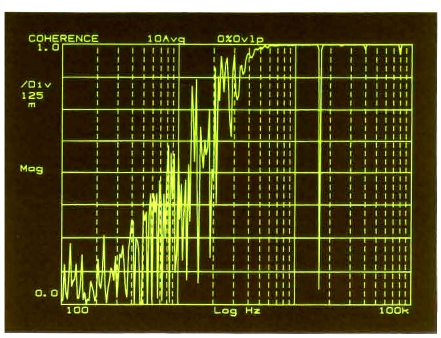


Figure 3-5: Three-decade coherence function

Chapter 4:

Frequency Response Measurements with Swept Sine

The HP 3562A Swept Sine Mode
The Swept Sine Preset Measurement
Narrowband Linear Sweep

Introduction

Low frequency network analysis has traditionally been addressed by a group of products known as frequency response analyzers. While these products perform the same measurements as a tuned network analyzer, the internal operation is quite different. Rather than use expensive low frequency (< 1 Hz) tracking filters, a frequency response analyzer performs time domain integration of the input signals to mathematically filter signals at very low frequencies. Measurement results are usually displayed as point-by-point numerical values or on an X-Y plotter.

In many applications, notably closed loop control systems, detailed or final system evaluation is performed using a frequency response analyzer. During the development of such systems, when time is a critical factor, initial characterizations of the system are often performed using an FFT analyzer. The analysis capabilities built into many FFT analyzers, and typically not found in frequency response analyzers, can also play an important role in the development process. The HP 3562A combines all of these capabilities into a single product.

The HP 3562A Swept Sine Mode

When the Swept Sine measurement mode is activated, the HP 3562A is reconfigured as a full-function dc-to-100 kHz frequency response analyzer. Key enhancements include the built-in high resolution vector display, the ability to perform plotting operations during a measurement and mass storage of results in an external disc drive.

Source capabilities include increasing or decreasing linear or logarithmic sine sweeps as well as manual control of the sweep. Start and stop frequencies, as well as the sweep rate, are also user selectable. Input channel capabilities include user-selectable averaging and integration time; automatic integration and up-and-down autoranging of input ranges can be activated to enhance testing of high performance systems.

The remainder of this chapter introduces the full span preset swept sine measurement as well as a narrowband linear sweep.

The Swept Sine Preset Measurement

A typical testing technique involves the use of wideband logarithmic sweep measurements followed by narrowband linear sweep tests at frequencies of interest. The HP 3562A preset Swept Sine measurement is a good starting point: a 100 Hz-to-100 kHz log sweep frequency response.

1. Select Mode

Press the **MEAS MODE** *key and select the* **SWEPT SINE** *mode.*

2. Preset

Press the green **PRESET** *key. The Swept Sine setup state can be displayed, as shown in Figure 4-1, by pressing the* **STATE/TRACE** *key. All values shown are the default preset measurement conditions.*

Figure 4-1

3. Set Source Level

Press the **SOURCE** *key, then select the* **SOURCE LEVEL** *softkey. Set the sine wave output level using the Entry group keys or knob. Note that dc offset and sweep parameters such as direction and rate are selected in this menu.*

4. Connect D.U.T.

Connect the device under test as shown in Diagram 4-1. This configuration is for high impedance systems due to the 50Ω output impedance of the signal source.

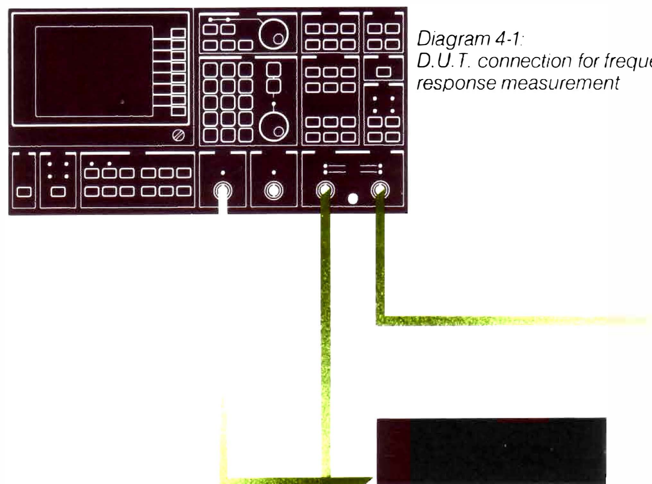


Diagram 4-1: D.U.T. connection for frequency response measurement

5. Input Coupling

Press the **INPUT COUPLE** *key and select the proper input coupling and grounding parameters.*

6. Input Ranging

Press the **RANGE** *key. Since the test signal is a sweeping sine wave rather than broadband noise, maximum input amplitude for the response channel will not be known until a resonance is reached. Up-and-down autoranging solves this problem by checking for under-half range and over range conditions at every measured point.*

7. Select Data

Press the **MEAS DISP** *key, then select the* **FREQ RESP** *(frequency response) softkey.*

8. Start

Press the yellow **START** *key. The 100 Hz-to-100 kHz frequency response is displayed as the sweep progresses across the screen. The final trace will be similar to Figure 4-2 (again, the crystal resonator). Notice the line of annotation at the top of the trace: "Y" is the instantaneous level and "F" is the instantaneous sweep frequency.*

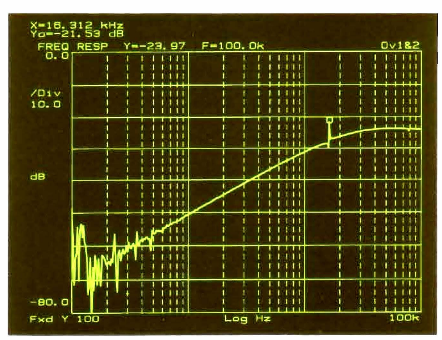


Figure 4-2

Narrowband Linear Sweep

The wideband log sweep frequency response may disclose resonances or other interesting characteristics that demand a more detailed measurement. A high resolution narrowband linear sweep is a good solution. To set up this measurement:

1. Linear Sweep *Press the* **MEAS MODE** *key, then select the* **LINEAR SWEEP** *softkey.*

2. Activate Band Marker *Activate the X-axis marker with the* **X** *key. Move the marker to a point of interest, then select the* **HOLD X CENTER** *softkey. Use the knob to spread the band marker.*

3. Set Start and Span *Press the* **FREQ** *key. Select* **FREQ SPAN** *and press the* **MARKER VALUE** *key to define the start and stop frequencies.*

4. Sweep Resolution *Select the* **RESLTN** *(sweep resolution) softkey. Measurement resolution can be selected as a fixed value in Hz/point or points/sweep (the automatic-resolution feature can also be activated; this feature increases or decreases resolution during the measurement as a function of relative changes in amplitude from point to point.)*

5. View State *To view the measurement state, press the* **STATE/TRACE** *key. Notice that the sweep rate and sweep time values are displayed: these values are set internally according to the selected sweep span and resolution.*

6. Input Ranging *Press the* **RANGE** *key. Activate autoranging for both channels with the* **AUTO 1 UP&DWN** *and* **AUTO 2 UP& DWN** *softkeys.*

7. Start *Press the yellow* **START** *key. The measurement will be displayed as the sweep progresses from start to stop. The linear sweep result will look like the display shown in Figure 4-3.*

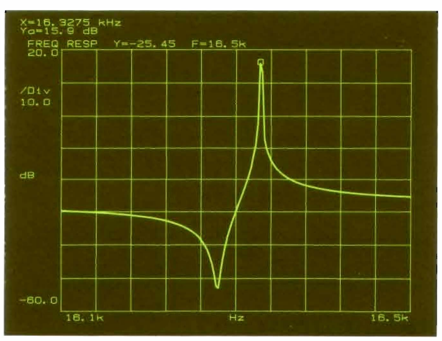


Figure 4-3

Chapter 5:

Spectrum Analysis with Demodulation

Spectrum Analysis with the HP 3562A
Baseband Analysis and Harmonic Markers
Zoom Analysis and Sideband Markers
Demodulation of Zoom Measurements

Introduction

Spectrum analysis can benefit from the speed, resolution and flexibility of single-channel Linear Resolution FFT measurements. Rapid baseband and high resolution zoom measurements lend themselves to detailed analysis of dynamic signals: rapidly changing frequency spectra and transient signals are typical examples. Additionally, the digital form of the time or frequency information lends itself to detailed analysis, such as AM, FM and PM demodulation. in external computers.

The frequency range of most dynamic signal analyzers, up to 25 kHz or 100 kHz, makes them ideal for analysis of audio, speech, noise control and machinery vibration signals. Measurements commonly made with dynamic signal analyzers include harmonic distortion, in-band power and phase noise.

Spectrum Analysis with the HP 3562A

The HP 3562A Dynamic Signal Analyzer is fundamentally a dc-to-100 kHz spectrum analyzer with 801 lines of frequency resolution and 80 dB of dynamic range. A pair of input channels, flexible zoom analysis and a built-in demodulation function makes the HP 3562A a powerful spectrum analyzer. Signals can be monitored on either or both input channels with baseband or zoom analysis. A full span dc-to-100 kHz spectrum and a zoom spectrum of a signal can be displayed simultaneously. Zoom measurements (over 60 spans are available) can be AM, FM or PM demodulated; results are displayed as a frequency spectrum with the carrier at 0 Hz.

