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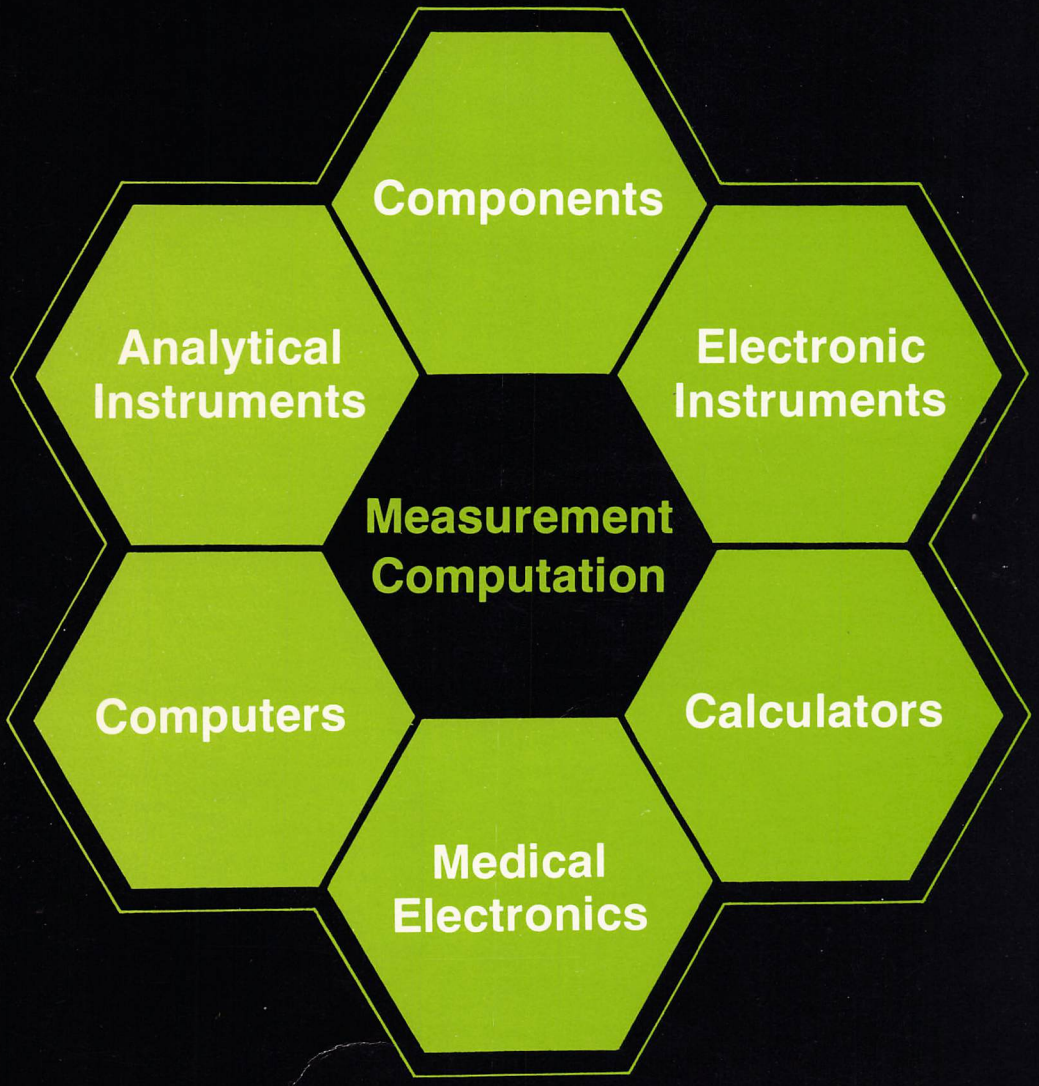

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100

200

300

400

500

600

700

800

900

1000

1000 (Cont'd.)

2000

3000

4000

5000

5000 (Cont'd.)

6000

7000

8000

8000 (Cont'd.)

9000

10000

10,000 (Cont'd.)

11000

12000

14000

15000 AND ABOVE

Model No. **AN No.**

ALPHANUMERIC

ABSTRACTS—ELECTRONIC INSTRUMENTS

52-1 FUNDAMENTALS OF TIME AND FREQUENCY STANDARDS

Provides a basic introduction to the principles of precision time and frequency standards. Types of standards discussed include cesium beam frequency standards, rubidium vapor frequency standards, and quartz oscillators. Appendices provide detailed information on definitions of time, on international standards of time and frequency, and on worldwide broadcasts of time and frequency.

52-2 TIMEKEEPING AND FREQUENCY CALIBRATION

Use of precise frequency standards as clocks, effects of frequency calibration on time, sources of errors, and compensation for these errors. Methods of frequency standard comparison are discussed. Time and frequency transfer techniques are described and evaluated.

57 NOISE FIGURE PRIMER

Detection-system sensitivity depends upon noise present with the signal and noise contributed by the system. This booklet defines noise figure, and illustrates its use in minimizing system-contributed noise.

63E MODERN EMI MEASUREMENTS

Surveys electromagnetic compatibility problem, and discusses how to use the HP Spectrum Analyzer for EMI measurements, particularly those discussed in DOD Standards MIL-STD-826A, -461, -463. Includes examples of typical EMI measurements using the 852A/8551B and 141S/8553L/8552A Spectrum Analyzers.

63E-1 QUASI-PEAK MEASUREMENTS USING A SPECTRUM ANALYZER

Gives a technique for converting spectrum analyzer readings to the quasi-peak values required for compliance with EMI specifications based on CISPR recommendations. (Supplement to AN63E)

64-1 FUNDAMENTALS OF RF AND MICROWAVE POWER MEASUREMENT

Describe the general principles of power measurement including basic standards and traceability. Explores in detail the three most popular power sensors; thermocouples, thermistors, and diodes. Provides a comprehensive error analysis with particular emphasis on mismatch error. Compares advantages and disadvantages of the methods mentioned as related to various applications. Also treats pulse power measurement.

64-2 EXPANDED APPLICATIONS OF AUTOMATIC POWER METERS

NEW

Describes a microwave mini-system for comparing calibration factor of power sensors against a sensor which has NBS traceability. Also discusses use of the system for accurate measurement of attenuation. Includes theory, error analysis, annotated program listings, and step-by-step procedures. Covers software routines for the HP 9825 and 9830 desktop computers and the HP 1000 distributed computers.

70 PRECISE DC MEASUREMENTS

Presents the fundamental techniques for precise DC measurements, the instruments available for such measurements, methods of precision measurements, and some common problems.

77-1 TRANSISTOR PARAMETER MEASUREMENTS

Details techniques for using the 8405A Vector Voltmeter for measuring "s" (scattering) parameters of transistors above MHz where h and y parameters are difficult to measure. Describes measurement systems and use of "s" parameters in design. Includes an appendix which converts "s" parameters to h, y, and z parameters.

77-3 COMPLEX IMPEDANCE MEASUREMENTS

Presents techniques for accurate determination of the magnitude and phase angle of impedance through use of the HP 8405A Vector Voltmeter. One of the techniques discussed involves use of precision wideband, high-directivity directional couplers to measure reflection coefficient. Another reflection method employs an accurate power splitter and precision terminations. Offers practical measurement examples and discusses accuracy considerations.

77-4 SWEPT-FREQUENCY GROUP DELAY MEASUREMENTS

Distortion results when phase shift through a device is a nonlinear function of frequency. Convenient indication of nonlinear phase shift is group delay. This booklet discusses group delay measurements in the 1 MHz to 18 GHz frequency range. Test setups are described, including step-by-step instructions for making the measurements with the 8405A Vector Voltmeter.

86 USING THE VECTOR IMPEDANCE METERS

Useful information on making impedance measurements with the 4800A and 4815A Vector Impedance Meters (5Hz-108MHz). Includes information on evaluation of components, transmission line measurements, transformer measurements, measurements on devices biased with dc, measurements in the presence of noise or external ac, in circuit measurements, plotting of impedance on an x-y recorder, general data on impedance and Q, transmission line equations, how to use the vector impedance calculator.

89 MAGNETIC TAPE RECORDING HANDBOOK

For people concerned with operation and maintenance of analog tape recorders who want a better understanding of the theories and techniques of magnetic recording. Practical considerations are offered relating to the application and limitations of the direct and FM recording processes.

91 HOW VECTOR MEASUREMENTS EXPAND DESIGN CAPABILITIES—1 to 1,000 MHz

Many voltage, or amplitude, ratio measurements are in reality vector quantities. That is, they have both magnitude and phase angle associated with the measurements. These vector measurements can speed up engineering design efforts by providing useful phase information that is normally inconvenient to measure. This note describes just a few of the many ways to effectively use a vector voltmeter that operates over a 1 to 1,000 MHz frequency band. Subjects covered are:

- Measuring the phase and gain margins of amplifiers.
- Transmission line electrical length measurements.
- Accurate matching of the electrical length of cables.
- Measuring group delay or phase nonlinearites.
- Determining resonant frequencies with high resolution.
- Using the vector voltmeter as an automatically-tuned selective analyzer.
- Making amplitude modulation measurements easily from 1 to 1,000 MHz with the vector voltmeter.

95-1 S-PARAMETER TECHNIQUES FOR FASTER, MORE ACCURATE NETWORK DESIGN

Describes s-parameters, their measurement, and their use in circuit design. Also relates s-parameters to other familiar concepts, including h, y, and z parameters.

114 A2A VIDEO TRANSMISSION SYSTEM ALIGNMENT

Equalizer alignment of local video loops has previously been a complicated procedure requiring considerable time, effort, and bulky equipment. Classical test equipment used and the sending end for setting the receive equalizer consists of four instruments costing approximately $5000, weighing 100 lbs., and requiring time-consuming adjustments and switching. The note discusses use of the 653A Test Oscillator which replaces these four instruments in a compact 21-lb. package at about 20% of the cost.

115 PRINCIPLES OF CATHODE-RAY TUBES, PHOSPHORS, AND HIGH-SPEED OSCILLOGRAPHY

Describes basic CRT operation and construction; includes discussions about beam deflection and focus, acceleration techniques, external and internal graticules, and contrast filters. The phosphor selection section includes spectral output and persistence charts, a color chromaticity chart, and a discussion about resolution and brightness with typical phosphor uses.

Background information about high-speed oscilloscope photographic techniques is also included. As an aid to determining writing speed, two nomograms are supplied for determining writing speed using single-shot damped or undamped sine waves or single-shot pulse techniques.

Operation of HP's mesh-type storage tube is also explained. This includes construction; storage, variable persistence, and conventional modes of operation; and erase operation.

117-1 MICROWAVE NETWORK ANALYZER APPLICATIONS

Discusses the basic theoretical concepts of microwave measurements, and presents a complete description of the Model 8410 Network Analyzer System.

117-2 STRIPLINE COMPONENT MEASUREMENTS WITH THE 8410A NETWORK ANALYZER

Describes how stripline components may be characterized in terms of s-parameters over the frequency range from 0.5 to 12.4 GHz. Discusses the setting of dc bias and RF signal levels and describes how the 11608A Transistor Fixture can be configured to accept different types of stripline components.

121-1 NETWORK ANALYSIS WITH THE HP 8407A 0.1-110 MHz

Describes many of the applications of the 8407A Network Analyzer, which characterizes the transmission and reflection properties of filters, amplifiers, antennas, and other RF networks from 0.1 to 110 MHz — on a swept-frequency basis. Shows the setup, techniques, and accuracy calculation for making Bode plots of magnitude and phase, Smith chart plots of magnitude and phase, Smith chart plots of impedance, and polar displays of complex reflection coefficient. It also discusses the basic theory of operation of the 8407A and answers typical questions, such as measurement accuracy for various types of applications.

121-2 SWEPT IMPEDANCE WITH THE 8407A NETWORK ANALYZER 0.1-110 MHz

Explains the use of the 8407A Network Analyzer to make swept impedance measurements from $<1\,\Omega$ to 10K Ω. Magnitude and phase of impedance may be displayed either as $R \pm jX$ or $Z\angle\theta$ as a function

121-2 (Cont'd.)
of frequency. Applications include antenna design and testing magnetic recording, head characterization, and a variety of common design applications such as amplifiers, filters, mixers, integrated circuits, and transmission lines.

123 FLOATING MEASUREMENTS AND GUARDING
Guarded instruments will solve most common-mode problems if the guard terminal is connected properly. This application note explains the advantages of the guard in floating measurements and how to make the proper guard connections. It also tells what causes common-mode voltages and how guarding increases the accuracy of floating measurements.

124 TRUE RMS MEASUREMENTS
Advantages of true RMS measurements are discussed in detail. This application note explains how the true-RMS-responding technique accurately measures sine waves with distortion as well as other ac voltages such as square waves, pulse trains, and signals with noise. Graphs show the effects of harmonic distortion on average-responding meters. By using dc coupling into the true RMS converter, it is possible to accurately measure a dc voltage plus an ac voltage. Crest factor and measuring speed are also discussed.

126 THEORY AND APPLICATIONS OF WAVE ANALYZERS
This application note is intended to aid those who must measure electrical signals that range widely in level and frequency. These signals can be individually measured in the presence of other signals by using a 3590A Wave Analyzer. A discussion of wave analysis vs. spectrum analysis explains the differences and advantages of each technique. A chapter on Applications and a chapter of Questions and Answers make this note very practical.

128 APPLICATIONS OF A DC CONSTANT CURRENT SOURCE
Describes applications of the 6177B, 6181B, and 6186B DC Constant Current Sources. The applications are divided into three groups: resistance measurements, semi-conductor device measurements and related applications, and component testing. Typical applications include the measurement of silicon wafer resistivity, contact resistance, temperature, diode temperature coefficient and reverse breakdown voltage, transistor junction breakdown voltages and h-parameters, zener diode dynamic impedance, magnetic field intensity, capacitance, and potentiometer running resistance. Each application is well illustrated and includes all the details necessary for the reader to immediately perform the test or measurement. The introduction discusses the desirable features of a constant current source.

134 AUDIO FREQUENCY MEASUREMENTS WITH THE 8556A-8552B SPECTRUM ANALYZER
Describes how to measure amplifier distortion, EMI, and oscillator distortion with the 8556A Spectrum Analyzer LF section, 20 Hz to 300 kHz. Setup and operation procedures are followed by examples of measuring harmonic distortion, measuring voltage and hum modulation, testing amplifiers and viewing resolution spectra.

135-16 MINICOMPUTER SYSTEMS AID MILITARY VEHICLE TESTING
Comprehensive testing of engines and transmissions for military vehicles is essential to properly evaluate specific progress. Computerized data acquisition systems provide large amounts of printed measured data. Another computer system is helping to perfect "simulation" testing.

135-21 VIGGEN AVIONIC SUPPORT
Nearly 40 HP automatic test systems are being used for all levels of support of the avionics used in the multi-purpose "System 37" Viggen combat aircraft of the Royal Swedish Air Force. Use of commercial instrumentation in the HP systems yielded substantial cost savings.

135-23 TELEVISION SET PRODUCTION REVOLUTIONIZED BY AUTOMATIC ALIGNMENT AND TEST
An HP automatic test system, working with automatic handlers devised by the user, automatically tests and aligns up to 6,000 TV modules per day.

135-25 AUTOMATION IN PRODUCTION TESTING
An automatic HP digital test system is being used to check ICs and PC board used in communications equipment that must exhibit high reliability even under harsh operating conditions. The speed of the HP automatic digital test system makes it feasible to check a wide variety of ICs and PC boards. At the same time, the system's accuracy and repeatability have increased confidence in the reliability of equipment using the tested subassemblies.

136 UNDERSTANDING AND OPERATING THE 8555A SPECTRUM ANALYZER AND 8445B AUTOMATIC PRESELECTOR
A discussion of microwave spectrum analysis using the HP 8555A. Includes theory of operation, control dictionary, introduction to harmonic mixing, and preselector operation. A guide for the user of the microwave spectrum analyzer.

140 FOURIER ANALYZER TRAINING MANUAL

An introduction to that very powerful and useful method of analyzing complex signals known as Fourier Analysis with emphasis on HP fourier analyzers. Major applications for this system include analyzing mechanical vibrations and sonar, seismic and neurophysiological signals. Electronic uses include servo, filter and communications system analysis.

140-3 DYNAMIC TESTING OF MECHANICAL SYSTEMS USING IMPULSE TESTING TECHNIQUES

Impulses applied to a structure allow the dynamic characteristics of that structure to be rapidly and accurately measured. The HP fourier analyzer measures both the force and response so that the true "impedance" can be determined. This technique can save time 100 fold over conventional sine sweep tests, with equal accuracy.

