HEWLETT PACKARD

BENCH BRIEFS

REFERENCE FILE COPY
PLEASE DO NOT REMOVE

SERVICE INFORMATION FROM HEWLETT-PACKARD

JULY-AUGUST 1980

Basic Transistor Troubleshooting Revisited

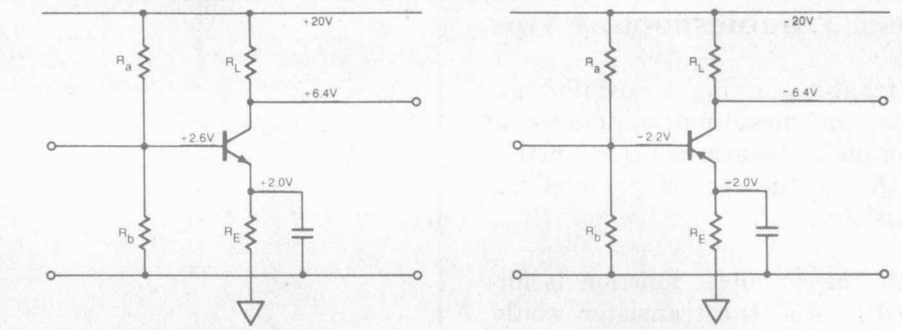
Editor's Note: Based on reader comments, the most popular articles printed in "Bench Briefs" are those dealing with basic electronics. One of these articles appeared six years ago and described how to troubleshoot transistorized circuits. Incorporated into the text was a description of a simple in-circuit transistor checker that utilized the X-Y display capabilities of an oscilloscope.

We have received many requests for copies of this article and especially information about the transistor checker. So, by popular demand, here is a repeat of "How to Troubleshoot Transistorized Circuits Faster," by George Stanley, based mostly on his book, Transistor Basics: A Short Course. Copyright © 1967, 1975 by Hayden Book Company, Inc. All rights reserved. This material is printed with the permission of Hayden Book Co., Inc., Rochelle Park, N.J.

Fundamental Characteristics of Transistors

Before describing specific troubleshooting tips, let's take a moment and review several important transistor characteristics.

Conventional PNP or NPN transistors are basically "off" devices and must be biased "on" to their operating point. This is done by forward biasing the base-emitter diode to make the transistor conduct. Refer to Figure 1 for examples of forward bias on NPN/PNP silicon and germanium transistors.



1a. NPN silicon transistor typical bias conditions

1b. PNP germanium transistor typical bias conditions

Figure 1. Transistor bias examples showing the "on" condition

As shown in Figure 1, an NPN transistor must have its base more positive than the emitter in order for current to flow.

In a PNP transistor, the base must be more negative than the emitter in order for current to flow.

So "on" bias voltages for a transistor can be summed up by referring to Figure 1 and the following two rules:

— For a PNP, the base is negative, the emitter is not quite as negative, and the collector is far more negative.

— For an NPN, the base is positive, the emitter is not quite as positive, and the collector is far more positive.

There is a distinct difference between a transistor being turned "on" and being "saturated." When a transistor is saturated, it's generally thought of as being almost a short, that is, the IR drop across the emitter and collector resistors equals the supply voltage as shown in Figure 2. Naturally this means that there is practically no voltage drop between the collector and emitter of the transistor. In this condition, both the base-emitter and base-collector diodes are forward biased (where in the "on" condition only the base-emitter is forward biased — the base-collector is reverse biased). A saturated germanium transistor may have as low as 0.05 volts between its emitter and collector, while a saturated silicon transistor may have 0.5 volts or less between these leads.

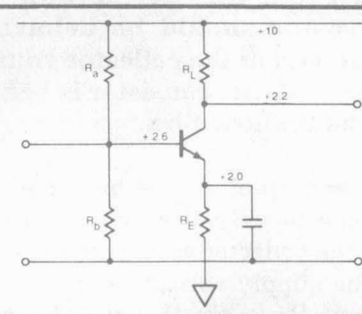


Figure 2. Transistor bias example showing the "saturated" condition

"Saturated" or "off" are the usual conditions found in digital circuits. In ac circuits where transistors are used as amplifiers instead of switches, the amount the transistor is turned on depends upon current gain (beta) of the transistor, the resistors in series with the collector and emitter, and the supply voltage.

Basic Troubleshooting Tips

In troubleshooting transistor circuits, the most important area to examine is the base-emitter junction as this is the control point of the transistor.

If the base-emitter junction is forward biased, the transistor would normally be "on."

If the base-emitter junction has zero bias or reverse bias, it should be turned off. If it is not off under these conditions, it is either shorted or leaky.

