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BENCH BRIEFS

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Switching Power Supplies

Editor's note: The material for this article was edited from HP's DC Power Supply Handbook (AN 90B), originally written by Richard Tomasetti of the Marketing Communications group at HP's power supply division in Rockaway, New Jersey.

Electronic power supplies are defined as units that convert power from an ac or dc source into ac or dc power at voltages suitable for supplying an electronic device.

Within this definition, electronic power supplies can be divided into four broad classifications:

(1) ac in, ac out — line regulators and frequency changers

(2) dc in, dc out — converters and dc regulators

(3) dc in, ac out — inverters

(4) ac in, dc out — "common" power supply

This last category is by far the most common of the four and is generally the one referred to when speaking of a "power supply."

Four basic outputs or modes of operation can be provided by dc output power supplies:

- *Constant Voltage:* The output voltage is maintained constant in spite of changes in load, line, or temperature.
- *Constant Current:* The output current is maintained constant in spite of changes in load, line, or temperature.
- *Voltage Limit:* Same as Constant Voltage except for less precise regulation characteristics.
- *Current Limit:* Similar to Constant Current except for less precise regulation.

Within each type of power supply, different forms of regulation are used to maintain a constant output. Switching is one of the forms used in a constant voltage power supply.

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Therefore, a switching power supply is defined as an ac in, dc out, constant voltage power supply that uses a "switching technique" for regulation.

Basic Switching Supply

In a switching supply, the regulating elements consist of series-connected transistors that act as rapidly opened and closed switches (Figure 1). The input ac is first converted to unregulated dc, then "chopped" by the switching element operating at a rapid rate (typically 20kHz). The resultant 20kHz pulse train is transformer-coupled to an output network which provides final rectification and smoothing of the dc output. Regulation is accomplished through control circuits that vary the on-off periods (duty cycle) of the switching elements.

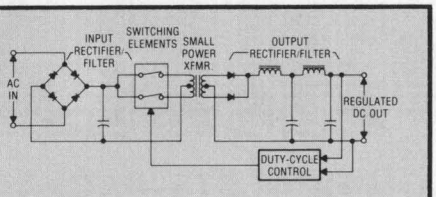


Figure 1. Basic Switching Supply

Operating Advantages. Because switching regulators are basically on/off devices, they avoid the higher power dissipation associated with the rheostat-like action of a series regulator. The switching transistors dissipate very little power when either saturated (on) or nonconducting (off); most of the power losses occur elsewhere in the supply. Efficiencies ranging from 65% to 85% are typical for switching supplies, as compared to 30% to 45% efficiencies for linear types. With less wasted power, switching supplies run at cooler temperatures, cost less to operate, and have smaller regulator heat sinks.

The size and weight reductions for switching supplies are achieved because of their high switching rate. The power transformer, inductors, and filter capacitors for 20kHz operation are much smaller and lighter than those required for operation at power line frequencies. Typically, a switching supply is less than one-third size and weight of a comparable series regulated supply.

Another aspect of performance is the switcher's ability to operate under low ac input voltage (brownout) conditions and substain a relatively long carryover (or holdup) of its output if input power is lost momentarily. The switching supply is superior to the linear supply in this regard because more energy is stored in its input filter capacitance. In a switching supply, the input ac is rectified directly and the filter capacitor charges to the voltage peaks on the ac line. This is opposed to the linear supplies' ac input being stepped down through a power transformer, then rectified, which results in a lower voltage across its filter capacitor.

Since the energy stored in a capacitor is proportional to CV^2, and V is higher in switching supplies, their storage capability (and thus their holdup time) is better.

Operating Disadvantages. Although its advantages are impressive, a switching supply does have some inherent operating characteristics that could limit its effectiveness in certain applications. One of these is that its transient recovery time (dynamic load regulation) is slower than that of a series regulated supply. In a linear supply, recovery time is limited only by the speeds of the semiconductors used in the series regulator and control circuitry. However, in a switching supply, recovery is limited mainly by the inductance in the output filter. This may or may not be of significance to the user, depending upon the specific application.

Also, electro-magnetic interference (EMI) is a natural by-product of the on-off switching. This interference can be conducted to the load (resulting in higher output ripple and noise), it can be conducted back into the ac line, and it can be radiated into the surrounding atmosphere.

For this reason, all Hewlett-Packard switching supplies have built-in shields and filter networks that substantially reduce EMI and control output ripple and noise.

Typical Switching Regulated Power Supply

Figure 2 shows a schematic of one of HP's higher power, yet less complex, switching supplies. Regulation is accomplished by a pair of push-pull switching transistors operating under control of a feedback network consisting of a pulse-width modulator and a voltage comparison amplifier. The feedback elements control the ON periods of the switching transistors to adjust the duty cycle of the bipolar waveform (E) delivered to the output rectifier/filter. Here the waveform is rectified and averaged to provide a dc output level that is proportional to the duty cycle of the waveform. Hence, increasing the ON times of the switches increases the output voltage and vice-versa.

The waveforms of Figure 2 provide a more detailed picture of circuit operation. The voltage comparison amplifier continuously compares a fraction of the output voltage with a stable reference (EREF) to produce the VCONTROL level for the turn-on comparator. This device compares the VCONTROL input with a triangular ramp waveform (A) occurring at a fixed 40kHz rate. When the ramp voltage is more positive than the control level, a turn-on signal (B) is generated. Notice that an increase or decrease in the VCONTROL voltage varies the width of the output pulses at B and thus the ON time of the switches.

Steering logic within the modulator chip causes switching transistors Q1 and Q2 to turn on alternately, so that each switch operates at one-half the ramp frequency or 20kHz.

Included, but not shown, in the modulator chip are additional circuits that establish a minimum "dead-time" (off time) for the switching transistors. This ensures that both switching transistors cannot conduct simultaneously during maximum duty cycle conditions.

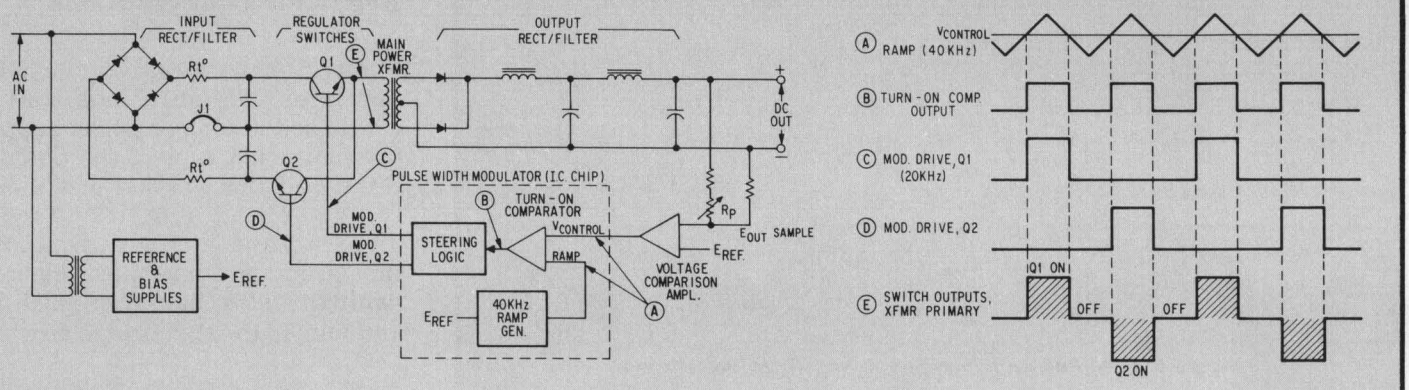


Figure 2. Switching Supply with Push-Pull Transistors and Feedback for Regulation

Ac Input Surge Current Protection. Because the input filter capacitors are connected directly across the rectified line, some form of surge protection must be provided to limit line surge currents at turn-on. If not controlled, large surges could trip circuit breakers, weld switch contacts, or affect the operation of other equipment connected to the same ac line. Protection is provided by a pair of thermistors (Rt^0) in the input rectifier circuit. With their high negative temperature coefficient of resistance, the thermistors present a relatively high resistance when cold (during the turn-on period) and a very low resistance after they heat up.

A shorting strap (J1) permits the configuration of the input rectifier-filter to be altered for different ac inputs. For a 174-250Vac input, the strap is removed and the circuit functions as a conventional full-wave bridge. For 87-127Vac inputs, the strap is installed and the input circuit becomes a voltage doubler.

Switching Frequencies. Presently, 20kHz is a popular repetition rate for switching regulators because it is an effective compromise with respect to size, cost, dissipation, and other factors. Decreasing the switching frequency would bring about the return of the acoustical noise problems that plagued earlier switching supplies, and would increase the size and cost of the output inductors and filter capacitors.

Increasing the switching frequency, however, would result in certain benefits, including further size reductions in the output magnetics and capacitors. Furthermore, transient recovery time could be decreased because a higher operating frequency would allow a proportional decrease in the output inductance, which is the main constraint in recovery performance.

Unfortunately, higher frequency operation has certain drawbacks. One is that filter capacitors have an Equivalent Series Resistance (ESR) that limits their effectiveness at high frequencies. Another disadvantage is that power losses in the switching transistors, inductors, and rectifier diodes increase with frequency. To counteract these effects, critical components such as filter capacitors with low ESRs, fast recovery diodes, and high-speed switching transistors are required. Some of these components are already available, others are not. Switching transistors are improving, but remain one of the major problems at high frequencies. However, further improvements in high-speed switching devices, such as the new power Field Effect Transistors (FETs) would make high frequency operation and its associated benefits a certainty for future switching supplies.

Preregulated Switching Supply

Figure 3 shows a schematic of another switching supply similar to Figure 2 except for the addition of a triac preregulator and associated control circuit. The triac is a bidirectional device and is usually connected in series with one side of the input primary. Whenever a gating pulse is received, the triac conducts current in a direction that is dependent on the polarity of the voltage across it. The goal is to control the triac so that the bridge rectifier output (dc input to the switches) is held relatively constant. This is accomplished by a control circuit that issues a phase-adjusted firing pulse to the triac once during each half-cycle of the input ac. The control circuit compares a ramp function to a rectified ac sinewave to compute the proper firing time for the triac.

Although the addition of the preregulator circuitry increases complexity, it provides three important benefits.

(1) By keeping the dc input to the switches constant, it permits the use of more readily available lower voltage switching transistors.

(2) The coarse preregulation it provides allows the main regulator to achieve a finer regulation.

(3) Through the use of slow-start circuits, the initial conduction of the triac is controlled, providing an effective means of limiting input surge current.

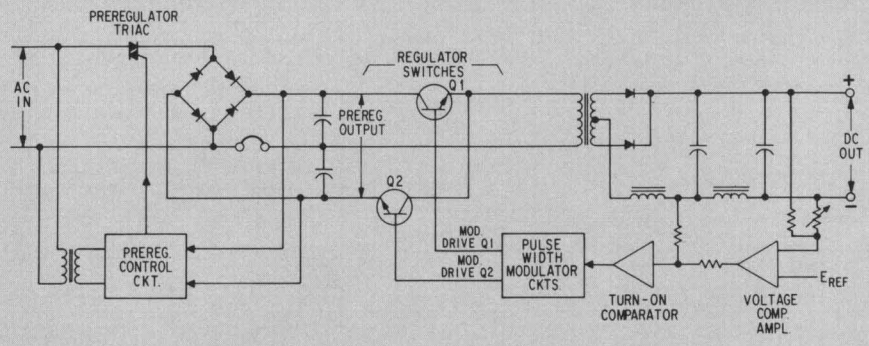


Figure 3. Push-Pull Switching Supply with Triac Preregulator

Note that the preregulator triac is essentially a switching device and, like the main regulator switches, does not absorb a large amount of power. Hence, the addition of the preregulator does not significantly reduce the overall efficiency of this supply.