140-4 DIGITAL AUTO-POWER SPECTRUM MEASUREMENTS

Deals with single-channel measurement of power using the HP fourier analyzer. The measurement is distributed in a frequency domain and is thus a power spectrum or a power spectral density. This note discusses classifying the type of data to be analyzed, choosing the proper window, calibrating the displayed spectra, statistical ensemble averaging, and the energy measurement of transients.

140-6 MEASUREMENT OF MACHINE TOOL VIBRATION

Vibrations in machine tools, commonly known as chatter, can cause poor machining operations and lost time. This note describes how the HP fourier analyzer was used to determine the cause of chatter in a high production automatic lathe. An HP laser interferometer was used as a displacement transducer for detecting the vibrations of the spindle relative to the carriage.

140-7 NUCLEAR POWER PLANT DIAGNOSTICS USING FOURIER ANALYSIS TECHNIQUES

Describes application of fourier analysis techniques to nuclear power plant diagnostics. Reactor core measurements discussed include: detection of core component vibration, detection of core motion, and detection of departure from nucleate boiling. Other reactor plant measurements discussed include: measurement of vibrations of rotating machinery, seismic measurements, and modal analysis of vibrating pipes.

141 AM, FM MEASUREMENTS WITH THE TRANSFER OSCILLATOR

Have you ever tried to measure the real time variables of a pulsed RF signal -- the pulse width and repetition rate or the incidental FM on a CW or pulsed RF signal in the 50 MHz to 18 GHz range? These and other difficult measurements can be easily performed using the HP 5257A Transfer Oscillator. AN-141 describes the techniques for making these measurements and some unusual and very useful applications for the transfer oscillator. Like any transfer oscillator, the 5257A makes simple CW frequency measurements too.

142 EMI MEASUREMENT PROCEDURE

Detailed calibration and operation procedure for using the HP 8550-series of plug-in spectrum analyzers to measure electromagnetic interference per the methods of MIL-STD-461. Includes equipment lists, control settings, and examples.

150 SPECTRUM ANALYSIS . . . SPECTRUM ANALYZER BASICS

Describes the theory and operation of spectrum analyzers and their application. Includes information on the fundamentals, harmonic mixing, preselection, and tracking generators. Also encluded is a glossary of spectrum analyzer terms.

150B SPECTRUM ANALYSIS . . . USING THE 8557A AND 8558B SPECTRUM ANALYZERS

A basic approach to the operation of the 8557A (0.01-350 MHz) and, 8558B (0.1-1500 MHz) Spectrum Analyzer. Gives application information, front panel adjustments and operating hints. Also covers the theory of operation.

150-1 SPECTRUM ANALYSIS . . . AM AND FM

A discussion of measurement of AM and FM spectra using a spectrum analyzer. The theory of basic modulation is given, and several examples acquaint the user with basic techniques.

150-2 SPECTRUM ANALYSIS . . . PULSED RF

Extends the discussion of AM to the special case of pulsed RF signal analysis. Provides techniques for the measurement of pulse parameters from the spectrum analyzer display. Includes a handy sliderule to simplify pulse calculations.

150-3 SPECTRUM ANALYSIS . . . TRACKING GENERATORS

Describes the theory and operation of tracking generators and spectrum analyzers as a swept measurement system. Detailed information is given on making swept frequency response measurements and accurate frequency measurements. Also describes special applications in some detail.

150-4 SPECTRUM ANALYSIS . . . NOISE MEASUREMENTS

Measurement of random and impulse noise signals. Includes carrier-to-noise ratio, amplifier noise figure, white noise loading oscillator spectral purity, and noise corrections.

150-5 SPECTRUM ANALYSIS . . . CRT PHOTOGRAPHY AND X—Y RECORDING TECHNIQUES

A source of practical information on CRT photography and recording, strip chart recording, and the use of magnetic tape. Also covered is the recording of spectra with fast rise and fall times such as impulse noise.

150-7 SPECTRUM ANALYSIS . . . SIGNAL ENHANCEMENT

Discusses techniques of improving sensitivity of spectrum analyzer measurements including use of preamplifiers. Also describes using wave analyzers for detailed analysis of the video output from the spectrum analyzer.

150-8 SPECTRUM ANALYSIS . . . ACCURACY IMPROVEMENT

Presents a discussion of the parameters affecting amplitude and frequency accuracy. Methods of reducing uncertainty in measurement situations are given.

150-9 SPECTRUM ANALYSIS . . . NOISE FIGURE MEASUREMENT

A how-to-do-it note on amplifier noise figure measurements without the need for a calibrated noise source.

150-10 SPECTRUM ANALYSIS . . . FIELD STRENGTH

A practical guide to using the spectrum analyzer as a field strength meter.

150-11 SPECTRUM ANALYSIS . . . DISTORTION MEASUREMENTS

Discusses the mechanics of distortion measurements including: accuracy considerations, maximizing dynamic range, etc. Types of distortion measurements include harmonic and intermodulation.

150-12 SPECTRUM ANALYSIS . . . USING THE HP 11517A EXTERNAL MIXER TO 40 GHz

Discusses application of spectrum analyzers to waveguide measurements from 12.4 to 40 GHz. Includes information on optimum drive levels, signal identification, typical sensitivity, and accuracy. In addition, a method for improving sensitivity is presented.

150-13 STIMULUS-RESPONSE MEASUREMENTS USING THE HP 8565A SPECTRUM ANALYZER FROM 2 TO 18 GHz

The loss, gain, frequency response, and return loss of microwave devices can be measured over wide dynamic ranges, free from source harmonics and receiver spurious products, if the test signal tracks the receiver's tuning. This note describes how to make the HP 8620C/8629B Sweeper track with the HP 8565A spectrum analyzer's tuning to achieve 60 dB or more range from 2 to 18 GHz.

150-14 SPECTRUM ANALYSIS USING EXTERNAL WAVEGUIDE MIXERS ABOVE 40 GHz

Describes the use of commercially-available waveguide mixers for spectrum analysis above 40 GHz with the HP 8555A and 8565A analyzers. The step-by-step procedure for calibration and measurement is discussed and applied in an example at 94 GHz.

152 PROBING IN PERSPECTIVE

With the increased bandwidths in today's oscilloscopes, one probe cannot be used for all measurements. This application note provides an approach that will allow you to select the best probe for most commonly encountered oscilloscope measurement situations. Major areas include: how to select the most accurate scope/probe for a particular measurement; how to quickly evaluate a given scope/probe in a particular measurement situation; and how to quickly estimate errors caused by the probe.

154 S-PARAMETER DESIGN

This note is the illustrated script for HP's four-part video tape presentation, "S-Parameter Design Seminar"—a contemporary approach to the design of high frequency solid-state circuits. After reviewing such concepts as s-parameters, the Smith Chart, signal flowgraphs, and stability considerations, the note discusses s-parameter characterization of microwave transistors and the application of constant gain and constant noise figure circles in the design of high-frequency amplifiers.

155-1 ACTIVE DEVICE MEASUREMENTS WITH THE HP 8755 FREQUENCY RESPONSE TEST SET

Describes amplifier characterization using the 8755. Four configurations are presented for measurements of: Swept-frequency gain and power output, CW frequency gain compression, swept frequency gain compression and swept frequency harmonic content. Included is a discussion of measurement accuracy and calculator control related to these measurement configurations.

155-2 100 dB DYNAMIC RANGE MEASUREMENTS USING THE HP 8755 FREQUENCY RESPONSE TEST SET

Describes methods for expanding the dynamic range of microwave transmission measurements to over 100 dB using the HP 8755. The 8755 has a single-channel dynamic range of 60 dB. By using standard equipment but in a new configuration, the reference channel dynamic range can be added to the test channel dynamic range. Two configurations are discussed: one utilizing a high power source (> +10 dBm), another utilizing an RF amplifier after the test device. The note discusses the theory of operation, limitations, and accuracy considerations of expanded dynamic range measurements.

156-1 REMOTE LASER INTERFEROMETRY

The wide range of benefits and applications of the multipurpose "Magic Cube" are described. Measurements discussed include linear, angular, flatness, non-contract and vibration analysis. Electronic resolution extension is also explained.

156-2 CALIBRATION OF A SURFACE PLATE

A step-by-step procedure is explained for calibrating surface plates with the HP Laser Interferometer. All steps are described in detail from alignment and taking readings to calculating deviations from a true plane.

156-3 PRINCIPLES OF AUTOMATIC COMPENSATION

The need for wavelength of light corrections with laser interferometers, and the theory of operation of the HP Model 5510A Automatic Compensator are explained in detail. Compensation for thermal expansion errors and the elimination of dead path errors are also discussed.

156-4 CALIBRATION OF A MACHINE TOOL

The use of the 5526A Laser Measurement System and the various optical accessories for the calibration of a machine tool are discussed. A description of a measurement set-ups, with sketches of the optical path, and a discussion of the potential sources of error is also provided.

156-5 MEASUREMENT OF STRAIGHTNESS OF TRAVEL

The HP Straightness Interferometer System has given the marketplace a technique for making very accurate, long distance, straightness measurements. This application note describes how the straightness interferometer works. It also covers the potential errors which can result from either misapply the HP Straightness Interferometer System or operating in a poor environment and shows how the measurement should be made to provide maximum accuracy and repeatability for the user.

157 LOW FREQUENCY GAIN PHASE MEASUREMENTS

Time pressures and equipment limitations often hindered phase measurements at low frequencies. This note explores different measurement possibilities: pole/zero measurements; open/closed loop measurements; envelope delay measurement techniques; impedance/return loss; capacitor LCR; OP amps/-rejection; characterization of delay lines; and crystal evaluation.

162-1 TIME INTERVAL AVERAGING

Explains a new technique for increasing the accuracy and resolution of short time interval measurements. Using this technique, the HP 5326/5327 universal counters can measure intervals as short as 150 ps with resolution to 100 ps. The note discusses when averaging is useful, factors that influence accuracy, and how to verify and evaluate time interval averaging measurements.

163-1 TECHNIQUES OF DIGITAL TROUBLESHOOTING

Explains how to troubleshoot digital integrated circuits quickly with inexpensive digital instruments. This note developes an analytic algorithm that will help remedy virtually every digital IC problem.

164-2 CALCULATOR CONTROL OF THE 8660A/C SYNTHESIZED SIGNAL GENERATOR

Because it is a programmable instrument, the 8660A/C equipped with the Hewlett-Packard Interface Bus, can be controlled by external devices such as computers, calculators, or card readers. The emphasis in this note is on calculator programming examples. Programmable functions include frequency, output level, plus modulation parameters.

164-3 NEW TECHNIQUES FOR ANALYZING PHASE LOCK LOOPS

Describes new techniques for analyzing phase lock loops made possible with a phase modulated synthesizer. Techniques for determining closed-loop frequency response, transient response, and phase detector characteristics are covered. Measurements can be made more easily and with greater accuracy than previously possible. Actual test procedures and actual results are illustrated.

164-4 DIGITAL PHASE MODULATION (PSK) AND WIDEBAND FM

Discusses methods for generating bi-phase

164-4 (Cont'd.)

shift keyed (BPSK) and quadri-phase shift keyed (QPSK) using the phase modulation capability of the 8660A/C synthesized signal generator. This capability allows great versatility in varying modulation parameters which is ideal for investigating unique modulation formats. Also the ability to simulate high-rate FM using θ M is discussed. Actual performance results are shown.

166 LARGE SCREEN DISPLAY APPLICATIONS AND INTERFACING

Explains methods of adapting HP 1310A, 1311A, 1317A and 1321A graphic displays to specific interface requirements; relates the modifications to typical application problems; and presents formulae and rules for determining optimum input configuration for most applications.

166-2 1304A LARGE SCREEN DISPLAY APPLICATIONS AND INTERFACING

The HP 1304A large screen, high speed graphic display is designed for easy adaptation for applications including: electronic test systems such as network analyzers or spectrum analyzers, machine vibration analysis readouts, weather or harbor radar, patient monitoring in ICU or CCU environments, diagnostic ultrasound systems, computer or calculator-based graphics, and chemical and physical analytical systems.

This note supplements AN 166; minor differences between the 1304A and the other HP large screen displays are explained as well as the setup, adjustments and/or modifications required for typical applications.

167-4 ENGINEERING IN THE DATA DOMAIN CALLS FOR A NEW KIND OF DIGITAL INSTRUMENT

Describes what the data domain is and why it is important in digital design and troubleshooting. Included is a discussion of the instruments available to perform these analyses: logic-state analyzers, logic-timing analyzers and logic-trigger generators.

167-5 TROUBLESHOOTING IN THE DATA DOMAIN IS SIMPLIFIED BY LOGIC ANALYZERS

Discusses the application of data-domain instruments to solving problems in digital circuits. Logic-state analyzers make quick work of troubleshooting data manipulators by pinpointing the errant data transactions.

167-6 MAPPING, A DYNAMIC DISPLAY OF DIGITAL SYSTEM OPERATION

Describes the unique advantages of this new measuring technique. Mapping enables a dynamic viewing of digital system operation by providing a pseudo-continuous sweep display of system performance. It saves time by leading the investigator quickly to a specific data sequence and eliminating the tedious task of performing a state-by-state logic analysis. Included in the note are a number of photographs of sample map displays and interpretations of what they indicate. A separate section is devoted to a comparison of map and tabular formats.

167-7 SUPPLEMENTARY DATA FROM MAP DISPLAYS WITHOUT CHANGING PROBES

While using the 1600A Logic State Analyzer for system checkout, there are times you may need to check additional test points to complete your analysis. Reconnecting all the test leads can be a tedious task when you only need supplementary information about flag, gate, or other system test point activity. Mapping makes this possible without extra instruments and without changing Trigger Word switch settings or probes. Included in the note are photos illustrating the testing steps.

167-8 STABLE DISPLAYS OF DISC SYSTEM WAVEFORMS SYNCHRONIZED TO RECORD ADDRESS

Describes the power of pattern triggering and digital delay in troubleshooting digital systems. The HP 7900A disc is used as an example, however, the technique is applicable to other disc systems as well as digital systems in general.

Stable analog signals can be achieved and displayed easily and with full confidence when an oscilloscope is triggered from an HP 1620A Pattern Analyzer. Set up the Pattern Analyzer trigger word switch to the logic pattern of the desired address, add digital delay to the desired clock pulse and you can generate a stable, reliable sync signal at a pre-determined point of interest anywhere on the disc.

The following series, 167-9 through 19, are intended to assist microprocessor users in real time analysis of systems—in both design and troubleshooting environments. These notes demonstrate real time analysis of program flow and triggering on specific events as well as paging techniques using the Hewlett-Packard 1600S Logic State Analyzer.

167-9 FUNCTIONAL ANALYSIS OF THE MOTOROLA M6800 MICROPROCESSOR SYSTEM

This note is designed to assist the M6800 Microprocessor family user in the real time analysis of this system—in both design and troubleshooting environments. Real time analysis of program flow in positive and negative time are described as well as triggering on a specific event plus paging techniques. The use of real time logic state analysis expedites rapid error detection and correction.

167-10 USING THE 1620A FOR SERIAL PATTERN RECOGNITION

Discusses in detail the capabilities of the HP 1620A Pattern Analyzer, and its operating format. Special sections are devoted to pattern recognition (including the setting of character triggers) and a diagrammatic exposition on how the analyzer reads a sample serial code. Case studies of the effective use of the 1620A in troubleshooting are included.

167-11 FUNCTIONAL ANALYSIS OF INTEL 8008 MICROPROCESSOR SYSTEM

Similar in format to Application Note 167-9.

167-12 FUNCTIONAL ANALYSIS OF FAIRCHILD F8 MICROPROCESSOR SYSTEMS

Similar in format to Application Note 167-9.

167-12A FUNCTIONAL ANALYSIS OF MOSTEK F8 MICROPROCESSOR SYSTEMS

167-13 THE ROLE OF LOGIC STATE ANALYZERS IN MICROPROCESSOR BASED DESIGNS

A collection of case studies are presented to cover a range of logic analysis problems. Included are sample display patterns, analyzer/configuration photographs, a flow chart (to illustrate software loop failure), and schematic diagrams.

Problems that heretofore have been difficult to solve are now quite routine with logic state analysis instrumentation. Discussed are time vs. state flow, location of software failure, spotting incorrect readings of flag signals and dual clock troubleshooting across an I/O port.

167-14 FUNCTIONAL ANALYSIS OF 8080 MICROPROCESSOR SYSTEMS

Similar in format to Application Note 167-9.

167-15 FUNCTIONAL ANALYSIS OF INTEL 4004 MICROPROCESSOR SYSTEMS

Similar in format to Application Note 167-9.

