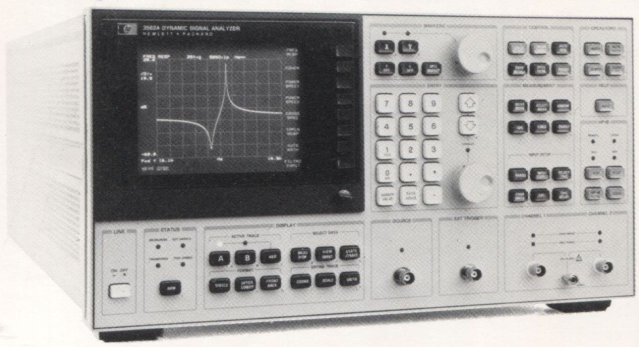
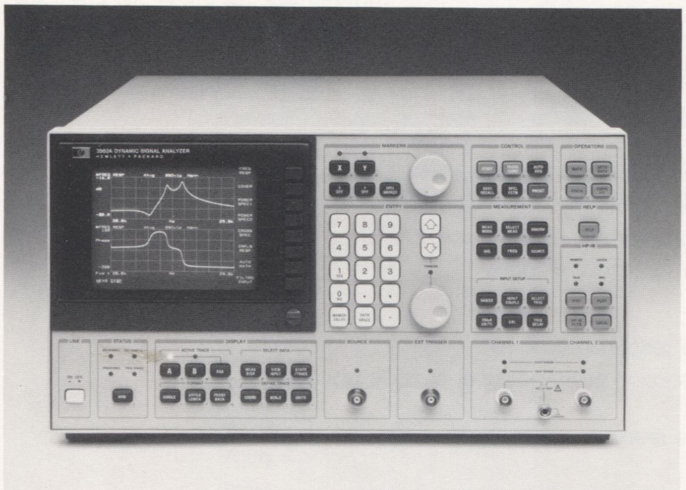
HEWLETT PACKARD

3562A DYNAMIC SIGNAL ANALYZER
FIELD TRAINING MANUAL



Contents



From 64 uHz to 100 kHz, the HP 3562A is:

A Network Analyzer

- Fast, accurate frequency response magnitude and phase
- Built-in source generates noise and sine signals
- FFT analysis provides real time network adjustment
- Powerful marker and display functions simplify analysis

A Spectrum Analyzer

- 801-line resolution and 80 dB of dynamic range
- Up to 100 times faster than swept spectrum analyzers
- AM, FM and PM demodulation on either or both inputs
- Correlation, histogram and spectral density measurements

A Waveform Recorder

- Capture and store transient events in the internal buffer
- Store long events directly to an external disc
- Analyze captured data in the time and frequency domains
- Perform frequency domain analysis with averaging and zoom

Which makes key contributions such as:

- Fast FFT-based linear and log resolution measurements, as well as true swept sine capability
- 801-line resolution in single- or dual-channel operation
- Built-in signal source for stimulus/response testing can be controlled manually or via HP-IB
- High performance 13-bit analog-to-digital converters provide a full 80 dB of dynamic range for each input
- Set ups, measurement results, and more, can be stored directly to an external HP-IB disc drive
- Curve fitting capability can create an analytical pole/zero model of a measured network
- Demodulation allows complete analysis of the detected signal in the time, frequency and amplitude domains
- Thorough documentation of results through direct control of HP-IB disc drives and HP-GL plotters
- Automation of testing and analysis through complete HP-IB programmability, or built-in auto sequence programming

Key features per application area:

Electronics

- Measurement versatility as six analyzers in one package
- Built-in signal source for network analysis
- Accuracy and resolution for precise network and spectrum analysis results
- Variety of display formats and marker functions simplify on-screen analysis
- Manipulate measured or stored data with waveform math
- Store results and set ups internally, or in an external disc drive

Servo Control Systems

- Predict system performance with frequency response synthesis
- Test systems quickly with 801-line linear resolution or 80-point-per-decade logarithmic resolution
- Full function swept sine frequency response analyzer capabilities are also built-in for easy comparison
- Fully differential inputs can float at different voltage levels for in-circuit testing
- Extract pole and zero values from measured frequency response data with the advanced curve fitter
- Document results completely through disc storage and direct digital plotting

Mechanical Applications

- Excellent low frequency coverage with complete aliasing protection
- Match the frequency-proportional response of structures with logarithmic resolution measurements
- Analyze closely spaced resonances or vibration harmonics with 801-line linear resolution measurements
- Enter transducer calibration factors and units with the engineering units calibration capability
- Normalize the frequency axis to orders of rotation through external sampling
- Perform modal, acoustic, and machinery analysis with available software solutions

A Dynamic Signal Analyzer

The HP 3562A Dynamic Signal Analyzer is a dual-channel FFT-based network, spectrum and waveform analyzer which provides unequaled analysis capabilities in both the time and frequency domains. An outstanding combination of performance and features at a great price makes this analyzer a powerful solution for industries such as:

Computer Peripherals: servo control systems, structural dynamics, vibration analysis, acoustics

Robotics: closed-loop positioning systems, structural dynamics, vibration analysis

Transportation: structural dynamics, vibration analysis, control systems, acoustics, electronic subsystems

Aerospace: control systems, structural dynamics, vibration analysis, acoustics

Telecommunications: audio distortion analysis, DTMF analysis, voice/data channel testing, modem testing

Electronics: filter testing (analog, crystal, switched capacitor), switching power supply development and testing, high volume production testing

Audio and Video: distortion analysis, speed control system analysis, vibration analysis of motors

Machinery: vibration analysis, bearing signature analysis, structural dynamics, control systems

Underwater Engineering: sonar/acoustics, transducer calibration

Market Overview

Why Did We Build the HP 3562A?

Improve our Leading Position

Hewlett-Packard has been an established leader in the FFT analyzer market since 1969 (Figure 2-1 is a vintage chart showing the introduction of HP FFT analyzers). Although the market is still relatively young, dual-channel Dynamic Signal Analyzers such as the HP 3582A, HP 5420A/B, and HP 5423A have done much to fuel growth and expansion.

Figure 2-1: HP DSA/low frequency spectrum analyzer vintage chart

Year	1-Channel	2-Channel	System
1975	3580A*		5451B
1976			
1977		5420A	
1978		3582A	5451C/5427A
1979		5423A	
1980			
1981		5420B	
1982			
1983	3561A		
1984		**3562A**	

*Low frequency swept spectrum analyzer; has been used in DSA application areas

The existing products have been accepted in a wide range of applications and have opened new markets for DSAs such as servo control systems. To continue the growth trend, and to maintain our share of the market, continued new product introductions are required. We introduced the first of our new products, the single-channel HP 3561A, in October 1983; the newest member of the HP Dynamic Signal Analyzer family is the dual-channel HP 3562A.

As the market matures, users are increasing their understanding of both their measurement needs and the capabilities of Dynamic Signal Analyzers. A natural consequence of this is a call for improvements and enhancements beyond the capabilities of existing products. Key examples include:

HP 3582A

- Frequency coverage above 25 kHz
- Direct digital plotting
- Logarithmic frequency display
- Frequency response resolution better than 128 lines
- Inputs more sensitive than 30 mV
- Engineering units calibration on inputs

HP 5420B/23A

- Frequency coverage above 25.6 kHz
- Frequency resolution better than 256 lines
- Faster access times to mass storage
- Swept sine test capabilities built-in
- Improved portability
- Lower cost

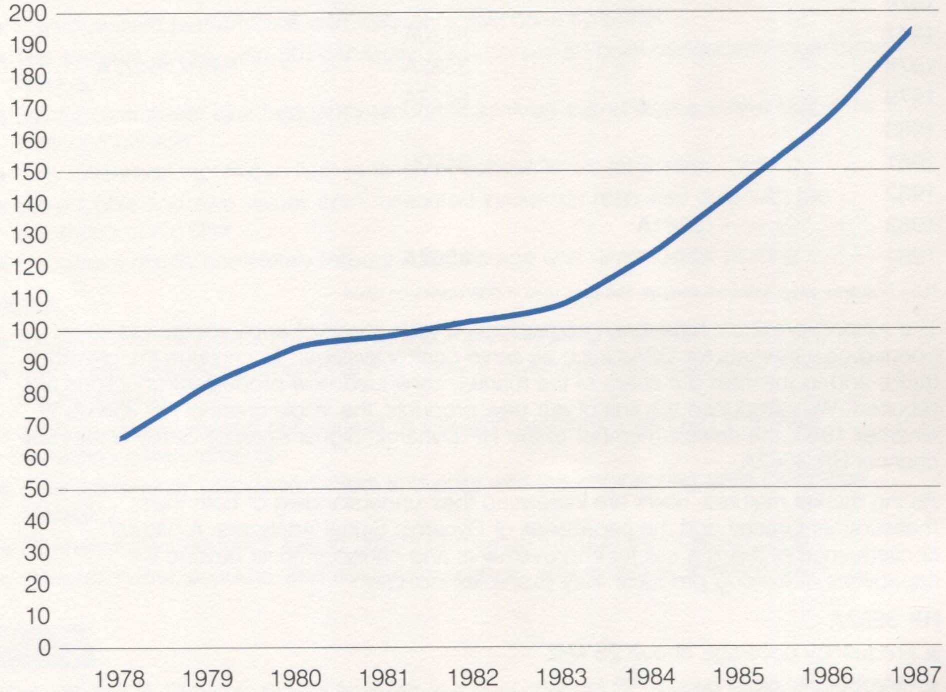
All of these improvements, and more, are included in the new HP 3562A.

The Market is Growing

The DSA market itself is very dynamic, in terms of product types, applications, and growth. Figure 2-2 shows the estimated market sizes for the years 1978-1987.

The current period represents an upswing from the 1980-1982 period of little growth. Present trends in the market (better economic conditions and a large number of new product introductions) are driving the upward trend. With the recent introduction of the HP 3562A and the HP 3561A, we expect this trend to continue with growth rates returning to past rates of 16% per year or better.

Figure 2-2: Estimated DSA market size, by year, for the period 1978 through 1987 [Source: Prime Data]



Electronic Applications

General electronics measurements, on the R&D bench or in an automated test system, require three types of equipment: network analyzers, spectrum analyzers, and waveform recorders. The HP 3562A can fill all of these roles, from dc to 100 kHz, on the bench or in a system.

As a solution for electronics testing, the HP 3562A is truly versatile, providing the capabilities of **six** analyzers in one package:

- Network analyzer
- Swept sine frequency response analyzer
- Spectrum analyzer
- Modulation analyzer
- Transient analyzer
- Waveform recorder

Additionally, simple solutions for documentation and automation requirements are built-in. Results can be saved in mass storage through direct control of HP-IB disc drives such as the HP 91XX and HP 794X families. Hardcopy results can be produced by attaching an HP-GL plotter such as the HP 7470 or the HP 7550 (sheet feed commands are built-in).

For computer control, the HP 3562A is fully HP-IB programmable (excepting power ON/OFF and display intensity). Automation is also possible through the built-in Auto Sequence programming function: a series of commands can be entered into an auto sequence program and then be executed at any time. Up to five 20-line auto sequence programs can be created and stored internally (non-volatile); additional programs can be stored on disc.