Single Transistor Switching Regulator

At lower output power levels, a one-transistor switch becomes practical. The single transistor regulator of Figure 4 is referred to as a forward, or feed-through, converter. It can receive a dc input from either one of two sources without a change in its basic configuration. For ac-to-dc requirements, the regulator is connected to a line rectifier and SCR preregulator. For dc-to-dc converter applications it is connected directly to an external dc source.

Like the previous switching supplies, the output voltage is controlled by varying the ON time of the regulator switch. The switch is turned on by the leading edge of each 20kHz clock pulse and turned off by the pulse-width modulator at a time determined by output load conditions.

While the regulating transistor is conducting, the half-wave rectifier diode is forward biased and power is transferred to the output filter and the load. When the regulator is turned off, the "flywheel" diode conducts, sustaining current flow to the load during the off period. A flywheel diode (sometimes called a freewheeling or catch diode) was not required in the two transistor regulators of Figures 2 and 3 because of their full-wave rectifier configuration.

Another item not found in the previous regulators is "flyback" diode CR_F. This diode is connected to a third transformer winding which is bifilar wound with the primary. During the off periods of the switch, CR_F is forward biased, allowing the return of surplus magnetizing current to the input filter, and thus preventing saturation of the transformer core. This is an important function because core saturation often leads to the destruction of switching transistors. In the previously described two transistor push-pull circuits, core saturation is easier to avoid because magnetizing current is applied to the core in both directions (i.e., before saturation, the current is reversed). Nevertheless, matched switching transistors and balancing capacitors must still be used in these configurations to ensure that core saturation does not occur.

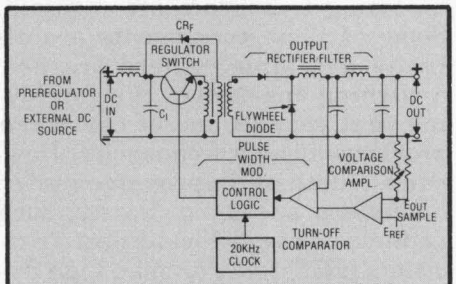


Figure 4. Single Transistor Switching Regulator called a Forward or Feed-Through Converter

Summary of Basic Switching Regulator Configurations

Figure 5 shows three basic switching regulator configurations that are often used in today's power supplies. Configuration A is of the push-pull class, and this version was used in the switching supplies shown in Figures 2 and 3. Other variations of this circuit are used also, including two-transistor balanced push-pull and four transistor bridge circuits.

As a group, push-pull configurations are the most effective for low-voltage, high-power and high performance applications. Push-pull circuits have the advantage of a ripple frequency that is double that of the other two basic configurations and, of course, output ripple is inherently lower.

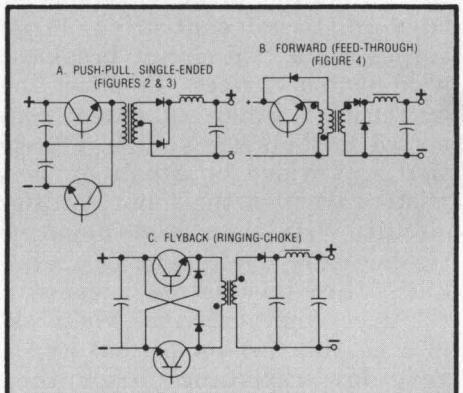


Figure 5. Summary of Basic Switching Regulator Configurations

Configuration B is a useful alternative to push-pull operation for lower power requirements. It is called a forward or feed-through converter because energy is transferred to the power transformer secondary immediately following turn-on of the switch. Although the ripple frequency is inherently lower, output ripple amplitude can be effectively controlled by the choke in the output filter. Two-transistor configurations of forward converters also exist wherein both transistors are switched simultaneously. They provide the same output power as the single transistor versions, but the transistors need handle only half the peak voltage.

Configuration C is known as a flyback, or ringing choke, converter because energy is transferred from primary to secondary when the switches are off (during flyback). In the example, two transistors are used and both are switched simultaneously. While the switches are on, the output rectifier is reverse biased and current in the primary inductance rises in a linear manner. When the switches are turned off, the collapsing magnetic field reverses the voltage across the primary, and the previously stored energy is transferred to the output filter and load. The two diodes in the primary protect the transistors from inductive surges that occur at turn-off.

Flyback techniques have long been used as a means of generating high voltages (e.g., the high voltage power supply in television receivers). As you might expect, this configuration is capable of providing higher output voltages than the other two methods. Also, the flyback regulator provides a greater variation of output voltage with respect to changes in duty cycle. Hence, the flyback configuration is the most obvious choice for high, and variable output voltages while the push-pull and forward configurations are more suitable for providing low, and fixed output voltages.

Protection Circuits for Switching Supplies

Figure 6 shows typical protection circuits that are used in HP switching regulated power supplies. The following is a brief description of those protection circuits shown.

A. EMI Filter. Helps prevent high frequency spikes (RFI) from being conducted to the load or back into the ac line. HP switching supplies also contain built-in shields for additional control of conducted and radiated interference.

B. Thermistor. Limits ac input surge current by its negative temperature coefficient of resistance. Has a high resistance when cold (during turn-on) and low resistance after it heats up.

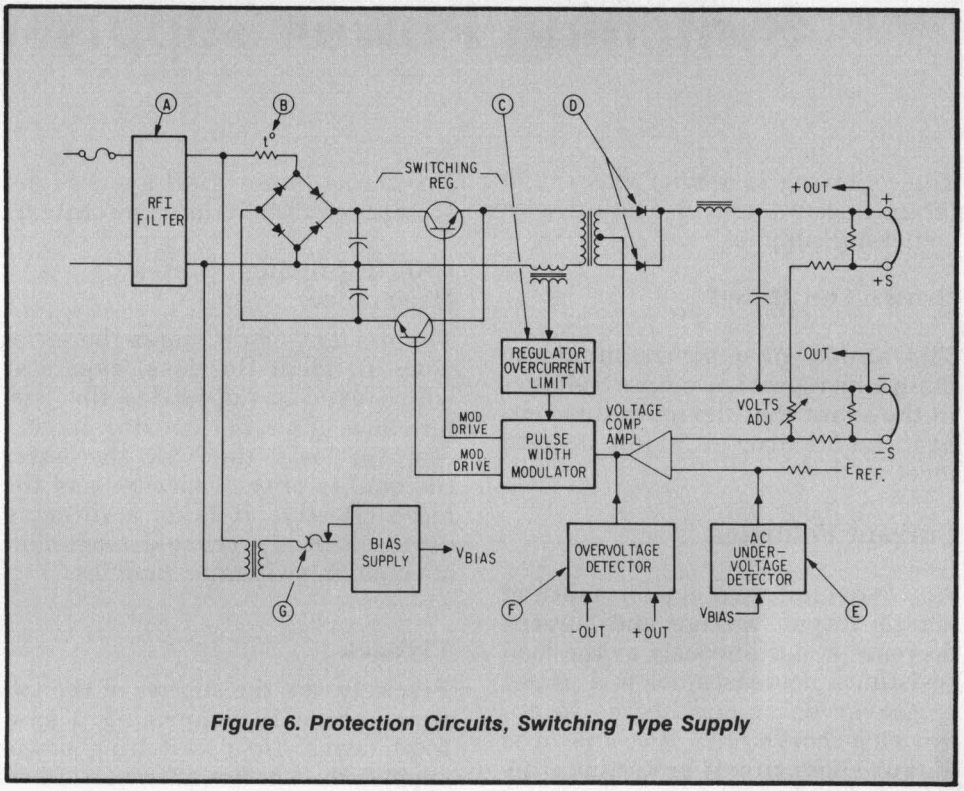


Figure 6. Protection Circuits, Switching Type Supply

C. Regulator Overcurrent Limit. This circuit is much faster than the current limit comparator and protects the regulator switches from overcurrent conditions of a transient nature. It monitors current flow through the switches and prevents it from exceeding a harmful level.

D. Output Rectifier Diodes. Besides final rectification, these diodes also protect internal components against reverse currents that could be injected into supply by an active load or series connected supply.

E. AC Undervoltage. This circuit performs a dual function. It protects the supply from damage that could result from a prolonged condition of low ac input voltage, and it limits output overshoot during turn-on. During undervoltage or turn-on conditions, the low ac input level reduces the V_{BIAS} voltage and activates the undervoltage detector. When activated, the modulator pulses are inhibited and the regulator switches turned off.

F. Overvoltage Detector. Monitors output voltage and turns off regulator switches if output attempts to rise above a preset value. Similar to a crowbar circuit except that output voltage is removed by turning off regulator rather than by shorting the output.

G. Temperature Switch. Opens in case of high ambient temperature that could be caused, for example, by a misapplication or cooling fan failure. The switch opens and removes V_{BIAS} which activates the ac undervoltage detector. The switch closes again after temperature cools to a safe level.

Additional Protection. Although not shown on Figure 6, all HP switching supplies contain some form of overcurrent protection, usually a current foldback circuit. Also included are remote sensing protection resistors and input protection components for the comparison amplifier.

Switching Power Supply Terminology

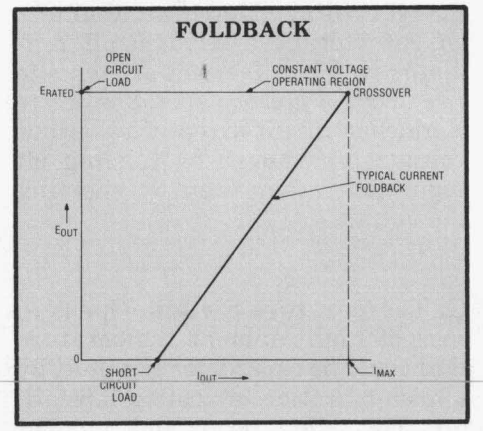
The following is a brief glossary of terms encountered in dealing with switching supplies.

Brown Out Rated

The ability of a power supply to maintain regulated output voltages in the event that the input line voltage should drop to a low or zero level.

Current Foldback

An overload protection method where output voltage and current decrease simultaneously as the load resistance decreases below a preset crossover point and begins to approach a short circuit. Also known as output short circuit protection, this mechanism monitors the output current and, if it exceeds a preset crossover value, turns down the regulator output.



EMI (RFI)

Electromagnetic interference (radio frequency interference) — unwanted high frequency energy caused primarily by the switching components in the power supply. EMI can be conducted through the input or output lines or radiated through the unit's case. Conducted EMI (RFI) can be reduced using proper filtering, and radiated EMI (RFI) can be reduced by judicious board layout and enclosing the supply in a metal enclosure.

The terms "noise" EMI and RFI are sometimes used in the same context.

ESR (Equivalent Series Resistance)

The amount of resistance in series with an ideal (lossless) capacitor which exactly duplicates the performance of a real capacitor. In general, the lower the ESR, the better the quality of the capacitor and the more effective it is as a filtering device. ESR is a prime determinant of ripple in switching supplies.

Flyback

Precisely, it's the shorter of the two time intervals comprising a sawtooth wave. In a switching power supply, the shorter interval is produced when the transistors are switched off. This causes a rapidly collapsing magnetic field in the transformer which reverses the voltage across the primary, transferring a high energy to the output.

Ground Loop

A feedback problem caused by two or more circuits sharing a common electrical line, usually a common ground line. Voltages gradients in this line caused by the first circuit may be resistively, inductively, or capacitively coupled into the other circuit via the common line. With power supplies, this problem can be reduced using single point grounding near the supply.

Hold-up Time

The total time any output will remain within its regulation band after line input voltage has suddenly dropped to zero or below rating. Hold-up is measured at full load and nominal line conditions.