167-16 FUNCTIONAL ANALYSIS OF INTEL 4040 MICROPROCESSOR SYSTEMS

Similar in format to Application Note 167-9.

167-17 FUNCTIONAL ANALYSIS OF NATIONAL IMP MICROPROCESSOR SYSTEMS

Similar in format to Application Note 167-9.

167-18 FUNCTIONAL ANALYSIS OF NATIONAL SEMICONDUCTOR SC/MP MICROPROCESSOR SYSTEM

Similar in format to Application Note 167-9.

167-19 SYSTEMATIC "TURN-ON" OF MICROPROCESSOR SYSTEMS USING LOGIC STATE ANALYZERS

Presents a systematic, section-by-section approach to test both hardware and software as you develop a microprocessor-based system. Bring up your system "bit-by-bit" using the HP 1600/1607A Logic State Analyzer.

170-1 HP 8640A/B SIGNAL GENERATOR OUTPUT LEVEL ACCURACY

Deals mainly with output level accuracy considerations in the HP 9640A/B signal generators (450 kHz to 550 MHz). It covers level accuracy specifications; shows how to operate these signal generators for best level accuracy; and compares the typical level accuracy of the 8640A/B and the 608 series signal generators. Step attenuators and waveguide-beyond-cutoff attenuators are discussed briefly. The effects of each type attenuator on level accuracy are presented.

170-2 THE 8640A/B THIRD ORDER INTERMODULATION PRODUCT CHARACTERISTICS

Certain radio receiver test procedures require 2 or 3 signals applied at the input. When several signal generators are summed together for these tests, careful consideration must be given to the third order intermodulation products caused by the interconnection. This note shows typical third order IM characteristics of the 8640A/B, and recommends ways to reduce the levels of intermodulation products.

171-1 CRYSTAL TESTING WITH THE 8640A/B AND 8405A

Describes a procedure to measure amplitude and phase characteristics of crystals, using the HP 8640A/B signal generator (450 kHz to 550 MHz) and HP 8405A vector voltmeter. Primary emphasis is on measuring the crystal resonant frequency which is defined as the frequency at which the crystal phase response goes through zero degrees. Series and parallel resonances of a typical crystal filter are measured and identified, and a complete phase response is plotted.

171-2 EXTENDING THE 8640B FREQUENCY DOWN TO DC

The 8640B VHF Signal Generator covers 450 kHz to 550 MHz. This note shows how to build a simple external heterodyne circuit which extends the output frequency down to DC. The circuit mixes the fixed 5 MHz from the 8640B with the tunable output. Frequency can be read directly on the digital display. This application is especially useful for IF test signals or for audio work and above.

173 RECENT ADVANCES IN PULSED RF AND MICROWAVE FREQUENCY MEASUREMENTS

The HP 5345A 500 MHz Electronic Counter together with the HP 5345A Automatic Frequency Converter Plug-in, measures pulsed RF as easily as CW signals to 4 GHz automatically. Both units are HP Interface Bus programmable for systems applications. External gate capability lets the operator define the time of measurement with respect to the signal of interest, and a unique frequency averaging capability gives high resolution on repetitive signals for gate times as short as 20 ns. Detailed information covers operation of the 5345A and evaluation of results with examples showing measurement of air navigation ATC and DME pulses. Also included is a section on use of the 5245 series high-frequency plug-in units to extend the range of the 5345A Counter to 18 GHz.

174-0 INDEX TO THE AN-174 APPLICATION NOTE SERIES

Application notes 174 describes HP Interface Bus systems using the 5345A Electronic Counter with the 9820, 9821 or 9830 calculator. Each note describes the measurement set-up, discusses important measurement considerations, and provides a complete listing of both the 9820/21 and 9830 programs.

174-1 MEASURING THE TRANSFER CHARACTERISTIC OF A VOLTAGE CONTROLLED OSCILLATOR

A 5345A counter, D-to-A converter, calculator, and plotter are used to automatically measure and plot the transfer characteristic (frequency out versus voltage in) of a VCO.

174-2 MEASURING DIFFERENTIAL NONLINEARITY OF A VOLTAGE CONTROLLED OSCILLATOR

The 5345A counter is used in conjunction with a D-to-A converter, a 9820 calculator, and a plotter to approximate the derivative of the VCO transfer characteristic and plot the modulation sensitivity of a VCO over a user specified range of input voltage.

174-3 MEASURING INTEGRAL NONLINEARITY OF A VOLTAGE CONTROLLED OSCILLATOR

The integral nonlinearity is defined in terms of the maximum departure of the actual VCO transfer characteristic from a first order least squares approximation of the data. A 5345A counter, calculator, and D-to-A converter are used to compute this parameter for a user's VCO.

174-4 MEASURING DUAL VCO TRACKING ERROR

In a fraction of the time required to perform the measurements and computations manually, the described set-up measures and plots the transfer characteristic of two VCO's and the corresponding percentage tracking error.

174-5 DETERMINING PROBABILITY DENSITIES (HISTOGRAMS) WITH THE 5345A ELECTRONIC COUNTER

Automatically plots a histogram of any quantity (e.g., time interval, period, etc.) measureable with the 5345A counter. The system has been successfully used to characterize frame-to-frame jitter in digital communications networks and time delay jitter through digital receivers as a function of S/N.

174-6 MEASURING THE STABILITY OF A FREQUENCY SOURCE

Automatically plots frequency deviation ($\Delta f/f$) vs. time. Uses the 59309A ASCII digital clock to time measurements and provides time-of-day information on the plot.

174-7 MEASURING FRACTIONAL FREQUENCY STANDARD DEVIATION (SIGMA) VERSUS AVERAGING TIME (TAU)

Automatically characterizes the short-term stability of oscillators with a "sigma vs. tau" plot. Averaging time from 100 ns to 10^4 sec. may be selected by the user.

174-8 MEASURING FM PEAK-TO-PEAK DEVIATION

The peak-to-peak deviation of FM signals with carriers in the range of 100 MHz to 500 MHz is semiautomatically measured.

174-9 MAKING AUTOMATIC PHASE MEASUREMENTS WITH THE 5345A ELECTRONIC COUNTER

Phase angle between two signals is automatically measured with .01° resolution for phase angles from 0° to 360°.

174-10 MEASURING ELECTRICAL LENGTH DELAY OF CABLES

Measures delay through cables with resolution up to $\pm$ 2 ps ($\pm$ .05 cm). Useful for trimming two cables to the same electrical length.

174-11 MEASURING WARM-UP CHARACTERISTICS AND AGING RATES OF OSCILLATORS

Automatically plots the logarithm of $\Delta f/f$ vs. time with user-selected resolution.

174-12 MEASURING FREQUENCY SWEEP LINEARITY OF SWEEP GENERATORS

Automatically plots the frequency vs. time characteristic of a sweep generator and also the differential nonlinearity curve.

174-13 MEASURING THE TUNING STEP TRANSIENT RESPONSE OF VCO'S TO 18 GHz

Automatically plots VCO output frequency vs. time after application of a voltage step to the VCO. Time increments as small as 1 μs make the system useful to users and designers of VCO's used in frequency agile systems, ECM, and frequency control systems.

175-1 DIFFERENTIAL PHASE AND GAIN AT WORK

Is intended to provide a more complete understanding of the swept frequency measurements performed by the HP microwave link analyzer (MLA). It is hoped that the note will form the basis of more advanced techniques in microwave link optimization, since the relationships between telephony baseband distortion and swept measurements are clearly defined.

181-1 MEASURING LINEARITY OF VCOs FROM 10 Hz TO 23 GHz

The 5340A frequency counter is used in three different calculator-based HP Interface Bus systems to measure and plot the transfer characteristics (frequency out vs. voltage in), the differential nonlinearity, and the integral nonlinearity of voltage-controlled oscillators in the frequency range of 10 Hz to 18 GHz (or 23 GHz when using an option).

181-2 DATA ACQUISITION WITH THE 5300B MEASURING SYSTEM

This note describes an example of a low-cost data acquisition system using the 5312A ASCII interface which permits the use of the 5300B measuring system on the HP Interface Bus. The example uses a multimeter/counter in a calculator-based HP Interface Bus system to plot histograms of dc voltage, ac voltage, resistance or frequency. The calculator computes the mean, standard deviation, and peak-to-peak deviation of the quantity measured.

183 HIGH FREQUENCY SWEPT MEASUREMENTS

Describes "magnitude only" swept network measurements at microwave frequencies. The basic elements of a swept measurement system -- oscillators, directional devices (couplers and bridges), detectors and displays--are discussed. Measurements of SWR, ρ (rho) and return loss using both reflectometers and swept slotted lines are presented in the section on impedance measurement. Measurements of gain and attenuation using directional couplers and power splitters are described in the section on transmission. Accuracy considerations are discussed extensively for measurements in coax and waveguide.

185 WAVEFORM PARAMETER MEASUREMENTS USING THE MICROPROCESSOR CONTROLLED OSCILLOSCOPE (1722)

Describes the operation and measurement techniques unique to the Model 1722 oscilloscope. Includes the waveform parameter measurements of period, frequency, pulse duration, rise time, amplitude, percent overshoot, average voltage, dc offset, propagation delay, and percent RF modulation. Additional topics include: the basic theory of operation of the microprocessor/oscilloscope interface and dual-delayed sweep, and an in-depth discussion of oscilloscope accuracy specifications and how they relate to specific measurement applications.

185-2 TRANSMISSION LINE MATCHING AND LENGTH MEASUREMENTS USING DUAL-DELAYED SWEEP

Using the dual-delayed sweep in the microprocessor-controlled HP 1722 oscilloscope, it is possible to measure the physical length of an open or shorted transmission line. Measuring the time interval between incident and reflected pulses is the round trip time for a pulse propagating along a transmission line. Accuracy is to within 0.5%.

Information is also presented on the method of matching a test transmission line up to 18 miles in length to a known reference within 10 ps of propagation delay.

185-3 PERCENT AMPLITUDE MODULATION MEASUREMENTS IN THE TIME DOMAIN

Describes the practical limitations and techniques of percent of amplitude modulation measurements with the HP 1722 and 1740A oscilloscopes.

The advantages in accuracy obtained plus convenience are given for both the standard volts versus time display of a modulated RF carrier and a volts versus volts display of the modulated RF carrier versus the modulation signal.

185-4 ELIMINATION OF COMPUTATION OF ANALOG MEASUREMENTS BY USING THE DIRECT READING OSCILLOSCOPE 1722

With new demands for measurement accuracy, and repeatability, the 1722 dual-delayed sweep oscilloscope provides an extra measure for making voltage and time interval measurements. No longer do you need to count divisions, interpolate between divisions, or multiply by the appropriate scale factor. Readings are direct on the LED display.

Techniques for making the following waveform voltage measurements are briefly presented: differential voltage, dc and average voltage, and waveform percentage.

Timing measurements including pulse width and period measurements, propagation delay plus transition time measurements are also described.

186 DUAL-DELAYED SWEEP FOR PRECISE TIME INTERVAL MEASUREMENTS

Explains why brief time interval measurements are easier and more accurate with the use of a dual-delayed sweep oscilloscope. This note shows how it is easy to overlap waveform 50% point to accurately measure pulse width; overlapping of waveforms for fast comparison and measurement of delay and phase changes. Accuracy of reading is improved 50% to 300%, compared with conventional oscilloscopes.

187-2 CONFIGURATION OF A 2 TO 18.6 GHz SYNTHESIZED FREQUENCY SOURCE USING THE 8620C SWEEP OSCILLATOR

Describes configuration of a desktop computer-controlled 2-18.6 GHz synthesized frequency source using the HP 8620C/86290 sweeper and the HP 8660 UHF synthesizer, with the Hewlett-Packard Interface Bus (HP-IB) as the common link between the instruments and the controller. Typical performance characteristics are shown. Program listings for the HP 9825A, 9830A, and 9830B computers are included.

187-3 THREE HP-IB CONFIGURATIONS FOR MAKING MICROWAVE SCALAR MEASUREMENTS

This application note describes three HP-IB configured systems for measuring the scalar transmission and impedance characteristics of microwave components. One employs the HP 436A Digital Power Meter, another the HP 8755 Frequency Response Test Set, and the third the HP 8410B Network Analyzer. The specific hardware requirements are discussed and the relative merits of each approach compared.

187-4 CONFIGURATION OF A TWO-TONE SWEEPING GENERATOR

Describes configuration of a source which will allow sweep testing of mixers, receiver front ends, etc. The source outputs a local oscillator signal and a receiver signal whose offset from each other (the IF) is phase-locked. IF stability of <1 Hz is realizable even while sweeping the RF from 2 to 18 GHz.

187-5 CALCULATOR CONTROL OF THE 8620C SWEEP OSCILLATOR USING THE HP-IB

Describes programmable capabilities of the 8620C and the procedures required to control it with the HP 9820A, 9821A, 9825A, 9830A/B calculators via the HP-IB. It also contains sample programs which can effectively improve the CW accuracy of the sweeper to approximately $\pm$ 0.005% of the bandwidth of the plug-in by using a counter feedback scheme.

187-6 PERFORMANCE OF THE 8620C SWEEP OSCILLATOR UNDER REMOTE PROGRAMMING

Documents the performance of the 86200-Series plug-ins in remote programming operation. Techniques for increasing precision, reducing errors, and source calibration are described to provide the system designer with enhanced measurement solutions through plug-in performance optimization.

188 THERMOCOUPLE MEASUREMENTS WITH THE 3050B

Describes how thermocouple measurements can be made with an HP 3050 data acquisition system. Basic thermocouple theory and connection are also described.

190 40 GHz FREQUENCY MEASUREMENT WITH STANDARD INSTRUMENTS

Frequency of microwave signals to 40 GHz can be measured with electronic counter ease and accuracy using a 2 to 4 GHz Counter. Also required is a 2 to 4 GHz microwave generator and an external mixer. A block diagram together with operating notes gives complete information on making these measurements.

191-1 AUTOMATIC ZERO CALIBRATION OF THE 5359A TIME SYNTHESIZER AT A DESIGNATED REMOTE LOCATION

In this note the 5363A Time Interval Probes and the 5359A Time Synthesizer are used to precisely calibrate time at an external location. With this technique other instruments, for example high powered pulse generators, may be given increased timing resolution.

191-2 DETERMINING DIGITAL CIRCUIT TIMING TOLERANCE TO OPTIMIZE ADJUSTMENT OR DESIGN

For the circuit designer optimizing logic circuit design, this note describes how the HP 5359A time synthesizer may be used to establish timing operating margins. Optimum timing can readily be established for a single integrated circuit but may be obscure in a complex gating system. The precise, digitally positioned, jitter free, output pulse of the 5359A may be shifted in steps as small as 100 ps to determine circuit operating limits.

191-3 PRECISION TIME INTERVAL MEASUREMENTS IN RADAR APPLICATIONS

The use of the 5370A Universal Time Interval Counter is discussed for making precise time interval measurements required to design, produce, and maintain radar equipment. The statistical functions of the 5370A allow pulse jitter to be conveniently characterized.

191-4 USING THE 5370A UNIVERSAL TIME INTERVAL COUNTER TO CHARACTERIZE PULSE WIDTH, REPETITION RATE, AND JITTER

The statistical capability of the 5370A is used to provide mean, maximum, minimum, and standard deviation of the time intervals measured.

192 USING A NARROW BAND ANALYZER FOR CHARACTERIZING AUDIO PRODUCTS

Significant advances in the "sound world" have necessitated that products must meet rigid specifications of frequency response, signal-to-noise ratio, channel separation, low distortion, etc. This application note describes the use of the HP 3580A Spectrum Analyzer and the HP 3581A Wave Analyzer to provide an inexpensive and easy-to-use method to provide detailed signal analysis for great measurement accuracy. Make swept response measurements faster than the simple oscillator, voltmeter system.

195 PULSE GENERATOR TECHNIQUES IN CMOS APPLICATIONS

New pulse generator techniques now make it possible to evaluate the performance of CMOS devices. This note offers a brief introduction to CMOS technology, a presentation of functional testing as well as parametric testing plus details on setting up a test set.

196 AUTOMATIC MEASUREMENTS USING THE HP 436A POWER METER

This note describes 5 specific measurement applications of the 436A Power Meter used with the HP-Interface Bus. Data logging and wide dynamic range output plots are described without using a calculator. Three applications describe a calculator-mini-system to calibrate an RF signal generator, an 18 GHz coaxial attenuator pad, and a calibration factor routine on an 18 GHz thermocouple sensor. Typical software listing are given.