The rest of Chapter 5 is divided into two sections, basic spectrum analysis, and spectrum analysis with demodulation. In addition to the capabilities mentioned in the previous paragraph, enhancements such as signal averaging will also be demonstrated.

Baseband Analysis and Harmonic Markers

Spectrum analysis measurements can begin quickly using the special preset power spectrum measurement. As shown below, the Marker group contains many time-saving features.

1. Special Preset *Press the green* **PRESET** *key. Select the* **P SPEC LINRES** *softkey to activate the preset dc-to-100 kHz power spectrum measurement. The state is shown in Figure 5-1.*

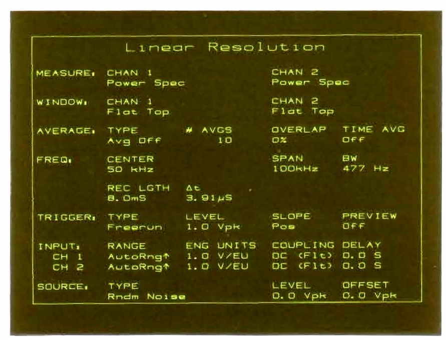


Figure 5-1

2. Connect Signal *Connect the signal to input channel 1. To change input coupling or grounding, press the* **INPUT COUPLE** *key and make the necessary choices in that menu.*

3. Start *Press the yellow* **START** *key to begin the measurement.*

The display will be similar to the results shown in Figure 5-2 (a square wave output from a function generator with powerline sidebands). To analyze the spectrum:

4. Activate Marker *Activate the X-axis marker with the* **X** *key. Move the marker to the fundamental frequency of the square wave.*

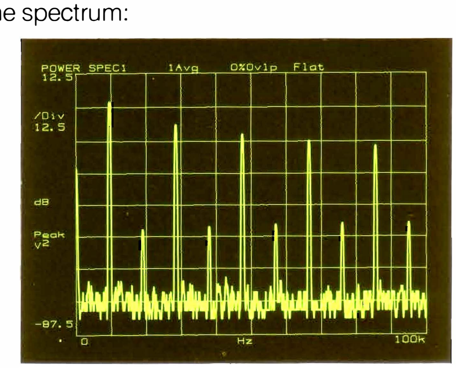


Figure 5-2

5. Harmonic Marker *Press the* **SPCL MARKER** *(special marker) key. Select the* **HMNC ON** *(harmonic on) softkey to activate the harmonic markers and the associated softkey menu. Twenty harmonic markers are displayed as shown in Figure 5-3.*

6. Set Fundamental *Select the* **FNDMTL FREQ** *(fundamental frequency) softkey. Press the* **MARKER VALUE** *key: this enters the X-marker value as the fundamental frequency.*

The arrow keys or entry knob can be used to "fine tune" the fundamental frequency and position the markers precisely on the harmonic components.

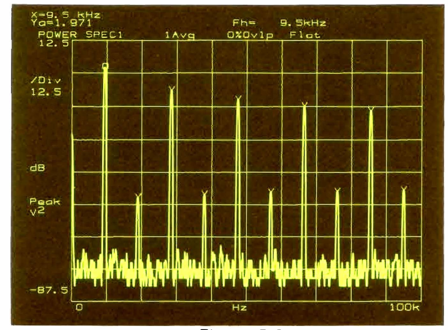


Figure 5-3

7. Display T.H.D. *Select the* **THD** *softkey to obtain a readout of total harmonic distortion for the displayed markers (the THD computation will exclude markers which are not displayed).*

A readout of THD for a specific number of harmonics can be obtained with the X-axis marker. To measure the fundamental through the sixth harmonic:

- **a.** *Move the X-axis marker into the noise to the left of the fundamental.*
- **b.** *Press the* **X** *key to activate the marker menu. Select the* **HOLD X LEFT** *softkey. Spread the band marker to the right to include the sixth harmonic.*
- **c.** *Press the* **SPCL MARKER** *key. Select the* **HMNC ON** *softkey, then the* **THD** *softkey. The total harmonic distortion value will be displayed as shown in Figure 5-4.*
- **d.** *To prepare for the next example, turn off the band marker by pressing the* **X OFF** *key.*

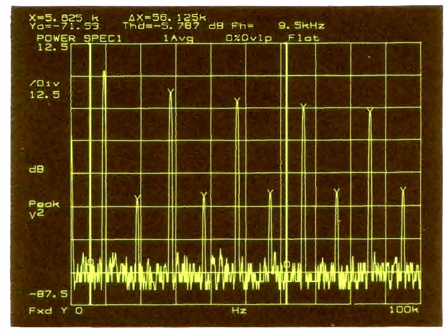


Figure 5-4

Zoom Analysis and Sideband Markers

Changing from baseband to high-resolution zoom analysis can be accomplished quickly with the frequency group (FREQ key) and the X-axis marker. Accurate characterization of sideband power can be performed with the sideband marker function. This example begins with the baseband spectrum from the previous section.

1. Turn Off Special Markers *Press the* **SPCL MARKER** *key. Select the* **X FCTN OFF** *softkey to turn off the harmonic markers.*

2. Activate Marker *Press the* **X** *key to activate the X-axis marker. Move the marker to the third harmonic.*

3. Set Center and Span *To set up the zoom measurement, press the* **FREQ** *key.*

Select the **CENTER FREQ** *softkey, then press the* **MARKER VALUE** *key. The marker frequency is entered as the center of the zoom span.*

Select the **FREQ SPAN** *softkey and enter the desired measurement span. For this example a span of 500 Hz was selected to include the first two powerline sidebands on either side of the third harmonic.*

4. Averaging *To make the sidebands easier to identify, averaging can be used to bring the noise floor to its mean value. Press the* **AVG** *key and enter 20 averages. Select the* **STABLE (MEAN)** *softkey.*

5. Start *Press the yellow* **START** *key. Figure 5-5 shows two spectra, one after two averages and another after twenty, to highlight the difference with averaging.*

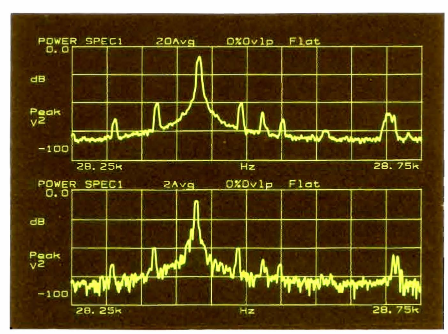


Figure 5-5

6. Marker to Peak *To analyze the sidebands in the measured power spectrum: Press the* **SPCL MARKER** *key. Select the* **MRKR → PEAK** *softkey to position the marker on the peak.*

7. Sideband Markers *Select the* **SBAND ON** *(sideband on) softkey, then* **CRRIER FREQ** *(carrier frequency). Press the* **MARKER VALUE** *entry key to enter the marker frequency as the carrier frequency.*

8. Sideband Frequency *Select the* **SBAND INCRMT** *(sideband increment) softkey and enter the powerline frequency (50, 60 or 400 Hz). The spectrum display should be similar to Figure 5-6.*

9. Display Power *Select the* **SBAND POWER** *softkey to display the sideband power value as shown in Figure 5-6.*

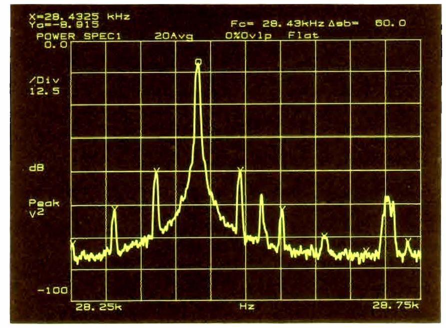


Figure 5-6

Demodulation of Zoom Measurements

This example begins with the modulated spectrum shown in Figure 5-6; the setup state for this zoom measurement is shown in Figure 5-7. The following procedure is a demonstration of AM demodulation of this signal with the HP 3562A.

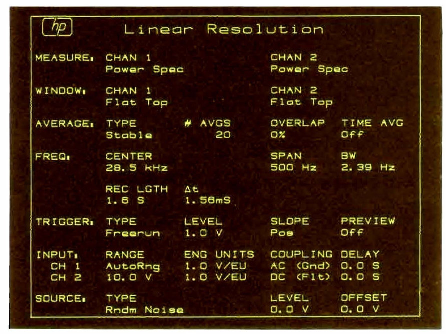


Figure 5-7

1. Activate Demodulation *Press the* **MEAS MODE** *key. Select the* **DEMOD ON/OFF** *softkey to turn on demodulation (the* **DEMOD SELECT** *softkey will appear).*

2. Set Up Demod *Select the* **DEMOD SELECT** *softkey to activate the demodulation menu.*

Select demodulation on either or both input channels, then the type of demodulation (AM, FM or PM; for this example, **DEMOD CHAN1** *and* **AM CHAN1** *were selected).*

3. Carrier *After selecting the type of modulation, select the* **RETURN** *softkey. If the carrier frequency is known, select* **PM/FM CRRIER** *and enter the frequency (<100 kHz); if the carrier frequency is not known, select* **AUTO CRRIER**.