Contributions Within Key Areas

Some specific contributions within network, spectrum and waveform analysis are worth a closer look.

Network Analysis

With a pair of well matched input channels and a built-in source, the HP 3562A is equipped to make precise network measurements:

- **80 dB** dynamic range and cross channel match of **±0.1 dB and ±0.5 degree** in linear resolution mode; dynamic range greater than **130 dB** is possible in swept sine with input autoranging activated
- built-in source provides **random noise** for testing non-linear networks, **fast sine chirps** for testing linear networks (or for fast characterizations of non-linearities) and phase continuous **linear or log sweeps** for swept sine testing

The linear resolution, log resolution and swept sine measurement modes in the HP 3562A provide a variety of accurate solutions for network testing:

- **801-line** linear resolution delivers fast, accurate measurements of resonances; zoom analysis provides resolution to 25.6 uHz with ±0.004% frequency accuracy
- **80-point-per-decade** log resolution creates results similar to a log sweep swept sine test with the speed of FFT analysis
- swept sine mode provides features such as: **automatic resolution adjustment** to save time in low-Q regions and increase resolution in high-Q regions; manual selection of **increasing or decreasing sweep frequency**

Quick on-screen analysis of results is easy through the high quality HP 1345A display, a variety of display formats, and independent X- and Y-axis markers:

- frequency response **magnitude** (linear or log) **and phase** can be displayed versus linear or log frequency; true **log-log graticule** can also be selected
- single trace, split trace and front/back **display formats** simplify analysis and comparisons, as well as plotting
- single-point X-axis marker provides **0.01 dB resolution**; band cursor capability simplifies measurement of parameters such as 3 dB bandwidth; X- and Y-axis band cursors can also be used to expand portions of displayed data for closer inspection

Finally, once the data has been gathered, mathematical manipulation may be required to put the results into a more useful form:

- **waveform math** performs user-defined algebraic operations on or between measured traces, stored traces and user-entered constants; higher level functions such as integration and differentiation are also selectable
- the unique HP 3562A **curve fitter** can transform a measured frequency response into **a table of poles and zeroes** for detailed mathematical analysis; curve fit results can be transferred to the frequency response synthesis table for manipulation and format transformation (pole/residue and ratio of polynomials)
- **network modeling** can be performed in the test instrument: **frequency response synthesis** transforms a table of user-entered values (pole/zero, pole/residue, or ratio-of-polynomials) into the predicted magnitude and phase response

For more details regarding network testing and analysis, please refer to the Modeling, Testing and Analysis portions of Section 4, Servo Control System Applications.

Spectrum Analysis

Excellent speed, resolution and accuracy, plus a wide variety of measurements, make the HP 3562A a great two-channel spectrum analyzer:

- calibration standard accuracy: single-channel absolute amplitude accuracy is **±0.15 dB**
- closely spaced frequency components can be analyzed with **801-line** linear resolution zoom measurements; resolve components as close as **25.6 uHz** with **±0.004% frequency accuracy**
- linear resolution mode provides measurements such as power spectrum, cross spectrum, auto correlation, cross correlation, histogram, and spectral density functions

The **demodulation** pre-processing function is a significant new capability for analyzers in this frequency range:

- zoom measurements can be demodulated (**AM**, **FM** or **PM**) on either or both input channels; the demodulated signal can be displayed in the time and frequency domains
- all linear resolution measurements, including **correlation** functions and **histograms**, can be performed on the demodulated signal

HP proprietary digital filters make possible some very useful display configurations:

- simultaneous display of a full span (100 kHz) linear spectrum and a zoom span measurement in upper/lower format
- for a selected zoom span with averaging, the averaged spectrum can be shown on one trace with the instantaneous (non-averaged) spectrum displayed on the other; when combined with the "peak hold" or "continuous peak" functions, informative monitoring measurements are easy to implement

Analysis of displayed data is enhanced by the versatile display functions, the independent X- and Y-axis markers, and the special marker functions:

- calibrate the vertical axis of the display in **dBm** with user-selected resistance
- relative frequency and amplitude measurements are fast and easy with the **band cursor** function
- **special marker functions** include marker-to-peak, in-band power, harmonic markers (with readout of harmonic power and total harmonic distortion), and sideband markers (with readout of modulation index and sideband power)

Waveform Recording

Internal and external storage of sampled time data, pre- and post-trigger delays, complete alias-frequency protection, time domain analysis, and frequency domain measurements and analysis, combine to make the HP 3562A a great solution for transient and waveform analysis:

Time Capture Mode

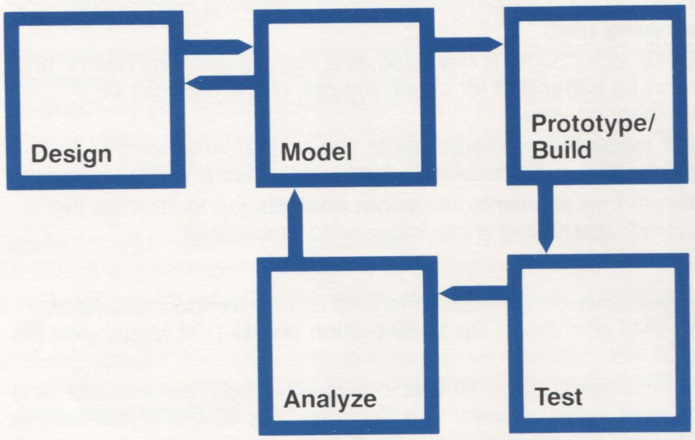
- transients can be recorded in the **20,480-point** internal storage buffer (single-channel time data); gather 20,480 consecutive samples of signals containing components up to 100 kHz (**256 kHz sampling rate**)
- for quick analysis, the 20K-point buffer is displayed as a compressed time history; any portion of the record can be **expanded** for closer analysis, or the data can be **scrolled** through the expanded view
- all single-channel **linear resolution measurements** can be performed on the captured data: power spectrum, auto correlation, histogram, spectral density functions
- perform frequency domain measurements with **zoom analysis** (up to 10 times the original resolution), and with **averaging** (including overlap processing)

Time Throughput

- for long events, data from either or both input channels can be sampled and stored directly to an external HP-IB disc drive—**up to 60-million points** (134 Megabytes) per throughput file
- **real-time** data collection for spans up to **10 kHz** in single-channel measurements, and up to **5 kHz** in dual-channel measurements, with Command Set 80 disc drives such as the HP 794X family
- time data can be recalled as single 2048-point time records for analysis with expansion and scrolling
- **frequency domain analysis** can be performed with linear or log resolution measurements, including demodulation (log resolution requires a minimum of 10^[(# of decades)−1] time records: 1 time record for 1 decade, 10 for 2 decades, etc.); dual-channel measurements such as frequency response and cross correlation can be made using the sampled data
- resolution of **zoom analysis** is limited only by the number of real-time data records collected (no gaps in the sampled data), and the number of available spans narrower than the one used during the throughput session
- to compensate for delays, **post-trigger delay** can be applied "after the fact" during measurements of throughput data

Servo Control System Applications

The HP 3562A is the most powerful standalone solution currently available for servo system development engineers. Within the cycle of Design, Test, and Analyze, shown below, several pieces of equipment are typically required in the development of a servo system: a dual-channel FFT analyzer, a swept sine frequency response analyzer, and a desktop computer with response modeling and curve fitting software. All of these capabilities, as well as versatile documentation functions, are built into our newest Dynamic Signal Analyzer.



Contributions Within the Cycle

The product development and manufacturing cycle shown above is a key element in both the HP 3562A data sheet and video tape. [A complete presentation can be found on page 11 of the data sheet.] This general process model provides an excellent framework for portraying the contributions of the analyzer within the servo application area.

Design/Model

During the design phase, system response can be modeled in the same device that will be used to test the prototype. This capability, called frequency response synthesis, provides several user-oriented features:

- a system model can be entered in three formats: **pole/zero**, **pole/residue**, and **ratio-of-polynomials**; the model can be transformed from one format to another with a single softkey
- frequency-normalized networks from a reference book can be entered and synthesized over any range by entering a **scale frequency constant**; **system gain** can also be entered directly
- to obtain proper resolution, the predicted response can be synthesized with **linear or logarithmic frequency scaling**
- to predict the effect of adding compensation or filtering to a system, synthesized data can be combined with measured data via **waveform math** operations

Test

For servo system testing, the HP 3562A makes a major contribution by putting FFT and swept sine measurement capabilities in a single analyzer. Measurement versatility, outstanding accuracy, and a built-in signal source combine to make the HP 3562A a powerful solution for demanding system tests.

The logarithmic resolution, linear resolution FFT and swept sine measurement modes all perform frequency response, input power spectrum, output power spectrum, and (with averaging activated) coherence function measurements. Each mode has several noteworthy attributes:

- multiple-decade measurements made with **logarithmic resolution mode** provide results similar to a log swept sine test, typically in much less time; spans from 1 to 5 decades wide can be selected with **80-point-per-decade resolution**; compatible source signals are random noise and fixed sine
- for high resolution measurements of closely spaced resonances, **linear resolution mode** provides 801 lines of frequency resolution; frequency response accuracy is **±0.1 dB and ±0.5 degree**; compatible source signals include random noise and periodic sine chirps
- **swept sine mode** reconfigures the HP 3562A as a full function frequency response analyzer; several **automated measurement functions** have been included to provide high-quality "hands off" testing: as an example, **automatic resolution adjustment** saves time in low-Q regions and increases resolution in high-Q regions

Analysis

Once a system has been measured, the analysis power of the HP 3562A can be used to provide fast, detailed characterizations of system performance.

- measurement results are easy to interpret on the high quality HP **vector display; linear or log graticule lines** can be selected for the magnitude and frequency axes; analysis is further simplified by a wide range of available display **formats, coordinates** and **units**
- functions such as open-loop response, noncoherent output power, and spindle run out can be computed and displayed quickly and easily using **waveform math**
- on-screen analysis of parameters such as gain and phase margins is simplified by the **independent X- and Y-axis markers**; special marker functions such as **power** and **slope** readouts further assist the analysis process
- for detailed mathematical analysis, a measured frequency response can be quickly transformed into a table of poles and zeroes with the HP 3562A's powerful **curve fitter**; curve fit results can be transferred into a frequency response **synthesis table** where compensation networks can be added to the curve fit poles and zeroes for "what if" analysis
- documentation is easy to implement through direct control of HP-GL **plotters** and external HP-IB **disc drives; synthesis tables, measurement results, curve fit tables, and more, can be plotted or stored for future reference**

Additional Contributions for Manufacturing

The HP 3562A clearly makes significant contributions to the development of closed-loop control systems, but the story goes further. In addition to versatile testing functions, the analyzer provides automation and documentation capabilities which support the needs of manufacturing test.