197-1 LASER INTERFEROMETERS FOR POSITION FEEDBACK

Numerically controlled machine tools and measuring machines of all types have benefited from the higher accuracy, resolution, and reliability offered by laser interferometers used as position feedback devices. This application note describes the 5501A Laser Transducer which has been designed for "built-in" position measurement and control applications.

198 EVENT-RELATED TRIGGERING : A CLEAR SOLUTION FOR DIGITAL SIGNALS

By using an HP 1230A Logic Trigger as a trigger source, an oscilloscope display for problems in digital instrumentation will be stable and jitter-free because the trigger is event (not time)-related. When a specific word is recognized, the 1230A begins to count clock pulses. When a preset number is attained, a trigger pulse is generated. Applications in which the 1230A can be used include phase-locked loop systems, microprocessors, interface bus systems, and algorithmic machines.

200 THE FUNDAMENTALS OF ELECTRONIC FREQUENCY COUNTERS

A 44-page introduction to the methods and techniques of frequency and time measurement. The characteristics of the fundamental frequency counter are discussed in detail, along with a chapter devoted to the special properties of the period measuring frequency counter. The time interval meter and the techniques for precise timing measurements are considered. The basic methods by which microwave frequency measurements are performed and the advantages of each method are also discussed.

200-1 FUNDAMENTALS OF MICROWAVE FREQUENCY COUNTERS

Discusses the four principal down-conversion techniques for extending the frequency range of counters into the microwave region: Prescaling, heterodyne, transfer oscillator, and harmonic heterodyne (with emphasis on the 5342A). Compares the major performance specifications between the techniques to allow the users to choose a counter appropriate for their applications.

200-2 FUNDAMENTALS OF QUARTZ OSCILLATORS

Describes the quartz crystal fundamentals, such as structure, crystal cuts, and vibration modes. It includes environmental influences on the crystal and causes of oscillator frequency changes. Typical performance of various oscillator compensation techniques are also discussed.

200-3 TIME INTERVAL MEASUREMENT USING AN ELECTRONIC COUNTER

Time interval measurement is discussed from the theoretical side to point up factors that have a great influence on measurement accuracy as well as from the practical side by way of examples, showing application of an electronic counter to specific measurements including pulse width and spacing on a complex pulse train and phase measurement.

The 5363A Time Interval Probes box which eliminates the major uncertainties in time interval measurements with an electronic counter is discussed in detail. Other ways of making time interval measurements are also discussed.

200-4 UNDERSTANDING FREQUENCY COUNTER SPECIFICATIONS

Describes frequency counter measurement errors and how these errors are specified. Defines Least Significant Digit Displayed, Resolution, and Accuracy.

201-1 ROUTINE QA MEASUREMENTS OF PRESCISION RESISTORS

Describes an HP-IB based 21MX computer-controlled instrumentation system capable of measuring printing and plotting statistical distribution of precision resistor values.

201-2 MEASURING DIFFERENTIAL NON-LINEARITY OF A VOLTAGE CONTROLLED OSCILLATOR

Describes an HP-IB based 21MX computer-controlled instrumentation system for measuring and plotting differential non-linearity of the modulation sensitivity of a voltage controlled oscillator.

201-3 A MULTIPLE STATION ELECTRONIC TEST SYSTEM

Describes an HP 1000 computer system with bus-connected instruments for component, sub-assembly, and final product tests at three different test stations.

204-1 AUTOMATIC ACCELEROMETER CALIBRATION

Testing air-dropped cargo packages is being performed by the U.S. Army. In these tests accelerometers are used to measure the ground impact forces on the cargo and its container package in order to relate the cargo's survivability to the force. Calibration of the accelerometers requiring numerous data points and lengthy mathematical calibration calculations is accomplished by the 3050 Automatic Data Acquisition System. More thorough calibration in less time and reduced errors are the 3050 System contribution.

204-2 ENERGY CONSERVATION IN A RESTAURANT

The Jolly Tiger Restaurant used the Data Acquisition system to monitor energy consumption and to evaluate heat reclamation equipment. Results of the evaluation will aid the U.S. Department of Energy to disseminate information to the public on all energy sources and energy conservation technology.

205-1 LOW FREQUENCY AMPLITUDE CONSIDERATIONS OF THE 3042A SYSTEM

Helps the user of the HP 3042A Network Analyzer System understand the measurement limitations below 50 Hz. Also a technique is provided for extending the low-end frequency response from 50 Hz to 2 Hz.

206-1 MEASURING WIDE-BAND NOISE WITH THE HP-3045A AUTOMATIC SPECTRUM ANALYZER

This application note outlines the basic concerns of measuring noise with the 3045A Spectrum Analyzer. The possible sources of error are discussed and a program for the HP 9825A controller is presented for making noise measurements in bandwidths wider than the 10 kHz available in the HP 3571A.

207 UNDERSTANDING AND USING PHASE NOISE IN THE FREQUENCY DOMAIN

Describes the theory and practice of making phase noise measurements from 5 Hz to 13 MHz from the carrier. Emphasis is placed on the correction factors required for making noise power spectral density measurements with wave and spectrum analyzers. Examples are given for both manual and automatic measurements.

210-1 MODELING AND SIMULATION FOR DIGITAL TESTING

This tutorial text explains software simulation techniques and the benefits that can be derived from modeling and simulation in digital testing.

Sections include fundamentals of digital testing, logic model elements, logic circuit simulation and modeling and simulating faults.

210-4 DESIGNING DIGITAL CIRCUITS FOR TESTABILITY

This note gives the designer some techniques to help avoid excessive costs of testing and fault isolation in the life of a complex digital logic product. These techniques are applicable to LSI, printed circuit board assemblies and complete digital systems.

Design considerations include initialization, feedback loops, bused logic, timing problems, test point selection, and addition of logic to help enable automatic test generation. A section of non-electronic design considerations includes connectors, layout and test fixtures.

213-1 DROPOUTS

Dropouts are a loss of signal in either the record or reproduce mode of a tape recorder. Dropouts are permanent, temporary, or a combination of both, and are a result of tape inperfections. Recording in an FM mode minimizes the effect of dropouts. Use good quality tapes, maintain a clean recording environment, and use care in storing and handling tapes.

213-2 CROSSTALK

Crosstalk is the undesired coupling of signals between channels. In a multitrack tape recorder, crosstalk is a wavelength effect related to the proximity of tracks on tape and is introduced by two sources. Head, or transformer cross talk, can be reduced by proper head design. Tape crosstalk is a

213-2 (Cont'd.)

direct function of the wavelength recorded on the tape and can be reduced by recording in an FM mode, selecting the slowest tape speed possible, or separating critical data by one or more channels.

213-3 INTERCHANNEL TIME DISPLACEMENT ERROR

When two or more channels of data are recorded using an instrumentation tape recorder, a certain time relationship between the channels is established. If during reproduction, the time relationship between channels is not the same as when it was recorded, the difference is known as Interchannel Time Displacement Error (ITDE). This note provides an understanding of the sources and magnitudes of the errors that can be introduced. Recommendations for minimizing ITDE are provided.

214-1 RECORDING WITH INPUT NOISE PRESENT

Inasmuch as an input noise level of only 1% can render many high-performance X-Y recorders inoperable, this note details problems caused by input noise and discusses their effects. A section describing how input noise can be minimized or eliminated provides the user with several solutions to the noise problem.

214-2 X-Y RECORDER DYNAMIC RESPONSE

Due to recent improvements in dynamic response, some X-Y recorders now provide excellent performance when used in the higher frequency ranges normally associated with instruments such as direct writing oscillograph recorders. This improved performance capability is possible because of a rather obscure specification called acceleration. This note explains acceleration and its companion specification, slewing speed, relates them to specific performance characteristics, and indicates the typical dynamic performance capabilities of several HP X-Y recorders.

214-3 X-Y RECORDER INPUT CONNECTION CONFIGURATION AND INPUT NOISE

"Traditional" and the "not so traditional" methods of minimizing the effects of common-mode noise are described in this note. The often overlooked but potentially serious noise source, input terminal connection configuration, is also discussed.

214-4 HIGH SENSITIVITY X-Y RECORDER HAS FEW INPUT RESTRICTIONS

This note discusses the HP 7047A X-Y recorder's high sensitivity capability and the 130 dB of common-mode rejection provision for virtually any input configuration. No "external guard" connection is needed unless the common-mode voltage exceeds 10 V peak.

215-1 A MORE RUGGED, CLEANER WRITING OSCILLOGRAPHIC INK RECORDER

Discusses the design of the HP 7402A recorder with emphasis on its lifetime pens and instant-dry ink system. This recorder was designed to withstand severe operating conditions.

Of special interest to mechanical designers is the dynamic writing system analysis included in the note.

216 A GUIDE TO THE USE OF THE HP 3570A/3571A ANALYZERS

This note is a guide to the use of the HP 3570A Network Analyzer and 3571A Spectrum Analyzers. Their differences and similarities are presented. Potential sources of error that occur when making swept Single shot measurements using the 1741A Storage Oscilloscope are also discussed.

218-1 APPLICATIONS AND PERFORMANCE OF THE 8671A/8672A MICROWAVE SYNTHESIZERS

Describes detailed performance of the 2-18 GHz synthesizer including modulation, switching, and signal characteristics. Provides recommended configurations to obtain finer frequency-setting resolution of 1, 2, or 3 Hz over the range 2 to 18 GHz. Another section covers techniques and equipment for obtaining microwave signals from 1 MHz to 36 GHz by use of a complementary synthesizer and exterior doublers. Detailed software examples are given with annotated subroutines to assist in writing application programs.

218-2 OBTAINING MILLIHERTZ RESOLUTION FROM THE 8671A AND 8672A

Some microwave applications of microwave synthesizers require finer resolution steps than the 1, 2, and 3 kHz available in the 8671/2 models. By combining the 8672 with an HP 3330B or HP 3335A synthesizer, programmable resolutions down to 1 or 3 millihertz can be obtained. Software subroutines are furnished.

218-3 A 1 MHz-18 GHz SIGNAL GENERATOR WITH 1, 2, OR 3 Hz RESOLUTION

A combination of the HP 8660 and the HP 8672A synthesized generators with suitable microwave switching provides a fully programmable signal source over a very wide band from 1 MHz to 18 GHz. Uses include design and calibration labs, automatic test systems and test of multiband components and receivers.

218-4 SYNTHESIZED SIGNALS FROM 18 TO 37.2 GHz USING THE 8672A

NEW

Outlines use of the 8672A Synthesized Signal Generator with the 938A and 940A Frequency Doublers. This combination of instruments yields synthesized signals from 18 to 37.2 GHz. Typical

218-4 (Cont'd.)

measured maximum output power, output flatness, modulation, and spectral purity characteristics are presented.

219 HP 8505A R.F. NETWORK ANALYZER BASIC MEASUREMENTS

Detailed operating procedures tell how to set up, calibrate, and make basic transmission and reflection measurements in the 500 kHz to 1.3 GHz frequency range using the HP 8505A and its associated test sets.

220 OPERATING THE HP 8565A SPECTRUM ANALYZER

A complete operating guide to the HP 8565A Microwave Spectrum Analyzer (10 MHz-22 GHz). The reader is taken step-by-step through all the operating controls. Techniques for achieving optimum dynamic range and improved measurement accuracy are described. Measurements of such parameters as distortion, modulation, noise and electromagnetic interference are discussed.

221 SEMI-AUTOMATIC MEASUREMENTS USING THE 8410B MICROWAVE NETWORK ANALYZER AND THE 9825A DESKTOP COMPUTER

Describes the configuration of a semi-automatic network analyzer using the Hewlett-Packard Interface Bus (HP-IB). Topics treated include: block diagram of suggested equipment; methods of digitizing magnitude and phase readings; sources of error in microwave measurements; fundamentals of one-port vector error correction; a sample program for the 9825A desktop computer; and typical results and operating procedures.

222 A DESIGNER'S GUIDE TO SIGNATURE ANALYSIS

Signature analysis is a technique for field troubleshooting of microprocessor-based products. By designing the technique into digital products, a manufacturer can provide field service procedures, employing the HP 5004A Signature Analyzer, for component-level repair without dependence on board exchange programs.

This application note explains to design engineers how to incorporate the principles of signature analysis into new digital products. It is specific and includes examples.

222-1 IMPLEMENTING SIGNATURE ANALYSIS FOR PRODUCTION TESTING WITH THE 3060A BOARD TEST SYSTEM

Focuses on testing and retrofitting microprocessor-based boards for signature analysis. Includes a discussion of general Signature Analysis testing techniques, testing ROM's, combination circuits, and sequential circuits. Examples are given for RAM test program and board test program.

223 OSCILLOSCOPE MEASUREMENTS IN DIGITAL SYSTEMS

Designers who have struggled to verify that output signals happen correctly as a result of program operation will appreciate the examples given in this note. Using an HP 1740A or 1741A, with its third channel trigger view, all three ports of three-port gates can be viewed simultaneously.

Measurements of signals in a microprocessor-based system are enhanced by using a variable persistence storage oscilloscope, such as the HP 1741A, in conjunction with an HP 1600A Logic State Analyzer. Single shot measurements using the 1741A Storage Oscilloscope are also discussed.

225 MEASURING PHASE SPECTRAL DENSITY OF SYNTHESIZED SIGNAL SOURCES EXHIBITING f^0 AND f^{-1} NOISE CHARACTERISTICS WITH THE 5390A FREQUENCY STABILITY ANALYZER

This note outlines additional measurement considerations in characterizing the frequency stability of synthesized sources with the 5390A Frequency Stability Analyzer. Measurement set-ups and external filtering are discussed and sample error calculations are performed. A Computing controller program for the use of an automatic bandpass filter is also included.

227 WORD GENERATOR TECHNIQUES IN MULTI-CHANNEL APPLICATIONS

This note is intended to acquaint the reader with the potential of a multi-channel signal source, the HP 8016A Word Generator, in applications demanding digital simulation or stimulation. Four devices fundamental to a microprocessor system take the role of DUT for the four applications described in this note.

Although a multi-channel source dictates the theme for this note, a receiver capable of multi-channel display is required for monitoring device response. An HP 1600A Logic State Analyzer is therefore used to make logic state comparisons of response to signal stimulus.

233-1 FUNCTIONAL ANALYSIS OF SIGNETICS 2650 MICROPROCESSOR SYSTEMS USING THE 1610A

This note assists the Signetics 2650 Microprocessor user in initial turn-on and system analysis by explaining the techniques of real-time state analysis using the general purpose HP 1610A Logic State Analyzer to perform measurements on a 2650 microprocessor based system. System instrumentation, data acquisition, data formatting, and measurement modes are explained and illustrated. Probe connections, instrument set-up and qualification required for tracing program flow, memory read and write operations, and I/O transactions are presented in example measurements using state table and graphing techniques.

233-2 FUNCTIONAL ANALYSIS OF TMS 9900 MICROPROCESSOR SYSTEMS USING THE 1610A

Similar in format to Application Note 233-1.

233-3 FUNCTIONAL ANALYSIS OF ZILOG Z80 MICROPROCESSOR SYSTEMS USING THE 1610A

Similar in format to Application Note 233-2.

233-4 FUNCTIONAL ANALYSIS OF INTEL 8080 MICROPROCESSOR SYSTEMS USING THE 1610A

Similar in format to Application Note 233-1.

233-5 FUNCTIONAL ANALYSIS OF MOTOROLA M6800 MICROPROCESSOR SYSTEMS USING THE 1610A

Similar in format to Application Note 233-1.

235 AN INTRODUCTION TO BALANCED CIRCUITS AND IMPEDANCE MATCHING

First a brief tutorial on balanced circuits. Then a description on balanced input/output configurations used in test instrumentation. Also explains common balanced measurement errors.

236-1 A "MAKE" OR "BUY" ANALYSIS FOR POWER SUPPLIES

Focuses on key economic considerations for a power supply make or buy decision. A discussion with examples and calculations covers Return on Investment, Manufacturing Cost, Inventory Cost and Warranty Cost. This application note will help the power supply user arrive at the best make or buy decision.

240-0 TIME AND FREQUENCY DOMAIN MEASUREMENTS

Defines, discusses, and illustrates a wide range of important measurements made by the 5420A Digital Signal Analyzer using sampled data techniques. Includes Time Record Averaging, Auto and Cross Correlation, Auto and Cross Spectrum, Transfer Function, and more.

240-1 FEEDBACK CONTROL SYSTEM MEASUREMENTS

Illustrates the application of the 5420A Digital Signal Analyzer to both time and frequency domain measurements of feedback systems. Includes a technique for obtaining the open loop gain from data taken with the loop closed and the system in normal operation. Several practical examples are illustrated.