4. Start *Press the yellow* **START** *key. The demodulation results are displayed as a baseband spectrum as shown in Figure 5-8. Notice that the frequency span of the demodulated spectrum is one-half that of the initial zoom span (this is always the case in demodulation).*

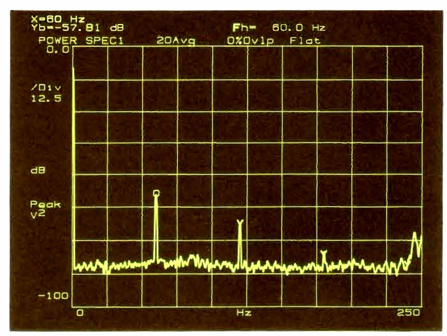


Figure 5-8

Chapter 6: Waveform Analysis with Time Capture

Waveform Recording with the HP 3562A
The Time Capture Preset Measurement
Time Domain Analysis
Frequency Domain Analysis

Introduction

Waveform analysis is typically performed with storage or digitizing oscilloscopes or a family of products known as waveform recorders. The basic technology in these devices is identical to the first stage of all FFT-based signal analyzers: analog signals are sampled, digitized and stored for later analysis. Consequently, many Dynamic Signal Analyzers such as the HP 3562A provide waveform recording capabilities as an extension of their frequency domain analysis functions.

While the sampling frequency of Dynamic Signal Analyzers is typically 80 times lower than typical waveform recorders (256 kHz versus 20 MHz), dynamic range is usually 20 to 40 dB better with a DSA. Also, most Dynamic Signal Analyzers provide complete filtering to prevent "aliased" frequency components, caused by input signals greater than 1/2 the sampling frequency; refer to HP Application Note 243 for further details.

Thus, the frequency and dynamic range of the application dictates which device provides the optimum solution. Waveform analysis applications such as speech recognition and synthesis, audio analysis, mechanical transients and electronic waveforms below 100 kHz can be addressed by properly equipped Dynamic Signal Analyzers.

Waveform Recording with the HP 3562A

The HP 3562A provides a 20,480-sample buffer for waveform recording with a 256 kHz sampling rate: real-time or "gap free" data can be recorded from either input channel for as many as 10 consecutive time records containing frequencies up to 100 kHz. Analysis can be performed in both the time and frequency domains with displayed and annotated results. The Time Capture mode is enhanced with complete triggering capabilities (including pre- and post-trigger delay) and post-capture zoom analysis with up to 10 times the original frequency resolution.

The example in this chapter demonstrates waveform analysis in the audio range; the actual measurement will be performed using the Time Capture preset state. Primary emphasis is given to analysis of the captured data in both the time and frequency domains, including post-measurement zoom analysis.

The Time Capture Preset Measurement

To become familiar with the operation of Time Capture, a good starting point is the capture and analysis of a non-transient signal such as the human voice:

1. Select Mode *Press the* **MEAS MODE** *key, then select the* **TIME CAPTUR** *softkey.*

2. Preset *Press the green* **PRESET** *key.*

3. Connect Channel 1 *Channel 1 is active. Connect the signal or transducer to the* **CHANNEL 1** *input (for this example a microphone was connected to the input).*

4. Input Range *Press the* **RANGE** *key, then select the* **CHAN 1 RANGE** *softkey. Enter the input range such that the green* **HALF RANGE** *light is on and the red* **OVER RANGE** *light is off when the signal is present.*

5. Start the Capture *Press the* **MEAS MODE** *key, select the* **TIME CAPTUR** *softkey, then select the* **CAPTUR SELECT** *softkey to display the Time Capture control menu.*

Select the **START CAPTUR** *softkey to initiate the capture (the preset capture is 1.6 seconds in duration—speak quickly if you are using a microphone!). When the capture record is complete, the compressed buffer containing 10 time records will be displayed as shown in Figure 6-1*

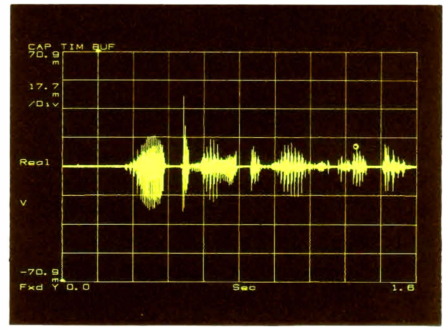


Figure 6-1

Time Domain Analysis

The X-axis marker provides several features which are very useful when analyzing a captured waveform:

1. Activate Marker *Press the* **X** *key to activate the marker. The marker will appear at the point of maximum amplitude on the waveform.*

2. Band Marker *Select the* **HOLD X CENTER** *softkey: use the marker knob to spread the band marker about a portion of the waveform. Select the* **HOLD X OFF** *softkey to hold the band width (with "hold off" active, the band marker can be moved across the display with the marker knob).*

3. Expand Display *To expand the portion of the waveform in the band select the* **X MRKR SCALE** *(X-marker band to scale) softkey. The expanded display will be similar to Figure 6-2*

4. Data Scrolling *Select the* **SCROLL ON/OFF** *softkey. Use the marker knob to scroll the waveform through the expanded "window"*

5. Return to Full View *To return to a view of the entire capture record select the* **X AUTO SCALE** *softkey.*

Note: the display amplitude can also be scaled via the **SCALE** *key. Press the* **SCALE** *key, then select the* **Y AUTO SCALE** *softkey*

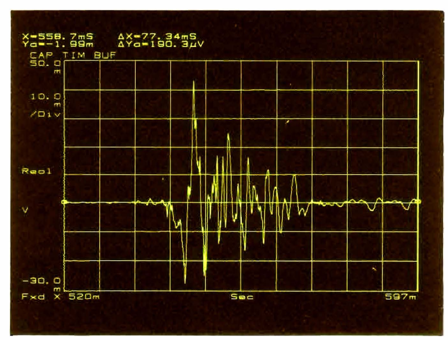


Figure 6-2

Frequency Domain Analysis

Captured time waveforms can also be analyzed in the frequency domain with Linear Resolution power spectrum, auto correlation and histogram measurements. Measurement configuration for input from the capture buffer proceeds as it would for data on either input channel:

1. Display Whole Record *Before starting the measurement, display the entire capture buffer. Press the* **SCALE** *key and select the* **X AUTO SCALE** *softkey.*

2. Select Measurement *Press the* **SELECT MEAS** *key, then select the* **POWER SPEC** *softkey.*

3. Select Window *Press the* **WINDOW** *key. Select* **FLAT TOP** for non-transient signals (voice) or **UNIFRM** *(uniform) for transients.*

4. Split Screen Display *Press the* **UPPER LOWER** *key to activate the split screen display.*

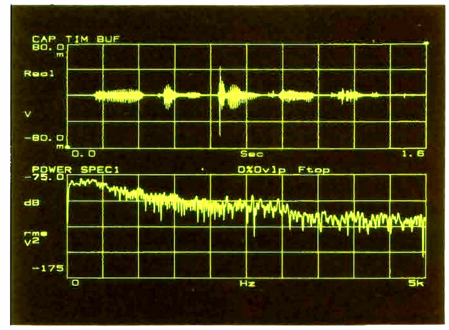


Figure 6-3

5. Start *Press the yellow* **START** *key. The power spectrum for the first 2048 points in the capture buffer is displayed in the lower trace, as shown in Figure 6-3.*

6. Averaging *To average all 10 records together press the* **AVG** *key. Press* **10** *on the keypad followed by the* **ENTER** *softkey.*

Select the **STABLE (MEAN)** *softkey.*

7. Start Average *Press the yellow* **START** *key. The averaged power spectrum will be displayed in the lower trace as shown in Figure 6-4. A feature called the "capture pointer" can be used to select the beginning of a new block to be analyzed:*

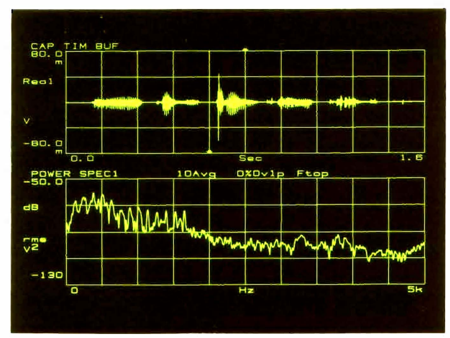


Figure 6-4

8. Capture Pointer *Press the* **AVG** *key, then select the* **AVG OFF** *softkey.*

Press the **MEAS MODE** *key followed by the* **TIME CAPTUR** *softkey then the* **CAPTUR SELECT** *softkey.*

Select the **CAPTUR POINTR** *softkey. Use the arrow keys or the entry knob to change the starting point: the default increment is 2048 points (one time record). Pressing the* **START** *key will produce the power spectrum for the selected time record.*

The **CAPTUR INCRMT** *(capture increment) softkey can be used to set a new pointer increment as a number of records, points, revolutions, minutes, seconds, milliseconds or microseconds.*

Chapter 7:

Data Collection with Time Throughput

Time Throughput with the HP 3562A
Preparing a Disc for Throughput
Setting Up the Session
Measurements with Throughput Data

Introduction

A common testing technique is the gathering of data for later analysis in a lab or office. Typical recording devices include portable instrumentation tape recorders, high speed tape drives and large-capacity disc drives. Data is played back into a spectrum analyzer or oscilloscope for detailed analysis.

Within the realm of computer-based Fourier analysis systems, this technique is referred to as data throughput or ADC throughput (where ADC stands for analog-to-digital converter). Analog input signals are sampled, digitized and then transferred to a disc drive for storage on a magnetic disc. The stored data is recalled from the disc as discrete time records for detailed analysis in the time or frequency domains. This technique is often used in applications where short test times are critical: access to the system-under-test is limited, or destructive testing is being performed.