- built-in **Auto Sequence programming** provides powerful automation of measurements and documentation operations without an external controller; five 20-line programs can be saved in nonvolatile internal memory, with additional programs stored on an external disc
- complete **HP-IB programmability** including direct programming of the HP 1345A display and user-definable softkey menus (power on/off and display intensity are not programmable)
- setup states and measurements can be stored directly to an external HP-IB **disc drive**; data files are created by the analyzer in HP's logical interchange format (LIF) and can be accessed as data files by a Series 200 computer

Mechanical Applications

The mechanical market is young and growing, presenting a great opportunity for HP dynamic signal analyzers. As you might expect within a young marketplace, there is a growing, but not yet universal, appreciation for the benefits of this type of technology. The key to spreading this appreciation is to demonstrate the benefits of DSA features such as dynamic range and measurement speed when applied to mechanical measurements.

When coupled with the appropriate transducers, DSAs provide the frequency range, resolution, and speed required for detailed analysis of mechanical vibrations in structures and machines. Additional features such as external sample rate control, "engineering units" input calibration, and "rpm" or "orders" labelling of the frequency axis, can be used to present results in mechanical terms.

Contributions Within Key Areas

Engineers working in the areas of structural dynamics and machinery vibration will find that the HP 3562A provides many significant features and benefits.

Structural Dynamics

Structural dynamics testing is the process of measuring and characterizing vibrations in a structure due to external forces. This is usually done by subjecting the structure to known input forces, measuring the resulting vibrations, and identifying any and all resonances large enough in amplitude to cause undesirable effects during normal operation.

The "known" force is typically applied to the test object in one of three ways: with an instrumented hammer, with an electromechanical shaker and amplifier, or via operating forces (for example, by driving an automobile over a rough road). A force transducer is used to convert the input force into an electrical signal, which is measured by the analyzer; the response is usually measured with an accelerometer which also converts the resulting vibration into an electrical signal. A frequency response measurement of acceleration divided by force provides a detailed plot of structural resonances versus frequency at the measured point.

Several important features are included in the HP 3562A which can speed and simplify structural dynamics testing.

For all types of structural testing:

- **801-line** linear resolution mode reduces test time: closely spaced resonances can be characterized over wide spans in fewer measurements
- **input autoranging** saves setup time and improves measurement signal-to-noise ratio

For shaker testing:

- the **signal source** is built in and provides band-limited and band-translated random noise and periodic sine chirp test stimuli, as well as fixed and swept sine signals; the **source amplitude ramp down** function can be activated to protect the shaker system and the device under test
- for lightly damped systems, linear resolution measurements made with the **burst-random** and **burst-chirp** test signals can provide better test results in less time; burst signals shut off before the end of the data sampling period, allowing the response to decay by the end of the time record; length of the burst is user-selectable as a percentage of the sampling period
- **log resolution** provides true proportional-bandwidth measurements — a technique which matches the "natural" response of vibrating structures by concentrating measurement points in the lower half of a decade, while maintaining good resolution in the upper half; compatible test stimuli are random noise and fixed sine
- detailed linear and log **swept sine** tests are also easy to perform with the HP 3562A; input autoranging and automatic or manual control of parameters such as resolution, averaging and integration save time and enhance results

For impact testing:

- **"up only" autoranging** saves time when setting the input attenuators with impulsive stimuli—the attenuator setting will hold the maximum range rather than try to follow the quiescent or impulse amplitudes
- measurement time can also be saved when averaging by activating **automatic overload rejection**; a measurement which overloads either input channel will not be included in the average, thus eliminating the need to repeat the entire averaged measurement
- measurement results can be improved with **force and exponential window** functions; the force window can be used to eliminate extraneous noise in the impact time record, while the exponential window can be used to dampen a decaying response within the response time record

Machinery Vibration

Dynamic signal analyzers provide a powerful solution for measuring and analyzing machinery vibration. As part of a predictive maintenance program, a DSA is an informative monitoring device which measures and displays machinery vibration spectra precisely with wide dynamic range. In product development or refurbishment, a dual-channel DSA provides an easy-to-implement solution for balancing of rotating machinery.

In this application area, the dual-channel HP 3562A and single-channel HP 3561A are both excellent measurement solutions. However, with an additional measurement channel, some advanced analysis capabilities, and built-in automation and documentation functions, the HP 3562A provides some key enhancements.

For predictive maintenance:

- both input channels provide **80 dB** of dynamic range; the key benefit is **early detection** of vibration components which may indicate wear in critical bearings
- with two input channels, **cause and effect measurements** can be performed which can help isolate vibration problems within a system such as a gear train
- for signature analysis, known-good baseline measurements can be stored in an **external disc drive** for future reference; each file is stored with the date, the time of day, and a user-entered file name

For machinery balancing:

- two input channels provide direct measurement of functions such as **orbits** (time 1 versus time 2) and **cross-channel phase** (with frequency response or cross power spectrum)
- the **balancing solution** can be calculated from a frequency response measurement using the built-in **waveform math** capability; the result can be shown on the analyzer display as a plot of relative phase
- the measurement and computation process can be automated, without a computer or special software, using the built-in **auto sequence programming** capability; results can also be plotted automatically if an HP-GL plotter is connected to the analyzer

Sales Aids & Demo Procedures

To help you present the HP 3562A to potential customers, LSID has assembled a promotional package with a consistent theme in terms of both content and graphic design. From the promotional flyer, to the video tape, to the user's guide, the product message is consistent and clear: Accuracy and Versatility for Complete Testing and Analysis. This concept is also maintained in the demonstration procedure described later in this section.

Sales Aids

To further support your sales efforts, Lake Stevens Division is actively supporting our "DSA family" concept with the HP 3562A literature package. In sales situations which require a presentation of the current product line, this promo package matches the HP 3561A literature in terms of concept, content, and color scheme.

Product Literature:

HP 3562A Dynamic Signal Analyzer **data sheet**		(5953-5130)
HP 3562A Dynamic Signal Analyzer **flyer**		(5953-5129)
HP 3562S Dynamic Signal Analyzer System **ordering guide**		(5953-5128)
Product Note 3562A-1, "Operator's Introduction to the HP 3562A Dynamic Signal Analyzer" **user's guide**		(5953-5127)
"The HP 3562A: the Advanced Dual-Channel Dynamic Signal Analyzer" customer-quality **video tape**		
Internal orders:	¾" **U-matic format**	(90312HZ)
	standard **VHS** format	(90312HV)
	standard **Beta** format	(90312HW)
Customer orders:	¾" **U-matic** format	(90312HD)
	standard **VHS** format	(90312HA)
	standard **Beta** format	(90312HB)

Application Notes: the AN 243 series of application notes addresses the fundamentals of dynamic signal analysis as well as how specific application areas can benefit from DSAs.

AN 243 "Fundamentals of Signal Analysis"	(5952-8898)
AN 243-1 "Effective Machinery Maintenance Using Vibration Analysis" (part of the HP 3561A introduction package)	(5953-5113)
AN 243-2 "Control System Development Using Dynamic Signal Analyzers" (part of the HP 3562A introduction package)	(5953-5136)

Seminars: Lake Stevens Division has put together a series of DSA seminars which are presented periodically by peaked Systems Engineers. Two of the seminars are currently in place with three more slated for completion by the middle of FY85.

The DSA Seminar—A one day introduction to DSA theory and applications using full color slides and real-world demonstrations.

The Rotating Machinery Seminar—A one day introduction to rotating machinery analysis with DSAs. Uses full color slides and real-world demonstrations with the HP 3561A.

Introduction to Servo Analysis—A half-day seminar featuring full color slides and realistic demonstrations with the HP 3562A. Available at introduction of the HP 3562A.

Servo Analysis Using DSAs—A three day course which presents an in-depth look at servo system analysis with dynamic signal analyzers. Features full color slides and hands-on experience with the HP 3562A. Available mid-FY85.

Making Better Measurements—A three day course dedicated to the fundamentals of good measurement techniques with DSAs. Features full color slides and hands-on experience with HP DSAs. Available mid-FY85.

Third Party Software Program: To provide solutions for specialized DSA applications such as modal analysis, LSID is working actively with qualified independent software vendors (ISVs). We are also working closely with the Design Systems Group HP+ software program and will use their services and expertise to recruit and develop third party ISVs. The result will be an expanding list of software products which extend the capabilities of our DSA products, including the HP 3562A.

At the time of this printing, a list of vendors and programs was not available; however, at introduction the following literature will be available to answer most of your questions regarding third party software activities and available software solutions:

Design Systems Group HP+ Field Training Manual

LSID Software Solutions Field Training Manual

Measurements Solutions Selection Guide

Software Solutions Brochure (HP+ data sheets and folder).

With these resources, plus help from your DSA RSE or peaked DSA SE, you will be able to provide your customer with a complete solution from measurement to analysis to documentation of results.

Front Panel Demo Procedure

This section presents an easy-to-follow demonstration of three key uses of the HP 3562A: network analysis, spectrum analysis, and waveform recording. A brief demonstration of the built-in service diagnostics is also provided.

An automated version of the entire demo is available as an auto sequence program. If you have a microfloppy disc drive with your demo unit, a 3½" disc containing the program is available from your Lake Stevens RSE.

Network Analysis

The HP 3562A provides a versatile solution for the full cycle of modeling, testing and analysis of dc-to-100 kHz networks. Predict system response with frequency response synthesis. Test the system with linear resolution, log resolution, and swept sine testing capabilities. Extract a mathematical model from the measured response with the curve fitter.

EQUIPMENT: This demo procedure highlights the use of the Linear Resolution measurement mode for fast baseband and zoom characterization of a device under test. The procedure is general enough to be applied to almost any dc-to-100 kHz network; it works very well with either **the HP 3562A Demo Unit** (**ET25325**, available from LSID) or **the HP 3582A Demo Set** (**ET11149**, no longer available but can still be found in some offices). Three BNC-to-BNC cables and a BNC "tee" are required to setup a network measurement.

[NOTE: To expand the demonstration to include synthesis, other measurement modes, and the curve fitter, please refer to Product Note 3562A-1, "Operator's Introduction to the HP 3562A." All procedures in the product note are very "demo oriented")].

Measuring System Response with Linear Resolution

Given an unknown network, a good starting point is a full span baseband (zero-start) frequency response measurement. This can be done very quickly with the Linear Resolution preset measurement:

1. **PRESET**: At power-up the analyzer defaults to the linear resolution mode. If the analyzer is "ON", press the **MEAS MODE** key and select the **LINEAR RES** softkey. Press the green **PRESET** key; to view the setup state, press the **STATE/TRACE** key.
2. **SOURCE**: To activate the signal source, press the **SOURCE** key, then select the **SOURCE LEVEL** softkey. The Entry group keypad, knob and arrow keys will be active (ENABLED LED is on): select the desired output level (random noise is the default and correct signal type).
3. **AVERAGING**: Since random noise is the active signal, averaging must be used. Press the **AVG** key: the Entry group is automatically activated for entry of the top menu item, number of averages; select the number of averages (10 is the default value). Select the **STABLE (MEAN)** averaging softkey.
4. **INPUT COUPLING**: If input coupling or grounding needs to be changed (summarized in the state table), press the **INPUT COUPLE** key to activate the menu.
5. **CONNECT D.U.T.**: Connect the device under test as shown below. Both input channels will autorange to the correct setting.
6. **SELECT DATA**: To create an upper/lower display of magnitude and phase, begin by pressing the **A & B** key. Press the **MEAS DISP** key, then select the **FREQ RESP** (frequency response) softkey. Press the **B** key to make only that trace active; press the **COORD** key, then select the **PHASE** softkey.
7. **START**: Press the yellow **START** key to perform the averaged frequency response measurement.