Input Surge Current

The peak line current which flows during turn-on. Surge current is caused by charging of the input capacitor, and limited primarily by an input thermistor or preregulator.

Input Voltage Range

The range of line voltages for which the power supply meets its specifications. The lowest line voltage is important in defining the relative degree of brown-out protection.

Isolation Voltage

The maximum voltage by which any part of the circuit can be operated away from chassis ground. Also the maximum voltage between any output and input terminal.

Line Regulation

See Source Effect.

Line Frequency Regulation

The variation of an output voltage due to a change in line input frequency with all other factors held constant. This effect is negligible in switching and most linear supplies, but is very critical in ferroresonant supplies.

Load Effect Transient Recovery Time

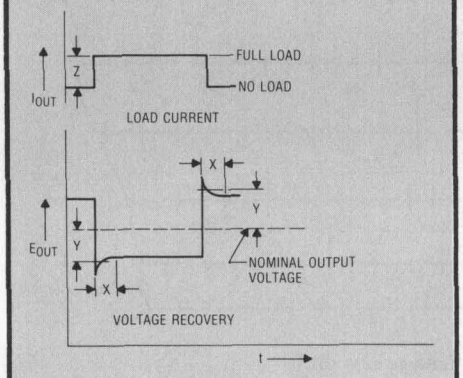
Sometimes referred to as transient recovery time or transient response time, it is, loosely speaking, the time required for the output voltage of a power supply to return to within a level approximating the normal dc output following a sudden change in load current. More exactly, Load Transient Recovery Time for a CV supply is the time "X" required for the output voltage to recover to, and stay within "Y" millivolts of the nominal output voltage following a "Z" amp step change in load current — where:

(1) "Y" is specified separately for each model, but is generally of the same order as the load regulation specification.

(2) The nominal output voltage is defined as the dc level halfway between the steady state output voltage before and after the imposed load change.

(3) "Z" is the specified load current change, typically equal to the full load current rating of the supply.

TRANSIENT RECOVERY TIME



Overcurrent Limiting

A protection mechanism which limits the output current of a supply without materially affecting the output voltage.

Overshoot

The amount by which an output exceeds its final value in a transient response to a rapid change in load or input voltage. In power supply design this parameter is particularly important at turn-on.

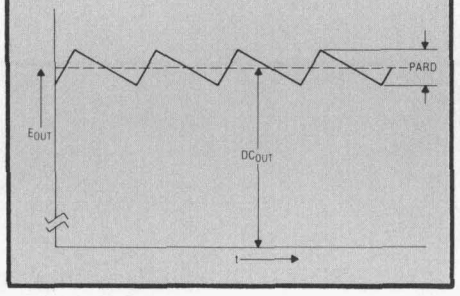
Overvoltage Protection

A protection mechanism for the load which reduces the output voltage to a very low value in the event that the output exceeds a certain threshold voltage. In a switching supply, the regulator is turned off if the threshold is exceeded, reducing the output voltage and current to zero. In linear supplies, an SCR "crowbar" is used to rapidly place a short circuit across the output terminals whenever the threshold voltage is exceeded.

PARD (Ripple and Noise)

The term PARD is an acronym for "periodic and random deviation" and replaces the former term ripple and noise. PARD is the residual ac component that is superimposed on the dc output voltage or current of a power supply. It is measured over a specified bandwidth with all influence and control quantities maintained constant. PARD is specified in rms and/or peak-to-peak values over a bandwidth of 20Hz to 20MHz. Fluctuations below 20Hz are treated as drift. Attempting to measure PARD with an instrument that has insufficient bandwidth may conceal high frequency spikes that could be detrimental to a load.

DC OUTPUT OF POWER SUPPLY AND SUPERIMPOSED PARD COMPONENT



Peak Charging

A rise in voltage across a capacitor caused by the charging of the capacitor to the peak rather than RMS value of the input voltage. This generally occurs when a capacitor has a high discharge resistance across it and large ripple or spikes on its input line. In a switcher this effect determines minimum load (discharge resistance) conditions on each output to maintain regulation.

Post Regulator

A linear (dissipative) regulator used on the output of a switching supply to further improve over-all regulation performance of the supply. Post regulators can be either the 3 terminal I.C. type or a custom discrete design. Since the differential voltage across the post regulator can be kept to a minimum, dissipative losses are generally small.

Rise Time and Fall Time

When applied to the switching transistor, that time in which non-zero currents and voltages result in high peak power dissipation. Careful attention must be paid to reducing these times, particularly when switching inductive loads.

Ripple and Noise

See PARD.

Short Circuit Protection

See Current Foldback.

Source Effect (Line Regulation)

Formerly known as line regulation, source effect is the change in the steady-state value of the dc output voltage (of a CV supply) or current (of a CC supply) due to a specified change in the source (ac line) voltage, with all other influence quantities maintained constant. Source effect is usually measured after a "complete" change in the ac line voltage from low line to high line or vice-versa.

Switcher

A common industry-wide name for a switching power supply.

Temperature, Coefficient

The average percent change in output voltage per degree change in temperature with load and input voltage held constant. The coefficient is usually derived from output voltage measurements taken at room temperature (25°C) and at the two specified operating temperature extremes.

Marking A New Frequency Dial

608 Signal Generator

Margaret Nagao
HP Service Center
Mtn. View

When the 608 Signal Generator is repaired in such a way as to alter its frequency setting (e.g., new RF oscillator tube), a new blank dial should be calibrated to match the generator's output. The blank can be purchased from HP (HP P/N 608A-40A) using the short order form shown in this issue of Bench Briefs.

Set the new dial in place on the drum. The drive pin hole may be located on the opposite end of the new dial as compared to the old one. If so, just wrap the new dial around the drum in the opposite direction, making certain that the wide space at the edge of the dial is at the top, and the top line is lined up with the "A" range indicator.

Use a sharp #2 or firmer lead pencil and make the frequency marks on each appropriate line. *Make certain each mark extends approximately 1/16 inch below the line* as shown in the drawing. This is important for precision alignment of the engraving tool.

Place the marked dial between two sturdy pieces of cardboard to prevent bending during shipment and send to the following address for engraving:

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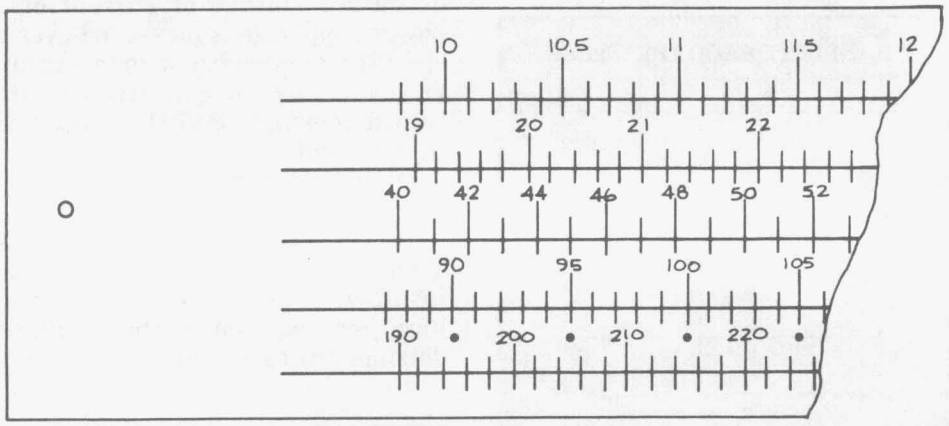
Customer Service Center
333 Logue Avenue
Mountain View, CA 94043



Marking a new 608 frequency dial.
Note that the narrow space is at the bottom of the dial.

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If an item cannot be shipped immediately, an acknowledgement will be mailed separately or included with a partial shipment of the remaining items of your order.

How To Order

First of all, you must be in the U.S. Due to customs regulations, we cannot ship parts outside the United States.

You must contact your local HP representative and obtain the *parts price and check digit.* If desired, you can call the HP parts center in California at (415) 968-9200 and ask for the "Parts Pricing Department." Hours are Monday-Friday, 7:30 a.m. to 4:30 p.m. (Pacific time).

Send your completed Mail Order form with your check or money order directly to:

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Special Instructions

Sub-total		
Your State & Local Sales Taxes*		
Handling Charge	1	50
TOTAL		

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Tel: (213) 776-7500

3003 Scott Boulevard
Santa Clara 95050
Tel: (408) 249-7000
TWX: 910-338-0518

Ridgecrest
Tel: (714) 446-6165

646 W. North Market Blvd.
Sacramento 95834
Tel: (916) 929-7222

9606 Aero Drive
P.O. Box 23333
San Diego 92123
Tel: (714) 279-3200

COLORADO
5600 South Ulster Parkway
Englewood 80110
Tel: (303) 771-3455

CONNECTICUT
12 Lunar Drive
New Haven 06525
Tel: (203) 389-6551
TWX: 710-465-2029

FLORIDA
P.O. Box 24210
2806 W. Oakland Park Blvd.
Ft. Lauderdale 33311
Tel: (305) 731-2020

Jacksonville
Medical Service only
Tel: (904) 398-0663

P.O. Box 13910
6177 Lake Ellenor Dr.
Orlando 32809
Tel: (305) 859-2900

P.O. Box 12826
Pensacola 32575
Tel: (904) 476-8422

GEORGIA
P.O. Box 105005
Atlanta 30348
Tel: (404) 955-1500
TWX: 810-766-4890
Medical Service Only
Augusta 30903
Tel: (404) 736-0592

P.O. Box 2103
Warner Robins 31098
Tel: (912) 922-0449

HAWAII
2875 So. King Street
Honolulu 96814
Tel: (808) 955-4455
Telex: 723-705

ILLINOIS
5201 Tollview Dr.
Rolling meadows 60008
Tel: (312) 255-9800
TWX: 910-687-2260

INDIANA
7301 North Shadeland Ave.
Indianapolis 46250
Tel: (317) 842-1000
TWX: 810-260-1797

IOWA
2415 Heinz Road
Iowa City 52240
Tel: (319) 338-9466

KENTUCKY
Medical Only
Atkinson Square
3901 Atkinson Dr.,
Suite 407 Atkinson Square
Louisville 40218
Tel: (502) 456-1573

LOUISIANA
P.O. Box 840
3229-39 Williams Boulevard
Kenner 70063
Tel: (504) 443-6201

MARYLAND
6707 Whitestone Road
Baltimore 21207
Tel: (301) 944-5400
TWX: 710-862-9157

2 Choke Cherry Road
Rockville 20850
Tel: (301) 948-6370
TWX: 710-828-9684

MASSACHUSETTS
32 Hartwell Ave.
Lexington 02173
Tel: (617) 861-8960
TWX: 710-326-6904

MICHIGAN
23855 Research Drive
Farmington Hills 48024
Tel: (313) 476-6400

724 West Centre Ave.
Kalamazoo 49002
Tel: (606) 323-8362

MINNESOTA
2400 N. Prior Ave.
St. Paul 55113
Tel: (612) 636-0700

MISSOURI
11131 Colorado Ave.
Kansas City 64137
Tel: (816) 763-8000
TWX: 910-771-2087

1024 Executive Parkway
St. Louis 63141
Tel: (314) 878-0200

NEBRASKA
Medical only
7171 Mercy Road
Suite 110
Omaha 68106
Tel: (402) 392-0948

NEW JERSEY
W. 120 Century Rd.
Paramus 07652
Tel: (201) 265-5000
TWX: 710-990-4951

Crystal Brook Professional Building
Eatontown 07724
Tel: (201) 542-1384

NEW MEXICO
P.O. Box 11634
Station E
11300 Lomas Blvd., N.E.
Albuquerque 87123
Tel: (505) 292-1330
TWX: 910-989-1185