Tip #1

Measure the base-emitter voltage. From this decide how the transistor should be behaving. Then look at the collector voltage and see if the transistor is behaving as it should be.

For example, if the base-emitter voltage is 0.6 volts forward biased and the collector voltage is the same as the supply voltage, something is wrong. Probably the collector-base junction is open.

Expanding on the above idea leads to our second troubleshooting tip.

Tip #2

Modify the control signals present and see if the circuit responds accordingly.

For example, if the transistor is forward biased as shown in Figure 1, see if it is behaving as an amplifier. Short the emitter to the base to remove the forward bias as shown in Figure 3. The collector voltage should then rise to the approximate level of the supply voltage. (Any difference is caused by Ico, the collector-to-base leakage current.) The higher the collector voltage rises, the lower Ico, and the better the transistor.

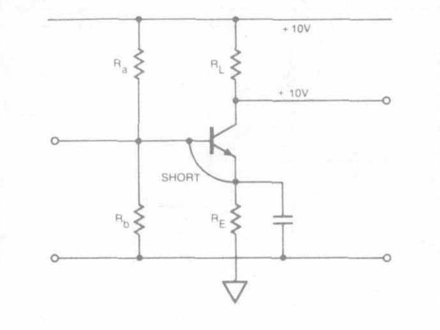


Figure 3. Amplifier with forward bias removed

If the collector voltage doesn't rise as expected, we've identified a bad transistor. This technique is perfectly safe in AC coupled circuits. However, in some DC coupled circuits, we could cause damage if base-emitter shorts are applied around high power levels (e.g., such as the output stage of a power amplifier).

Now, back to Ico, the collector-to-base leakage current mentioned previously. As we implied, if the transistor was perfect it would have no Ico leakage current. Look at Figure 1a again. Note the collector voltage is more positive than the base voltage. In this "on" condition the base-collector diode junction is reverse biased. This reverse biased diode should be off, but because we have never been able to make a perfect diode, there is a very small current leaking across it. This leakage current flows through the collector-base junction and part of it goes through the base-emitter (control point) junction.

Since leakage current is extremely temperature sensitive, we can use this to our advantage in troubleshooting. For example, in an amplifier stage, excessive leakage current can cause clipping distortion because of the shift in the quiescent operating point.

Tip #3

In an amplifier with clipping distortion, try cooling each transistor with spray coolant. Quite likely you will find that when the leaky transistor is cooled the clipping distortion disappears. Conversely, heating a leaky transistor will make the problem much worse by greatly increasing the Ico leakage.

Basic Circuit Analysis

An interesting problem is illustrated in Figure 4. In this circuit, both transistors are of the NPN type. Note that Q_2 has 0.8 V *reverse* bias on its emitter-base junction, but the 2.0 volts on the emitter means that there is 2 mA of emitter current. Now, since the emitter-base junction is not shorted, this 2 mA of current also flows through the 8K resistor in the collector of Q_2. Therefore, the collector voltage, V_{CC}, is:

$$18V - (8K) \times (2\ mA) = 2V$$

Thus, it would appear that Q_2 has a short between collector and emitter.

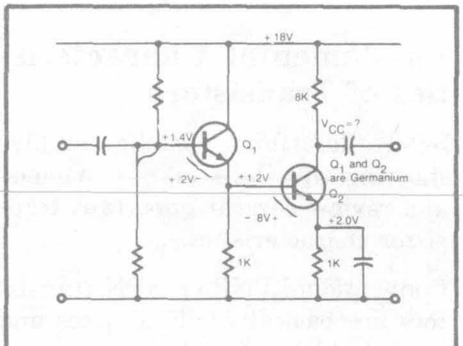


Fig. 4. Direct coupled two-stage example circuit

Another interesting problem in troubleshooting illustrated in Figure 5. Although the emitter current of Q_1 is 1 mA, the collector current is only 0.52 mA (i.e., 5.2V÷10K). Stage Q_2 shows 5 mA flowing in both the emitter and collector circuits, so Q_2 is either

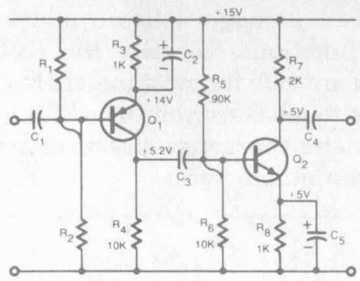


Fig. 5. Capacitive coupled two-stage example circuit

shorted or saturated. The one voltage that would answer this question is not given; i.e., the voltage on the base of Q_2. If everything were working correctly, this voltage would be approximately 1.5V.

$$V_B = \frac{(V_C) \times (R_6)}{R_5 + R_6}$$

$$V_B = \frac{(15V) \times (10K)}{90K + 10K}$$

$$V_B = 1.5V$$

What appears to have happened is that C_3 is shorted. This would explain why there is only 0.52 mA flowing through resistor R_4. The other 0.48 mA is flowing through C_3 and resistor R_6. If C_3 were shorted, it would also explain the voltages on Q_2. The 5.2 V on the base produces 5.0 volts on the emitter, which, in turn, causes the 5 mA of d-c current to flow and Q_2 to saturate.