The full span measurement provides a quick look at the entire response, but may not have sufficient resolution to show details. A zoom measurement makes it possible to concentrate the full 801 lines of resolution in a narrow band centered on a resonance. The X-axis marker combined with the Entry group **MARKER VALUE** key makes the setup fast and simple:

1. **ACTIVATE MARKER**: To activate the X-axis marker, press the **X** key. Position the marker on a point of interest in the display.
2. **BAND MARKER**: In the X-marker softkey menu, select **HOLD X CENTER** to activate the band marker capability. Turn the marker knob to adjust the width of the band (the center will be held constant).
3. **SET START and SPAN**: Press the **FREQ** key, then press the **MARKER VALUE** key in the Entry group. When the FREQ key is pressed, the FREQ SPAN entry is automatically activated. With the band cursor active, the span and start frequency will be entered according to the marker values.

   NOTE: when the frequency span is changed both input channels may autorange—the source level is constant, the span is increased or decreased, and the inband power changes accordingly, possibly requiring a change to the input range.
4. **START**: Press the yellow **START** key to start the new measurement. The zoom measurement will be performed and displayed; for greater resolution, repeat steps 2 and 3.

The Display group keys, MEAS DISP and COORD in particular, can be used to view other formats, functions and coordinates.

Spectrum Analysis

The HP 3562A is fundamentally a dual-channel spectrum analyzer with 801 lines of resolution and 80 dB dynamic range. Flexible zoom analysis and built-in demodulation capabilities enhance the power of this instrument as a spectrum analyzer.

EQUIPMENT: This demonstration shows some of the basic spectrum analysis measurements which can be made with the HP 3562A Linear Resolution mode. A function generator or modulated signal source (HP 3314A, 3325A, 3326A; ET 25325) should used to provide the signal to be measured. At least one BNC cable is necessary to connect the source output to the analyzer input.

Baseband Analysis and Harmonic Markers

Spectrum analysis measurements can begin quickly using the special preset power spectrum measurement. Several time saving features in the marker group are also demonstrated.

1. **SPECIAL PRESET**: Press the green **PRESET** key. Select the **P SPEC LINRES** (power spectrum, linear resolution) softkey to activate the preset dc-to-100 kHz measurement.
2. **CONNECT SIGNAL**: Connect the signal source to input channel 1. To change the input coupling or grounding, press the **INPUT COUPLE** key and make any required selections.
3. **AVERAGING**: To average the noise floor to its mean level, press the **AVG** key and select the **STABLE (MEAN)** softkey.
4. **ACTIVATE MARKER**: Activate the X-axis marker by pressing the **X** key. The marker will appear at the largest peak in the response; if the fundamental is not the largest peak in the response, move the marker to the fundamental.
5. **HARMONIC MARKERS**: Press the **SPCL MARKER** (special marker) key. Select the **HMNC ON** (harmonic on) softkey to activate the special markers and the associated menu.
6. **SET FUNDAMENTAL**: Select the **FNDMTL FREQ** (fundamental frequency) softkey. Press the **MARKER VALUE** key: this enters the X-marker frequency value as the fundamental.

   The Entry group arrow keys and knob can be used to "fine tune" the fundamental frequency setting to position the markers precisely on the harmonic components.
7. **DISPLAY T.H.D.**: Select the **THD** softkey to obtain a readout of the total harmonic distortion for the displayed markers (the THD value is shown at the top of the display in the second line of the annotation field).

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.

1. **HARMONIC OFF**: Select the **RETURN** softkey, then select the **X FCTN OFF** softkey to turn off the harmonic markers.
2. **MARKER AT FUNDAMENTAL**: Verify that the X-axis marker is on the fundamental frequency component.
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 frequency span.
4. **START**: Averaging should still be active. Press the yellow **START** key to perform the averaged zoom measurement. The fundamental and several sidebands should appear on the display trace.
5. **MARKER TO PEAK**: To analyze the sidebands in the measured spectrum: press the **SPCL MARKER** key; select the **MARKER —>** PEAK softkey to position the marker on the peak (fundamental).
6. **SIDEBAND MARKERS**: Select the **SBAND ON** (sideband on) softkey, then **CRRIER FREQ** (carrier frequency). Press the **MARKER VALUE** key to enter the marker frequency as the carrier value.
7. **SIDEBAND FREQUENCY**: Select the **SBAND INCRMT** (sideband increment) softkey and enter the sideband frequency (for example, 50 or 60 Hz power line). The Entry group arrow keys and knob can be used to "fine tune" the sideband increment and position the markers precisely on the harmonics.
8. **DISPLAY INDEX or POWER**: Select the **MOD INDEX** or **SBAND POWER** softkeys to display the computed modulation index or sideband power values, respectively (these values are displayed at the top of the trace in the second line of annotation).

Waveform Recording

The HP 3562A provides a 20,480-sample buffer 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. Pre- and post-trigger delay capabilities as well as post-capture zoom analysis (up to 10X) are also provided.

EQUIPMENT: This demonstration emphasizes the time domain analysis capabilities in the HP 3562A, including expansion and scrolling of captured data. Either a transient generator or a microphone (with BNC connector) should be used as the "waveform generator" (the HP 3562A demo box, ET 25325 contains both a transient generator and a microphone/speaker).

Capture a Spoken Phrase or a Transient

1. **SELECT MODE**: Press the **MEAS MODE** key, then select the **TIME CAPTUR** softkey.
2. **PRESET**: Press the green **PRESET** key. The Time Capture setup state will be displayed.
3. **CONNECT SIGNAL:** Input channel 1 is active. Connect the microphone or transient generator to the **CHANNEL 1** input.
4. **SET RANGE**: Press the **RANGE** key, then select the **CHAN 1 RANGE** softkey. While speaking into the microphone or generating a series of transients, set the input range (using the Entry group keypad, arrow keys or knob) such that the green **HALF RANGE** light is on and the red **OVER RANGE** light is off when a signal is present.
5. **CAPTURE AN EVENT**: Press the **MEAS MODE** key, then select the **TIME CAPTUR** softkey to display the Time Capture control menu.

   When ready, select the **START CAPTUR** softkey and speak into the microphone or generate a transient. (the preset capture is 1.6 seconds in duration — a 5 kHz frequency span starting at 0 Hz). When the capture is complete, the compressed buffer containing 10 time records (20,480 points) is displayed.

Analyze in the Time Domain

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.
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. Repeat steps 2 and 3 as necessary to expand further.
4. **DATA SCROLLING**: Select the **SCROLL ON/OFF** softkey. Use the marker knob to scroll the waveform through the expanded viewing area.
5. **RETURN TO FULL SCALE**: To return to a view of the entire capture record, select the **X AUTO SCALE** softkey. NOTE: the display amplitude scale can also be set with the **SCALE** key. Press the **SCALE** key, then select the **Y AUTO SCALE** key.

Simultaneous Frequency Domain Analysis

The linear spectrum for blocks of 2048 points can be displayed simultaneously with the full captured buffer.

1. **DISPLAY FORMAT**: press the **UPPER/LOWER** key to create a split screen display. Press the **B** key to make the lower trace active.
2. **SELECT DATA**: Press the **VIEW INPUT** key, then select the **LINEAR SPEC** softkey. The linear spectrum for the first 2048 points will be displayed.
3. **SCROLL THROUGH**: Press the **MEAS MODE** key, then select the **TIME CAPTUR** softkey. To set the step size for scrolling, select the **POINTR INCRMT** (pointer increment) softkey, then enter **.25 RECORD** with the keypad and terminator menu. Select the **CAPTUR POINTR** softkey; press the arrow keys or knob to move the capture pointer through the buffer. The linear spectrum for each time record will be displayed on the lower trace.

Demonstration of Self-Diagnostics

The HP 3562A contains an extensive set of self-diagnostic routines that can be used to verify correct operation (and to help service technicians isolate problems quickly). At power-up, the analyzer performs a complete self-test: the digital boards are tested first, then all of the boards are used to perform a self-calibration.

The user can check instrument operation at any time by pressing the SPCL FCTN (special function) key, then selecting the SELF TEST softkey. This activates an extensive battery of diagnostic tests which verify the operation of nearly every board in the analyzer. The entire test is completed in about one minute. Test results can be viewed by pressing the SPCL FCTN key and the SERVIC TEST, TEST RESULT and TEST LOG softkeys.

A typical example of a service test is the Source Functional Test. This test can be activated by pressing the SPCL FCTN key followed by the SELF TEST, TEST SOURCE, and SOURCE FUNCTN softkeys. Problems in the analog source, the calibrator, and the input channels can be isolated with this test in about 30 seconds.

Questions and Answers

The following is a list of potential questions regarding the HP 3562A, and our best responses. To get you to an answer as quickly as possible, the questions have been grouped as Measurement, Analysis, Documentation/Automation and Ordering Information. Where possible, application subheadings (electronics, etc.) have also been added.

Measurement Questions

General

How does a 13-bit ADC provide 80 dB of dynamic range?
The input channel ADCs are 13 bits plus a sign bit producing an effective 14-bit ADC (a dithering technique is also used to improve the measurement of low-level signals). Thus, dynamic range is effectively 20log(2^14) = 84 dB, or ≥80 dB.

What functions can the analyzer measure directly?
The answer depends on the selected measurement mode. Following is a table of the measurements with the valid modes indicated as LN (linear res), LG (log res), SS (swept sine), and TC (time capture).

Time Record (chans 1 & 2)	LN*, TC
Compressed Time Buffer (chan 1 or 2)	TC
Orbits (chan 1 versus chan 2)	LN*
Input Time Record (full span; chans 1 & 2)	LN, LG, SS, TC
Input Linear Spectrum (full span; chans 1 & 2)	LN, LG, SS, TC
Filtered Linear Spectrum (chans 1 & 2)	LN*, TC
Power Spectrum (chans 1 & 2)	LN*, LG, SS, TC
Power Spectral Density (PSD; chans 1 & 2)	LN*, LG, SS, TC
Square Root of PSD (chans 1 & 2)	LN*, LG, SS, TC
Energy Spectral Density (ESD; chans 1 & 2)	LN*, LG, SS, TC
Cross Power Spectrum	LN*, LG, SS
Frequency Response, linear freq spacing	LN*, SS
Frequency Response, log freq spacing	LG, SS
Coherence Function (with averaging)	LN*, LG, SS
Impulse Response	LN*
Histogram (chans 1 & 2)	LN*, TC
Probability Density Function (chans 1 & 2)	LN*, TC
Cumulative Density Function (chans 1 & 2)	LN*, TC
Auto Correlation (chans 1 & 2)	LN*, TC
Cross Correlation	LN*

Demodulation is a valid pre-processing function for all starred Linear Resolution (LN*) measurements (when zooming). All Linear Resolution and Log Resolution measurements can be performed on Time Throughput data (with the exception of full span Input Linear Spectrum and Input Time Record).