Time Throughput with the HP 3562A

Through direct control of external HP-IB disc drives and the Time Throughput capability, data throughput can be implemented with the HP 3562A and an HP disc drive. Each time throughput is called a "session": a session is stored in a file (named by the user) on a disc for later recall. More than 32,000 time records (>134 Mega-bytes) can be gathered in any session—thus, the amount of data which can be gathered in a session is typically limited by the capacity of the disc. Real-time or "gap free" data can be collected for frequency spans as wide as 10 kHz (with Command Set-80 disc drives such as the HP 7941).

Analysis can be performed with Linear or Log Resolution and proceeds exactly as it would with analog input data. Measurements are configured using the steps outlined in Chapters 2 and 3, including averaging; if Time Throughput is active when the START key is pressed, data will be recalled from the selected disc file and loaded into the time record for processing.

Preparing a Disc for Throughput

Before starting the throughput session, **the disc drive must be connected and the disc media initialized** as described in Chapter 12, "Documentation of Results." When the disc is connected and a disc initialized, the next step is the creation of the throughput file or files (although files are reuseable, each session or test requires a new file).

1. Disc Functions *Press the* **DISC** *key, then the* **DISC FCTN** *(disc functions) softkey.*

2. Create Throughput File *Select the* **THRUPT SIZE** *(throughput size) softkey and enter the length as a period of time, a number of points or a number of time records. For this example* **40 RECORD** *(40 time records) was entered. This entry sets the total size of the throughput file: 40 time records means up to 40 time records from a single channel or 20 from each input for dual-channel measurements.*

Select the **CREATE THRUPT** *softkey. The alphanumeric entry menu will be activated and the front panel keys are redefined as alpha keys (notice the blue letters and characters at the lower right of every key except Help). For disc files, up to eight letters and numbers (no characters, math symbols or punctuation marks) can be combined to name the throughput file. In this example the file name USER1 was used.*

Setting Up the Session

Measurement set up proceeds as described in Chapters 2 and 3: Linear Resolution and Log Resolution measurements can be used with Time Throughput. For this example the Time Throughput preset measurement will be used.

1. Special Preset

Press the green **PRESET** *key. In the preset menu, select the softkey labelled* **TIME THRUPT.** *A dc-to-100 kHz Linear Resolution frequency response measurement will be set up as shown in Figure 7-1.*

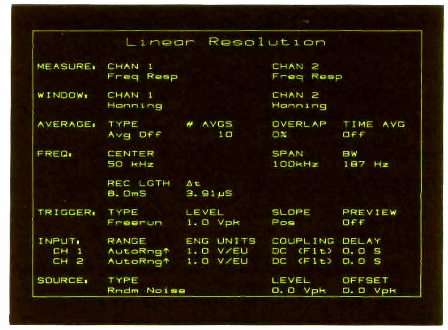
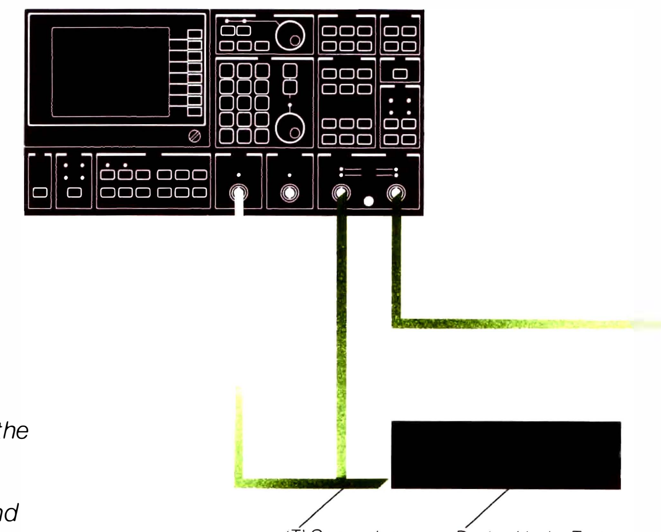


Figure 7-1

2. Set Up Measurement

As described in Chapter 2, set up the signal source (**SOURCE** *key) and measurement averaging (* **AVG** *key); connect the device under test as shown in Figure 7-2; set up the input coupling (* **INPUT COUPLE** *key).*

Diagram 7-1: D.U.T. connection for frequency response measurement



3. Throughput Select

To start the throughput session, press the **MEAS MODE** *key, then the* **THRUPT SELECT** *softkey.*

4. Enter Active File

Select the **ACTIVE FILE** *softkey and enter the file name, USER1 in this case.*

5. Set Length

Select the **THRUPT LENGTH** *softkey and enter the length of the throughput session (20 RECORD in this case for a total of 40—frequency response is dual-channel).*

6. Start Throughput

Select the **START THRUPT** *softkey to start the throughput session. The 'THROUGHPUT IN PROGRESS' message is displayed at the lower right of the trace. The* **STATUS** *group LEDs indicate measurement status; interaction with the disc is indicated by the* **HP-IB** *group LEDs.*

7. View Header

When the throughput is completed the **HP-IB** *and* **STATUS** *LEDs will indicate no disc or measurement activity. Select the* **THRUPT HEADER** *softkey to display the disc file header for the session. The header for this example is shown in Figure 7-2.*

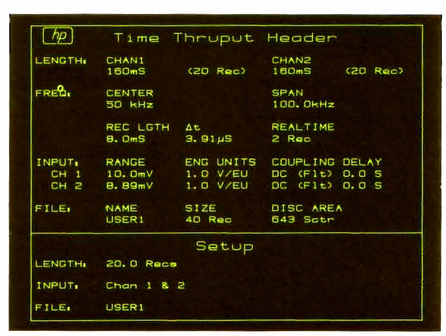


Figure 7-2

Measurements with Throughput Data

For recall and analysis of the throughput data, set up measurement parameters in the same manner described in Chapters 2 or 3 (with the exception of the source, input coupling and input range—these steps were performed when the throughput session was set up). To analyze the data with the preset full span frequency response:

1. Verify Mode *Press the* **MEAS MODE** *key to verify that Time Throughput is active: the* **THRUPT ON/OFF** *softkey should be set for* **THRUPT ON**.

2. Enter Active File *Select the* **THRUPT SELECT** *softkey, then the* **ACTIVE FILE** *softkey. The active throughput file name is displayed at the lower right of the trace. If the displayed file is correct, select the* **CANCEL ALPHA** *softkey; if not, enter the active file name using the alphanumeric entry keys.*

3. Start *Press the yellow* **START** *key. Time records are recalled from the disc and the measurement proceeds using the digitized data.*

4. Zoom Measurement *For real-time throughput sessions (up to 10kHz span in single-channel or 5kHz span in dual-channel), zoom measurements can be performed. Use the* **FREQ** *(frequency) key and the X-marker to configure a zoom measurement. Measurement averaging, with overlap, can be selected with the averaging menu (***AVG** *key). Press the yellow* **START** *key to perform the new measurement.*

Chapter 8:

Block-Operation Waveform Math

Waveform Math Concepts
Math with a Constant
Math with Measured or Synthesized Data

Introduction

Once measurements have been taken, mathematical manipulation of test results may be required to put the information into a more useful form. To speed and simplify this process the measurement results must be in a form that is easy to manipulate. Within Dynamic Signal Analyzers such as the HP 3562A, digitized analog signals form finite blocks of time data (time records) or frequency spectra (the FFT result) which lend themselves readily to block manipulation.

Several powerful analysis functions are built into the HP 3562A including display formatting, marker functions and block-operation Waveform Math. Since the marker functions and display formatting capabilities have been emphasized in earlier chapters, Chapter 8 will focus on the Waveform Math capabilities of the HP 3562A.

Waveform Math Concepts

While data within the HP 3562A exist in relatively large blocks (2048-point time records and 801-line FFT results), using the Waveform Math keys to manipulate data is very similar to using a handheld calculator. Operations such as square root, inverse FFT or division by a constant can be performed on a displayed trace; operations such as +, −, × and ÷ can be performed between displayed traces or between a displayed trace and a trace stored internally. Results are displayed graphically in the appropriate domain (time or frequency).