245-1 SIGNAL AVERAGING WITH THE HP 3582A SPECTRUM ANALYZER

Provides an understanding of the signal averaging techniques commonly used in digital signal analysis and how they relate to the corresponding swept analyzer techniques. The specific topics covered include:

- Power Spectrum averaging and its relationship to video filtering for smoothing measurements of random signal.
- Time averaging and its relationship to narrow band analysis for enhancing signal-to-noise ratios.
- Time averaging of recurrent transients.
- Peak-hold operation which is not strictly an averaging technique.

Examples of the various techniques are included to help clarify the theory involved.

245-2 MEASURING THE COHERENCE FUNCTION WITH THE HP 3582A SPECTRUM ANALYZER

Provides a theoretical and practical introduction to the coherence function. The specific topics covered include:

- The use of the coherence function as an indicator of the statistical quality of a transfer function measurement.
- The use of the coherence function as an indicator of casuality.
- The theoretical details of the coherence function and its calculation.

Examples of the uses of the coherence function are included to help clarify the theory involved.

246 USING THE HP 3585A SPECTRUM ANALYZER WITH THE HP 9825A COMPUTING CONTROLLER

A brief description of the HP-IB programmability of the HP 3585A is followed by examples of subroutines with flowcharts and listings. These subroutines are useful for automated spectral analysis on the bench or in production to reduce measurement time and provide new capability such as CRT limit tests and logarithmic sweeps.

250-1 HP-IB POWER SUPPLY INTERFACE GUIDE

This 28-page booklet describes applications for the four different HP-IB power supply interfaces currently available. It describes in detail how to connect and control HP power supplies rated from 0 to 600V and 20W to 11kW with the HP-IB interface bus (Hewlett-Packard's implementation of IEEE Std. 488-1975). The 71 different HP power supplies that can be connected to the bus are listed in a convenient capabilities table. Topics included in the booklet are in-

250-1 (Cont'd.)

terface configuration, timing and accuracy considerations, and programming formats.

260-1 UNDERSTANDING HEWLETT-PACKARD'S MODEL 1615A LOGIC ANALYZER

Provides familiarization with 1615A Logic Analyzer operation and describes digital measurements using its powerful measurement set. The 1615A can be formatted as a 24-bit state analyzer, an 8-bit timing analyzer, or a simultaneous 8-bit timing and 16-bit state analyzer. The 24-bit wide, 256 word deep memory operates with external or internal clocks to 20 MHz. Keyboard control and a menu concept make the analyzer exceptionally easy to use and easy to understand.

262 ELIMINATING TIME BASE ERRORS FROM OSCILLOSCOPE MEASUREMENTS

Discusses time interval measurements and compares standard delayed sweep oscilloscope techniques to the more accurate and reliable HP developed delta time techniques used in oscilloscopes such as the 1715A, 1725A, 1722B, 1742A, and crystal referenced 1743A.

270-1 AN EXAMPLE OF AUTOMATIC MEASUREMENT OF CONDUCTED EMI WITH THE HP 8568A SPECTRUM ANALYZER

Describes the application of the HP 8568A Spectrum Analyzer to automatic measurement of conducted EMI from 200 kHz to 50 MHz in accordance with MIL-STD 461 (test CE03). Annotated program listing is included.

272 PRECISE TIME INTERVAL MEASUREMENTS USING THE CRYSTAL CONTROLLED TIME BASE MODEL 1743A OSCILLOSCOPE

Describes how to perform precise time interval measurements using the Model 1743A (Crystal reference time base) Oscilloscope. Emphasis is on propagation delay and pulse parameter measurements. The most valuable feature of the 1743A oscilloscope is its ability to perform time interval measurements by triggering the delayed sweep on selectable start and stop events while showing the precise trigger points on screen. Accurate time interval measurements can be made within sub-nanoseconds with minimum difficulty and ambiguity from trigger uncertainty.

275-1 USING THE HP 1640A SERIAL DATA ANALYZER WITH THE EPICOM, INC. MODEL 200 CS047 EPITAPE RECORDER

Describes a procedure for using the HP 1640A Serial Data Analyzer with Epicom, Inc. Model 200 CS047 Epitape Recorder.

275-2 USING THE 1640A SERIAL DATA ANALYZER WITH THE SPECTRON CORP. T-511 RECORDER

Describes a procedure for using the HP 1640A Serial Data Analyzer with the Spectron Corp. T-511 Recorder.

280-1 MAKING COMPLEX MEASUREMENTS WITH THE HP MODEL 1602A LOGIC STATE ANALYZER

Describes methods of using the 1602A Logic State Analyzer to make measurements in digital systems with complex program execution. Capabilities that are not readily apparent from the analyzer keyboard are explained through practical applications. These include use of multiple key stroke sequences to specify complex data acquisition, and format specification.

280-2 MONITORING THE IEEE-488 BUS WITH THE 1602A LOGIC STATE ANALYZER

Describes monitoring of HP-IB (IEEE-488) activity with a 1602A Logic State Analyzer and a 10050A/10051A HP-IB Adapter and Test Probe.

280-3 THE 1602A LOGIC STATE ANALYZER AS AN AUTOMATIC TEST INSTRUMENT

Describes use of the 1602A Logic State Analyzer as part of an automatic production test system. The system consists of a 1602A Opt. 001, a 9825A Computing Controller, and the Hewlett-Packard Interface Bus (HP-IB).

280-4 MAKING MEASUREMENTS ON WIDE BUSES WITH HP's MODEL 1602A LOGIC STATE ANALYZERS

Describes how 1602A can be connected in parallel for collecting data on buses or bus combinations greater than 16 bits wide. This allows the paralleled 1602As to capture information from address to data buses or other signal lines in response to the occurence of a selected trigger word determined by a master 1602A. This capability is useful when used with the HP-IB option in automated systems.

283-1 8662A RF SYNTHESIZED SIGNAL GENERATOR PERFORMANCE, FAMILIARIZATION, AND APPLICATIONS

A detailed users guide for the HP 8662A 10 kHz to 1280 MHz RF Synthesized Signal Generator. Gives helpful information on instrument operation (both manual and remote), performance characteristics, and a general background on applications. Software programming examples are provided along with a quick reference programming guide. Digital sweep capabilities along with other signal generator features are covered.

284 GUIDE TO QUARTZ THERMOMETRY MEASUREMENT ACCURACY

Discusses the sources of measurement errors affecting the accuracy of the 2804A Quartz Thermometer's readings. Accuracy levels of high, medium and low are specified under application situations over wide and narrow temperature ranges. Those specified levels allow the user to determine expected accuracy for a range of measurement requirements and situations.

285 SUCCESSFUL BURIED CABLE FAULT LOCATING

Describes concepts and procedures for locating faults in buried telephone cable with HP Delcon instruments. Based upon practical field experience, this information has resulted in faster clearing time and overall cost savings.

286-1 APPLICATIONS AND OPERATION OF THE 8901A MODULATION ANALYZER

Describes general operation of the 8901A Modulation Analyzer. Includes information and procedures needed for applications such as signal generator calibration, broadcast monitoring, mobile radio transmitter testing, measuring residual FM noise of oscillators, measuring VCO differential nonlinearity, and accurately measuring peak modulation transients. Discusses the theory and operation of the optional modulation calibrator. Describes remote HP-IB operation and includes detailed software examples and application subroutines with annotated listings for various computing controllers.

287-1 WAVEFORM ANALYSIS USING THE 5328A UNIVERSAL FREQUENCY COUNTER

Describes the use of an HP 5328A Universal Frequency Counter together with an HP 9825A Desktop Computer for the waveform analysis of unknown input signals. Measurements that can be made are amplitude, frequency/period, rise time, fall time, pulse width, slew rate, and duty cycle.

ABSTRACTS—COMPUTERS

161-1 HEWLETT-PACKARD SERIES 9800: THE NAME AND NUMBER THAT SAVES TIME AND MONEY

A structural design firm uses an HP 9830 calculator to improve service and performance while significantly reducing engineering time and expense. For example, calculating the length of members in a certain space frame structure used to take two weeks; computed on the 9830 calculator, it takes one person less than half a day.

161-7 LOW-COST CALCULATOR SYSTEM SAVES TIME, IMPROVES ACCURACY FOR RADIATION THERAPISTS AND PHYSICISTS

Describes how the Radiology Department of a 475-bed hospital has improved the accuracy and reduced the costs of cost and treatment calculations. Included is a summary of the HP 9830 software programs used by the department, with sample printouts and plots of two of the programs.

161-10 HP 9830 SYSTEM TACKLES ADMINISTRATIVE DATA PROCESSING TASKS AT LEOMINSTER HIGH SCHOOL

Information is now being handled quickly and accurately at this 2500-student secondary school. The 9830 system has automated such tasks as arena scheduling, grade reporting, and attendance record keeping. The desktop computer has also been integrated into the classroom for programming by students and problem solving.

201-4 PERFORMANCE EVALUATION OF HP-IB USING RTE OPERATING SYSTEMS

This brief contains performance data to help determine whether the Hewlett-Packard Interface Bus is suitable for various interface applications. A model is developed to help the HP-IB user determine the total time to send or receive a data message and the amount of HP 1000 or 21MX computer utilization. Performance examples with various devices, such as the HP 3455 digital voltmeter and the HP 2240 measurement and control processor are included.

201-5 THE HP-IB LINK: CONTROL OF DISTRIBUTED HP-IB DEVICES

This note describes the use of HP 3070A terminals to control HP-IB devices at distances up to 2 Km (1.25 miles) remote from HP 1000 computer systems. A typical programming example is included.

201-6 COMPUTER INTERCONNECTIONS: A CHOICE OF WAYS TO LINK HP 1000 SYSTEM TO HP 9825A DESKTOP COMPUTERS

Describes three ways to link HP 1000 computer systems to HP 9825A desktop computers. These methods include HP-IB, RS-232, and the 3070A serial link. This application note contains flowcharts, listings, and detailed hardware and software documentation.

201-7 HP 1000/HP-IB: HIGH PERFORMANCE SOFTWARE FOR THE HP 3455/3495A SUBSYSTEM

Describes a high-speed software driver (DVS71) which improves performance of the HP 3455/3495A subsystem under HP 1000 computer control.

202-1 OPTICAL MARK READERS SUBSTANTIALLY INCREASE PRODUCTIVITY

HP 7260A Optical Mark Readers have allowed a structural wood engineering firm to maintain a very competitive edge in quotations of difficult structures. Salespeople provide the design department with the requirements are noted on the card forms.

On the hour, the HP 2100 Computer receives the information from the remote stations. When all plants are polled, the system, at a rate of 35 seconds per plan, automatically computes the structure parameters along with the manufacturing specifications. Computerized results are ultimately printed on the HP 7260As associated terminal.

202-2 OPTICAL MARK READERS PROVIDE LOW COST DATA ENTRY INTO AN HP 3000 COMPUTER SYSTEM

Combining HP 7260A Optical Mark Readers with the HP 3000CX minicomputer and associated remote job entry stations, the State of Maryland Education Department is able to generate necessary reports for multiple state and federal agencies as well as providing students with practical hands-on data processing experiences.

202-3 DISTRIBUTED HP OPTICAL MARK READERS PROVIDE EASY REMOTE DATA COLLECTION

A nationwide network of HP Optical Mark Readers located in the 254 district offices of the National Life and Accident Insurance Company provide an effective data collection system which provides better service to the company's agents and policy owners.

By using the optical forms, National can maintain its computerized Cash Accounting System on a daily basis. Ninety-five percent of their transactions are now individually recorded by a single pencil mark.

212-1 BUILDING AN INVENTORY CONTROL DATA BASE

Using an HP 1000 computer system, the implementation of a common data base is simplified for a manufacturing information control system. The data networking capability of IMAGE/1000 integrates the data for both inventory and purchase order control. The interactive dialog involving the QUERY language for several sample inquiries and reports is also shown.

212-2 BUILDING AN ORDER PROCESSING DATA BASE

This application note illustrates how an HP 1000 data base management system can be dedicated to order processing. By consolidating in a single data base current customer orders, and information on items in production and scheduled for production, all relevant order information is available to those who need it.

224-2 SIGNAL CONDITIONING: HP 22914A BREADBOARD CARD

NEW

Describes how to use the HP 22914A Breadboard Card with an HP 2240A Measurement and Control Processor. Circuit diagrams are shown for use in differential amplifiers, instrumentation amplifiers, analog filters, current loop I/O, stepper motor control, and voltage regulators.

229-1 HP-PLOT/21 SOFTWARE CONVERSION GUIDE

This note provides sufficient information for the systems programmer to determine the feasibility of converting the HP-PLOT/21 package to operate on their systems.

271-1 ADDING SOFT COPY GRAPHICS TO 9825A BASED SYSTEMS USING THE MODEL 1350A GRAPHICS TRANSLATOR

NEW

Describes the capabilities of the 1350A Graphic Translator as an interface between the 9825A Computing Controller and HP CRT displays. This note includes detailed directions for the integration of a Graphics Translator into a 9825A based HP-IB system with plotter software.

281-1 MICROPROGRAMMING: A WAY TO GET HIGHER PERFORMANCE FROM HP1000 COMPUTERS

NEW

Introduces reader to the subject of microprogramming, discusses uses, covers the HP 1000 Computer as a microprogrammable machine, presents a microprogramming example, and provides a sample microprogram.

282-1 6940B MULTIPROGRAMMER SYSTEM THROUGHPUT ANALYSIS (FOR MULTIPROGRAMMER SYSTEMS USING THE 9825A DESKTOP COMPUTER)

NEW

Allows a 6940B/9825A user to determine how long his operations will take to complete. It gives potential customers a way to find out if this equipment can do the job they require. This desktop computer/multiprogrammer combination now has been documented as a system and the user can see what throughput rates he can expect. The user can also see how he should structure his programs for maximum throughput speeds.

ABSTRACTS—CALCULATORS

HP-80 FINANCIAL POCKET CALCULATOR

The following notes help you solve specific problems with the HP-80 financial pocket calculator.

80-001 DIRECT REDUCTION LOAN AMORTIZATION CALCULATIONS

Describes how to calculate payment-to-principal/payment-to-interest loans (e.g., mortgages). Gives keystrokes for determining accumulated interest/-remaining balance and generating an amortization schedule.

80-002 ANNUITY DUE CALCULATIONS FOR SAVINGS FUNDS

Assists the HP-80 user wishing to solve for future value, payment amount, number of payment periods, and interest rate in annuity due calculations.

80-003 ANNUITY DUE CALCULATIONS FOR SAVINGS PLANS WHEN COMPOUNDING PERIODS DIFFER FROM PAYMENT PERIODS

Explains how to do financial calculations when a series of payments are not equally spaced in time with periodic compounding.

80-004 ANNUAL PERCENTAGE RATE FOR LOANS WITH A BALLOON PAYMENT

How to calculate the actual rate or annual percentage rate of loans terminated by a balloon payment, or the rate of return (yield) of a series of even cash flows terminated by an uneven cash flow.

80-005 PRICE AND YIELD CALCULATIONS FOR MORTGAGES TRADED AT A DISCOUNT/ PREMIUM

For HP-80 users who buy and/or sell mortgages at lower (discounted) or higher (at a premium) than the remaining balance of the loan at the time of purchase.

80-006 ANNUITY DUE AND PRESENT VALUE

How to calculate payments in advance or arrears where equal payments are made at the beginning or end of equally spaced periods.

80-007 CALCULATING LOGS, ANTI-LOGS, AND ROOTS OF NUMBERS

How to calculate logs and roots of numbers on the HP-80.

80-008 YIELD AND PERIODIC PAYMENT AMOUNT CALCULATIONS FOR LEASES WITH A BALLOON PAYMENT OR RESIDUAL VALUE

How to calculate yield for leases with a balloon, or rate of return for even stream of cash flows in advance (annuity due) ended by an uneven cash flow. Given the yield, the user may calculate the payment in the same situations.

80-009 INTERNAL RATE OF RETURN (IRR) FOR UNEVEN CASH FLOWS

How to iteratively compute the internal rate of return (yield) for an uneven stream of cash flows.

80-010 LINEAR REGRESSION CALCULATIONS

How to compute a two-variable trend line on the HP-80 by a statistical method called least squares linear regression.

ABSTRACTS—MEDICAL ELECTRONICS

199 SMALL SCREEN DISPLAYS — MEDICAL DIAGNOSTIC SYSTEM APPLICATIONS AND INTERFACING

For the designer with the task of interfacing an HP 1332A, 1333A or 1335 display with an electronic medical diagnostic system, this note provides in-depth descriptions of the models including information about electrical performance, interface characteristics, packaging and internal circuits.