156 Wyatt Drive
Las Cruces 88001
Tel: (505) 526-2484
TWX: 910-9983-0550

NEW YORK
6 Automation Lane
Computer Park
Albany 12205
Tel: (518) 458-1550

201 South Avenue
Poughkeepsie 12601
Tel: (914) 454-7330
TWX: 510-253-5981

650 Perinton Hill Office Park
Fairport 14450
Tel: (716) 223-9950

5858 East Molloy Road
Syracuse 13211
Tel: (315) 454-2486
TWX: 710-541-0482

1 Crossways Park West
Woodbury 11797
Tel: (516) 921-0300
TWX: 710-990-4951

NORTH CAROLINA
P.O. Box 5188
1923 North Main Street
High Point 27262
Tel: (919) 885-8101

OHIO
16500 Sprague Road
Cleveland 44130
Tel: (216) 243-7300
TWX: 810-423-9430

330 Progress Rd.
Dayton 45449
Tel: (513) 859-8202

1041 Kingsmill Parkway
Columbus 43229
Tel: (614) 436-1041

OKLAHOMA
P.O. Box 32008
Oklahoma City 73132
Tel: (405) 721-0200

OREGON
17890 SW Lower Boones Ferry Road
Tualatin 97062
Tel: (503) 620-3350

PENNSYLVANIA
111 Zeta Drive
Pittsburgh 15238
Tel: (412) 782-0400

1021 8th Avenue
King of Prussia Industrial Park
King of Prussia 19406
Tel: (215) 265-7000
TWX: 510-660-2670

SOUTH CAROLINA
6941-0 N. Trenholm Road
Columbia 29260
Tel: (803) 782-6493

TENNESSEE
3027 Vanguard Dr.
Director's Plaza
Memphis 38131
Tel: (901) 346-8370

Nashville
Medical Service only
Tel: (615) 244-5448

TEXAS
P.O. Box 1270
201 E. Arapaho Rd.
Richardson 75080
Tel: (214) 231-6101

10535 Harwin Dr.
Houston 77036
Tel: (713) 776-6400

205 Billy Mitchell Road
San Antonio 78226
Tel: (512) 434-8241

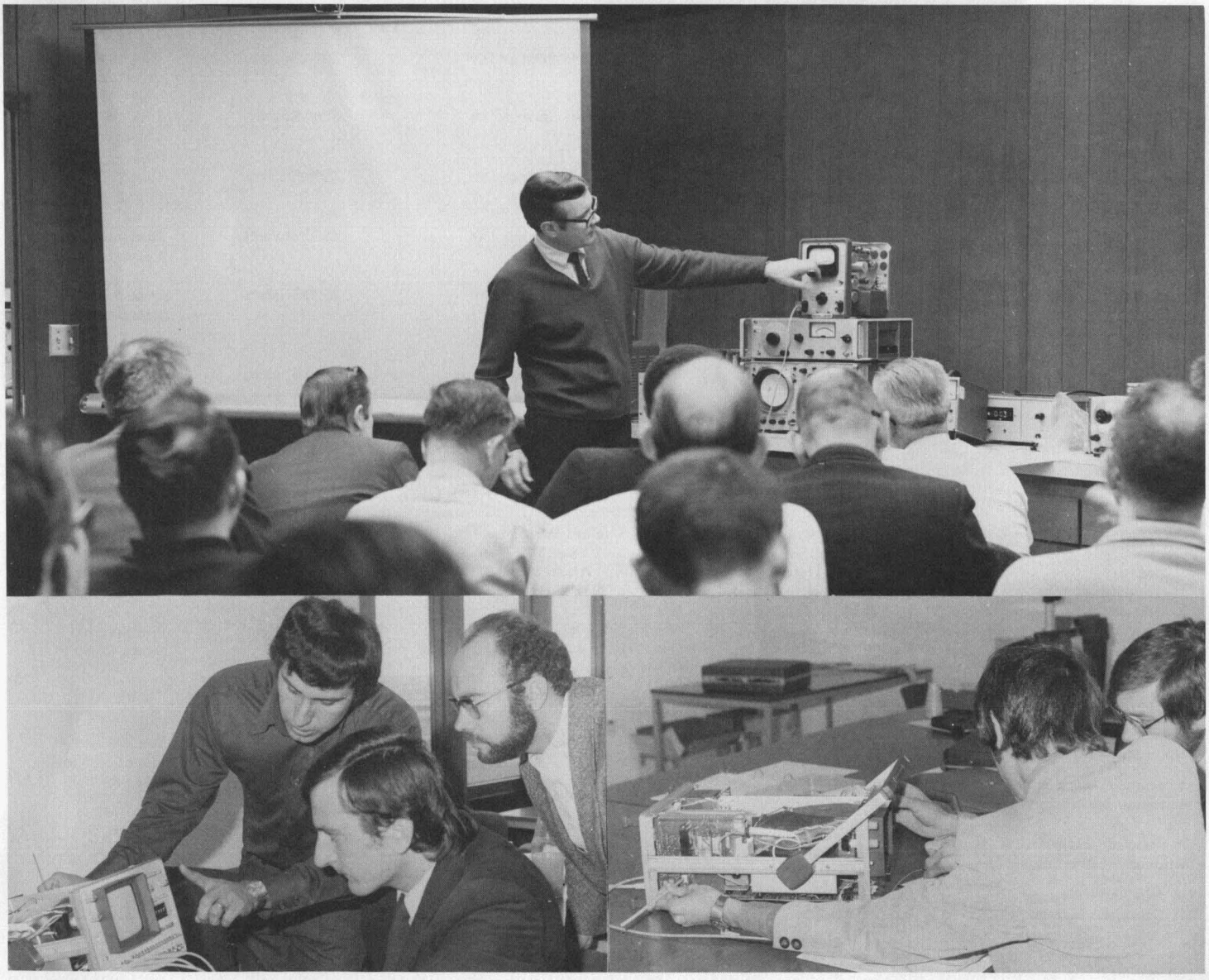
UTAH
2160 South 3270 West St.
Salt Lake City 84119
Tel: (801) 972-4711

VIRGINIA
P.O. Box 12778
No. 7 Koger Exec. Center
Suite 212
Norfolk 23502
Tel: (804) 461-4025/6

P.O. Box 9669
2914 Hungary Springs Road
Richmond 23228
Tel: (804) 285-3431

WASHINGTON
Bellefield Office Park
1203-114th Ave. S.E.
Bellevue 98004
Tel: (206) 454-3971
TWX: 910-443-2446

Instrument Group Service Training For Customers



Trai

Calendar

DATE	CONTENT	LOCATION	TUITION	COORDINATOR
June 11 thru 15, 1979 August 13 thru 17, 1979	Fourier Analyzer User's Guide	Santa Clara Div.	$500/Student	André Rudé Santa Clara
October 1 thru 3, 1979	Oscilloscope Maintenance Models 1715A/1725A	Colorado Springs Div. P.O. Box 2197 Colorado Springs, CO 80901 (303) 598-1900	$250/Student	Dick Browne Colorado Springs
October 8 thru 11, 1979	Oscilloscope Maintenance Models 1740A/1741A/ 1742A/1744A	Colorado Springs Div.	$300/Student	Dick Browne Colorado Springs
September 10 thru 12, 1979	Logic State Analyzer Maintenance Models 1600A/1607A	Colorado Springs Div.	$250/Student	Dick Browne Colorado Springs
September 17 thru 19, 1979	Logic State Analyzer Maintenance Model 1610A	Colorado Springs Div.	$250/Student	Dick Browne Colorado Springs
September 20 thru 21, 1979	Serial Network Analyzer Maintenance Model 1640A	Colorado Springs Div.	$200/Student	Dick Browne Colorado Springs
September 24 thru 26, 1979	Logic State Analyzer Maintenance Model 1611A	Colorado Springs Div.	$250/Student	Dick Browne Colorado Springs
October 15 thru 17, 1979	Logic State Analyzer Maintenance Model 1615A	Colorado Springs Div.	$250/Student	Dick Browne Colorado Springs
October 22 thru 23, 1979	Small Screen Displays Maintenance Models 1332A/1333A/1335A	Colorado Springs Div.	$200/Student	Dick Browne Colorado Springs
October 25 thru 26, 1979	Large Screen Displays Maintenance Models 1310A/1311A/1317A/1321A	Colorado Springs Div.	$200/Student	Dick Browne Colorado Springs
October 4 thru 5, 1979	Tri-Color Display & Graphics Translator Maintenance Models 1338A/1350A	Colorado Springs Div.	$200/Student	Dick Browne Colorado Springs
September 10 thru 14, 1979	8640AM/FM Signal Generator 8660 Synthesizers 435/6 Power Meter *or* 8672A Microwave Synthesizer	Stanford Park Div. 1501 Page Mill Road Palo Alto, CA 94303 (415) 856-2980	$350/Student	Steve Thomas Palo Alto
September 17 thru 21, 1979	8505A RF Network Analyzer	Santa Rosa Division 1400 Fountain Grove Parkway Santa Rosa, CA 95404 (707) 525-1400	$350/Student	Jim Simpson Santa Rosa
On demand* (class size: Minimum=1 Maximum=30)	Digital Troubleshooting Techniques (using HP logic lab)	Customer site	$4,200 flat rate	Tom O'Connor Mountain View (415)968-9200 ext. 372
On demand* (class size: Minimum=15 Maximum=30)		HP field office	$300/Student	
On demand* (class size: Minimum=1 Maximum=20)	Microprocessor Troubleshooting Techniques (using 5036A's)	Customer site	$4,200 flat rate	Tom O'Connor Mountain View
On demand* (class size: Minimum=10 Maximum=20)		HP field office	$300/Student	

*30-day leadtime for scheduling required.

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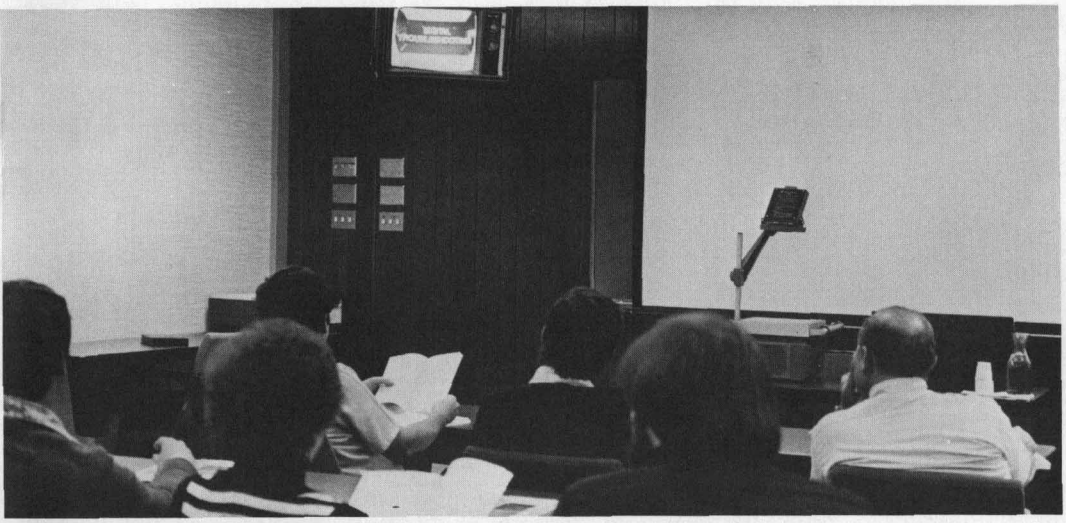
.....Videotapes/Trainers.....



HP videotapes provide both service and applications training at your convenience, in your facility. This means you can tailor your training program to suit the growing needs of your organization.

Videotapes

Hewlett-Packard offers professionally produced videotapes and books that communicate important electronics information quickly and effectively.