Math with a Constant

Division by a constant (resistance) can be used to convert a measurement of voltage versus frequency or time to a plot of current versus frequency or time. In this example a sine wave is connected to the Channel 1 input and the waveform display is converted from voltage to current:

1. Special Preset *Press the green* **PRESET** *key, then select the* **P SPEC LINRES** *(power spectrum) softkey.*

2. Connect Source *Connect the HP 3562A* **SOURCE** *output BNC to the Channel 1 input BNC.*

3. Set Source Level *Press the* **SOURCE** *key, then the select* **SOURCE LEVEL** *softkey. To enter the source level, press 1 on the keypad then select the* **V** *(volt) softkey.*

4. Enter Frequency *Select the* **FIXED SINE** *softkey. To enter the output frequency, press 1 on the keypad, then select the* **kHz** *softkey.*

5. Pause *Press the yellow* **START** *key; then press the yellow* **PAUSE/CONT** *(pause/continue) key once to pause the measurement.*

6. Display Time Record *To display the last time record, press the* **MEAS DISP** *key, then select the* **FILTRD INPUT** *(digitally filtered input) softkey. Select the* **TIME REC 1** *softkey to display the last time record. The display will be similar to Figure 8-1.*

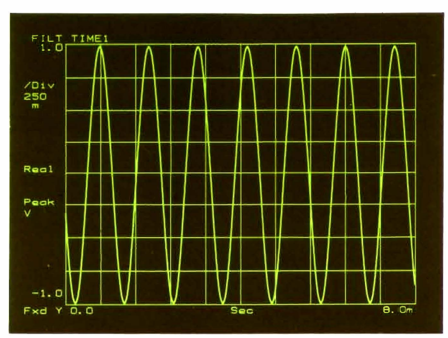


Figure 8-1

7. Activate Math *To divide the voltage versus time trace by the 1 MΩ* input impedance, press the **MATH** *key.*

8. Divide *Select the* **DIV** *(divide) softkey then, to enter 1 × E6: press* **1** *on the keypad, select the* **EXP** *(exponent of 10) softkey, press* **6** *on the keypad and select the* **ENTER** *softkey.*

9. Activate Marker *Press the* **X** *key to activate the X-axis trace marker. Notice that the marker readout is in terms of time (msec) and (voltage) ÷ (1 × E6) as shown in Figure 8-2.*

[While the preceding technique is useful for introducing Waveform Math, the voltage-to-current conversion can be done in real time using the "engineering units", or "EU", input calibration feature. An EU label for current can also be entered for the display. For details, please refer to Chapter 7 of the HP 3562A Operating Manual.]

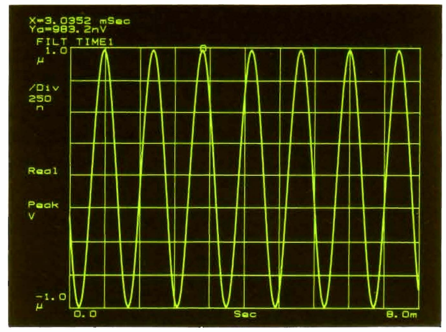


Figure 8-2

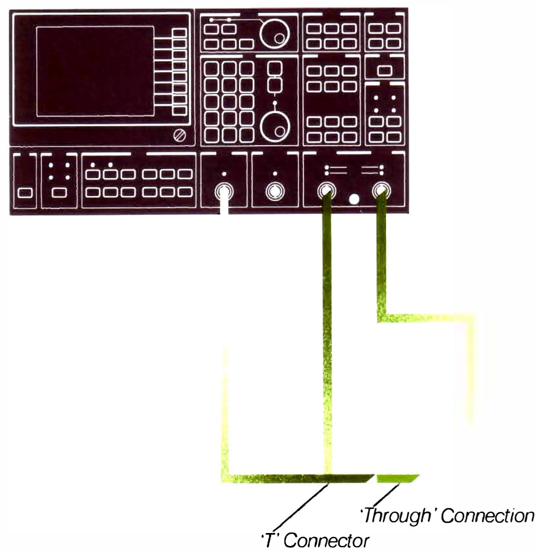
10. Display FFT *To compute and display the fast-Fourier transform of the time record: press the* **MATH** *key, the* **NEXT** *softkey, then another* **NEXT** *softkey. Select the* **FFT** *softkey; to reverse the transform, select the* **FFT⁻¹** *softkey.*

Math with Measured or Synthesized Data

Removal of system errors is often necessary in frequency response measurements. The test setup, including cabling and transducers, may induce a phase shift or amplitude response rolloff in the frequency response measurement. To compensate for these external effects:

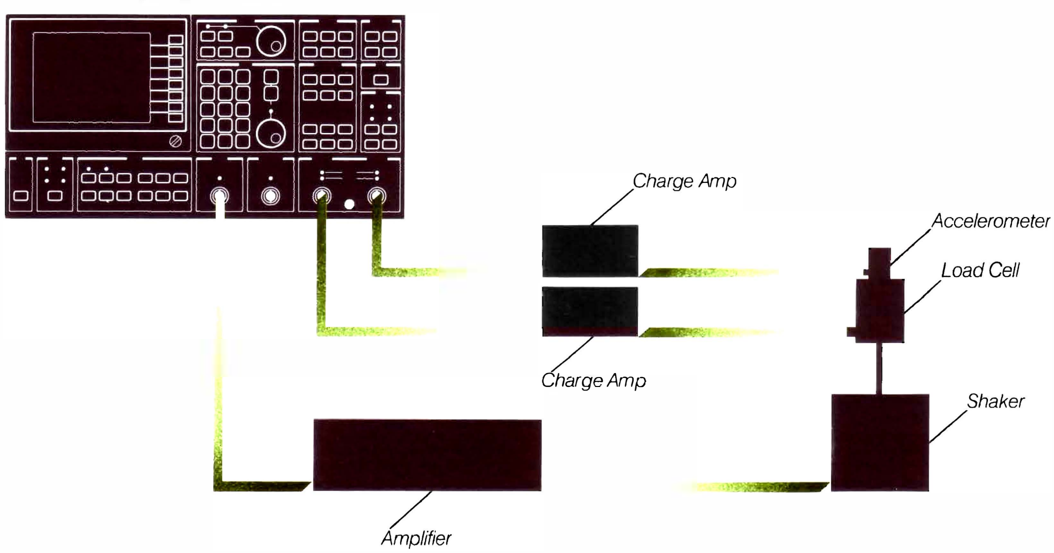
1. Calibration Measurement *Perform a frequency response measurement (as described in Chapters 2, 3 or 4) without the device under test. In electronic network measurements this means replacing the D.U.T. with a through connection as shown in Diagram 8-1; for a mechanical shaker test, the response accelerometer would be attached directly to the driving point load cell, as shown in Diagram 8-2.*

Diagram 8-1: Connection for frequency response calibration measurement



2. Verify Span *The calibration measurements must be made at the same frequency span and start, center or stop frequency which will be used in the actual measurements. If any of the frequency parameters (span, start, center or stop) are changed, a new calibration measurement must be performed.*

Diagram 8-2: Configuration for shaker test calibration measurement



3. Store Cal Trace *Store the calibration measurement in one of the two internal storage registers or in an external disc drive (see Chapter 12; if the calibration measurements are stored on disc, time can be saved by recalling the needed calibration trace and then storing it one of the internal registers).*

4. Perform Measurement *Set up and perform the frequency response measurement with the device under test in the circuit as described in Chapter 2, 3 or 4.*

5. Display Response *Press the* **UPPER LOWER** *key to create a split screen display. Display the frequency response log magnitude on trace A and the phase response on trace B:*

a. *Press the* **A&B** *key to activate both traces.*

b. *If frequency response is not displayed, press the* **MEAS DISP** *key, then select the* **FREQ RESP** *softkey.*

c. *Press the* **A** *key to activate trace A. Press the* **COORD** *key, then select the* **MAG (dB)** *softkey.*

d. *Press the* **B** *key to activate trace B. Select the* **PHASE** *softkey in the* **COORD** *menu.*

6. Activate Traces *Press the* **A&B** *key to activate both traces again.*

7. Divide *To divide the measurement by the calibration measurement, press the* **MATH** *key. In the* **MATH** *menu select the* **DIV** *(divide) softkey, then the* **SAVED 1** or **SAVED 2** *softkey, depending on which register contains the calibration measurement. The corrected frequency response magnitude and phase traces will be displayed.*

Chapter 9:

Laplace Domain Analysis with Curve Fitting

The HP 3562A Curve Fitter
Using the Curve Fitter

Introduction

Frequency response magnitude and phase plots, including Bode, Nyquist and Nichols charts, provide informative representations of a system response in the frequency domain; the impulse response provides an equally important perspective in the time domain. However, in applications such as closed loop control system design and analysis, complete system characterization often requires detailed information about the location of system poles and zeroes in the complex-valued s-plane (the Laplace domain).

A technique known as curve fitting can be used to convert frequency response measurements into a detailed listing of system poles and zeroes. Conceptually, curve fitting is an iterative mathematical algorithm which "fits" a math model to a measured frequency response "curve". As part of the analysis process, the resulting pole and zero values can be used in a root locus analysis of the measured system.

The HP 3562A Curve Fitter

The curve fitting process begins with a frequency response measurement and its accompanying coherence function (refer to Chapters 2, 3 or 4 for frequency response measurement procedures; all three types of frequency response measurements in the HP 3562A, Linear Resolution FFT, Log Resolution and Swept Sine, are compatible with the Curve Fitter). Although the coherence function is not required for an accurate curve fit, the "best fit" is usually obtained when the coherence function is available.

As many as 40 poles and 40 zeroes can be extracted from a measurement with the HP 3562A Curve Fitter. You can specify the order of the system or let the fitter find it automatically (fastest results are obtained if you provide an approximation of the system order). For detailed analysis, the curve fit results can be transferred to the Frequency Response Synthesis pole/zero table for editing and modification, followed by synthesis of the new response (refer to Chapter 10 for details regarding Frequency Response Synthesis).