Is there an easy way to measure functions such as coherent output power or cepstrum?
Yes, with the Auto Math capability (a combination of Auto Sequence programming and Waveform Math). Auto Math lets the user enter math functions which operate on measured data as it is taken. The AUTO MATH softkey in the measurement display menu can be given a user-entered label; the softkey label becomes part of the display trace annotation. Example Auto Math programs for functions such as the two mentioned above are provided in the HP 3562A Operating Manual.

What are the benefits of 801-line frequency resolution?
In general, increasing the lines of resolution tends to decrease actual measurement time. If a particular *frequency resolution* (delta f) is required for a measurement, 801-line resolution means that the test can cover a wider span in the same amount of time when compared to an analyzer with fewer lines. In cases where a particular *span* is needed, 801 lines provide increased resolution, possibly reducing the number of additional zoom measurements required to show closely-spaced details.

What are some typical accuracy specifications for log resolution and swept sine frequency response measurements?
Typical (not specified) accuracy specifications are:

Log Resolution	±0.5 dB, ±3.0 degrees
Swept Sine	±0.1 dB, ±0.5 degree

How is maximum real-time bandwidth achieved?
As is the case with the HP 3561A, maximum real-time bandwidth is achieved with the "fast averaging" function. The display trace is updated when the ensemble is finished; this function can be repeated automatically via Auto Sequence programming. Typical real-time bandwidths with fast averaging are 10 kHz single-channel, 5 kHz dual-channel.

What types of averaging can be selected?
Stable (or mean), exponential, peak hold, and continuous peak averaging functions are user-selectable. Time averaging (or synchronous averaging) can also be activated for use with any of the preceeding functions.

Can the frequency range be extended above 100 kHz?
The internal architecture of the HP 3562A makes it impossible to display frequency information above 100 kHz (the internal workings are not identical to the HP 3561A).

Can the anti-aliasing filters be switched out of the signal path?
No, this capability is not provided.

Can multiple units be triggered simultaneously?
Yes and no. A common trigger signal can be sent to the external trigger input of two or more units; for best results, the external reference input of all units should be connected to the same precision reference signal. [However, at the time of this writing this technique had not been benchmarked and the resulting accuracy is unknown. Performance of simultaneous triggering via HP-IB is uncertain (all units at the same address).]

What does the "Realtime" message mean after a measurement?
If the "Realtime" message is displayed following a measurement, it indicates that the measured data contained no gaps. The analyzer keeps track of this internally within the data gathering and digital filtering assemblies — the analyzer knows when samples are taken and whether or not they are used.

Technical Details

What is Logarithmic Resolution and how does it work?
Log resolution is a measurement technique which uses linear resolution FFT points to create a result similar to a log swept sine test. The benefit: a rapid FFT-based frequency response measurement with resolution distributed proportionally from low to high frequencies.

Depending on the frequency range, linear resolution measurements are taken in parallel at two or three different spans to provide points with two or three different resolution values. These points are recombined (not just reformatted, which is a standard feature of most DSAs) into 80 proportional-bandwidth filters per decade; the center frequency of each filter is spaced *linearly on a logarithmic frequency scale*.

What is a frequency response analyzer and how does it work?
A frequency response analyzer is a network analyzer intended for use at low frequencies (typically from tens of kiloHertz down into the milliHertz range). An important difference between network analyzers and frequency response analyzers is the input filtering for the low frequency range. Network analyzers typically use frequency-domain tracking filters with fixed bandwidth; frequency response analyzers avoid the high cost of narrow bandwidth (<1 Hz) filters by filtering in the time domain via integration.

In a frequency response analyzer, the signal source is typically stepped from the start to stop frequencies. The frequency, and therefore the period, of the signal is known at each step. By integrating the response over the period of the stimulus, spurious, harmonic and noise signals are filtered out of the measurement. The greater the number of periods integrated, the narrower the resulting "filter".

How is demodulation performed: hardware or software?

Demodulation is a preprocessing function which is performed by software on blocks of 4096 sampled time points. Recall that the demodulated power spectrum is one-half the span of the original zoom measurement (the FFT computations are two-sided and require twice as much data); however, by starting with 4096 samples, the resulting half-width span still provides 801-line resolution in the demodulated spectrum.

Are there any major differences between TIME CAPTURE and TIME THRUPUT?

Yes: Time Capture can gather data from *either* of the two input channels (single-channel measurements only) with a maximum real-time bandwidth of 100 kHz. Time Throughput can gather data from *either or both* input channels simultaneously (single- or dual-channel measurements); maximum real-time bandwidth is a function of the attached disc drive (see Documentation/Automation for specifics).

Capacity is also different: Time Capture can store up to 10 time records (2 to 20,480 points); Time Throughput can store up to 32,767 time records *per throughput file* (64 million words or 134 Megabytes; thus, disc capacity will be a limiting factor for throughput).

Throughput data can be analyzed with linear resolution (including demodulation for zoom measurements) and logarithmic resolution measurements. Linear resolution zoom measurements can be performed on any portion of a baseband (zero start) throughput file which is real-time (the number of real-time records is indicated in the throughput header).

Capture data can be analyzed with linear resolution baseband and zoom measurements. Zoom measurements can also be demodulated.

Why are there HALF RANGE and OVER RANGE indicators on the front panel above each input connector?

For optimum performance (best signal-to-noise ratio in the input circuitry) and maximum dynamic range, the input attenuators should be set such that the input signal is greater than half of the input range, but less than full range. Thus, when set properly, the HALF RANGE indicator is bright green and the red OVER RANGE indicator is off.

Electronics

Can the display be calibrated in dBm?

Yes, in the coordinates menu (press the COORD key). After selecting the MAG (dBm) softkey, the impedance can be entered in ohms.

Can dc voltage be measured accurately?

Not with any confidence. In a complex-valued FFT computation, the real and imaginary parts both contribute to the dc (or 0 Hz) component. Also, input-circuit offsets and drifts (which vary with temperature and attenuator settings) contribute a varying dc component to the displayed response.

Can suppressed carrier signals be demodulated? Pulsed signals?

Suppressed carrier signals cannot be measured directly; however, if the carrier is added back in (perhaps using the built-in fixed sine source and an external combiner), the resulting signal could be demodulated.

Is the built-in source HP-IB programmable?

Yes: source type, frequency (for the sine wave signals), burst length (for burst random and burst chirp), ac output level, and dc-offset level are all HP-IB programmable.

Servo Control Systems

What is a Frequency Response Analyzer?

This special type of low frequency network analyzer is described fully in the Technical Details section, above.

Can the signal source be floated?

The source cannot be floated above ground potential; however, an external isolation transformer can be connected to the source output in cases requiring a floating source.

How long does a typical curve fit take?

A typical 10-pole/10-zero curve fit can be completed in less than 60 seconds with a user-selected system order. A complete 40-pole/40-zero curve fit (again, with user-selected order) can typically be generated and tabulated in less than 8 minutes.

Mechanical Analysis

Why two input channels instead of four?
In the case of the HP 3562A, most of the major application areas require only two input channels to perform most measurements. The added cost (and increased price) of two additional high performance inputs would have adversely effected the price and performance value for users not requiring four channels.

Can two or more units be linked together as master and slave?
This capability is not available for the HP 3562A.

Why isn't modal analysis built-in?
As was mentioned above regarding two versus four channels, the increase in price could not be justified for the majority of users.

Why was ICP (integrated circuit piezoelectric) power not included on each input channel?
In the development of the analyzer, it was learned that a greater measurement contribution could be made for a majority of the users by providing truly differential inputs. The differential input circuitry in the HP 3562A is not compatible with a built-in ICP current supply.

Who are some recommended transducer/charge amplifier manufacturers and suppliers?
Until these accessories are available from the "instrument store," direct contact with the following manufacturers is recommended:

PCB Piezotronics
3425 Walden Ave
Depew, NY 14043
(716) 684-0001

Kistler
John Glenn Drive
Amherst, NY 14120
(716) 691-5100

Bently-Nevada
P.O. Box 157
Minden, NV 89423
(702) 782-3611

Endevco
Rancho Viejo Road
San Juan Capistrano, CA 92675
(714) 493-8181

Why was the magnitude map display not included?
Map-type displays require a large amount of internal memory (particularly with 801 frequency lines per spectrum) which requires additional space and adds cost. The analyzer also uses a vector display which is excellent for one or two data traces, but not for high quality multiple-trace maps such as those made by the HP 3561A (which uses a high resolution raster display).

Is the EXTERNAL TRIGGER input level user selectable? How about EXTERNAL SAMPLE?
External trigger level *is* user selectable from −10 to +10 volts peak in 80 mV steps. The external sample input is TTL-compatible only.

What is RNG UP autoranging?
Range up or up-only autoranging is very useful when performing impact testing of structures. The input channel ADCs will only be ranged upward (when the hammer is striking the object) and will hold that level; the autoranging will *not* attempt to change to a lower level when the signal level is low (the quiescent non-striking output level of the hammer transducer).

Acoustics

Why were 1/3, 1/1, or 1/N octave analysis capabilities not included in the analyzer?
The HP 3561A includes both 1/3 and 1/1 octave measurement capabilities, where the HP 3562A contains contributions such as log resolution, swept sine, and disc throughput. As part of our development of a family of DSA products, it was decided to include complementary capabilities which will help us address a wider range of applications and user needs.

A computer-based solution is available for HP 3562A users who need ⅓ octave measurements. A listing for this program (which uses log resolution data to speed up the process) is provided in the HP 3562A programming manual.

Will the logarithmic resolution mode work with transient data?
Because the log resolution computation is a parallel measurement of two or three time record lengths, transient data is not compatible with this technique. As shown in the figure below, this is due to the fact that a single trigger point does not exist.

Time records through two paths in the digital filter for a single channel would occur as shown below:

Path 1	T.rec 1			T.rec 2
Path 2	T.rec 1'	T.rec 2'. . .	T.rec 10'	T.rec 11'

As you can see, it would not be possible to select a "correct" trigger point for a transient-type signal.

Can the source generate periodic random noise or impulse signals?
Periodic random noise is not available with the HP 3562A. Periodic sine chirp signals were included instead due to the improved peak-to-rms ratio and the resulting improvement when fast characterization of nonlinearities is required.

Impulsive signals can be generated using the burst sine chirp or burst random noise signals. Burst length is selected as a percentage of the time record length. Percentage is user selectable from 1 to 99 in increments of 1.

Analysis Questions

Is Waveform Math in the HP 3562A the same as Trace Math in the HP 3561A?
No. Waveform Math operates on the complex-valued measurement data block; Trace Math in the HP 3561A only manipulates data in the display buffer. Thus, in the HP 3562A a computation of open-loop response from a closed-loop measurement will yield *both* magnitude and phase information from a single computation (Trace Math requires one computation for magnitude and another for phase).