Sections in the note discuss display adjustment, photographic considerations for X-Y displays as well as an appendix describing field installation of electrical options.

710 8800 MEDICAL SYSTEMS -- PRESSURE MEASUREMENT

A thorough survey on "Techniques for Measuring Physiological Pressures" in diagnostic, OR and ICU applications. It includes many of the pitfalls indigenous to measuring pressure and all of the advantages of good methodology.

712 8800 MEDICAL SYSTEMS — HEART SOUND MEASUREMENT

A compilation of basic information and techniques that HP has found very useful in the measurement of heart sounds. It includes data on the cardiac system and its purpose is to guide users of phonocardiographic equipment through potential problem areas. This note illustrates the best method we've found in acquiring heart sounds.

715 MODEL 1513A AUTOMATIC CARDIOGRAPH MODEL 1514A ECG/PHONO SYSTEM

Until the introduction of the HP 1513A Automatic Cardiograph and HP 1514A ECG/Phono System, high-fidelity ECG recording could only be accomplished with expensive high-frequency optical recorders and oscilloscopes. The note describes the galvanometer used in the 1513A and 1514A and discusses how the additional physiological data on the record can assist the cardiologist in his diagnosis.

718 PATIENT SAFETY

Discusses the technical and subtle factors involved in accidentally-induced ventricular fibrillation. Safety design considerations in electronic equipment (particularly patient monitoring), power wiring systems, isolation transformers, and new safe grounding procedures, including HP's engineering efforts in this discipline, are discussed. Efforts being made by professional orgainzations to improve safety through the development of a unified body of standards which will serve equipment users and manufacturers alike are briefly treated in the foreword. The common goal among those involved is to achieve the greatest attainable protection for the patient.

721 ECG APPLICATION NOTE FOR NURSES

Describes how and where to apply electrodes for taking electrocardiograms. It also illustrates proper equipment operation and care. Several pages are devoted to artifacts in recording and how to remedy them.

725-1 ESOPHAGEAL MOTILITY

Describes several current tests of esophageal function and HP systems recommended for use in recording the test data. Techniques for esophageal manometry are presented as well as suggestions for recording pressure, respiration and swallowing. Other related esophageal tests described include acid clearing and pH reflux. An extensive bibliography is included.

729 PULMONARY FUNCTION ANALYZER

The pulmonary function analyzer automates clinical procedures and analysis techniques associated with pulmonary testing. This note describes how a technician can perform the following tests with the HP 4702A Pulmonary Function Analyzer: multiple-breath nitrogen washout, single-breath nitrogen washout, forced vital capacity, and maximum voluntary ventilation.

732 RECORDING PHONOCARDIOGRAPHY AND EXTERNAL PULSE WAVE RECORDING

The sounds emitted from the cardiovascular system are extremely low in intensity. These sounds are commonly recorded by phonocardiography (sounds and murmurs within the frequency range of 25 Hz to 1000 Hz) or by pulse wave cardiography (subaudible sounds between 0.05 Hz and 25 Hz). This note discusses general considerations and principles of phonocardiography, then describes how to use the HP 1514 ECG/-Phonocardiograph.

733 PHYSICIANS GUIDE TO THE HP CATH LAB COMPUTER SYSTEM

This guide summarizes the hardware elements of the HP Cath Lab Computer System, and describes how this online conversational system performs data entry, signal acquisition, analysis, and reporting operations under the operator's command. The note also discusses signal sampling and processing techniques, and methods used for analyzing pressures, cardiac output calculations, plus shunt and derived calculations.

735 USING ELECTRICALLY OPERATED EQUIPMENT SAFELY WITH THE MONITORED CARDIAC PATIENT

A guide for physicians, nurses, and technicians in the safe operation of patient monitors and other electrically operated equipment at the patient's bedside. Includes lists of recommended safe operating practices and cautions for hospital personnel, also a section dealing with Technical Considerations on Electrical Safety in Medicine.

738 ARCHITECTURAL GUIDELINES— PATIENT MONITORING SYSTEMS

Describes the planning required for successful installation and operation of a patient monitoring system. Not only should planning include decisions as to size and location of a unit, selection of equipment, financing, etc., but you should also consider those elements of a more indefinite nature such as selection of staff, staff training, admission policies, future requirements, and equipment maintenance and service. Related reference data is included.

739 GUIDE TO PHYSIOLOGICAL PRESSURE MONITORING

This pressure monitoring guide contains an overview of several invasive and non-invasive blood pressure monitoring techniques. The guide includes a discussion of invasive pressure monitoring for the following measurement sites: peripheral artery pressure, mean arterial pressure, central venous pressure, pulmonary artery and wedge pressures, left atrial pressure, and pressure measurement in the infant patient. Information is presented to aid in setting up and using a pressure monitoring system.

742 A COMPENDIUM ON AUTOMATED ARRHYTHMIA DETECTION

Surveys the history and development of the monitoring and treatment of coronary care patients, and then goes on to describe the contribution made by HP's 78220 Arrhythmia Monitoring System. The growth and impact of coronary care units (CCU's), the importance of detecting and treating premonitory and life-threatening arrhythmias, the problems of current arrhythmia detections methods, and the characteristics of an ideal computer-based arrhythmia detection system are all discussed.

743 ELECTROSURGERY INTERFERENCE — MINIMIZE ITS EFFECTS ON ECG MONITORS

Discusses several techniques for maximizing the effectiveness of ECG monitoring in the presence of electrical interference from electrosurgical and electrocoagulating devices. By offering brief explanations of the electrical phenomena involved as well as specific procedures to follow, it is hoped that the reader will gain a greater insight into both the "why" and "how" of better ECG monitoring in the operating suite.

Two types of electrical interference are considered: conduction — the RF energy carried into the monitoring instrument, and radiation — the RF energy is transmitted through air and is induced into the circuits of the monitoring device and its cables.

744 FLUID COLUMN ECG ELECTRODES

The best monitoring instrumentation will deliver ECG information that is only as good as the electrodes that are used to initially pick up the signal. This note focuses exclusively on fluid column electrodes. From the technical analysis of this model, it is possible to draw certain conclusions as to what are desirable electrode characteristics.

The discussion includes the analysis of metal/electrolyte interface, the characteristic resistance of various electrolytes, plus a brief look at the skin interface.

746 PROPER CLEANING OF HP CABLES

NEW List of recommended cleaning agents and methods used for proper cleaning of HP cables.

747 DEFIBRILLATOR ENERGY DOSAGE

NEW Discussion centers on the energy dosage concept and the amount of energy required to restore a fibrillating heart to normal sinus rhythm in both children and adults. The concept of defibrillator stored vs. delivered energy is also discussed, with several clinical research studies referenced.

748 MONITORING INSTRUMENTATION: ISOLATED INPUTS, ELECTROSURGERY FILERTING, BURNS PROTECTION

NEW The problems of "isolated input" monitoring instrumentation, electrosurgery protection units, and patient safety are discussed, specifically for the European hospital environment. (Reprint of a paper presented at a Symposium on Monitoring in Anesthesia, University of Ghent, Belgium.)

749 X-RAY FILM AND INTENSIFYING SCREEN COMBINATIONS

NEW A brief explanation of medical X-ray films and intensifying screens used in diagnostic radiology. Includes recommended film/screen combinations for use with the 43815P and 43820A chest X-ray systems.

750 X-RAY FILM PROCESSING AND TROUBLESHOOTING

NEW A brief explanation of automatic film processors and a procedure for troubleshooting processing problems.

751 PERFORMANCE VERIFICATION

NEW A simple method for separating 43815P and 43820A X-ray system malfunctions from application induced problems. Intended primarily for use by HP medical field engineers.

752 DEMONSTRATION AND INSTALLATION LOG—MODEL 43820A

NEW Formatted procedure for conducting on-site demonstrations and installations of the Model 43820A Mobile Chest X-ray System. Includes recommended procedures and forms for recording required data.

759 A TECHNICIAN'S GUIDE TO STRESS TESTING

Includes background information on why ECG stress testing is done, characteristics of typical stress test systems, and basic stress test protocols. Describes in detail ECG techniques for use with stress testing such as choice of electrodes, electrode placement, and skin preparation. Includes a troubleshooting guide for recognizing and correcting common problems with stress test ECG recordings. Replaces AN 745.

760 HIS BUNDLE AND EPICARDIAL ELECTROGRAMS—CLINICAL APPLICATIONS

Describes the purposes and methods of recording electrical activity from the HIS bundle within the heart and from sites on the heart surface. Reviews basic cardiac conduction physiology, discusses how electrograms are recorded using intracardiac catheters and epicardial probes, lists conduction disorders studied by these techniques, and defines typical electrogram measurements.

ABSTRACTS—COMPONENTS

922 APPLICATION OF PIN DIODES

Discusses how the PIN diode can be applied to a variety of RF control circuits. Such applications as attenuating, leveling, amplitude and pulse modulating, switching, and phase shifting are discussed in detail. Also examines some of the important properties of the PIN diode and how they affect its application.

923 HOT CARRIER DIODE VIDEO DETECTORS

Describes the characteristics of HP hot carrier (Schottky barrier) diodes intended for use in video detector or video receiver circuits, and discusses some design features of such circuits.

Though less sensitive than the heterodyne receiver, the many advantages of the video receiver make it extremely useful. The hot carrier diode can be used to advantage in applications such as beacon, missile-guidance, fuse-activating, and counter-measure receivers, and as power-leveling and signal-monitoring detectors.

Among the subjects discussed are the performance characteristics of video detector diodes— tangential sensitivity, video resistance, voltage sensitivity and figure of merit; how these characteristics affect the bandwidth of a video detector; video detector design considerations; considerations that affect dynamic range; and considerations that vary the level at which burnout can occur.

928 Ku-BAND STEP RECOVERY MULTIPLIERS

Discusses the use of step-recovery diodes in a times-eight, single-state frequency multiplier which, at 16 GHz, has a typical maximum output of 75 mW. The note also provides design modifications, together with references, for meeting other performance requirements.

929 FAST-SWITCHING PIN DIODES

Discusses the switching speed of the PIN diodes and the considerations which affect switching capability. For HP's 5082-3041/3042 fast-switching PIN diodes, AN 929 outlines basic drive requirements and comments on a few practical switching circuits. Considerations involved in the design of the filters required for use with the diodes are also discussed. For the 5082-3041, AN 929 provides two curves: 1) typical isolation vs. forward bias and 2) switching time vs. forward bias for peak reverse current as a parameter.

931 SOLID STATE ALPHANUMERIC DISPLAY DECODER/DRIVER CIRCUITRY

A discussion of decoder/driver circuitry for HP's 5082-7100 series of 5x7 dot arrays of gallium arsenide phosphide light emitting diodes. Material covers general strobing techniques, block diagrams, specific schematic diagrams, and parts lists necessary to drive solid-state alphanumeric displays.

932 SELECTION AND USE OF MICROWAVE DIODE SWITCHES AND LIMITERS

Helps the systems designer select the proper switching or limiting component and assists him in integrating this component into the overall design of the system. This note is a practical, user-oriented approach to problems encountered with switching and limiting microwave signals.

934 5082-7300 SERIES SOLID-STATE DISPLAY INSTALLATION TECHNIQUES

The 5082-7300 series numeric/hexadecimal indicators are standard displays for commercial, industrial and military applications. This note describes display mounting, p.c. board mounting, heat sinking, electrical interfacing, and optical considerations.

935 MICROWAVE POWER GENERATION AND AMPLIFICATION USING IMPATT DIODES

Describes the construction and principles of operation of microwave avalanche (IMPATT) diodes. This note presents practical circuit designs and describes how these devices meet the stringent oscillator noise requirements of most military and commercial microwave systems.

936 HIGH PERFORMANCE PIN ATTENUATOR FOR LOW-COST AGC APPLICATIONS

PIN diodes offer an economical way of achieving excellent performance in AGC circuits. Significant improvements in crossmodulation and intermodulation distortion performance are obtained, compared to transistors. This note discusses other advantages of PIN diodes, such as low frequency operation, constant impedance levels, and low power consumption.

937 MONOLITHIC SEVEN SEGMENT LED DISPLAY INSTALLATION TECHNIQUES

The 7400 series displays are designed for strobing, a drive method that allows timesharing of the character generator among the digits in a display so that only 8 + N lead connections need to be made to the display cluster for N characters. This note explains the strobing technique, discusses the uses of right-hand and center decimal points, and presents several circuits for typical applications.

939 HIGH SPEED OPTICALLY COUPLED ISOLATORS

Describes the 5082-4350/4360 high-speed optically coupled isolators and their applications in digital and analog systems.

940 DIODES FOR HYBRID INTEGRATED CIRCUITS

Better reproducibility, lower cost and the smaller size of hybrid integrated circuits mean that they are replacing circuit boards with packaged diodes. This note discusses the different diode package styles for hybrid integrated circuits: chips, beam lead, ministrip, leadless

940 (Cont'd.)

inverted device (LID), and microstrip post. Also presents a technique for designing impedance matching elements.

941 5082-7700 SERIES SEVEN-SEGMENT LED DISPLAY APPLICATIONS

Begins with dc drive techniques and circuits, followed by an explanation of the strobe drive techniques and the resultant increase in device efficiency. Also discusses general strobing circuits, with some typical applications such as clocks, calculators and counters. Includes information on general operating conditions, including intensity uniformity, light output control as a function of ambient, contrast enhancement, and device mounting.

942 SCHOTTKY DIODES FOR HIGH VOLUME LOW COST APPLICATIONS

Discusses switching, sampling, mixing and other applications where the substitution of Schottky diodes will provide significant improvement over PN junction devices.

944-1 MICROWAVE TRANSISTOR BIAS CONSIDERATIONS

A practical discussion of the temperature dependent variables in a microwave transistor that cause RF performance degradation due to changes in quiescent point. Passive circuit networks that minimize quiescent point drift with temperature are analyzed, and the general equations for dc stability factors are given. Emphasis on practical circuit design is highlighted by typical circuit examples.

945 PHOTOMETRY OF RED LEDs

When designing LEDs into equipment, there are several factors that should be considered: LED size, anticipated viewing angle and the distance, character height and font (shape), viewing background and filtering, on-to-off contrast ratio, and anticipated ambient light conditions. To help the potential LED designer choose the appropriate device, this note answers the following questions: what to measure (definition of term), how to measure it (apparatus arrangement), and whose equipment to use (criteria for selection).

946 5082-7430 SERIES MONOLITHIC SEVEN-SEGMENT DISPLAYS

Describes use of the 5082-7430 displays in circuits where low power drain and high luminous intensity are important.

947 DIGITAL DATA TRANSMISSION USING OPTICALLY COUPLED ISOLATORS

Optically coupled isolators make ideal line receivers for digital data transmission applications. They are especially useful for elimination of common mode interference between two isolated data transmission systems. This application note describes design considerations and circuit techniques with special emphasis on selection of line drivers, transmission lines, and line receiver termination for optimum data rate and common mode rejection. Both resistive and active terminations are described for multiplexing applications, and for common mode rejection and data rate enhancement.

948 PERFORMANCE OF THE 5082-4350/51/60 ISOLATORS IN SHORT TO MODERATE LENGTH DIGITAL DATA TRANSMISSION SYSTEMS

Describes use of HP 5082-4350/51/60 optically-coupled isolators as a line receiver in a TTL-TTL compatible NRZ (nonreturn-to-zero) data transmission link. It describes several useful total systems including line driver, cable, terminations, and TTL compatible connections.

949-1 LINEAR POWER AMPLIFICATION USING HP 35850 TRANSISTORS

The design and construction of a 1.5 GHz linear power amplifier is presented. An output power at the 1 dB compression point of +29 dBm is achieved together with 20 dB of gain. The design concept is of balanced amplifiers using hybrid couplers.

949-2 HP 35826E 1.5 GHz LUMPED ELEMENT AMPLIFIER

This note considers the use of lumped circuit elements for an amplifier design at 1.5 GHz. A novel mounting technique for the transistor is used resulting in a small low cost form of construction.

951-1 APPLICATIONS FOR LOW INPUT CURRENT, HIGH GAIN OPTICALLY COUPLED ISOLATORS

Optically-coupled isolators are useful in line receivers, logic isolation, power lines, medical equipment, and telephone lines. This note discusses use of the 5082-4370 series high CTR isolators in each of these areas.

951-2 LINEAR APPLICATIONS OF OPTICALLY COUPLED ISOLATORS

Optically coupled isolators can be used to transfer an analog signal between two isolated systems. In many instances, isolators can replace expensive transformers, instrumentation amplifiers, and A/D conversion schemes. This application note discusses several circuit techniques by which 5082-4350 series coupled isolators can be used to transmit analog information. The operation of each circuit performance is given.