Using the Curve Fitter

This example uses the zoom measurement from Chapter 2, the crystal filter, to demonstrate the curve fitting process. The frequency response measurement should be displayed in trace A and the coherence function in trace B. Set up the display as follows:

1. Active Trace *Press the* **A** *key to make trace A active.*

2. Display Response *Press the* **MEAS DISP** *(measurement display) key, then select the* **FREQ RESP** *(frequency response) softkey. If the measurement data is stored internally or on disc, it should be recalled at this point.*

3. Activate Trace *Press the* **B** *key to activate trace B.*

4. Display Coherence *Select the* **COHER** *(coherence) softkey (in the* **MEAS DISP** *menu). If the coherence data is stored internally or on disc, it should be recalled at this point.*

5. Perform Measurement *If stored data is not being used, a frequency response measurement should be performed following the methods described in Chapters 2, 3 or 4.*

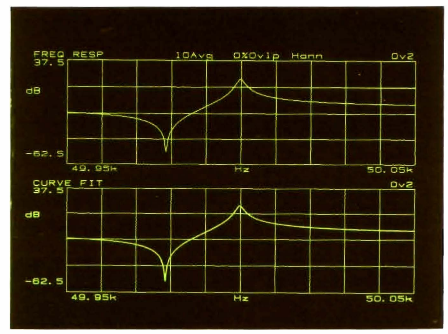


Figure 9-1

6. Activate Traces *Press the* **A&B** *key to activate both traces (be sure that the frequency response is in trace A and the coherence function is in trace B).*

7. Select Data *Press the* **CURVE FIT** *key. If recalled data is being used, select the* **A&B TRACES** *softkey; if the current measurement is being used, select the* **LAST MEAS** *softkey.*

8. Number of Poles *Select the* **NUMBER POLES** *softkey and enter an approximate number of poles (3 poles were selected for this example).*

9. Number of Zeroes *Select the* **NUMBER ZEROS** *softkey and enter an approximate number of zeroes (3 zeroes were selected for this example).*

10. User Order *Select the* **FIT FCTN** *(fit functions) softkey; select the* **USER ORDER** *softkey, then the* **RETURN** *softkey.*

11. Start the Fit *Select the* **CREATE FIT** *softkey to start the curve fit operation. The message CURVE FIT IN PROGRESS will be displayed at the lower right of the trace; intermediate results will be displayed in trace B as the fit progresses.*

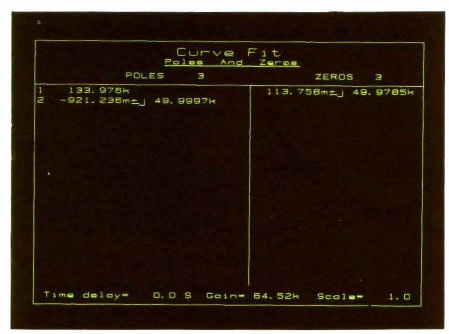


Figure 9-2

12. View Results *When the curve fit is completed, the message "Fit Complete" is displayed. The display will appear as shown in Figure 9-1; trace A shows the original measurement and trace B the curve fit result.*

13. View Table *Select the* **EDIT TABLE** *softkey to display the pole/zero table for the curve fit. The table for this example is shown in Figure 9-2.*

Chapter 10: System Modeling with Frequency Response Synthesis

Using Frequency Response Synthesis
Creating a Synthesis Table
Editing the Synthesis Table
Conversion to Other Formats

Introduction

Within the development of an electronic or electromechanical system, product specifications become the design parameters. Once the system has been designed on paper, the predicted response of the system can be modeled in a computer and the design refined to meet the intent of the specifications. Prototypes are then built and tested: measured responses are compared to the predicted response and necessary changes are made to the model, the system, or both.

The Frequency Response Synthesis capability in the HP 3562A makes it possible to create a system model in the same device which will be used to test the actual system. System models can be entered in pole/zero, pole/residue and ratio-of-polynomial formats and then be synthesized over a linear or logarithmic frequency span. Curve Fit results can also be transferred to a synthesis table for editing or for conversion to other formats.

Chapter 10 is an introduction to entering, creating and editing a synthesized frequency response. Transformation between the three formats is also demonstrated.

Using Frequency Response Synthesis

As an Example

A 20 Hz low pass filter with 80 dB/decade rolloff and a gain of 10 will be synthesized. Additional design constraints include a 60 dB notch at 60 Hz to remove powerline signals; passband ripple less than ±3 dB.

The design for the filter produced the equation

$$\frac{10(s + 6)(s + 4 + j60)(s + 4 - j60)}{(s + 2)[(s + 5 + j20)(s + 5 - j20)]^2}$$

To begin the frequency response synthesis, specify the mode (linear or log) and the frequency span. For this example:

1. Press the **MEAS MODE** key. Select the **LOG RES** softkey.
2. Press the **FREQ** key.
3. Select the **START FREQ** softkey and enter **500 mHz**.
4. Select the **SPAN** softkey and enter **3 Decade**.

Creating a Synthesis Table

To enter the function into the synthesis table:

1. Select Pole/Zero

Press the **SYNTH** *key. Select the* **POLE ZERO** *softkey to display the pole/zero synthesis table.*

2. Clear Table

Any values in the table can be cleared with the **CLEAR TABLE** *softkey (push twice to clear).*

3. Enter Poles

Poles will be entered first. Select the **EDIT POLE #** *and* **ADD VALUE** *softkeys.*

Enter the pole values with the real and imaginary parts separated by a comma. For example, the complex pole pair is entered as −5, 20; the entry is terminated with the "Hz" softkey. Thus, the pole values are entered as −2, 0 Hz, −5, 20 Hz and −5, 20 Hz.

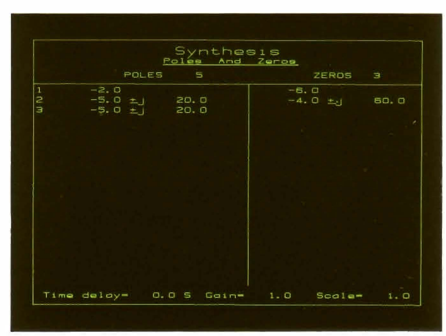


Figure 10-1

4. Enter Zeros

System zeroes are entered in the same manner. Select the **EDIT ZERO #** *and* **ADD VALUE** *softkeys. The example parameters are entered as −6, 0 Hz and −4, 60 Hz.*

The synthesis table should appear as shown in Figure 10-1. If you made any errors, select the **EDIT POLE #** *or* **EDIT ZERO #** *softkey followed by the number of the pole or zero (each active line of the table is numbered). Select the* **CHANGE VALUE** *softkey and enter the correct values.*

5. Enter Gain Factor

To enter the system gain (10), select the **SYNTH FCTN** *(synthesis functions) softkey.*

Select the **GAIN FACTOR** *softkey and enter the value* **1 0**. *Select the* **RETURN** *softkey to return to the editing menu.*

6. Return

Select the edit menu **RETURN** *softkey to return to the main synthesis menu.*

7. Create Response

Select the **CREATE TRACE** *softkey to activate the frequency response synthesis; the message "SYNTHESIS IN PROGRESS' is displayed. The results for this example are shown in Figure 10-2.*

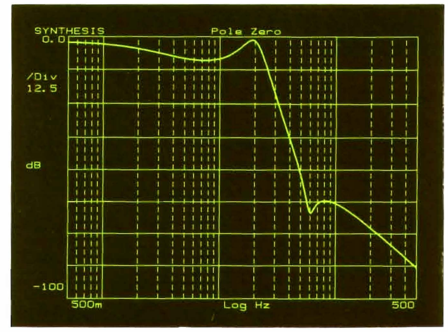


Figure 10-2

Editing the Synthesis Table

A quick inspection with the Y-marker shows that the passband flatness is not within the specifications due to the peak at 20 Hz (as shown in Figure 10-2). One possible solution is to move one of the complex pole pairs farther from the jω axis:

1. Edit Table

Press the **SYNTH** *key; select the* **POLE ZERO** *softkey.*
Select the **EDIT POLE #** *softkey; enter the pole number or use the arrow keys or entry knob to highlight one of the pole pairs.*

2. Change Pole

Select the **CHANGE VALUE** *softkey and enter the trial value: – 10, 20 Hz.*

3. Create Response

Select the **RETURN** *softkey; select the* **CREATE TRACE** *softkey. The trial response magnitude and phase traces are shown in Figure 10-3.*
Another quick inspection with the Y-marker indicates that the passband flatness is within the ± 3 *dB tolerance.*

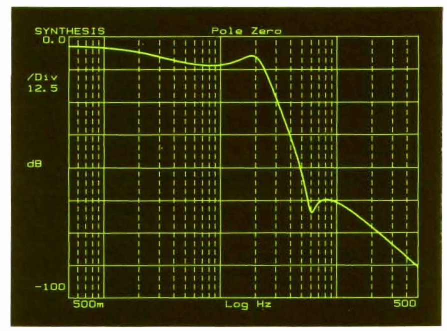


Figure 10-3

Conversion to Other Formats

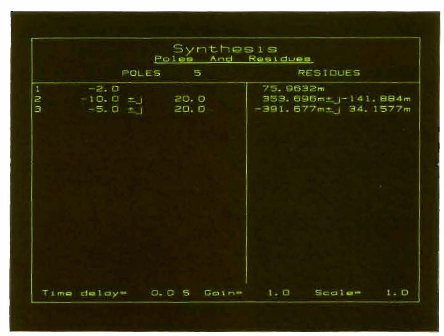
To convert the pole/zero table to pole/residue or ratio-of-polynomials format:

1. Convert

Select the **CONVRT TABLE** *softkey, then the* **TO → POL RESIDU** *softkey.*

2. Display Table

To display the new table select the **POLE RESIDU** *softkey. The table will appear as shown in Figure 10-4.*


Synthesis
Poles And Residues

	POLES 5		RESIDUES
1	-2.0		75.9632m
2	-10.0 ±j	20.0	353.696m±j-141.884m
3	-5.0 ±j	20.0	-391.677m±j 34.1577m

Time delay= 0.0 S Gain= 1.0 Scale= 1.0

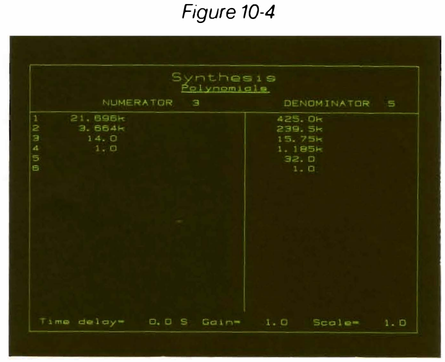
Figure 10-4

3. Convert

Select the **RETURN** *softkey; again select the* **CONVRT TABLE** *softkey followed by the* **TO → POLY** *softkey.*

4. Display Table

The polynomial synthesis table will appear as shown in Figure 10-5.