If capacitor C_3 were replaced, the base voltage of Q_2 would be 1.5 V dc, and the voltage on the emitter would be about 1.3 V dc. This, in turn, would cause about 1.3 mA of dc to flow. The resultant collector voltage would be 12.4 V dc.

In-Circuit Transistor Tester

Even though all the above tips are good ones, there is a transistor tester that will speed up troubleshooting even more. This tester works on the known fact that PNP and NPN transistors are made up of two diodes. Each diode is examined with an AC signal which tests the diode's forward conductivity and reverse resistance. The voltage-to-current ratio is displayed on an oscilloscope with voltage plotted on the horizontal axis and current plotted on the vertical axis.

Figure 6 shows a simplified schematic of the transistor checker and the ideal voltage vs. current waveforms you can expect to see.

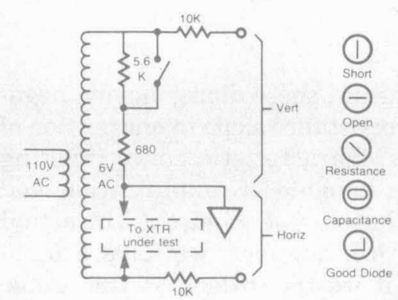


Figure 6. Transistor checker and ideal waveforms

Since the transistor checker puts out a sine wave that has alternatively positive and negative half cycles, we would expect a perfect diode to behave as shown in Figure 7.

NOTE: All references to a diode also imply the base-emitter or base-collector diode junctions of a transistor.

In actual practice, the waveforms shown in Figure 7 are all possible because the test leads are not polarized (i.e., since the tester puts out AC, there is no positive or negative test lead).

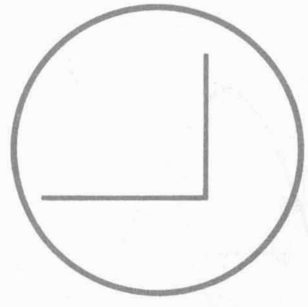


Figure 7. Ideal waveform of good diode

The waveforms shown in Figure 8 are ideal out-of-circuit diode checks. Figure 9 shows a typical waveform of an in-circuit transistor test with associated resistance and capacitance. The loop is caused by the capacitance (probably a coupling capacitor), and the fact that the waveform is not a perfect "right" angle is because of the associated resistance (probably bias or load resistors).

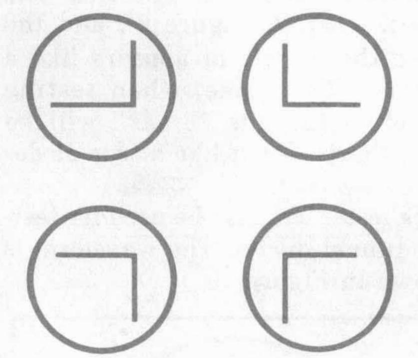


Figure 8. Ideal waveforms for a good diode

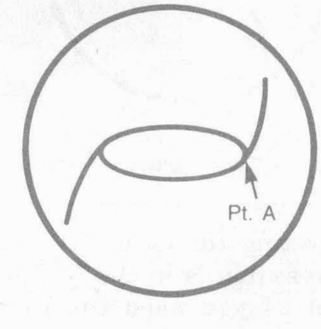


Figure 9. Typical in-circuit waveform for a good transistor

The schematic of the tester shows a switch that shorts out a 5.6K resistor. This switch is primarily for current limiting so you don't damage sensitive transistors. You can also use it for in-circuit vs. out-of-circuit testing.

This transistor tester leads to our next troubleshooting tip.

Tip #4

Use the transistor checker for rapid testing. Make sure to test both the base-emitter and base-collector diodes.

A little experimenting with a printed circuit board containing many transistors will rapidly show you the various waveforms you will encounter for good transistors. The main point to look for is whether or not the waveform has a "break" in it (Pt. A in Figure 9). If it does, the transistor diode is good. Remember, the lower the resistance of the bias resistors, the less defined the "break" (Pt. A Figure 9), and the more the waveform appears like a "short". Of course, when testing out-of-circuit, the "break" will be very sharp — just like a true diode.

This tester can also be used for testing tunnel diodes. The waveform is shown in Figure 10.

Figure 10. Tunnel diode waveform

When testing tunnel diodes, make sure the switch is in the *In-Circuit* position as you need the higher current.