Tutorial series tapes are instructional modules that can be integrated together to form customized curricula to meet individual or group objectives. Most of the available tapes tend to be concerned with technical concepts rather than specific instrumention. Some of the subjects covered are:

— Practical Transistors, a 15-tape series that examines the practical aspects of transistors in order to make troubleshooting easier.
— Digital Troubleshooting, a 14-tape series that makes the transition from transistors to digital electronics.
— Counters, a separate series of videotapes that train technicians in the basic techniques of frequency measurement using an electronic counter.
— Oscilloscopes, a 3-tape series showing technicians the basic techniques of waveform measurement using an oscilloscope.
— Troubleshooting FET Circuits, a 16-minute tape dealing with FET theory and troubleshooting at the compononet level.

Instrument series tapes, including DSA (Fourier Theory), medical, and computer systems, provide both service and applications training on specific instrumentation. Some of the instrumentation described is:

— Spectrum analyzer operation. How to reduce the usual "fumble time" common to equipment unfamiliarity.
— Microwave test equipment maintenance.
— Oscilloscopes and voltmeters, use and service.
— Fourier analysis description.
— Pulmonary physiology (medical), learn what goes on in your lungs.
— Line printer service training.
— 2640/2644/2645 computer terminal service.

ORDERING INFORMATION

Contact your local HP office to order videotapes and trainers. For a complete listing of available videotapes, ask for catalog no. 5952-0074.

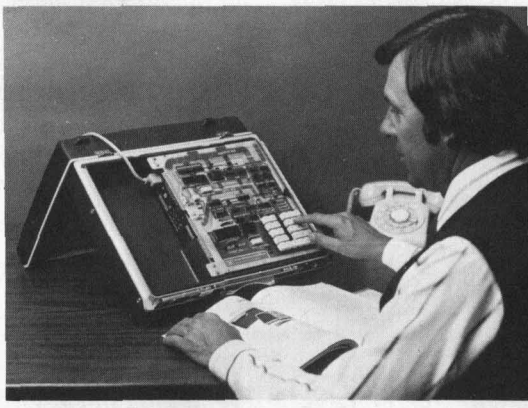
Multilingual videotapes are available in both the tutorial and instrumentation series. French, German, Portuguese, and Spanish are just a few of the languages offered.

Trainers

Hewlett-Packard offers two products for self-study courses — the 5035T Logic Lab and 5036A Microprocessor Lab.

Digital logic training begins with simple circuits and builds up to complete numerical readout clocks. Each experiment begins with textbook theory that is then proven using the 5035T lab and experiment workbook.

Microprocessor troubleshooting is the main thrust of the 5036A Lab and study material. The right blend of entry level programming, hardware, and troubleshooting information are all combined to provide the digital technician the basic knowledge required to learn how microcomputers work, and more importantly, how to fix them when they don't.



The 5036A Microprocessor Lab is a complete, practical, hands-on training system covering microprocessor basics. It provides a general course on hardware, software, and troubleshooting designed for self-study or classroom.

Training

Microprocessors

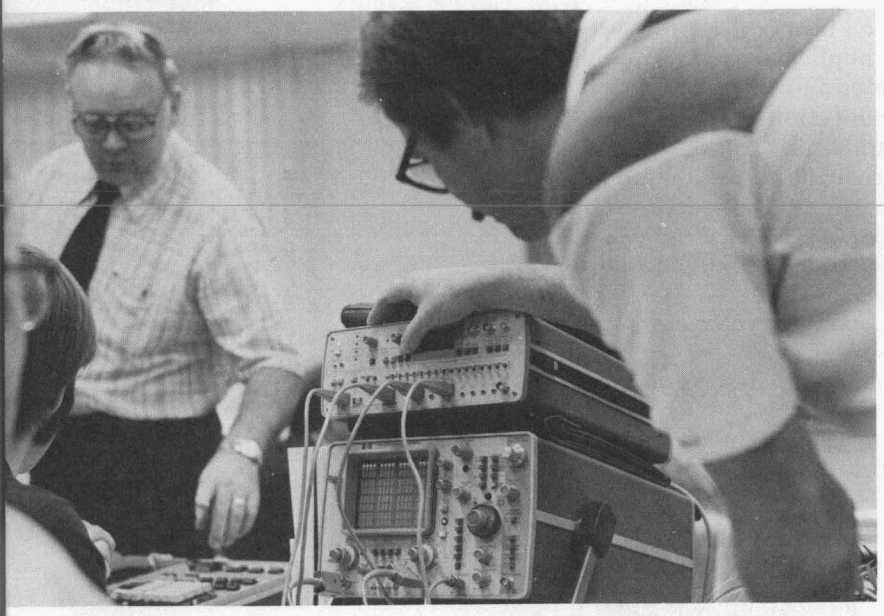
FIRST DAY:

- Analog vs. digital.
- Signal transmission techniques.
  1) One wire, one signal.
  b) Digital.
  c) Open collector drivers.
  d) Three-state drivers.
- Workshop — four hours of hands-on familiarization using an Intel 8085 based microprocessor trainer.

SECOND DAY:

- Introduction to programming.
  a) Flow charts.
  b) High level language.
  c) Machine language.
  d) 8085 Command set.
- Algorithmic State Machine Concepts
- Workshop — four hours of hands-on experiments using logic analyzers and oscilloscopes to view correct microprocessor operation.

Microprocessor and Digital Troubleshooting sem procedures as shown in the accompanying course format to present theory problems.



Afternoon workshop sessions provide students with hands-on familiarization using the 5035T or 5036A Trainer and HP test equipment.

THIRD DAY:

- The Intel 8085 Microprocessor.
  a) Block diagram.
  b) Timing diagrams.
  c) Analysis of pin functions.
  d) Assessing improper operation.
- Workshop — four hours of troubleshooting experiments on the microprocessor trainer using pulsers, probes, current tracers and the signature analyzer.

FOURTH DAY:

- The micro-computer.
  a) Micro-computer memories.
  b) Input/output ports.
  c) Keyboards.
  d) Displays.
- Analyzing self-test features.
- Workshop — four hours of troubleshooting experiments on the microprocessor trainer using pulsers, probes, current tracers and the signature analyzer.

(in the classroom)

Digital Troubleshooting

inars address fundamental troubleshooting
e outlines. The first half of each day utilizes lecture

FIRST DAY:

- Analog vs. digital.
- IC Technology: DCTL, RTL, DTL, CTL, TTL, ECL, EECL, HTL, MOS, I^2L.
- Specialized tools and techniques to troubleshoot these technologies.
- Workshop — four hours of hands-on experiments with gates and troubleshooting tools.

SECOND DAY:

- Logic Symbology.
- Positive/Negative logic notation.
- Understanding the implication of logic schematics.
- Implementation of logic gates: AND, OR, NOR, NAND, XOR, Wired-OR.
- Decoders and their uses.
- Comparators and their uses.
- Flip-flops: R-S, D, J-K (standard and master-slave).
- Workshop — four hours of hands-on experiments with decoders, comparators and flip-flops.

Students will also have an opportunity to use modern tools to troubleshoot faults in a printed circuit assembly.

THIRD DAY:

- Often encountered circuits containing flip-flops: Counters (BCD and binary, synchronous and ripple), dividers, shift registers, ring counters.
- Numbering systems including binary, BCD, octal and hexidecimal.
- Introduction to binary math including half and full adders.
- Workshop — four hours of hands-on time building and debugging counter circuits.

FOURTH DAY:

- ROM'S/PROM (masked, E and UV).
- RAM'S: bipolar and MOS (static and dynamic).
- Typical failures and the troubleshooting difficulties encountered with ROM'S, PROM'S and RAM'S.
- Typical memory addressing techniques.
- Modern display technologies, their application and common failure modes.
- Introduction to the ROM controlled device with emphasis on methods used to fault isolate.
- Workshop — four hours of experiments leading to the building of a functioning strobed display device.

Individual applications or problems are addressed during workshop sessions.

Training

Signal Generators

***September 10-14, 1979**

This one-week customer seminar on Signal Generators takes place at the HP manufacturing facility in Palo Alto, California, which is approximately 30 miles south of San Francisco, or 20 miles north of San Jose, both having a major airport and car rental facilities.

Attendance is limited to 20 participants so file your applications early (registration cut-off date is August 10) to avoid disappointment. The application form is at the end of BENCH BRIEFS.

The course objective is to teach front panel control operations, circuit theory, interpretation of signal waveforms and voltage levels at test points, how to efficiently perform critical adjustments during calibration, and how to isolate troubles to individual circuits.

COURSE CONTENT

LECTURE

I. Introduction
II. Features and Model Options
III. Front Panel Features
  A. Video Tape
  B. Demonstration
IV. Theory
  A. Block Diagram
  B. Assembly Locations
  C. Schematic

LAB

I. Adjustments
II. Performance Tests
III. Troubleshooting

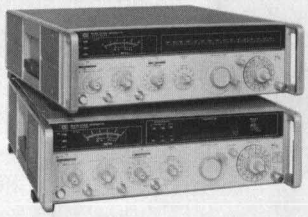
*Notice that these courses can be taken concurrently.

PREREQUISITES — Basic knowledge of digital logic circuits and general knowledge of electronics including operational amplifiers and phase lock circuits.

PRESTUDY — Review digital logic and block diagram information in 8640, 8660, and 435/436 or 8672A manuals.

Read pages 1-48 in "Signal Generator Seminar" testbook.

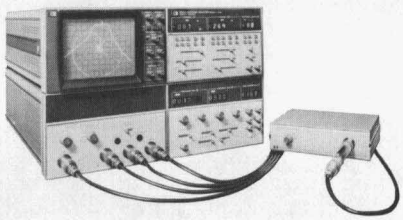
View videotape 90030-566 (Optional).



NOTE: Please specify if you prefer training on the 8672A *or* 435/436.

RF Network Analyzers

***September 17-21, 1979**



This one-week customer seminar on the 8505A RF Network Analyzer takes place at the HP manufacturing facility in Santa Rosa, California, which is approximately 60 miles north of San Francisco. Attendance is limited to 20 participants so file your applications early (registration cut-off date is August 10) to avoid disappointment. The application form is at the end of BENCH BRIEFS.

The course objective is to teach front panel control operations, circuit theory, interpretation of signal waveforms and voltage levels at test points, how to efficiently perform critical adjustments during calibration, and how to isolate troubles to individual circuits.

COURSE CONTENT

LECTURE

I. Introduction
II. Specifications, Features, and Options
III. Simplified Block Diagram
IV. Front Panel Operation
V. Detailed Block Diagram
VI. A1 Source/Converter
  A. Circuit Description
  B. Circuit Alignment
  C. Troubleshooting
VII. A2 Frequency Control
  A. Circuit Description
  B. Circuit Alignment
  C. Troubleshooting
VIII. A3 Signal Processor
  A. Circuit Description
  B. Circuit Alignment
  C. Troubleshooting Using Signature Analysis
IX. Option 001, HP-Interface Bus
  A. Circuit Description
  B. Troubleshooting Using Signature Analysis

LAB — The lecture is given in a lab environment. Attendees make measurements during circuit alignment and troubleshooting sessions.

PREREQUISITES — Basic understanding of network analysis. Good understanding of digital logic circuits.

PRESTUDY — Application Note 219, "8505A Network Analyzer Basic Measurements."

(at an HP factory)

Oscilloscopes

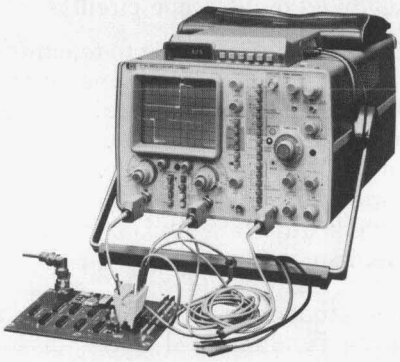
Hewlett-Packard, Colorado Springs Division, offers the following Service Training Seminars to customers. All training will be conducted at Colorado Springs, Colorado, on the dates indicated.