Synthesis
Polynomials

	NUMERATOR 3	DENOMINATOR 5
1	21.696k	425.0k
2	3.664k	239.5k
3	14.0	15.75k
4	1.0	1.185k
5		32.0
6		1.0

Time delay= 0.0 S Gain= 1.0 Scale= 1.0

Figure 10-5

Chapter 11:

Automation with Auto Sequence Programming

Labelling an Auto Sequence Program
Creating and Running an Auto Sequence Program
Editing an Auto Sequence Program

Introduction

High performance test instruments such as the HP 3562A derive much of their versatility and flexibility from the power of microprocessors. Beyond impressive data handling and measurement capabilities, enhancements such as direct programming of front panel key sequences without a computer have been made possible by microprocessors.

In the HP 3562A, the Auto Sequence programming capability lets you create as many as five separate key sequence programs for the automation of measurements, analysis computations, plotting and mass storage. Additional Auto Sequence programs can be stored on an external disc for manual recall or recall by another Auto Sequence program.

This chapter introduces labelling, creating and editing of an Auto Sequence program. Advanced features such as run-time pauses and program looping will also be described.

Labelling an Auto Sequence Program

This example uses the frequency response function that you synthesized in the previous chapter. The Auto Sequence program developed here will display the synthesized response in various formats. To start:

1. Pause the Measurement *If the analyzer is making a measurement, press the yellow* **PAUSE/CONT** *key once to pause the test.*

2. Activate Editor *Press the* **AUTO SEQ** *key, then select the* **SELECT ASEQ #** *softkey Press* **1** *on the keypad followed by the* **EDIT** *softkey.*

3. Create Labels *Select the* **LABEL ASEQ** *softkey. The alphanumeric entry menu is activated and the front panel keys are redefined as alpha keys (notice the blue letters and characters at the lower right of every key, except Help).*

Press the alpha keys for the letters **T R A C E**; *press the comma* (**,**) *key in the entry group; press the alpha keys for the letters* **D E M O**. *Select the* **ENTER** *softkey. (Note: an Auto Sequence label can be two lines of up to six characters. The comma indicates the separation between the first and second lines.)*

4. View Label *The label appears at the top of the Auto Sequence entry area, as shown in Figure 11-1, and on the Auto Sequence menu.*

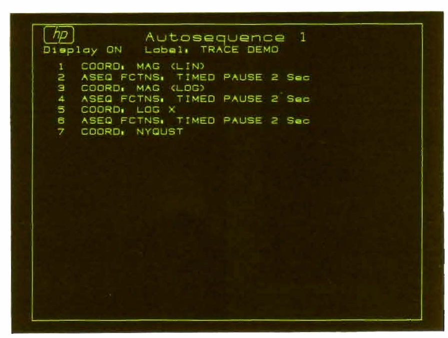


Figure 11-1

Creating and Running an Auto Sequence Program

The Auto Sequence editor should still be active from the previous section. Keystrokes can now be entered directly into the Auto Sequence program.

1. Select Coordinate

Press the **COORD** *key followed by the* **MAG (LIN)** *softkey.*

2. Set Timed Pause

To program a timed delay into the program, select the **ASEQ FCTN** *(Auto Sequence functions) softkey. Select the* **TIMED PAUSE** *softkey; press* **2** *on the keypad, then the* **SEC** *(seconds) softkey. Notice how the editor moves the new entry to the next line in the table (this is automatic when the* **ADD LINE** *softkey is active).*

3. Select Coordinate

Press the **COORD** *key then select the* **MAG (LOG)** *softkey.*

4. Set Timed Pause

Repeat step 2 to enter another 2 second pause.

5. Select Coordinate

Press the **COORD** *key, the* **NEXT** *softkey, then the* **LOG X** *softkey (this will produce a log frequency scale).*

6. Set Timed Pause

Repeat step 2 above to enter another 2 second pause.

7. Select Coordinate

Press the **COORD** *key, then select the* **NEXT** *softkey. Select the* **NYQUST** *(Nyquist—real versus imaginary) softkey.*

8. End Edit

Select the **END EDIT** *softkey to end editing the Auto Sequence program. The Auto Sequence menu will be displayed and the top softkey should be labelled* **TRACE DEMO**.

9. Select Mode

To display the synthesized frequency response, press the **MEAS MODE** *key, then select the* **LINEAR RES** *softkey.*

10. Set Span

Press the **FREQ** *key, then select the* **ZERO START** *softkey. Select the* **FREQ SPAN** *softkey, then press* **5 0 0** *on the keypad followed by the* **Hz** *softkey. This sets up a 0-500 Hz frequency span.*

11. Create Response

Press the **SYNTH** *key, then the* **CREATE TRACE** *softkey; to start the trace demo Auto Sequence program, press the* **AUTO SEQ** *key, then the softkey labelled* **TRACE DEMO**. *The synthesized frequency response will be displayed in the programmed formats with a 2-second delay between each format.*

Editing an Auto Sequence Program

To make the demo more interesting, the timed pauses will be lengthened and the program will be put into a loop:

1. Activate Editor — *Press the* **AUTO SEQ** *key. Select the* **SELECT ASEQ #**, *then press* **1** *on the keypad followed by the* **EDIT** *softkey. The listing of the* **TRACE DEMO** *program will be displayed with the last line highlighted.*

2. Select Line — *Select the* **EDIT LINE #** *softkey. Use the arrow keys or the entry knob to move the pointer and highlight to line number 2.*

3. Select 'Change' Function — *Select the* **CHANGE LINE** *softkey.*

4. Change Pause — *To change the pause to 4 seconds, select the* **ASEQ FCTN** *softkey. Select the* **TIMED PAUSE** *softkey, then press* **4** *on the keypad followed by the* **SEC** *softkey.*

5. Select Line — *Select the* **EDIT LINE #** *softkey and position the pointer on line 4.*

6. Change Pause — *Repeat step 4 above to change the length of the pause.*

7. Select Line — *Select the* **EDIT LINE #** *softkey and position the pointer on line 6.*

8. Change Pause — *Repeat step 4 above to change the length of the pause.*

9. Select 'Add' Function — *Select the* **ADD LINE** *softkey: the program lines to "initialize" the display and loop the program will be added on after line 7*

10. Set Timed Pause — *Repeat step 4 above to add another 4 second pause.*

11. Select Coordinate — *Press the* **COORD** *key. Select the* **MAG (dB)** *softkey.*

12. Select Coordinate — *Press the* **COORD** *key. Select the* **NEXT** *softkey, then the* **LIN X** *softkey.*

13. Create Loop — *To loop the program, press the* **AUTO SEQ** *key, then the* **TRACE DEMO** *softkey. This causes the program to restart itself every time line 11 is reached.*

14. End Edit — *Select the* **END EDIT** *softkey.*

15. Start Auto Sequence — *Select the* **TRACE DEMO** *softkey to start the modified program. To stop the program select the* **PAUSE ASEQ** *softkey.*

Chapter 12: Documentation of Results

Plotter Operations
Getting Ready to Plot
Plotting the Display
Disc Drive Operations
Getting Ready for Disc Access
Initializing a Disc
Saving Data on Disc
Saving Tables on Disc
State Tables
Curve Fit Tables
Synthesis Tables
Auto Sequence Programs
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Introduction

Another benefit of microprocessor-based test instrumentation has been the ability to control high speed digital plotters for fast hardcopy of test results. A logical extension of the "system controller" capability is direct control of external disc drives for mass storage of results for future reference.

For complete documentation of test results, direct control of Hewlett-Packard Graphics Language (HP-GL) digital plotters and HP-IB disc drives is built into the HP 3562A. Enhancements such as automatic page advance (for plotters with paper feeders) and a complete disc catalog have been added to further simplify the documentation process. The remainder of this chapter introduces many of the plotting and disc interface capabilities of the HP 3562A. [Please refer to the HP 3562A Ordering Information Guide for details regarding compatible plotters and disc drives.]

Plotter Operations

When connecting a plotter, the first step is to set the power switch of both devices to the "OFF" position. Next, connect the Hewlett-Packard Graphics Language (HP-GL) compatible digital plotter to the HP 3562A rear panel HP-IB connector with an interface cable (HP model 10833A, B, C or D). [Please refer to the plotter operating manual for proper connection of line voltage.] Set the line switch on each device to the "ON" position.