956-1 THE CRITERION FOR THE TANGENTIAL SENSITIVITY MEASUREMENT

Discusses the meaning of Tangential Sensitivity and a recommended measurement technique.

956-2 THE E-2 MIXER EQUIVALENT CIRCUIT

Develops an equivalent circuit for the 5082-2217 microstrip mixer diode.

956-3 FLICKER NOISE IN SCHOTTKY DIODES

Treats the subject of flicker (1/f) noise in Schottky diodes, comparing 4 different types.

956-4 SCHOTTKY DIODE VOLTAGE DOUBLER

Explains how Schottky detectors can be combined to achieve higher output voltages than would be produced by a single diode.

956-5 DYNAMIC RANGE EXTENSION OF SCHOTTKY DETECTORS

Discusses operation of two types of detectors: the small signal type, also known as square-law detectors; and the large signal type, also known as linear or peak detectors.

Techniques for raising the compression level are presented. An example is given illustrating the effect of bias current level on an HP 5082-2751 detector.

956-6 TEMPERATURE DEPENDENCE OF SCHOTTKY DETECTOR VOLTAGE SENSITIVITY

A discussion of the effects that temperature changes have on Schottky barrier diodes. Performance improves at lower temperatures in a predictable manner. Data presented were obtained using HP 5082-2750 detector diodes.

957-1 BROADBANDING THE SHUNT PIN DIODE SPDT SWITCH

Covers an impedance matching technique which improves the bandwidth of shunt PIN diode switches.

957-2 REDUCING THE INSERTION LOSS OF A SHUNT PIN DIODE

Examines a simple filter design which includes the shunt PIN diode capacitance into a low pass filter, thereby extending the upper frequency limit.

957-3 RECTIFICATION EFFECTS IN PIN ATTENTUATORS

Attenuation levels of PIN diodes are changed by high incident power. Variation in attenuation may be minimized by proper choice of bias resistance. Performance of a PIN diode is limited by both carrier level and frequency because of rectification effects. This note presents the effects of frequency, power level, and bias supply for three types of HP diodes: 5082-3170, 3140 and 3141.

959-1 FACTORS AFFECTING SILICON IMPATT DIODE RELIABILITY AND SAFE OPERATION

Treats silicon IMPATT diode reliability with heavy emphasis on how to avoid bias circuit related and tuning induced burnout.

959-2 RELIABILITY OF SILICON IMPATT DIODES

Covers the major failure mechanism in silicon IMPATT diodes with a summary of life test results on both single and double drift silicon IMPATT diodes.

961 SILICON DOUBLE-DRIFT IMPATT DIODES FOR PULSE APPLICATIONS

Offers an in-depth look at the theory and applications of silicon double drift IMPATTS designed for use in pulsed oscillators and amplifiers. Major sections include device theory, circuits, performance and injection locking techniques. An appendix on pulse bias circuits is included.

962 SILICON DOUBLE-DRIFT IMPATT DIODES FOR HIGH-POWER CW MICROWAVE APPLICATIONS

Provides a thorough treatment of the theory and application of silicon double drift IMPATTS designed for use in CW oscillators and amplifiers. Major sections include device theory, circuits, performance and injection locking techniques.

963 IMPEDANCE MATCHING TECHNIQUES FOR MIXERS AND DETECTORS

Presents a methodical technique for matching complex loads, such as Schottky diodes, to a transmission line. Direct application to broadband mixers and detectors is illustrated.

964 CONTRAST ENHANCEMENT TECHNIQUES

Presents various criteria and techniques that a display engineer should consider to obtain optimum contrast enhancement for red, yellow and green LED displays. A representative list of filter manufacturers and available filters is given at the end of this discussion.

965 PRINTED CIRCUIT BALANCED MIXER DESIGN AND APPLICATIONS

Discusses the mixing performance and use of the 5082-9200 Printed Circuit Balanced Mixer (PCBM). In addition to theory and performance, this note presents a basic approach to the diplexer design necessary to use the PCBM.

966 APPLICATIONS OF THE HP HDSP-2000 ALPHANUMERIC DISPLAY

This note is intended to serve as a design and application guide for users of the HP HDSP-2000 alphanumeric display device. Information presented covers the theory of the device design and operation,

966 (Cont'd.)

considerations for specific circuit designs, thermal management, power derating, and heat sinking; and intensity modulation techniques.

967 A LOW NOISE 4 GHz AMPLIFIER USING THE HXTR-6101 SILICON BIPOLAR TRANSISTOR

Describes in detail the design of a single-stage, state-of-the-art low noise amplifier at 4 GHz using the HXTR-6101 silicon bipolar transistor. Both the input and output matching networks are described.

968 IMPATT AMPLIFIER

Discusses IMPATT amplifier design. A waveguide amplifier produced 2 watts of power with 10 dB gain at 11.2 GHz. Using a coaxial structure, similar performance was obtained at 8.4 GHz.

969 AN OPTIMUM ZERO BIAS SCHOTTKY DETECTOR DIODE

Describes the use of the HSCH-3171 and HSCH-3486 zero bias detector diodes. Their forward voltage characteristics are detailed, as well as discussion of voltage sensitivity including effects of junction capacitance, load resistance and reflection loss on sensitivity. Temperature characteristic curves for both devices are also included.

970 A 6 GHz AMPLIFIER USING THE HFET-1101 GaAs FET

This application note highlights some of the design tradeoffs when using a GaAs FET. The example is an amplifier for use in the 5.9 to 6.4 GHz telecommunications band. The amplifier's performance over this band is excellent, with a maximum noise figure of 3.3 dB, a minimum associated gain of 10.9 dB, a flatness of $\pm$ 0.4 dB and a 9.5 dBm minimum power output at 1 dB gain compression. The maximum input and output SWR are 2.67:1 and 1.90:1 respectively.

1000 DIGITAL DATA TRANSMISSION WITH THE HP FIBER OPTIC SYSTEM

Fiber optics can provide solutions to many data transmission system design problems. The purpose of this application note is to aid designers in obtaining optimal benefits from this relatively new technology. Following a brief review of the merits, as well as the limitations, of fiber optics relative to other media, there is a description of the optical, mechanical, and electrical fundamentals of fiber optic data transmission system design. How these fundamentals apply is seen in the detailed description of the Hewlett-Packard system. The remainder of the note deals with techniques recommended for operation and maintenance of the Hewlett-Packard system, with particular attention given to deriving maximum benefit from the unique features it provides.

1001 INTERFACING THE HDSP-2000 TO MICROPROCESSOR SYSTEMS

Over the past two years, the need for alphanumeric displays has grown very rapidly due to the extensive use of microprocessors in new system design. The presence of the microprocessor in such systems substantially simplifies the traditionally difficult task is further simplified by using a display element such as the HDSP-2000 which has in one package a four character display, as well as most of the basic electronics necessary to drive the display. This note deals with four different techniques for interfacing the HDSP-2000 display to microprocessor systems.

AB 1 CONSTRUCTION AND PERFORMANCE OF HIGH EFFICIENCY RED, YELLOW, AND GREEN LED MATERIALS

The high luminous efficiency of Hewlett-Packard's High Efficiency Red, Yellow, and Green lamps and displays is made possible by a new kind of light-emitting material utilizing a GaP transparent substrate. This application bulletin discusses the construction and performance of this material as compared to standard red GaAsP and red GaP materials.

AB 3 SOLDERING HEWLETT-PACKARD SILVER PLATED LEAD FRAME LED DEVICES

Many of Hewlett-Packard's commercial LED devices use a silver plated lead frame. Soldering to a silver lead frame provides a reliable electrical and mechanical connection and is no more complicated than soldering to a gold lead frame. Some suggestions on how to handle and solder silver plated lead frame devices are presented.

AB 4 DETECTION AND INDICATION OF SEGMENT FAILURES IN 7-SEGMENT LED DISPLAYS

The occurence of a segment failure in certain applications of 7-segment displays can have serious consequences if a resultant erroneous message is read by the viewer. This application discusses three techniques for detecting open segment lines and presenting this information to the viewer.

AB 5 CURRENT SOURCE FOR DIODE TESTING

This application bulletin describes a constant current source designed primarily for the ease of use in laboratory measurements. Easily programmable by thumb wheel switches in 10μA steps from 10μA to 700 mA, its accuracy exceeds most commercially available current sources.

AB 6 PIN DIODE RF RESISTANCE MEASUREMENT

The use of the HP 4815 Vector Impedance Meter, in conjunction with a tunable test fixture, provides an efficient and reliable means for measuring the RF resistance of a PIN diode.

AB 7 MIXER DISTORTION MEASUREMENTS

Describes the measurement of distortion in a balanced mixer by the two tone method.

AB 9 DERIVATION, DEFINITION AND APPLICATION OF NOISE MEASURE

The associated gain at optimum noise figure bias becomes an important parameter at microwave frequencies. The noise measure of a device is a term including both noise figure and associated gain.

AB 10 TRANSISTOR NOISE MEASUREMENTS

The increasing acceptance of GaAs field effect and silicon bipolar transistors in low noise preamp applications has stressed the importance of the techniques used in measuring noise figure. This application bulletin discusses the various techniques and possible sources of error in making a transistor noise figure measurement.

AB 11 CHIP PARAMETERS FOR HXTR-6001

The HXTR-6001 is the chip used in the HXTR-6101, an NPN bipolar transistor designed for minimum noise figure at 4 GHz.

AB 12 CHIP PARAMETERS FOR HXTR-2001

The HXTR-2001 is the chip used in the HXTR-6105, the NPN silicon bipolar microwave transistor designed for a good compromise between low noise and high output dynamic range.

AB 13 TRANSISTOR SPEED UP USING SCHOTTKY DIODES

Significant reduction in transistor switching delay time can be achieved by adding a Schottky diode and a PIN diode to the transistor switching circuit. This improvement in switching performance also extends the oscillator capability of the transistor to higher frequencies.

AB 14 WAVEFORM CLIPPING WITH SCHOTTKY DIODES

Consideration is given in this application bulletin to the design requirements of clipping circuits which are used to limit the transmission of signals above or below specified levels. The characteristics of Schottky diodes needed to achieve the required performance in these circuits are discussed and recommendations made.

AB 15 WAVEFORM CLAMPING WITH SCHOTTKY DIODES

Discussed in this application bulletin are the circuit design and diode performance requirements for a clamping circuit, which is used as a DC restorer or level shifter. Schottky diodes having the required characteristics for this type of circuit are recommended.

AB 16 WAVEFORM SAMPLING WITH SCHOTTKY DIODES

This application bulletin discusses the design considerations for a sampling circuit used to sample high frequency repetitive signals and reproduce them at lower frequencies for ease of monitoring. Schottky diode performance requirements important in the realization of a sampling circuit are considered.

AB 17 NOISE PARAMETERS AND NOISE CIRCLES FOR THE HXTR-6101, -6102, -6103, -6104 AND -6105 LOW NOISE TRANSISTORS

Noise figures as a function of source reflection coefficient (r_S) can be expressed using three parameters, Fmin, Rn to ro known as noise parameters. Three parameters are presented for five microwave transistors. The method of generating noise circles is given in a step-by-step fashion.

AB 18 THE PERFORMANCE OF THE HXTR-6101 AT SUBMILLIAMPERE BIAS LEVELS

Describes the performance of a low noise microwave transistor at bias conditions of $V_{CE} \pm 3V$ and $I_C \pm 1.0$ mA, 0.5 mA, 0.25 mA and frequencies 1.0, 1.5, 2.0 and 3.0 GHz.

AB 19 NOISE AND POWER PARAMETERS FOR THE HFET-1101

The noise parameters Fmin, R_n to r_o are given for the HFET-1101, a general purpose microwave GaAs FET. The source and load reflection coefficients are given for maximum output power at an input power level of 5 dBm. The gain, power at 1 dB compression, and power at 3 dB compression are given for frequencies of 4, 6, 8, 10 and 12 GHz.

AB 20 AMPLITUDE TO PHASE CONVERSION IN IMPATT AMPLIFIERS

Curves show the amplitude to phase conversion of a 5082-0610 IMPATT diode in an 11 GHz amplifier using a cavity similar to that described in AN 962.

AB 22 EQUIVALENT CIRCUITS FOR DOUBLE DRIFT CW IMPATT DIODES

NEW

Small signal equivalent circuits were derived for 5082-0610 and 5082-0611 IMPATT diodes in AN 962. This bulletin extends the analysis to provide both small and large signal equivalent circuits for 5082-0607, 0608, 0610, and 0611 diodes.

AB 51 INTERFACING THE HDSP-2000 DISPLAY TO A MICROPROCESSOR

Interface of the HDSP-2000 alphanumeric display to a microprocessor involves the design of a

AB 51 (Cont'd.)

relatively simple interface element. This bulletin briefly discusses the trade-offs involved in the design of such an interface and provides a specific example of an interface to the 8080 microprocessor with appropriate software.

AB 52 LARGE MONOLITHIC LED DISPLAYS

The trend to incorporate more complex functions into smaller package configurations that are portable and battery powered is reaching a point where the limiting items are the space and power constraints imposed upon the display at the operator-to-machine interface. The large monolithic LED display has been designed to meet many of these constraints. This application bulletin describes the beneficial features of a large monolithic LED display and presents circuits which interface the display to CMOS logic and to a microprocessor.

AB 53 INTERFACING THE HDSP-6504/6508 16-SEGEMENT ALPHANUMERIC DISPLAY

Advances in monolithic LED manufacturing technology have permitted the introduction of an alphanumeric display using a 16-segment font with a decimal and colon. The use of this new display is the topic of this bulletin, intended to assist the designer in the following areas; 1) electrical drive conditions; 2) design of a stand-alone ASCII to eighteen segment decoder, and; 3) a 6800 microprocessor interface.

AB 54 MECHANICAL HANDLING OF SUB-MINIATURE LED LAMPS AND ARRAYS

To obtain long operating life, from a series of small individual epoxy-encapsulated LED lamps and lamp arrays these subminiature devices must be carefully installed on the printed circuit board in such a manner as to insure the integrity of the encapsulating epoxy. This bulletin describes the subminiature package assembly, its mechanical limitations and offers specific suggestions for proper installation.

AB 55 LOW COST INTERFACE FOR A 32-CHARACTER HDSP-2000 ALPHANUMERIC DISPLAY

The cost of the support electronics necessary to operate the HDSP-2000 can be reduced through the selection of cost-optimized, rather than function-organized components. The circuit depicted in this bulletin is accompanied by a discussion of its advantages, which are realized by using predominan, Hy TTL logic, a low cost 128 byte NMOS RAM, and a low cost, single supply NMOS character generator.

ABSTRACTS—ANALYTICAL INSTRUMENTS

176-1 LINE SHAPE AND HIGH MASS SENSITIVITY OF THE DODECAPOLE

To overcome the quadrupole mass filter's shortcomings, HP developed the dodecapole. Four pairs of electrodes were added to the quadrupole structure and were energized to produce optimum results. This note summarizes dodecapole performance throughout the mass range.

176-3 500-FEMTOGRAM DETECTION OF DDT BY GC/MS

A standard pesticide mixture is analyzed to illustrate the sensitivity and efficiency of HP's gas chromatograph/mass spectrometer system.

176-4 ANALYSIS OF COMMERCIAL ALPHA-OLEFIN: OPEN TUBULAR COLUMN GC/MS

Quantitative and qualitative analyses of alphaolefins are of interest because of their wide use in flavor, perfume, medicine, dye and resin chemistry. This note describes how to analyze commercial grade samples using gas chromatography/mass spectroscopy.

176-5 A COMPARISON OF MAGNETIC SECTOR AND DODECAPOLE SPECTRA

To overcome the high mass falloff common with quadrupole type mass spectrometers, HP designed a new lens system for the 5930A GC/Mass Spectrometer. To evaluate the performance of the HP dodecapole with this lens, the system controls were set using a conventional reference material (PFTBA), and spectra were obtained for comparison using a number of compound types and molecular weight regions.

176-6 COLUMN TECHNOLOGY IN GC/MS

Describes special considerations important to GC/MS, such as choice and flow rate of carrier gas, column packing, the column conditioning.

176-7 DOUBLY-CHARGED IONS

Often, peaks caused by doubly-charged ions are not resolved under unit resolution settings. This note describes a technique for revealing these ions.

176-8 EXPLOSIVES: ANALYSIS USING DUAL CHEMICAL/ELECTRON IONIZATION GC/MS

Describes analysis of a sample of explosives using both electron ionization (EI) and chemical ionization (CI) techniques to illustrate the advantages and complementary nature of CI.