These seminars directed to calibration and repair technicians teach operation, circuit-theory, calibration and troubleshooting to component level repair. Attendees should have some prior knowledge of standard oscilloscope circuits, such as differential amplifiers, integrators, comparators and basic logic devices.

In case of insufficient enrollment, classes may be cancelled.

Service training for other instruments is also available at factory, local HP facility or at customer facility. Consult your local HP Sales/Service office for further information.

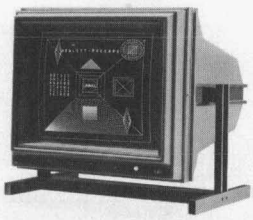
1715A/1725A Oscilloscopes
October 1-3, 1979
1740A/1741A/1742A/1744A Oscilloscopes
October 8-11, 1979



The Oscilloscope seminars are taught to component-level of troubleshooting and repair. Popular options such as state-display and digital-multimeter and ΔT options are included.

1332A/1333A/1335A Small Screen Displays
October 22-23, 1979
These small-screen displays are offered in a 2-day class consisting of 1 day of theory (including variable persistence and storage) and 1 day of calibration, troubleshooting and repair.

1310A/1311A/1317A/1321A Large Screen Displays
October 25-26, 1979



Large-screen displays comprise a 2-day seminar; 1 day of theory and 1 day of calibration, troubleshooting and repair.

Fourier Analysis

June 11-15, 1979
August 13-17, 1979
The Fourier Analyzer 5-Day User Training Course is geared primarily for 5451C users, although 5451B users will also find it relevant.

The course emphasizes measurements, applications, and system operation. Pre-study material will be mailed prior to the course to bring all attendees up to a basic theoretical understanding. Each day includes lab exercise with time for discussion and review of key points.

COURSE OBJECTIVES

LECTURE

I. Enable the attendee to:
   A. Utilize documentation to:
      1. Cold start the system.
      2. Find appropriate data and instruction formats.

   B. Perform and understand all "standard" calibrated time and frequency measurements.
   C. Utilize Mass Store, Zoom and Graphics Software.
   D. Generate and modify keyboard programs.
   E. Make use of variable parameters and other "Gold Key" functions.
   F. To sort, analyze and manipulate data.

II. Provide the attendee with:
   A. Basic measurement principles.
   B. A basic understanding of keyboard programming principles.
   C. A basic appreciation of the system architecture and the various programming levels.

PREREQUISITES — Basic understanding of Fourier Analysis and time and frequency domain measurements.

PRESTUDY — Application Note 140-0 (part no. 02-5952-0651), Fourier Analysis Training Manual.

Training (at an HP factory)

Logic Analyzers

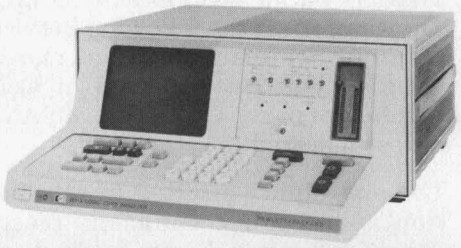
Hewlett-Packard, Colorado Springs Division, is offering Service Training Seminars to customers on most all models of Logic Analyzers. All training will be conducted at Colorado Springs, Colorado, on the dates indicated on both the registration form and training calendar.

The courses are directed to calibration and repair technicians and will teach application, circuit-theory, calibration, and troubleshooting to component-level repair. Attendees should have some prior knowledge of logic and oscilloscope circuits.

The course objective is to teach front panel control operations, circuit theory, and learn the fundamental components used throughout the unit. Other areas covered are the power supply, trigger recognition, data acquisition and storage, and the display circuitry.

The student is guided through the three fundamental areas of logic analyzers:

— Recognizing a trigger
— Storing the data
— Displaying the data



Toward the end of the course, the instructor summarizes by discussing overall troubleshooting from symptom to repair. The student is shown how to "milk" the front panel to learn how failures affect the instrument's behavior. From the behavior patterns, the student learns how to isolate the fault to a particular function within the instrument and finally to the faulty component.

Tri-Color Graphics

October 4-5, 1979

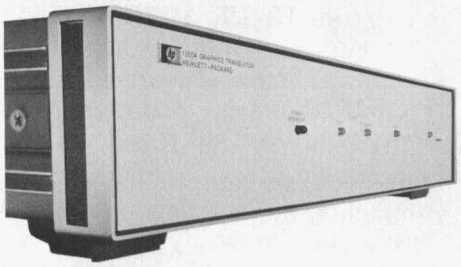
This two-day customer seminar on the 1338A/1350A Tri-color Graphics Display System takes place at the HP manufacturing facility in Colorado Springs, Colorado.

The seminar is directed to calibration and repair technicians and will teach operation, circuit theory, calibration and troubleshooting to the block and component level. Attendees should have some prior knowledge of standard oscilloscope circuits and the graphics concept.

The course objective is to teach students how the 1338A Tri-color Display interfaces with the 1350A Graphics Translator so that block-diagram troubleshooting can be utilized to get the student to the defective area within the instrument and finally the component.

Toward this end, the student is shown:

— How circuits within the 1338A differ from those of B/W displays, including the CRT and Tri-color operation.
— How the color switching network operates.
— Fundamentals of the color logic board.
— Exactly how the 1338A is driven by the 1350A.



— How the I/O board in the 1350A operates.
— How to communicate to the 1350A via the RS232 or HP-IB interface.
— The command set and how to use the existing test tape.

This seminar does not confine students to "bit-chasing", but shows them how to isolate problems to an area within the total logic box.

Transistors and Diodes

Replacement Part Cross Reference

When selecting replacement parts for your HP products, you may notice that many manuals list only an HP part number for the part, even though it appears that this part is manufactured by one of the large semiconductor manufacturers. Service personnel often ask why only HP part numbers are listed.

It is recommended that HP replacement parts be used to ensure that original performance of the product will be retained. While some parts used in HP instruments are identical to those that can be purchased at a local electronics distributor, many times parts will be selected for certain characteristics, such as gain, bandwidth, capacitance, etc. There may also be slight mechanical differences, such as the shaping or length of leads. In some cases special quality checks are used to ensure that high reliability parts are used at the factory and at HP field offices.

Therefore, we suggest obtaining replacement parts from HP to maintain the quality that you have paid for in your instrument. There may be situations however where HP replacement parts are not in stock and substituting parts will allow you to return the product to service immediately. In these cases it may be worthwhile to see if a substitute part will work in the circuit. Perhaps an HP part could be ordered and installed at some later date.

To help you in these situations, here's a cross-reference of HP part numbers to JEDEC numbers for transistors and diodes.

HP P/N	JEDEC NO.
0122-0005	1N4810
0122-0017	1N4804
0122-0025	1N4811A
0122-0062	1N5468A
0122-0070	1N5456A
0122-0245	1N5139
0122-0247	1N5140
0122-0248	1N5140A
0122-0249	1N5141
0122-0251	1N5142
0122-0253	1N5143
0122-0255	1N5144
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3N186	1855-0279
3N214	1855-0250

Replacement FET's

Attention 5363A Owners

Original equipment 5363A Probe FET's (HP part no. 1858-0042) are becoming increasingly hard to purchase and now have an indefinite delivery time.

In the event your instrument requires a replacement FET, please order HP part no. 1858-0068.

CAUTION

This new FET is subject to the same static hazards as the old FET.

Some minor changes in equipment specifications occur due to this part change.

Trigger Level Accuracy (A&B)

±8 mV ± 0.4 mV/°C ±.25% of trigger point. (Old: ±8 mV ± 0.4 mV/°C ±.15% of trigger point.)

Differential Trigger Level Accuracy (A&B)

With both thumbwheels set to same value, actual trigger points will be within ±3 mV ±0.5% of trigger point setting (old: ±3 mV ±.3%).

Dynamic Range

Trigger levels can be set from −9.00 V to +9.99 V in 10 mV steps (old: −9.99 V to +9.99 V).

As a permanent update for your 5363A manual, please order service note 5363A-3. It contains all the new specifications.

Safety-Related Service Notes

Service Notes from HP relating to personal safety and possible equipment damage are of vital importance. To make you more aware of these important notes, HP has recently modified the Safety Service Note format. The note is now printed on paper with a red border, and a "-S" suffix has been added to the note's number. In order to make you immediately aware of any potential safety problems, we are highlighting safety-related Service Notes here with a brief description of each problem. Also, in order to draw your attention to safety-related Service Notes on the Service Note order form at the rear of Bench Briefs, each appropriate number is highlighted by being printed in color.

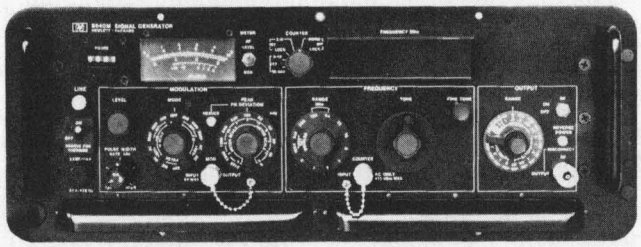
1610A/1611A/1615A/1640A Logic State Analyzers

A shock hazard may exist at the power socket (with cord removed) of the following logic Analyzers.

1610A serials 1812A00645 and below
1611A serials 1723A00927 and below
1615A serials 1825A00626 and below
1640A serials 1827A00315 and below

If the LINE switch is turned OFF and the power cord removed from the 1611A, line filter capacitors retain a change at the power socket that can shock an operator.

To eliminate the possibility of this hazard, it is necessary to install a 4.7 megohm 1/2 watt resistor across the line terminals of the power socket. Safety service notes 1610A-4-S, 1611A-7-S, 1615A-1-S, and 1640-1-S describes the procedure. You may order this safety service note from Hewlett-Packard with the form provided at the back of Bench Briefs.



8640B, Option 323 (AN/USM-323) and 8640M Signal Generator

A possible safety hazard exists in these instruments (refer to the service note list for specific serial numbers), where a terminal board, used as a junction for the power cord and line filter wiring, is secured to an aluminum side panel with no intervening insulation. A direct short of the power line to the panel is possible only when one of several unlikely conditions should occur. The problem is corrected with the installation of an insulator (HP part no. 0841-00064) following the procedure outlined in the safety service note. Order the note from HP with the form provided at the back of Bench Briefs.

8750A Storage-Normalizer

8750A Storage-Normalizers with serial numbers 1808A00510 and below may have a potential shock hazard on the front panel due to the neutral primary power lead being reversed with a ground lead at the front panel. To check and repair your instrument, perform the following steps:

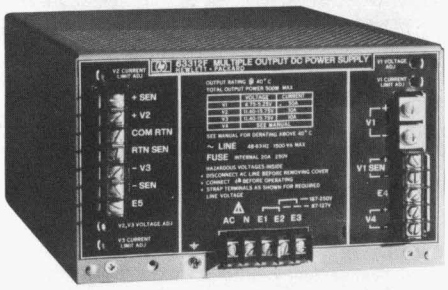
1.) Disconnect the power cord and remove bottom cover.

2.) Make certain that the white/yellow/gray wire #948 is connected from the rear panel to a ground lug adjacent to the front panel ON/OFF switch and *not* to a terminal on the ON/OFF switch.

3.) Make certain that the white/gray wire #98 (the neutral primary power lead) is connected to a terminal of the ON/OFF switch and *not* an adjacent ground lug.

Order Safety Service Note 8750A-3-S with the order form at the rear of Bench Briefs.