Can Waveform Math combine a linear resolution frequency response measurement (linear res or swept sine) with a log resolution frequency response measurement (log res or swept sine)?
Yes, but the curve fitter and frequency response synthesis must be used as an intermediate step. One of the two measurements must be curve fit and the results transferred to the synthesis table. The response must then be synthesized over an identical frequency span with linear or log resolution (whichever is required); the two responses can then be combined.

Can a forward FFT be performed on an arbitrary sized time block? Does an inverse FFT use a full data block?
Forward FFT operations can only be performed on 2048-point time records. Inverse FFT calculations do not use a full data block—missing values are zero-padded in the computation.

What is a curve fitter? Why is the HP 3562A curve fitter so special?
A curve fitter is a mathematical algorithm which computes the roots (poles and zeroes, frequency and damping values) from a measured frequency response. The results are complex-valued numbers which are typically displayed in a tabular format. In general, two types of curve fitters are in use: single degree of freedom (SDOF) which fit one resonance at a time, and multiple degree of freedom (MDOF) which fit one or more resonances at a time.

The HP 3562A curve fitter is an MDOF algorithm which can fit as many as 40 poles (resonances) and 40 zeroes (anti-resonances) simultaneously—**original frequency response data can be linear resolution, log resolution, linear sine sweep or log sine sweep**. Other noteworthy capabilites include: user-selected or automatic selection of the system order (total number of poles and zeroes); the use of a weighting function (based on the coherence function) to enhance accuracy when fitting a typical noisy measurement.

How quickly can the curve fitter solve and tabulate a response?
Recent benchmarks show that the curve fit for a 10-pole/10-zero system can be computed and displayed in less than 60 seconds with user-order activated. [Results are typically faster with user-order because a bounded problem is easier to solve than an unbounded one.]

How well does the HP 3562A curve fitter work with structural dynamics measurements?
Very well. However, the user must pay close attention to the tabulated results when zooming with very high resolution, or when the zoom span is distant from dc. Symmetry assumptions in the algorithm tend to create out-of-band poles to achieve a good fit: the in-band computed results will tend to be accurate but the out of band components may not actually exist.

A more fundamental requirement is "good measurements", or measurements with adequate resolution. Under-resolved resonances and anti-resonances typically appear as narrow spikes and will be treated as noise rather than part of the response.

If a user wants to predict the effect of compensation on a system, can a synthesized frequency response be added to a measured frequency response?
Yes. Frequency responses can be synthesized with linear or logarithmic resolution over any linear resolution, log resolution, or swept sine frequency span. As long as the measurement and synthesis frequency parameters (center, span; linear, log resolution) are identical, measured and synthesized responses can be combined for prediction and analysis.

Documentation and Automation

General Questions

Which peripherals are supported with the HP 3562A?
All HP-GL plotters (including the large format 758Xs), the 794X series of Command Set/80 (CS/80) disc drives, the 9122D/S and 9133D Sub Set/80 (SS/80) disc drives, and the 91XX series of "Amigo" protocol disc drives are supported by the HP 3562A on the HP-IB. The HP 9144 tape drive is also supported.

What are some typical HP-IB data transfer rates?
The transfer rate is 60 Kbytes/second. Data can be transferred to a controller in three formats: internal binary, ANSI binary, and ASCII. Internal binary is the fastest because no conversions are performed before the transfer; the other two formats are slower since they are converted from internal binary before the transfer takes place.

Typical *total* transfer time for internal and ANSI binary are approximately: frequency response, 250 msec and 500 msec repectively; power spectrum, 200 msec and 400 msec respectively.

Are outputs for large screen analog displays provided?
Yes, X, Y, and Z outputs are built-in for driving large screen displays such as the HP 1310B, 1311B, 1317B, and 1321B.

Can the display be programmed directly via HP-IB?
Yes. The analyzer uses the HP 1345A vector display unit. Random vector plotting as well as the complete character set can be accessed through the HP 3562A's HP-IB port.

Are user-defined softkey menus possible?
Yes. User SRQ (service request) menus can be created via HP-IB for interactive testing situations. Each key can be given a twelve character label (two lines, six characters per line) to personalize or clarify a particular function.

Mass Storage

What is the internal storage capacity?
The internal battery-backed CMOS memory can store five user-defined setup states, the power-down setup state, five Auto Sequence programs (with a maximum of 50 keystrokes each), and one measurement (the user-defined window function, if used, is stored in this register.)

Why wasn't a disc drive built-in?
Flexibility was a primary concern, followed by space limitations and reliability/durability concerns. By making the disc drive an external option, the user can select a drive with the features and performance to fit the task at hand: a large capacity CS/80 disc drive with tape backup for data throughput applications, or a smaller portable micro floppy for storage of setup states and measurements.

How much information can be stored on a double-sided 3.5″ disc?
The HP 3562A keeps track of disc files in terms of sectors. A single-sided 3.5″ disc is formatted for approximately 1000 sectors; a double-sided 3.5″ disc is formatted for about 2300 sectors. Example file sizes for records created by the HP 3562A are: time record, 33 sectors; frequency response, 28 sectors; power spectrum, 15 sectors; setup state, 3 sectors; Auto Sequence, Auto Math, curve fit tables, and synthesis tables, 4 sectors each. Thus, one double-sided 3.5″ disc can hold about 80 frequency response measurements.

What are some typical real-time bandwidth specs for throughput of data to disc?

	Maximum Real-Time Bandwidth	
Protocol, Model #	Single-channel	Dual-channel
CS/80, 794X series	10 kHz	5 kHz
SS/80, 9122S, D	1.56 kHz	800 Hz
9133D floppy	1.56 kHz	800 Hz
Winch.	2.5 kHz	1.25 kHz
Amigo, 9121S, D	500 Hz	200 Hz
9133V, XV	500 Hz	200 Hz

Why wasn't DMA built into the analyzer?
When the analyzer was originally defined, direct memory access (DMA) was considered as a feature. However, in light of the design goals (such as low cost), the cost in terms of pc-assembly space and device count was unjustifiably high (particularly when the cost of a suitable disc drive was considered—the combination of analyzer and disc was no longer a cost effective solution).

The time throughput capability, when combined with one of the new HP 794X fixed disc drives, is an excellent solution for most applications of the HP 3562A. The most noteworthy exception is audio/acoustics work which could benefit from a 20 kHz real-time bandwidth.

Is a bubble memory mass storage option available?
No, bubble memory is not available for the HP 3562A.

Plotting

Are data-only plots possible for users with pre-printed plotting forms?
Yes! If the markers are active, the marker annotation and values can also be included in the data-only plot.

How long does it take to make a plot?
With either the HP 7470 or 7475 HP-GL plotters, a fully annotated plot takes approximately 80 seconds and a data-only plot takes about 35 seconds.

Can the analyzer control a plotter with a desktop computer on the bus?
Yes, if the controller passes control to the analyzer before plotting begins. An example program which does this is given in the HP 3562A Programming Manual.

Are outputs provided for X-Y recorders? Can a 'scope camera be attached to the display bezel?
X-Y recorder outputs and a camera-compatible display bezel are not provided with the HP 3562A. The low cost and high performance of digital plotters has made them the most widely accepted solution for cost-effective documentation of results.

Ordering Questions

What is the HP 3562S Dynamic Signal Analyzer System?
The HP 3562S includes the HP 3562A and one of several HP disc drives (the HP 3562S Ordering Information Guide provides a detailed list). The system configuration includes compatible (supported) disc drives, ensures coordinated delivery to the customer, and ensures quota credit for the Field Engineer. Accessories listed on the ordering guide other than disc drives are for information purposes only and should be ordered by model or part number.

The HP 3562S is *not* a modal analysis product. For information regarding modal analysis solutions, please refer to your Lake Stevens DSA RSE and the third party program literature.

Are rear panel inputs (RTIP) available as a special option?
Degradation of performance and physical space limitations prevent us from offering this option.

Can the unit be operated from 400 Hz ac line?
Yes, with 115 Vac (+10%, −25%) line voltage.

What is the HP Part Number for the transit case?
Hewlett-Packard Part Number 9211-2663.

Glossary of Common Terms

Accelerometer. An accelerometer is a form of mechanical-to-electrical transducer which is typically mounted on a vibrating object to measure acceleration. Accelerometers are available in a variety of sizes, sensitivities ("volts per g"), and frequency ranges. Some form of signal conditioning or amplifier is required, be it an external charge amp or an ICP (integrated circuit piezoelectric) current supply built into the analyzer. (See also SIGNAL CONDITIONING.)

Acoustic Intensity. A vector quantity which indicates the direction and magnitude of sound propagation at a point in space. It is proportional to the imaginary part of the cross spectrum measurement between two closely spaced microphones in the sound field. Acoustic Intensity can be measured directly with the HP 3562A.

Aliasing. Aliasing is an error that occurs when an A-D converter attempts to digitize a signal that is higher in frequency than ½ the sample rate of the converter. In a spectrum analyzer the result of this would be a false reading. In swept spectrum analyzers the analogous phenomena is called "imaging".

Anti-Alias Filter. A low pass filter which removes frequencies above ½ the sample rate of the A-D converter that could otherwise cause alias or false readings.

Auto-Calibration. A process for removing the systematic errors in an instrument to achieve the highest possible accuracy. In the HP 3562A, this is done by internally switching a known signal through the input, measuring the amplitude and frequency errors, and adjusting subsequent measurements with these factors.

Auto Correlation. A time domain measure of the similarity of a signal and a time-lagged version of itself. The time-lag is not a physical time delay, it is introduced in the mathematical formula for the Auto Correlation. Random noise, for example, correlates perfectly when the time-lag is zero. On the other hand, the Auto Correlation of a sine wave is another sinusoid with the same period. For this reason, the Auto Correlation is often used to extract periodic signals from noise in the time domain when no synchronous trigger is present. Mathematically, Auto Correlation is also the inverse Fourier transform of the Auto Spectrum.

Autoranging. The analyzer automatically selects the optimum input range for the current input signal.

Auto Spectrum (Power Spectrum). A DSA spectrum display whose magnitude represents the power at each frequency, and which has no phase. RMS averaging produces an auto spectrum.

Averaging. In a DSA, digitally averaging several measurements improves accuracy or reduces the level of asynchronous components. Refer to definitions of RMS, time, and peak hold averaging.

Balancing. Rotating machines can be balanced using a Dynamic Signal Analyzer. In the HP 3562A this can be done using triggering or with a technique known as multiplane balancing to find the location of the imbalance forces. Weights are then added 180 degrees away from, or subtracted, at the imbalance point. (This is similar to "computer spin balancing" of automobile tires.)

Band Selectable Analysis. See ZOOM.

Bandwidth. The spacing between frequencies at which a bandpass filter attenuates the signal by 3 dB. In a DSA, measurement bandwidth is equal to (frequency span)/(number of lines) × (window factor). Window factors are : 1 for Uniform, 1.5 for Hanning, and 3.82 for Flat Top.

Baseline Spectrum. A vibration spectrum taken when a machine is in good operating condition; used as a reference for monitoring and analysis.