176-10 METHANE: ITS USEFULNESS AS BOTH CARRIER AND REACTANT GAS IN CHEMICAL IONIZATION GC/MS

176-11 FEMTOMOLE ANALYSIS OF A BIOGENIC AMINE BY GC/MS

176-12 PICOGRAM DETECTION OF TETRACHLORODIBENZODIOXIN

176-13 REACTANT GAS SELECTION IN CHEMICAL IONIZATION MASS SPECTROMETRY PART I (See 176-18 for Part II)

176-14 PICOGRAM DETECTION OF AN ANTICONVULSANT BY CHEMICAL IONIZATION GC/MS

176-15 ANALYSIS OF PULLUTANTS IN URBAN AIR BY GC/MS

176-16 ANALYSIS OF DERIVATIZED AMINO ACIDS BY CHEMICAL IONIZATION GC/MS

176-17 EFFECT OF A MEMBRANE SEPARATOR ON GC/MS PEAK SHAPE AND RETENTION CHARACTERISTICS

176-18 REACTANT GAS SELECTION IN CHEMICAL IONIZATION MASS SPECTROMETRY: PART II. See 176-13.

A practical guide to the use of some of the more commonly used reagent gases. Although historically methane has been the choice reactant gas in chemical ionization (CI) gas chromatograph/mass spectrometry, the note shows that other gases such as hydrogen, isobutane and ammonia can be used effectively to complement CI results.

176-19 USE OF A MIXED REAGENT GAS FOR CHEMICAL IONIZATION GC/MS

The use of an argon-methane mixture as a carrier/reagent gas in the CI mode of the GC/MS provides an added dimension for obtaining mixed EI-CI spectra during a GC/MS analysis.

This technique can be used to differentiate between certain isomers whose analysis may not be possible with conventional mass spectrometry techniques.

176-21 AUTOMATIC DATA REDUCTION AND ANALYSIS USING BATCH PROCESSOR GC/MS

176-22 ANALYSIS OF CHLOROPESTICIDES AND PCB'S IN CHEESE BY GLASS CAPILLARY GC/MS USING THE SELECTED ION MONITORING TECHNIQUE

176-23 CAPILLARY COLUMN GC/MS ANALYSIS OF ESSENTIAL OILS

176-24 GC/MS ANALYSIS OF VOLATILE ORGANICS IN WATER

176-25 ENSURING REPRODUCIBLE MASS SPECTRAL PATTERNS WITH AUTOMATICALLY TUNED GC/MS SYSTEMS

228-3 DETERMINATION OF BENZENE AND TOLUENE IN GASOLINE

Since benzene and toluene are classed as toxic compounds, a new EPA ruling has been made that these components must be measured in all commercial gasolines. A new ASTM method for "Benzene and Toluene in Finished Motor and Aviation Gasolines" has been developed for this analysis. This method will appear as a new standard in the 1977 "Annual Book of ASTM Standards". This analysis should open up a very significant market for a special GC package system because every refinery and many government laboratories will be required to make this analysis.

228-4 APPLICATIONS AND OPERATION OF THE NITROGEN-PHOSPHORUS DETECTOR

Elaborate extraction procedures prior to gas chromatographic separation are frequently necessary when trace constituents of complex matrices must be quantitated. The use of the nitrogen-phosphorus detector is shown to facilitate the quantitation of N- or P-containing compounds in such samples. Several applications of this detector to clinical chemistry, toxicology, biomedical research, food analyses, and environmental assays are given, and the detector operation is described.

228-5 OPTIMIZING ANALYSES USING SPLITLESS INJECTION ON CAPILLARY COLUMNS

The combination of high resolution glass capillary columns and "purged splitless" injection provides the analyst with a very useful technique for determining trace components in mixtures. Contrary to popular belief, splitless injection is not a difficult procedure to use, provided some basic guidelines are followed. This note lists those guidelines and demonstrates that reproducible, quantitative results are achievable with splitless injection.

228-6 AUTOMATED DETERMINATION OF BENZENE ADSORBED ON CHARCOAL TUBES

Monitoring for benzene in the air is usually accomplished by sampling the air through a charcoal tube and then desorbing the benzene with CS_2. The subsequent GC determination of the benzene concentration can be done quickly and accurately using a two-column system with backflush provision. The use of an Automatic Liquid Sampler and Run Programming enables up to 35 samples to be analyzed unattended, with the benzene in air concentration printed directly on the report.

228-8 ANALYSIS OF VOLATILE HALOGENATED ORGANICS IN WATER BY DIRECT AQUEOUS INJECTION WITH ELECTRON CAPTURE DETECTOR

Direct aqueous injection gas chromatography with the Hewlett-Packard constant current .63Ni electron capture detector provides a rapid screening technique for the analysis of certain volatile organohalides in water. With a graphitized carbon black column support and temperature programming less than 20, ppb of each trihalomethane can be measured with 5 % precision in less than fifteen minutes.

228-10 HYDROCARBON GROUP TYPE ANALYSIS OF GASOLINE BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

Automated column backflushing and data reduction is used in the HPLC analysis of gasoline for saturated, olefinic, and aromatic hydrocarbons. An infrared detector is used which provides good quantitation due to its long-term baseline stability.

232-1 HPLC OF PHARMACEUTICAL PRODUCTS: ANALGESIC TABLETS

Describes a method of separating analgesics in tablets using reverse phase chromatography. This method will give more reliable and repeatable results than the most usual method involving ion-exchange chromatography.

232-2 HPLC METHOD DEVELOPMENT ON THE HP 1084A

Describes how the microprocessor-controlled HP 1084A Liquid Chromatograph can be used to help the analyst develop optimum methods. An example is given for a barbiturates sample.

232-3 THEOPHYLLINE ASSAY BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

Theophylline is widely used as a bronchodilator in the treatment of asthma. This note describes an HPLC analysis method with total analysis time of less than 25 minutes, which represents a considerable saving when compared with alternative methods.

232-4 HPLC ANALYSIS OF FOOD ADDITIVES I: PRESERVATIVES

Monitoring the parity and composition of food products and beverages is an important area of chemical analysis. High quality standards must be maintained to insure market acceptance and to meet numerous legal controls. This note shows that fast and accurate determination of various food preser-

232-4 (Cont'd.)

vatives can be obtained with HPLC after dilution of, or simple extraction from, the original food samples.

232-5 HPLC ANALYSIS OF FOOD ADDITIVES II: ANTIOXIDENTS

Antioxidents are added to many food products to prevent deterioration due to gradual oxidation by atmospheric oxygen. Fats, bread and other baked products, potato products, milk products, confectionary products, and many pharmaceutical and cosmetic preparations are all suseptible to oxidation. This note shows that a fast and accurate determination of the various antioxidents in food can be obtained with HPLC after the simplist preparation procedures.

232-6 HPLC OF PHARMACEUTICAL PRODUCTS: VITAMINS

Describes two methods–one isocratic and one gradient. Recommended for analyzing the most important water-soluble vitamins. In addition, two other methods are described for analyzing folic acid and the fat-soluble vitamins.

GC 1-73 ANALYSIS OF POLYCHLORINATED BIPHENYLS

Because of their chemical inertness, once polychlorinated biphenyls are introduced into the ecosystem, they are extremely persistent chemicals. Quantitation is difficult because of the number of peaks; analysis is further complicated by overlapping composition and high temperature requirements. When the 5713A Electron Capture Gas Chromatograph with higher column temperature was used, analysis time was reduced and excellent sensitivity was achieved.

GC 2-73 OPERATING CONDITIONS FOR OPTIMUM PERFORMANCE OF THE 5711A FLAME IONIZATION DETECTOR

Optimum operating conditions for the 5711A are dependent upon the type of carrier gas used. This note discusses the considerations of using nitrogen vs. helium. Other performance factors discussed are: jet flow and pressure, detector linearity and linear range.

GC 3-73 HEROIN ASSAY USING GAS CHROMATOGRAPHY

A study done in conjunction with the New York Police Department, this note describes a screening procedure for heroin in the presence of assorted dilutents (an analysis of street samples).

GC 4-73 AUTOMATIC FLAME PHOTOMETRIC ANALYSIS WITHOUT SOLVENT FLAME-OUT

Usually solvent flame-out has been circumvented by solvent venting valves and automatic reignite devices, both of which result in significant baseline instabilities. HP has developed a simple modification to the flame photometric detector that results in better signal-to-noise ratios, increased dynamic range, elimination of solvent flame-out, and no loss of sensitivity.

GC 5-74 NATURAL GAS ANALYSIS

The analysis of natural gas is extremely important because the price of the gas is established by its calorific value. This note describes the HP 5786 gas chromatograph system that provides a total component analysis (with no separation of oxygen and nitrogen) in approximately 15 minutes. Both "wet" and "dry" samples were examined.

GC 6-74 DETERMINATION OF ACETALDEHYDE, ETHYL ACETATE AND FUSEL OILS IN ALCOHOLIC BEVERAGES

Describes a total analysis of alcoholic beverages for low molecular weight aldehydes, esters and alcohols — performed in 20 minutes using the HP 5830A processor-based gas chromatograph.

GC 7-74 THE DETERMINATION OF CHROMIUM BY GAS CHROMATOGRAPHY USING A FLAME PHOTOMETRIC DETECTOR

Describes use of the flame photometric detector that offers reasonable sensitivity and excellent selectivity for chromium, even in complex samples.

GC 9-74 CLASSIFICATION OF ANAEROBIC BACTERIA BY GAS CHROMATOGRAPHY

A major problem associated with bacterial classification is the lengthy characterization of bacteria by culture growth, staining, biochemical tests and susceptibility tests. Recently, gas chromatography has been introduced as a rapid test for anaerobes through the analysis of the free volatile acids produced by culture metabolism.

GC 1-75 THE GAS CHROMATOGRAPHIC DETERMINATION OF VINYL CHLORIDE MONOMER

Vinyl chloride monomer is the base material for the production of vinyl chloride polymer plastic used in such things as electrical insulation, plumbing tubing, and packaging of foods and beverages. Recently, the Federal Government set a new minimum allowable limit for VCM in air. This note describes how to analyze several types of samples using an HP 5831A gas chromatograph.

GC 2-75 ANALYSIS OF ESSENTIAL OILS BY GAS CHROMATOGRAPHY

The essential oil analyst finds gas chromatography an ideal tool for characterization and

GC 2-75 (Cont'd.)

control. When coupled with other techniques, such as infra-red and mass spectrometry, a fairly complete identification and quantitation of the peaks can be made.

The quality and reliability of analytical results is strongly dependent on column technology i.e. resolution, efficiency, and these are two of the major operating variables examined in this paper. A discussion of functional group analysis follows, in which simple chemical reactions permit function assignments to be made, based on changes in peak height or peak position after reaction.

GC 3-75 THE AUTOMATIC DETERMINATION FO CO, CH^4, AND TOTAL HYDROCARBONS

The automatic direct analysis of carbon monoxide, methane and C^2 + hydrocarbons is easily achieved using the Model 5830A gas chromatograph. The analysis is performed in 7 minutes or less with 0.1 ppb sensitivity using one injection per sample, data reports on an 8½ x 11 numbered page, computer interface capability, auto rezero, auto ranging and high sensitivity to the environmental analyst.

GC 4-75 AUTOMATED ANALYSIS OF ESSENTIAL OILS

Essential oils, and the entire related field of flavors and fragrances, present an unusual combination of analytical problems.

A study was made of the practicality of automating such analysis so that samples could be injected, analyzed, and the results calculated around the clock.

A model 7671 Automatic Liquid Sampler was used to minimize sample handling. The results indicate that fully automatic operation with S.C.O.T. columns is quite practical and that the effective working time of the GC can be extended considerably without requiring additional operator attention.

GC 5-75 THE RAPID DETERMINATION OF H_2S, COS AND SO_2 BY GAS CHROMATOGRAPHY

The ease of preparation resolution of COS and H_2S, short analysis time and equivalent performance make the short Porapak ZS + 0.5% H_3PO_4 column an attractive alternate to the long Polyphenyl ether + 0.5% H_3PO_4 column for the analysis of ambient levels of light sulfur gases.

GC 6-75 A NEW GC COLUMN FOR THE ANALYSIS OF PHENOBARBITAL, PRIMIDONE, AND DIPHENYLHYDANTOIN

Because serious side effects can result if the concentration of the subject drugs becomes too high, it is important to monitor serum drug levels while dosages are being adjusted. A method of analysis which can quantitate all three drugs at once is desirable because the drugs are often prescribed in some combination and primidone is metabolized to phenobarbital. Gas chromatography, which can provide such data in a single chromatogram, is therefore and important technique for this analysis.

GC 3-76 THE ANALYSIS OF GAS IN TRANSFORMER OILS BY GAS CHROMATOGRAPH

Gives details on an automated analyzer which performs an entire analysis of gas extracted from electrical-transformer oil with a single sample injection of only 0.5 ml and prints out an analysis report.

The 5830 series-based gas chromatograph system provides rapid and precise determination of the components in the gas mixture. The note is illustrated with tables, gas chromatograms and diagrams of the oil gas analyzer.

GC 5-76 THE AUTOMATIC ANALYSIS OF VOLATILE ORGANICS IN WATER

The cumbersome analysis of volatile organics from aqueous samples can now be performed easily and automatically using the HP 5830/40 Reporting Gas Chromatograph.

With the use of the column described in the text, the analysis of the seven chloro and bromo solvents of interest in finished water can be performed in less than 30 minutes per sample.

GC 6-76 TRACE ORGANIC CONSTITUENTS IN WATER

The dilute nature of the organic constituents from most environmental samples requires some form of isolation and concentration prior to analysis. Splitless injection has advantages over other capillary column injection techniques.

The HP 18835A multi-purpose capillary column inlet system functions well as a splitless injector as demonstrated by the chromatograms of organic contaminants found in water. Regardless of the sample preparation technqiue, however, the 5830A/40A gas chromatograph is a practical method for characterizing the organic substances present.

GC 7-76 QUANTITATIVE ANALYSIS USING A "PURGED SPLITLESS" INJECTION TECHNIQUE

Quantitative trace component analysis, using a "purged splitless" gas chromatography technique is described in this note.

The technique is well suited to the needs of chromatographers who frequently encounter dilute complex mixtures in environmental, flavor, fragrance and biomedical investigations. The note gives two examples of quantitative trace analysis on open tubular columns which were completed on an HP 5830A repor-

GC 7-76 (Cont'd.)

ting GC equipped with a recently introduced capillary column inlet system.

GC 8-76 THE GAS CHROMATOGRAPHIC DETERMINATION OF RESIDUAL ACRYLONITRILE MONOMER

The HP 5711B Gas Chromatograph, equipped with a dual nitrogen detector, offers the analyst the capability of determining acrylonitrile in concentrations well below the 50 ppb level in synthetic standards. Because of the high stability of the detector, this analysis may be routinely performed with analysis times of less than 10 minutes per sample.

GC 9-76 ANALYSIS OF AMMONIA PLANT GASES

The HP 5840 GC system described in this paper can provide a convenient and precise means of analyzing all gas streams involved in an ammonia synthesis plant. Analysis time for all samples is very short and one system should be sufficient for all the analysis required in most plants.

The principal analysis problems encountered in these samples are: the determination of ammonia, measurement of low levels of hydrocarbons, measurement of CO and CO_2 from PPM to levels as high as 18%; and the determination of hydrogen at concentrations ranging from 50 to 80%.

GC 1-77 APPLICATION OF THE NITROGEN-PHOSPHORUS DETECTOR TO THE ANALYSIS OF 1,4-BENZODIAZEPINE DRUGS

A number of drugs in wide use today belong to the 1,4-benzodiazepine class of compounds. Gas chromatography with electron capture detection has been widely used in the analysis of these drugs and their metabolites. In this work, another selective and sensitive detector, the nitrogen-phosphorus detector is evaluated for the analysis of these drugs. This detector is shown to have adequate sensitivity even for monitoring therapeutic clonazepam concentrations, and it has better sensitivity than the EC detector for some of the drug metabolites.

GC 2-77 THERAPEUTIC DRUG MONITORING

The Nitrogen Phosphorus detector has many applications in therapeutic drug monitoring. Its increased sensitivity makes micro methods possible for drugs such as theothylline. Other drugs which have therapeutic levels too low for flame ionization detection can be determined with the more sensitive nitrogen-phosphorus detector. The N-P detector is also a very selective detector and this often makes shorter extraction procedures possible.

IN-1 PERFORMANCE DATA FOR THE VARIABLE VOLUME INJECTION SYSTEM

IN-3 QUANTITATIVE ANALYSIS WITH HP 1084A

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