63312F DC Power Supply



A potential shock hazard may exist on 63312F Power Supplies with serial numbers 1809A00487 and below, if wires coming from RFI choke AIL2 should rub against the thermal switch bracket, and the safety earth ground is not connected to the power supply.

Safety service note 63312F-1-S lists a new bracket, insulation for the choke wire, and the procedure for modification.

supplement to

BENCH BRIEFS SERVICE NOTE INDEX

NEED ANY SERVICE NOTES?

Here's the latest listing of Service Notes available for Hewlett-Packard products. To obtain information for instruments you own, remove the order form and mail it to the HP distribution center nearest you.

GENERAL
5083-4. Recommended use of black tape on C.R.T. bases to prevent cracking.

403B/BB PORTABLE AC VOLTMETER
403B/BB-9A. Serials 0986A20520 and below. Recommended new battery replacement.

410C ELECTRONIC VOLTMETER
410C-17. Serials 0982A19038 and below. Recommended replacement transistor for A3Q1 & Q2.

435A POWER METER
435A-U-4. Serials 1823U and below. Recommended power supply crowbar modification.

465A AMPLIFIER
465A-5. Serials 0970A05055 and below. Recommended replacement for R28.

467A POWER AMPLIFIER SUPPLY
467A-3. Serials 0994A03870 and below. Recommended replacement for R1.

740A/740B DC STANDARD/DIFFERENTIAL VOLTMETER
740A-6B-S. Elimination of a potential safety hazard.
740B-8B-S. Elimination of a potential safety hazard.

741A/B AC-DC DIFFERENTIAL VOLTMETER/DC STANDARD
741A-9C-S/741B-10C-S. All serials. Elimination of a potential safety hazard.

1220A OSCILLOSCOPES
1220A-26. All serials. Instructions for high voltage board (A3) or focus and intensity potentiometers modifications.

1300A X-Y DISPLAY
1300A-13B. All serials. High-voltage oscillator replacement modification.

1308A X-Y DISPLAY
1308A-13B. All serials. IF high-voltage oscillator replacement modification.

1309A X-Y DISPLAY
1309A-13B. All serials. High-voltage oscillator replacement modification.

1332A X-Y DISPLAY
1332A-8. All serials. CRT replacement kits.

1610A LOGIC STATE ANALYZER
1610A-1. Recommended modification to extender board with connector reversed.
1610A-2. Serials below 00350. Modification to prevent A903 failure (preferred replacement for A9U4).
1610A-3A. Serials 1733A and below. Preferred replacement for A10 power supply board.

1611A LOGIC STATE ANALYZER
1611A-7-S. Serials 1723A00927 and below. Modification to prevent power socket shock hazard.
10258B-1. 1611A Option A80. Recommended modification to "trace-then-wait/hold" test mode for 1611A, option A80.

1707B OSCILLOSCOPE
1707B-6B. Recommended handle replacement kit.

1740A OSCILLOSCOPE
1740A-3B. All serials. Modification instructions for converting standard 1740A to an option 101.

1742A OSCILLOSCOPE
1740A-3B. All serials. Modification instructions for converting standard 1742A to an option 101.

1743A OSCILLOSCOPE
1740A-3B. All serials. Modification instructions for converting standard 1743A to an option 101.

3335A SYNTHESIZER/LEVEL GENERATOR
3335A-1. Serials below 1640A00261 (options 002, 003, 004) and all serials (standard models and all other options). Modification to prevent auto sweep mode ROM error.

3420A/B DC DIFFERENTIAL VOLTMETER/RATIOMETER
3420A/B-5B-S. Elimination of a potential safety hazard.

3455A DIGITAL VOLTMETER
3455A-3A. Serials 1622A01055 and below. Modification to improve stability of zero detect amplifier.
3455A-9A. All serials. Modification in instrument performance test.
3455A-10. All serials. Modification to improve performance of front panel pushbuttons.
3455A-11. Serials 1622A03305 and below. Modification to improve true RMS response to low level high frequency voltages.
3455A-12. Serials 1622A02566 to 1622A03135. Improvement in ohms converter response time.

3466A MULTIMETERS
3466A-3. All serials. Clarification of instruction specifications on AC range with input shorted.
3466A-4. All serials. Recommended replacement of integrator op amp U400.
3466A-5. All serials. Improved test for A4 logic board.

3551A TRANSMISSION TEST SET
3551A-10. All serials. Modification to prevent intermittent time base problems.

3552A TRANSMISSION TEST SET
3552A-U-6. Serials 1733U-00745. Recommended power supply fuse change.
3552A-U-7. All serials. Modification to prevent intermittent time base problems.

3556A PSOPHOMETER
3556A-U-1003A. Serials 1547U and below. Recommended battery modification to accept new style batteries.

3702B IF/BB RECEIVER
3702B-39. Serials below 1737U-02166. Modification to resistor in I.F. amplifier (A22R34).
3710A-20. All serials. New performance checks and troubleshooting procedures for 3702B with 3703B or 3705A plug-ins.

3703B GROUP DELAY DETECTOR
3703B-3. All serials. (Option 14 only). Recommended replacement of resistors A1R141, A1R142, and A1R143.
3703B-4. All serials. Recommended replacement for J-K flip-flops, A1MC1 and A1MC2.
3703B-5. Serials below 1326U-01309. Recommended modification to A1R195, A1R197, and A1R199 resistors.
3710A-20. All serials. New performance checks and troubleshooting procedures for 3702B with 3703B or 3705A plug-ins.

3703Z GROUP DELAY DETECTOR
3703Z-1. All serials. Recommended replacement for A1R141, A1R142, and A1R143 resistors.
3703Z-2. All serials. Recommended modifications to J-K flip-flops, A1MC1 and A1MC2 (1820-0595).

3705A GROUP DELAY DETECTOR
3710A-20. All serials. New performance checks and troubleshooting procedures for 3702B with 3703B or 3705A plug-ins.

3710A IF/BB TRANSMITTER
3710A-19. Serials below 1637U-02271. Recommended replacement resistors in I.F. amplifier assembly A6R28, A6R29, and A6R33.
3710A-20. All serials. New performance checks and troubleshooting procedures for 3710A with 3715A or 3716A plug-ins.

3715A BB TRANSMITTER
3710A-20. All serials. New performance checks and troubleshooting procedures for 3710A with 3715A and 3716A plug-ins.

3716A BB TRANSMITTER
3710A-20. All serials. New performance checks and troubleshooting procedures for 3710A with 3715A and 3716A plug-ins.

3721A CORRELATOR
3721A-10A. Serials 1123U-00371 and above (world wide) and serials 1112A-00135 and above (USA only). Recommended procedure for installation of delay offset, option 01 series.

3745B SELECTIVE LEVEL MEASURING SET
3745A/B-16. Serials between 1607U and 1726U (inclusive). Clarification of low output level from 3745B balanced audio output and preferred replacement of A300T1.
3745A/B-17. Serials 1726U and below. Modification to prevent illegal state of input attenuator logic.
3745A/B-18A. Serials 1812U and below. Recommended retrofit kit for 50 Hz special option HO7.
3745A/B-20A. Serials 1812U and below. Recommended retrofit kits for special options H15 and H16 that operate in conjunction with H07.

3762A DATA GENERATOR
3762A-2. Serials below 1812U-00156. Recommended modification to reduce susceptability of the 3762A to conducted line interference.

3770A AMPLITUDE/DELAY DISTORTION ANALYZER
3770A-2C. Serials below U-00483. Recommendations to increase receiver frequency display stability.
3770A-35. All serials. Recommended replacement part numbers of A15IC10, IC11, IC14 and IC15.

3770B TELEPHONE LINE ANALYZER
3770B-12A. Serials below U-00246. Recommended procedure to increase receiver frequency display stabiltiy.
3770B-15. All serials. Recommended replacement part numbers of A15IC10, IC11, IC14 and IC15.

3780A PATTERN GENERATOR/ ERROR DETECTOR
3780A-4A. Serials below 1804U-00531. Modification to reduce noise on the AC line supply.
3780A-10A. Serials below 1804U-00531. Recommended modification to reduce susceptibility of the 3780A to conducted mains supply interference.

3964A INSTRUMENTATION TAPE RECORDER

3964A-15. All serials. Procedure for elimination of noise in combined flutter compensation and tape servo mode.

3964A-16. Serials 1715A through 1814A. Recommended modification of A24 F1 and F2 to 5 amps.

3968A INSTRUMENTATION TAPE RECORDERS

3968A-15/8868A-13. All serials. Recommended procedure for elimination of noise in combined flutter compensation and tape servo mode.

3968A-16/8868A-14. Serials 1715A through 1814A. Recommended modification of A24 F1 and F2 to 5 amps.

4910G OPEN-SPLIT LOCATOR

4910G-3. All serials. Recommended installation of battery support plate.

4930A CONDUCTOR FAULT LOCATOR

4930A-5. All serials. Recommended installation of battery support plate.

4961A/B PAIR IDENTIFIER FIELD UNIT

4961A-1. All Serials. Recommended installation of battery support plate.

4961B-1. All serials. Recommended installation of battery support plate.

5004A SIGNATURE ANALYZER

5004A-1B. Serials 1736 and above. Recommended procedures for adjustment and compensation of data probe threshold voltage.

5004A-3. Serials 1808 and below. Recommended resistor modifications to meet narrow negative pulse specification.

5150A THERMAL PRINTER

5150A-4. Recommended HP-IB verification program for option 001.

5308A 75 MHz TIMER/COUNTER

5308A-3A. Serials 1720A2951 and above. Recommended in-cabinet performance update.

5328A UNIVERSAL COUNTER

5328A-U-15. Serials 1818U-00761 and above. Recommended replacement for A2 power supply assembly.

5328A-17. All serials. Option 011. Recommended HP-IB verification using the 9825A.

5328A-19A. All serials. Recommended modification to improve performance.

5328A-20. All serials. Recommended procedures for performance test for 5328A.

5328A-21. All serials. Recommended procedures for adjustments for the 5328A.

5345A ELECTRONIC COUNTER

5345A-9. Recommended HP-IB verification program, option 011.

5345A-12. Recommended HP-IB verification program, option 012.

5345A-13. All serials. Clarification of special extender board compatibility with 5345A counters.

5353A CHANNEL C PLUG-IN

5353A-1. Recommended HP-IB verification program.

5354A FREQUENCY CONVERTER

5354A-6. Recommended HP-IB verification program, option 011.

5354A-7. All serials. Recommended new adjustment procedures.

5363A TIME INTERVAL PROBES

5363A-1. Serials 1748A and below. Recommended circuit modifications to prevent trigger output oscillations.

5363A-2. Recommended HP-IB verification program.

8165A PROGRAMMABLE SIGNAL SOURCE

8165A-1. All serials. Procedure to prevent incorrect duty cycle being printed.

8444A TRACKING GENERATOR

8444A-3. All serials. Recommended replacement power line module.

8551A/B SPECTRUM ANALYZER, RF SECTION

8551A/B-9A. All serials. Recommended RF input attenuator replacements.

8552B SPECTRUM ANALYZER

8552B-10A. All serials. Spectrum analyzer assembly instructions.

8554B SPECTRUM ANALYZER, RF SECTION

8554B-5. All serials. Recommended modification to install option 003, internal RF input limiter.

8555A SPECTRUM ANALYZER, RF SECTION

8555A-8. All serials. Recommended tools for servicing the interconnecting connectors A1J6 and P6 (8555A A1 front panel assembly to RF section body).

8557A SPECTRUM ANALYZER

8557A-1B. Serials 1652A and below. Recommended modification kit for use with 8750A storage-normalizer.

8558B SPECTRUM ANALYZER

8558B-11B. Serials 1652A and below. Recommended modification kit for use with 8750A storage-normalizer.