Block Size. The starting point in FFT analysis is a collection of time samples, called the data block. The size of this block is always a power of 2, typically 2048 samples (the HP 3562A) or 1024 samples (the HP 3561A).

Bode Plot. A log-magnitude amplitude versus log-frequency display typically used to plot the frequency response of a control system. It is useful because each pole or zero of the system causes a 6 dB change in the slope of straight line segments which are used to approximate the actual response. The HP 3562A X-axis cursor (in point or band mode) and the special slope marker can be used to measure slope directly at any region in the response.

Burst Chirp. A periodic fast sine sweep with a sweep time typically less than the time record length (sampling period). By ending the sweep before the end of the time record, a lightly damped response can be forced to decay to zero within the record by adjusting the burst length. In the HP 3562A the burst length is user-definable as a percentage of the time record length. Very useful when testing lightly damped systems; also useful for fast characterization of system linearity.

Campbell Diagram. A mathematically constructed diagram used to check for coincidence of vibration sources (i.e., 1x imbalance, 2x misalignment) with rotor natural resonances. The form of the diagram is a rectangular plot of resonant frequency (y-axis) vs excitation frequency (x-axis). Also known as an interference diagram. (See also Application Note AN243-1 for more detail.)

Cascade Plot. See SPECTRAL MAP.

Charge amplifier. Amplifier used to convert accelerometer output impedance from high to low, making calibration much less dependent on cable capacitance.

Closed-Loop Gain. The frequency response of a control system measured between the control signal input and the system's output. The measurement is made with the feedback elements in place (i.e., loop closed) and the system operating in its normal fashion.

Coherence. A very useful indicator of the quality of a frequency response measurement. Can indicate the relative amount of noise or other non-coherent signals present at the output of the system, but not at the input to the system. In the absence of such signals, the coherence will be unity. Any non-coherent signals will reduce its value below one. In the extreme case where none of the output signal was present at the input, the coherence will be zero. Since coherence is not a quantitative measurement, it must be interpreted with some care. Leakage, non-linear distortion, interfering signals, noise, and a number of other phenomena can all cause poor coherence. In addition to its use as an indicator of measurement quality, the coherence function can be used to compute system signal-to-noise ratio, and as a means of isolating sources sources of noise and interference. (Also called the "gamma squared" function.)

Compensation Network. Circuitry added to a control system to ensure that adequate gain and phase margins will be achieved for stable operation. The Waveform Math and Frequency Response Synthesis functions can be important aids when designing compensation networks and predicting their effect on the control system.

Constant Bandwidth Filter. A band-pass filter whose bandwidth is independent of center frequency. The filters simulated digitally in a DSA are constant bandwidth. (See also LINEAR RESOLUTION.)

Cross Correlation. A two channel measurement of the similarity between the signal on one channel and a time-lagged version of the signal on the other channel. One major application for Cross Correlation is the measurement of time delays in systems—such as a room, a large structure, or between gaps on a tape head. The maximum value of the Cross Correlation function will occur at a time equal to the delay present in the system. Mathematically, the Cross Correlation is also the inverse Fourier Transform of the Cross Spectrum. Therefore, the presence of a time delay can also be seen as a linear ramping of the Cross Spectrum phase.

Cross Spectrum. This two channel measurement is computed by multiplying the Linear Spectrum of Channel 1 by the complex conjugate of the Linear Spectrum on Channel 2. The imaginary part of the cross power spectrum is used to compute ACOUSTIC INTENSITY.

Curve Fitting. A mathematical process used to extract numerical values for resonant frequency, damping (Q), and residue (amplitude) from a frequency response measurement. These values are then used to define the mode shape for modes of vibration or the poles and zeroes for an electronic network. There are a number of curve fitting algorithmns currently in use. Most can be classified as either single or multiple degree of freedom, depending on whether they fit one or many resonances simultaneously. The HP 3562A curve fitter is multiple degree of freedom (40-poles/40-zeroes) and can use the coherence function to weight the frequency response data.

Digital Filter. A digital filter performs filtering operations on sampled (digital) data. In the HP 3562A the digital filter is responsible for performing zoom analysis on the data, and also allows HP to implement alias protection on all spans using only one analog filter. A key advantage of digital filtering is consistent, precisely-matched phase and amplitude performance at all spans.

Discrete Fourier Transform (DFT). A procedure for calculating discrete frequency points (or lines) from a time record. Since the frequency domain result is complex, the number of frequency points is usually ½ the number of points present in the time record.

Displacement Transducer. A transducer whose output is proportional to the distance between it and the measured object (usually the shaft in a rotating machine). This type of transducer typically uses induced currents and inductance or laser-based measuring techniques.

Dynamic Range. The dynamic range figure tells you how far below the input range an analyzer can detect a signal. In the HP 3562A this is 80 dB.

Dynamic Signal Analyzer (DSA). Spectrum/network analyzer that uses digital signal processing and the Fast Fourier Transform to convert sampled time points into frequency domain components. DSAs can display results as time, frequency (including phase spectrum) and amplitude (histogram, PSD) functions. Most DSAs are also directly programmable with desktop computers for automated or advanced applications.

Engineering Units. In many vibration, rotating machinery, and acoustic applications the user would like to see results in units such as "mils", "inches per second", and "g's". Engineering units capability allows the analyzer display to be calibrated and labelled with these units; the marker may also read out in such units.

External Sample. A technique frequently used in the study of rotating machinery where the internal sample clock is replaced by a signal derived from a tachometer attached to the machine being analyzed. Since the sample rate is actually varying with the speed of the machine, the vibration spectrum appears stationary — even as the machine changes speed (see "ORDERS"). This makes it easy to study vibration levels over wide RPM ranges.

Fast Fourier Transform (FFT). The FFT is the algorithm used by Dynamic Signal Analyzers to convert time domain information (the time record) into frequency domain information. Given 2048 time points, the FFT returns 1024 pairs of amplitude and phase points. In DSA's only the first 800 pairs are used since the rest may contain slight alias errors. These 800 pairs thus correspond to the 800 "lines" available in the HP 3562A. [The data sheet correctly states that the analyzer has 801 lines of resolution: the extra line is the inaccurate dc component in a baseband measurement, but a valid data point in a set-start or set-center zoom measurement.]

Finite Element Modeling. A computer-aided design technique for predicting a structure's dynamic behavior prior to actually building and testing it. These programs provide a choice of simple structural elements such as plates, triangles, spheres and cylinders which the user combines to define the structure. The mechanical properties of each element are defined and combined with boundary conditions to determine the structure's behavior. A number of finite element programs exist, of which one of the best known is NASTRAN. Most of these programs must run on large computers because of the large amount of data which must be computed, but at least two finite element programs are available for HP desktop and mini-computers. Finite element modeling and modal analysis are complementary techniques. In fact, a major application for modal analysis is verifying the accuracy of finite element models.

Flat Top Window. DSA window function which provides the best amplitude accuracy for measuring discrete frequency components. In the HP 3562A, flat top window accuracy is +0, -0.01 dB.

Frequency Response. The measurement traditionally associated with network analyzers. It is the ratio of the system's output spectrum to its input spectrum. It includes both magnitude ratio and phase difference information. In most DSAs it is calculated as the ratio of the CROSS SPECTRUM to the input AUTO SPECTRUM. This approach has two advantages: it provides the qualitative COHERENCE function, and does not require a trigger signal for averaging (which is required for the coherence function). This approach provides excellent rejection of non-coherent signals which may be present in the test system (conventional swept Network Analyzers are not capable of this discrimination).

Frequency Response Analyzer. A special class of low frequency swept sine-based network analyzer commonly used in servo system testing. Uses time domain integration rather than expensive narrow bandwidth (<1 Hz) tracking filters. The signal generator is typically stepped from frequency to frequency; the period of the discrete signal is used as the integration period to filter out other frequencies; a single point DFT is computed at each measurement point. Results are typically displayed on an alphanumeric readout or X-Y recorder; in the HP 3562A results are shown as a constantly updated data trace with numeric readout at the sweep frequency.

Gain and Phase Margins. Measures of the degree of stability in a control system. Adequate margins are required to ensure stability even as components age and temperatures drift. These margins can be read directly from a Bode plot of the open-loop frequency response.

Hanning Window. Hanning is a window function (also called "passband" in the HP 3582A) that is used in general purpose noise and vibration measurements. It provides optimum frequency resolution while trading off amplitude accuracy. It should not be used when optimum amplitude accuracy is desired since the window amplitude accuracy is +0, -1.5 dB (see FLAT TOP WINDOW).

Imbalance. Unequal radial weight distribution on a shaft or rotor; a shaft condition such that the mass and shaft geometric centerlines do not coincide.

Impact Testing. A popular test technique used mainly with mechanical structures. The object is hit with an instrumented hammer to provide a "known" force input to generate a frequency response measurement (the input force is measured by a transducer mounted on the hammer). The response of the structure is measured at a desired point with an accelerometer or other suitable pickup. The popularity of impact testing stems from its relative speed, low cost, and little need for specialized accessories.

Impedance, Mechanical. The mechanical properties of a machine system (mass, stiffness, damping) that determine the response to periodic forcing functions.

Impulse Response. The impulse response is the time domain response of a network or device due to an ideal impulse function input. The impulse response is a Fourier transform pair with the frequency response function. Thus, if the impulse response is Fourier transformed, the result is the frequency response; if the frequency response is inverse-Fourier transformed, the result is the impulse response.

Keyphasor. A signal used in rotating machinery measurements, generated by a transducer observing a one-per-revolution event. The keyphasor signal is used in phase measurements for analysis and balancing. (Keyphasor is a Bently Nevada trade name.)

Leakage. This is a term that describes the result of having a finite time record length and appears as a "smearing" of frequency content in the displayed signal. Leakage errors degrade the accuracy of a DSA. To reduce these errors, window functions are applied to the time record (the sampled time data). A good analogy for the effects of leakage is what is seen in a swept spectrum analyzer when you sweep too fast. This topic is covered in more detail in AN243.

Linearity. The response of a linear system remains constant with input level. That is, if the response to input "a" is A, and the response to input "b" is B, the response of a linear system to input (a + b) will be (A + B). Most real-world systems are non-linear, but have a linear operating region which does, in fact, display this type of behavior. An example of a non-linear system is one whose response is limited by a mechanical stop, such as occurs when a bearing mount is loose.

Lines. Common term used to describe the filters of a DSA (e.g., "801-line analyzer").

Linear Averaging. See TIME AVERAGING.

Linear Resolution. The measurement technique common to all fast Fourier transform-based analyzers. A finite-sized block of time samples is transformed into a block of frequency domain points which are spaced apart linearly; the resulting filter bandwidths are constant across the measurement span. Can also be accomplished with a linear sweep swept sine test. (Compare with LOGARITHMIC RESOLUTION).

Linear Spectrum. The Fourier transform of a time record.

Lines of Resolution. The number of lines of resolution provided by a DSA refers to the number of discrete data elements, points or bins in the frequency domain which result from performing an FFT on a time record. The maximum number of lines available is equal to ½ the number of points in the time record. In the HP 3582A, 5420B, and 5423A the number of lines displayed is 256. In the HP 3561A 400 lines are available, and in the HP 3562A 801 lines are available.