Getting Ready to Plot

1. Plotter Address

Check the plotter address. Set the address to 5 (0101 on the address switch). If you change the plotter address, power may have to be turned "OFF" then "ON" for the change to be accepted in the plotter.

2. Enter Plotter Address

Refer to the HP 3562A front panel. Press the **HP-IB FCTN** *(HP-IB functions) key. Select the* **SELECT ADDRES** *softkey; select the* **PLOT ADDRES** *(plotter address) softkey. The current plotter address will be shown as PLOT ADDRESS = at the lower left of the display. If the plotter address is not 5, press* **5** *on the keypad followed by the* **ENTER** *softkey. Select the* **RETURN** *softkey.*

3. System Controller

Finally, also in the **HP-IB FCTN** *menu, select the* **SYSTEM CNTRLR** *(system controller) softkey if it is not already highlighted.*

The plotter and the HP 3562A are now ready for direct digital plotting.

Plotting the Display

Data traces, setup state tables, curve fit tables and disc catalogs are among the displays that can be plotted. Display a measurement or table on the HP 3562A then proceed:

1. Activate Menu *Press the* **PLOT** *key.*

2. Set Pen Colors *Select the* **SELECT PENS** *softkey. Different colored pens can be chosen for the data grid, each data trace (A and B) and the annotation for each trace. Multi-pen plotters are supported by this feature—pens are selected as a number between 0 and 32767*

3. Return *Select the* **RETURN** *softkey.*

4. Paging Control *If a plotter with automatic paper feed is being used, select the* **PAGING CONTRL** *(paging control) softkey. Select the* **PAGE FOR-WRD** *and, if necessary,* **CUT PG ON** *(cut page on) softkeys.*

5. Return *Select the* **RETURN** *softkey.*

6. Set Plot Speed *Select either fast (F) or slow (S) plotting speed with the* **SPEED F S** *softkey.*

7. Load Paper *If a plotter with manual paper loading is being used, load a piece of plotter paper.*

8. Start Plot *Select the* **START PLOT** *softkey—a hardcopy of the display will be produced.*

As an enhancement to testing, the HP 3562A can perform plotting operations while a measurement is underway (this capability is known as "plot on the fly"). For additional details regarding plotting operations please refer to the HP 3562A Operating Manual.

Disc Drive Operations

When connecting a disc drive, the first step is to set the power switches on both devices to the "OFF" position. Next, connect the disc drive to the HP 3562A rear panel HP-IB connector with an interface cable (HP model 10833A, B, C or D). [Please refer to the disc drive operating manual for proper connection of line voltage.] Set the line switches of all devices to the "ON" position.

Getting Ready for Disc Access

1. Disc Address *Check the address setting on the rear panel of the disc drive. Set the address to 1*

2. Enter Disc Address *Refer to the HP 3562A front panel. Press the* **HP-IB FCTN** *(HP-IB functions) key. Select the* **SELECT ADDRES** *softkey; select the* **DISC ADDRES** *(disc drive address) softkey. The current disc address will be shown as DISC ADDRESS = at the lower left of the display. If the address is not 1, press* **1** *on the keypad followed by the* **ENTER** *softkey.*

3. Enter Unit Number *For disc drives with more than one unit, select the* **DISC UNIT** *softkey. The disc unit number will be shown as DISC UNIT = at the lower left of the display. Use the keypad and the* **ENTER** *softkey to select the unit number. Select* **RETURN.**

4. System Controller *Finally, also in the* **HP-IB FCTN** *menu, select the* **SYSTEM CNTRLR** *(system controller) softkey if it is not highlighted already.*

Initializing a Disc

Please refer to the disc drive operating manual for instructions regarding proper care of disc media. Also refer to the disc operating manual for proper insertion of removable floppy or cartridge media. To initialize the disc via the HP 3562A:

1. Activate Menu

Press the **DISC** *key on the front panel of the HP 3562A.*

2. Disc Functions

Select the **DISC FCTN** *(disc functions) softkey, then the* **FORMAT** *softkey.*

3. Initialize Disc

Select the **INIT DISC** *(initialize disc) softkey. The alphanumeric entry menu is activated and the front panel keys are redefined as alpha keys (notice the blue letters and characters at the lower right of each key except Help). Enter a name of one to six characters for the disc (disc names can be made up of letters and numbers only, no punctuation marks, special characters or math symbols).*

Disc initialization will take a few minutes depending on the capacity of the disc. When the initialization process is finished, the disc is ready to accept data from the HP 3562A.

Saving Data on Disc

To save a measurement on disc:

1. Select Trace

Press either the **A** *or* **B** *key: only one trace at a time can be stored on disc (if both traces are active, only trace A will be saved).*

2. Save File

Press the **DISC** *key, then select the* **SAVE FILE** *softkey. The alphanumeric entry menu is displayed and the front panel keys are redefined as alpha keys (notice the blue letters and characters at the lower right of every key except Help).*

3. Name the File

Name the file with up to eight letters, numbers or underscores (blanks, special characters, math symbols and punctuation marks cannot be used in a disc file name) and select the **ENTER** *softkey. The* **TALK** *and* **LISTEN** *LEDs will flash while data is transferred between the analyzer and the disc.*

Saving Tables on Disc

To save a state table, curve fit table, synthesis table, Auto Sequence program or Auto Math program, the first step must be modified.

State Tables

1. Select State

Press the **STATE/TRACE** *key to display the setup state. Follow steps 2 and 3 above.*

Curve Fit Tables

1. Select Curve Fit

Press the **CURVE FIT** *key. Select the* **EDIT TABLE** *softkey to display the curve fit table. Follow steps 2 and 3 above.*

Synthesis Tables

1. Select Synthesis

Press the **SYNTH** *key. Select the* **POLE ZERO**, **POLE RESIDU** *or* **POLYNOMIAL** *softkey. Follow steps 2 and 3 above.*

Auto Sequence Programs

1. Select Auto Sequence — *Press the* **AUTO SEQ** *key. Select the* **SELECT ASEQ #** *softkey, then press the appropriate number (1 through 5) on the keypad followed by the* **VIEW** *softkey (this will display the program listing). Follow steps 2 and 3 above.*

Auto Math Programs

1. Select Auto Math — *Press the* **AUTO MATH** *key. Select the* **VIEW MATH** *softkey. Follow steps 2 and 3 above.*

Recalling a File

The fastest way to recall files from the disc is with the disc catalog and the catalog pointer. To recall the catalog and display it with the pointer:

1. View Catalog — *Press the* **DISC** *key, then select the* **VIEW CATLOG** *softkey.*

2. Activate Pointer — *Select the* **CATLOG POINTR** *softkey to activate the catalog pointer. The catalog with pointer is displayed as shown in Figure 12-1 (the line indicated by the pointer is also highlighted).*

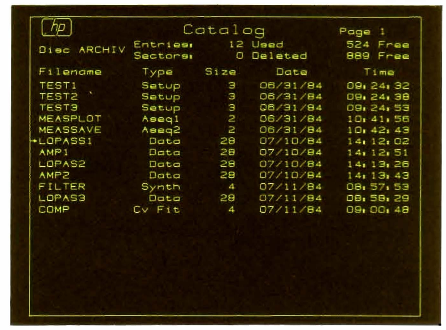

Figure 12-1

3. Recall File — *Use the arrow keys or the entry knob to move the pointer to the desired file (the* **NEXT PAGE** *and* **PREV PAGE** *softkeys may also be necessary, depending on the number of files in the catalog). Select the* **RECALL FILE** *softkey, then the* **AT POINTR** *softkey. [Note: if you know the name of the file you want to recall, the name can be entered directly. Select the* **RECALL FILE** *softkey—the alphanumeric entry menu is active. Press the appropriate alpha keys, then select the* **ENTER** *softkey.]*

Displayed measurement data is stored on disc as real or complex values, depending on the measurement. Thus, when data is recalled from disc it can be displayed using all applicable choices in the **COORD** *(coordinate) menu.*

To display a recalled table or program, follow the same steps you would normally use to display the table or listing.

Recalling an Auto Sequence Program

When recalling an Auto Sequence program, the program will be placed where it was created— location 1, 2, 3, 4 or 5. However, this can be avoided with the following procedure:

1. View Catalog — *Press the* **DISC** *key, then select the* **VIEW CATLOG** *softkey.*

2. Recall File — *Select the* **RECALL FILE** *softkey—the alphanumeric entry menu will be activated.*

3. Select Location — *To recall the program into a specific Auto Sequence location, enter the filename as [filename],[location number]. For example, if you wanted to recall the file DEMO into location 3: select the* **RECALL FILE** *softkey, then enter the filename and location as* **DEMO,3**.

For more information, call your local HP sales office listed in the telephone directory white pages. Ask for the Electronic Instruments Department. Or write to Hewlett-Packard: **U.S.A.:** P.O. Box 10301, Palo Alto, CA 94303-0890. **Europe:** P.O. Box 999, 1180 AZ Amstelveen, The Netherlands. **Canada:** 6877 Goreway Drive, Mississauga, L4V 1M8, Ontario. **Japan:** Yokogawa-Hewlett-Packard Ltd., 3-29-21, Takaido-Higashi, Suginami-ku, Tokyo 168. Elsewhere in the world, write Hewlett-Packard Intercontinental, 3495 Deer Creek Road, Palo Alto, CA 94304, U.S.A.

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