8558B-15. All serials. Recommended new attenuator mounting bracket.

8568A SPECTRUM ANALYZER

8568A-1. All serials. Recommended new RF and IF-display interconnect cables.

8614A SIGNAL GENERATOR

8614A-19. Serials 1748A and below. Recommended replacement for germanium transistors on A500.

8616A SIGNAL GENERATOR

8616A-17. Serials 1739A and below. Recommended replacement for germanium transistors on A500.

8640B SIGNAL GENERATOR

8640B-32-S. All serials, option 323. Elimination of terminal board short hazard.

8640B-33. Serials 1827A and below, option 004. Recommended modification to improve AM phase shift.

8640M SIGNAL GENERATOR

8640M-1-S. Serials 1820A and below. Elimination of barrier block short hazard.

8699B RF UNIT

8699B-4A. Serials 1406A02325 and below. Recommended replacement for E4 power amplifier.

8750A STORAGE-NORMALIZER

8750A-3-S. Serials 1808A00510 and below. Elimination of a potential safety hazard.

8868A INSTRUMENTATION TAPE RECORDERS

3968A-15/8868A-13. All serials. Recommended procedure for elimination of noise in combined flutter compensation and tape servo mode.

3968A-16/8868A-14. Serials 1715A through 1814A. Recommended modification of A24 F1 and F2 to 5 amps.

10258B LOGIC STATE ANALYZER

10258B-1. Recommended modification to "trace then wait/hold" test mode for 1611A, option A80.

59405A HP-IB CALCULATOR INTERFACE

59405A-3. Serials 1444A01915 and below. Recommended procedure for data reliability improvement.

63312F DC POWER SUPPLY

63312F-1-S. Serials 1809A00487 and below. Elimination of potential safety hazard.

86350A OSCILLATOR MODULE

86350A-5A. All serials. YTO replacement kit, HP P/N 86350-60021 and YTO replacement kit, HP P/N 86350-60022.

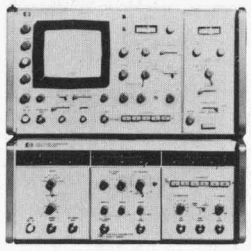
3710/3702 Users

Telecommunications Test Equipment

A service note, 3710A-20, has been issued that provides detailed information on troubleshooting the 3710/3702 MLA.

The 35-page service note replaces the Back-to-Back Performance Checks and Troubleshooting Section III of the service manual. There are waveform pictures, troubleshooting notes, and blank test records.

Owners of the 3710/3702 combination can order the service note with the order form located on the last page of Bench Briefs.



READERS CORNER

Here's your chance to share your ideas and views with other *Bench Briefs* recipients. In Reader's Corner, we will print letters to the Editor, troubleshooting tips, modification information, and new tools and products that have made your job easier. In short, Reader's Corner will feature anything from readers that is of general interest to electronic service personnel.

If there is something you have to share with other *Bench Briefs* readers, let us hear from you.

The last issue of Bench Briefs listed a series of questions submitted by the "Calibrators of Red Stone Arsenal." I thought they were straightforward and humorous and would not provoke anyone as had the sheep puzzle and petals round a rose problem. Little did I suspect!

Editor, Bench Briefs:

I enjoy, by and large, the Readers Corner and its puzzles. However, the recent issue (Vol. 18, No.2) contains some very childish (no pun intended — it is literally so!) ones.

Specifically, of the problems submitted by the "Calibrators of Red Stone Arsenal", problems #1, 2, 3, 4, 7, 8, 10 are well-known to my 11 year old girl ("Oh, dad, this is DUMBBBB!!!).

Problem #5 is more challenging (and not quite so simple) if stated as follows: "From my point of departure, I travelled 1 mile south, 1 mile west, and 1 mile north — and found myself at the point of departure. Where was I?" (answer: a *locus* of points on a circle of latitude, located at approximately 1 $1/2\pi$ miles north of the south pole. The north pole is another — trivial — solution.)

Problem #9 is wrong — with today's 24hr. alarm clocks, I *can* get 13 hrs. of sleep.

Finally, here is a dandy one, similar to the famous

$$\begin{array}{r} \text{SEND} \\ +\ \text{MORE} \\ \hline \text{MONEY} \end{array}$$

problem. This one requires some thought:

$$\begin{array}{r} \text{ABCDE} \\ \times\quad\ 4 \\ \hline \text{EDCBA} \end{array}$$

Here, of course, every letter stands for a digit. Find them! (answer will be supplied upon request.)

Sincerely,

S. Karni, Professor
Albuquerque, NM

Editor, Bench Briefs:

In the May-October 1978 issue of 'Bench Briefs' I read with some interest the Readers Corner, on p.12. Unfortunately, all of your so-called "logical answers" to logical questions are wrong.

Below I will supply the correct answers to these same questions.

1. Q. How many birth days does the average woman have?
   A. One, on the day she is born; a second, 29 years before her 30th birthday; a third one, 30 years before her 31st birthday; and so on until she is too old to care.
2. Q. Divide thirty by one-half and add ten.
   A. When you divide thirty teeth by one-half you need a dentist; after you add ten you are tendentious.
3. Q. Do they have a 4th of July in England?
   A. No, but they have a fifth of May wine.
4. Q. A man has two coins that are worth 30¢, one of which is not a quarter. What are the two coins?
   A. A quarter and a silver dollar; the silver dollar is not the quarter.
5. Q. A man built a house rectangular in shape and each side has a southern exposure. A bear came wandering by. What color is the bear?
   A. Any man who builds a house such that each side has a southern exposure has to be a bug on suntans. Therefore, the animal that "wanders by" is a bugbear.
6. Q. Is it legal for a man to marry his widow's sister?
   A. It may not be legal, but it sounds like a lot of fun.
7. Q. Why can't a man living in North Carolina be buried west of the Mississippi river?
   A. You can't find an undertaker in North Carolina who knows how to spell Mississippi.
8. Q. How many outs are there in an inning of baseball?
   A. As many inns as are visited in an outing after a ball.
9. Q. If you set the alarm clock for nine o'clock in the morning at eight p.m., how many hours of sleep will you get?
   A. None. If I had an electric clock I would worry that I had forgotten to plug it into the outlet, if it were non-electric I'd have a nagging feeling that I had neglected to wind it.
10. Q. How far can a dog run into the woods?
    A. A dog who runs into the woods will knock himself unconscious. Does that answer the question?
11. Q. A man gave a beggar 50¢. The beggar is not the man's brother, but the man is the beggar's brother. Why?
    A. Most men don't give any money to a beggar, so a beggar given 50¢ by a man will consider the man to be his brother; the man should be thankful that the beggar doesn't try to adopt him.

Sincerely yours,

Bernard Rasof, Professor
Chicago, IL

Editor, Bench Briefs:

I'm taken aback that HP, of all companies, would run an answer to a Readers Corner quiz such as the one to Question 9 in your May-October Bench Briefs. The question was:

> "If you set the alarm clock for nine o'clock in the morning at eight PM, how many hours of sleep will you get?"

The answer offered ("one hour before the alarm goes off") was true in the era BDC (sorry, Before Digital Clocks), when mechanical or electric clocks couldn't be expected to figure out whether you'd set them to ring at 9 p.m. or 9 a.m. The same isn't true of electronic digital clocks, though, God knows, they have their own traumas (such as not tolerating even the briefest power outage). So with an electronic clock, the correct answer is just what an illogical, muddleheaded reader would think: 13.

Shame on you and on the Calibrators of Red Stone Arsenal, but for God's sake don't cut off my BB subscription.

Sincerely yours,

Avery Comarow
Washington, DC

And Dr. R. N. Caffin from Australia writes:

Dear Sir,

May-October 1978 Bench Briefs Readers Corner, question 9: If I set my "alarm clock for nine o'clock in the morning at 8 p.m.", I get *13* hours sleep. Not one. Reason? Because my "alarm clock" is a digital clock and on it 9 a.m. is *9 a.m.* and 8 p.m. is *8 p.m.* That is, it functions as a 24 hour clock. And if you have a modern, electronic, digital clock, so will you get 13 hours!

Question 7: No reason why you can't bury a living man — other than legal ones!

Dr. R. N. Caffin
Australia

U.S. SEMINAR REGISTRATION FORM

	COURSE	DATES	TUITION	COORDINATOR
☐	Fourier Analyzer User's Guide	June 11 thru 15, 1979 August 13 thru 17, 1979	$500/Student	André Rudé 5301 Stevens Creek Blvd. Santa Clara, CA 95050 (408)246-4300
	Logic State Analyzers			
☐	1600A/1607A	September 10 thru 12, 1979	250/Student	
☐	1610A	September 17 thru 19, 1979	250/Student	
☐	1640A	September 20 thru 21. 1979	200/Student	
☐	1611A	September 24 thru 26, 1979	250/Student	
☐	1615A	October 15 thru 17, 1979	250/Student	
	Oscilloscope Maintenance			Dick Browne P.O. Box 2197 Colorado Springs, CO 80901 (303)598-1900
☐	1715A/1725A	October 1 thru 3, 1979	250/Student	
☐	1740A/1741A/1742A/1744A	October 8 thru 11, 1979	300/Student	
☐	Tri-Color Display & Graphics Translator Maintenance 1338A/1350A	October 4 thru 5, 1979	200/Student	
☐	Small Screen Display Maintenance 1332A/1333A/1335A	October 22 thru 23, 1979	200/Student	
☐	Large Screen Display Maintenance 1310A/1311A/1317A/1321A	October 25 thru 26, 1979	200/Student	
*☐	Signal Generator Maintenance 8640/8660 and 435/436 Power Meters *or* 8672A Microwave Synthesizer	September 10 thru 14, 1979	350/Student	Steve Thomas 1501 Page Mill Rd. Palo Alto, CA 94303 (415)856-2980
*☐	8505A RF Network Analyzer	September 17 thru 21, 1979	350/Student	Jim Simpson 1400 Fountain Grove Parkway Santa Rosa, CA 95404 (707)525-1400

*Notice that these courses can be taken concurrently.

	COURSE	LOCATION	TUITION	COORDINATOR
On demand* (class size: Minimum=1 Maximum=30)	Digital Troubleshooting Techniques (using HP logic lab)	Customer site	$4,200 flat rate	Tom O'Connor Mountain View (415)968-9200 ext. 372
On demand* (class size: Minimum=15 Maximum=30)		HP field office	$300/Student	
On demand* (class size: Minimum=1 Maximum=20)	Microprocessor Troubleshooting Techniques (using 5036A's)	Customer site	$4,200 flat rate	Tom O'Connor Mountain View
On demand* (class size: Minimum=10 Maximum=20)		HP field office	$300/Student	

*30-day leadtime for scheduling required.

REGISTRATION INSTRUCTIONS

To enroll in any of the seminars, fill out the registration form and mail it with your check to the address shown for the coordinator. Please use separate registration forms for each student.

Make your check payable to Hewlett-Packard Company in U.S. Currency.

Upon receipt of your registration and check, we will confirm your enrollment by returning all necessary prestudy material along with a list of nearby motel accommodations. Attendees are responsible for their own transportation, accommodations, and meals.

Name _____

Company Name _____

Address _____

City _____ State _____ Zip _____

If you want service notes, please check the appropriate boxes below and return this form separately to one of the following addresses.

Hewlett-Packard
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Palo Alto, California 94303

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AMSTELVEEN—1134
Netherlands

NAME_____

COMPANY NAME_____

ADDRESS_____

CITY_____

STATE_____ ZIP_____

- ☐ 403B/BB-9A
- ☐ 410C-17
- ☐ 435A-U-4
- ☐ 465A-5
- ☐ 467A-3
- ☐ 740A-6B-S
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