Logarithmic Resolution. A measurement which provides frequency-proportional resolution. Filter bandwidths are frequency proportional; filter center frequencies are spaced apart linearly on a logarithmic frequency axis. Can be accomplished with a log sweep swept sine test, or with the log resolution mode in the HP 3562A. (Compare with LINEAR RESOLUTION.)

Modal Analysis. The process of breaking down the total vibration of a structure into its component parts. Just as spectrum analysis allows us to separate and display the frequency components of a time waveform, modal analysis breaks down a complex vibration into its components (or modes) and displays the vibration shapes of each one separately. More information and examples can be found in AN243.

Mode Shape. This term is used to describe the structure's deformation patterns for each mode. Most modal analyzers provide an animated display of the mode shape to aid the user in visualizing the structure's behavior and identifying areas of excessive deflection and stress which could lead to potential problems, such as early fatigue and breakage. The mode shape data is also usually available in tabular form for input to computer-aided design programs which allow the user to predict the effect of proposed design changes without having to implement the change and re-test the item. These programs are commonly referred to as "Structural Modification".

Mooz. This term, coined by HP, is not in general usage even though a number of manufacturers provide the capability. Mooz (zoom spelled backwards) refers to the process of band-limiting the noise source signal so that most of the output energy is concentrated in the analysis frequency range. This improves signal-to-noise ratio, ensures that out-of-band resonances are not excited, and produces more accurate results when measuring non-linear devices.

Natural Frequency. The frequency of free vibration of a system. The frequency at which an undamped system with a single degree of freedom will oscillate upon momentary displacement from its rest position.

Nyquist Criterion. Requirement that a sampled system sample at a frequency greater than twice the highest frequency to be measured.

Nyquist Plot. A real versus imaginary display of the control system's frequency response. It is useful because the Nyquist Stability Criterion is often stated in terms of the open-loop behavior in the real/imaginary plane.

Nyquist Stability Criterion. In servo control system analysis, the point (−1,0) on a Nyquist plot is a critical part of the system response. The Nyquist stability criterion states that a feedback system is stable if and only if the plotted response does not encircle the (−1,0) point when there are no poles present in the right-hand s-plane. If poles exist in the right-hand s-plane, the system is stable if and only if the number of counterclockwise enciclements of (−1,0) is equal to the number of poles with positive real parts.

Octave. The interval between two frequencies with a ratio of 2:1.

Open-Loop Gain. The frequency response of a control system measured with the feedback elements disconnected (i.e., open-loop). The open-loop gain is important because it provides a means of evaluating the stability of the system. It is typically a difficult measurement to make directly because the open-loop gain is usually very high and many systems will not operate with the loop open. However, a great benefit of the Waveform Math capability in the HP 3562A and 5423A is the ability to compute this result mathematically from a closed-loop measurement. It can also be computed using an external calculator with the HP 3582A.

Orbit. The path of the shaft centerline motion during rotation. The orbit is observed with an oscilloscope connected to X- and Y-axis displacement transducers. Some dual-channel DSAs such as the HP 3562A have the ability to display orbits.

Orders. Similar to harmonics, but applies to peaks in the vibration spectrum of a rotating machine. Major vibration components occur at frequencies corresponding to the speed of rotation and integer multiples. These are called "orders." For example, the 10th order of a machine rotating at 600 RPM is 10 × 600 RPM = 6000 RPM. Frequency spectra referenced to an external sampling signal are displayed in orders of revolution.

⅓ Octave. A measurement made with resolution that varies proportionally across the frequency range being analyzed. Each measurement point or bin is ⅓ octave wide. This technique provides more frequency resolution at the low end of the frequency scale, and less at the high end. One-third octave analysis was originally used because it was easy to build spectrum analyzers which were a collection of parallel filters spaced at ⅓ octave intervals. In fact, some of the first spectrum analyzers were built this way. One benefit of ⅓ octave analysis is that it can reduce a complex spectrum into a few frequency bands in "real time." Hence, if you are just trying to get a feel for the shape of a noisy spectrum, ⅓ octave analysis is ideal (many noise regulations specify the use of ⅓ octave analyzers). A second benefit is that human hearing and mechanical vibration are both proportional bandwidth in nature, and can be analyzed using this technique.

Peak Hold. In a DSA, a type of averaging that holds the peak signal level for each frequency component.

Periodic Noise (also called pseudo-random noise). A type of noise which is random from sample to sample within the time record, but which repeats exactly from record to record. Thus, it appears "periodic" to the analyzer. Periodic noise is useful because it requires no windowing or averaging to obtain good results. However, it does not work well as a stimulus for non-linear devices (for non-linear devices, random noise with averaging is best).

Power Spectrum. The power spectrum is available by multiplying the linear spectrum by it's conjugate. Hence it is phaseless. It is used primarily in two channel analysis. (Also called the Auto Spectrum.)

Pre/Post Trigger Delay. Post trigger delay refers to starting data sampling after the trigger signal has been received. It is used when the data to be analyzed has a delay relative to the trigger it is synchronized to (for example, a delay caused by propogation time of an acoustic signal through the air). Pre-trigger delay is used in transient analysis to capture the beginning of a transient event by sampling before the trigger occured.

Random Noise Generator. A signal generator designed to produce random noise. It is most often used as a test stimulus for making frequency response measurements with a DSA. Because it contains energy at all frequencies (i.e., broadband), random noise is well suited to the parallel detection nature of a DSA. Pure random noise is particularly useful when non-linearities are present because, with sufficient averaging, the distortion products will average out. A slight disadvantage of pure random noise, however, is that many averages may be required to reduce variance in the measurement.

Real Time Analyzer. See DYNAMIC SIGNAL ANALYZER

Real Time Bandwidth. The real-time bandwidth of a DSA is the maximum span or bandwidth at which the analyzer can be operated and still be sampling data continuously. When the time record length becomes equal to the time it takes to compute the FFT, the analyzer has reached its real time rate. At spans higher than this the analyzer is sampling data, pausing to wait for the FFT to finish, and so on. Real time rate is usually of concern to those who cannot afford to miss any data (e.g., acoustic applications).

Rectangular Window. See UNIFORM WINDOW.

Root Mean Square (RMS). Square root of the sum of a set of squared instantaneous values. DSAs can perform RMS averaging digitally to reduce the variance on noisy measurements. Also called STABLE averaging.

RPM Spectral Map. A spectral map is a 3D-like display that shows many spectra stacked on top of each other. This provides a means for viewing a large amount of data at one time. The RPM map plots these spectra as frequency vs amplitude vs RPM (RPM is the variable on the vanishing point axis). This is useful in machinery run-up and coast-down analysis when trying to find operating speeds that excite resonances in the machine (or its mount) to dangerous levels. A spectral map can also be used to study how electronic circuits change with time, temperature, etc., or to examine speech signals.

Sampling. The process by which an analog signal is converted to a series of digital numbers that represent its amplitude as a function of time. In a DSA, samples are normally spaced at equal intervals of time. Other instruments that operate by sampling data include digital scopes and waveform recorders.

Shaker Testing. Another common means of providing a force stimulus to a mechanical structure. The shaker is usually excited with random noise or a swept sine signal which is converted into a force using hydraulic or electro-dynamic techniques. Electro-dynamic shakers operate very much like loudspeakers and come in a variety of sizes—from small enough to hold in your hand to large enough to fill a room. Shaker testing has advantages over impact testing in that a variety of stimulus signals (e.g., burst random, swept sine) can be used to obtain superior measurement results—especially with zoom measurements. However, the equipment required is often expensive and difficult to set up.

Signal Conditioner. A device placed between a signal source and a readout instrument to change the condition of the signal. Examples: attenuators, pre-amplifiers, charge amplifiers.

Signature and Signature Analysis. Signature is a term usually applied to the measured vibration frequency spectrum associated with a specific machine or component, system or subsystem, at a particular point in time, under known machine operating conditions, etc. Signature analysis is the process of periodically remeasuring the vibration spectrum and comparing with previously measured signature (historical data).

Sine Chirp. A band-limited, band-translated (for zoom measurements) sine sweep with a sweep time equal to the time record length. Start and stop frequencies are automatically set to match the measurement span values. When synchronized with the time record, no windowing is required for this signal. Useful for fast characterizations of nonlinear systems and for real-time network analysis of tunable filters.

Step Response. The time domain response of a control system to a step input. It provides a measure of the transient performance of the system. Using Waveform Math, it is easy to calibrate the step response in percent to facilitate direct reading of rise time and overshoot.

Time Averaging. In a DSA, averaging of time records that results in reduction of asynchronous components.

Time Record. A record of sampled time domain data. It is most often used for transient capture measurements and for extracting signals from noise by means of synchronous averaging. The term "synchronous averaging" refers to the technique of externally triggering a DSA with a signal related to the data being analyzed. For example, if a signal with the same frequency as the trigger is present in noisy data, it will average to its mean value. Noise, which is not synchronous with the trigger, will average to zero. In this way, the synchronous signal will average out of the noise. Note, however, that this is not possible without a synchronous trigger signal.

Trace Math. Trace math is a function in the HP 3561A which is used like a handheld calculator to operate on displayed frequency spectra. Operations are performed on the trace data, not the actual real- or complex-valued measurement data. Common operations include +, −, ×, /, integrate and differentiate.

Tracking Filter. A low-pass or band-pass filter which automatically tracks the input signal. A tracking filter is usually required for aliasing protection when data sampling is controlled externally.

Transfer Function. See FREQUENCY RESPONSE.

Uniform Window. In a DSA, a window function with uniform weighting across the time record. This window does not protect against leakage, and should be used only with transient signals contained completely within the time record, or with self-windowing signals such as sine chirps, burst chirps, and burst random noise.

Waterfall Plot. See RPM SPECTRAL MAP

Window. A time domain weighting applied to a time record to reduce leakage errors. In the frequency domain the window function is analogous to the bandpass filter through which we would analyze a signal with a swept analyzer. Just as the swept analyzer provides a choice of filters for various purposes, DSAs provide a choice of window functions to suit different analysis needs. The five major windows (or passband shapes) available on HP DSAs are:

Flat Top (or Sinusoidal)—trades off frequency resolution for best amplitude accuracy (+0, −0.01 dB)

Hanning (or Random)—trades off amplitude accuracy (+0, −1.5 dB) for best frequency resolution.

Uniform (or Transient)—used with transient signals that decay to zero by the end of the time record. Also used with self-windowing source functions such as sine chirps and periodic noise since the signal is periodic in the time record.

Exponential—used with transient signals (typically during impact testing) that do not decay to zero by the end of the time record.

Force—used during impact testing to eliminate extraneous noise from the time record (a special case of the uniform window).

Zoom. Normally, the FFT gives results only from dc to some maximum frequency. Using zoom (also called Band Selectable Analysis), a segment of the spectrum beginning at an arbitrary frequency can be analyzed in detail: all of the available lines of resolution are concentrated into a specified frequency band. Zoom is similar to setting the scan of a swept analyzer to a particular center frequency.