Transistor Tests with a VOM

Another way to test transistors is to perform a forward and reverse ohmmeter check on the two transistor diodes. It's much slower than with the transistor checker. Also you have to be careful about the short-circuit current and open-circuit voltage of your ohmmeter. On Rx1 and Rx10 scales, VOM's often have a very high short circuit. This current may be as high as several hundred mA and can damage small delicate transistors. On the other hand, VOM's often have high open circuit voltages (22.5V) on their high resistance scales. These voltages also can damage delicate emitter-base junctions. Usually the Rx1K scales are safe for most meters but it is best to measure your own. Table 1 shows the characteristics of several common ohmmeters.

More On Testing Tunnel Diodes

The working technician is quite likely to encounter tunnel diodes in the trigger circuits of scopes, frequency counter front ends, and elsewhere.

In theory, these diodes have a negative resistance slope in one portion of their characteristic curve, making them capable of amplification and oscillation. See Figure A. In actual practice, however, we have a problem if we try to look at this slope. Any simple circuit that we can devise to gradually increase the current through the diode will have some internal resistance. Therefore, it's almost impossible to arrive at point B because the diode will abruptly switch from A to C and vice versa on the decreasing swing. This switch action results in about 0.5 volt change across the diode and occurs at nominally 5 to 15 mA current. The voltage change occurs very rapidly. Circuits like Figure B can produce discrete pulses at several hundreds of MHz.

Due to very high impurity levels, the diode's quiescent forward voltage drop is very low and its reverse leakage current very high. This would lead your ohmmeter to conclude that the diode is shorted in both directions. A first glance with the transistor tester will give the same appearance. However, a little extra effort and a closer look may reveal that at or near its rated current the diode does, in fact, switch states. If the transistor tester has a 100 ohm current limiting resistor, then 1 volt vertical deflection will correspond to 10 mA of junction current. Any reasonable facsimile will work so long as you can display about 0 to 30 mA vertically. The curve on a good diode will be similar to Figure 10 in the main article allowing you to discern the switch points and get a fair idea of the current magnitude.

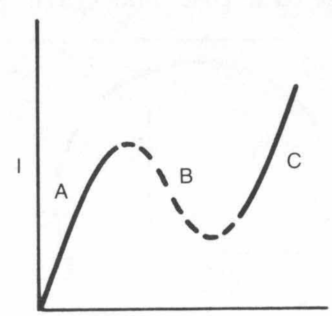


Figure A.

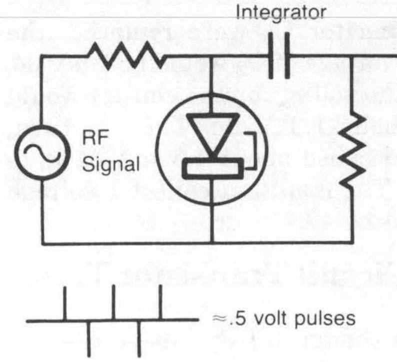


Figure B.

TABLE 1. CHARACTERISTICS OF COMMON OHMMETERS

Make, Model, and Range	Open Circuit Voltage	Short Circuit Current	Polarity
HP 412A (VTVM)			
R × 1	0.01 V	8.0 mA	
R × 10	0.1 V	10.0 mA	RED +
R × 100	1.0 V	10.0 mA	
***R × 1K**	**1.0 V**	**1.0 mA**	BLACK −
R × 10K	**1.0 V**	**100.0 μA**	
R × 100K	**1.0 V**	**10.0 μA**	
R × 1M	**1.0 V**	**1.0 μA**	
R × 10M	**1.0 V**	**0.1 μA**	
HP 410B (VTVM)			
R × 1	1.1 V	120 mA	
R × 10	1.1 V	11 mA	RED −
R × 100	**1.1 V**	**1.1 mA**	
R × 1K	**1.1 V**	**110.0 μA**	BLACK +
R × 10K	**1.1 V**	**11.0 μA**	
R × 100K	**1.1 V**	**1.1 μA**	
R × 1M	**1.1 V**	**0.11 μA**	
HP 410C (VTVM)			
R × 10	1.3 V	55 mA	
R × 100	1.3 V	5.7 mA	RED +
R × 1K	**1.3 V**	**0.57 mA**	BLACK −
R × 10K	**1.3 V**	**57 μA**	
R × 100K	**1.3 V**	**5.7 μA**	
R × 1M	**1.3 V**	**0.5 μA**	
R × 10M	**1.3 V**	**0.05 μA**	
SIMPSON 260 (VOM)			
R × 1	1.5 V	125 mA	RED +
R × 100	**1.5 V**	**1 mA**	
R × 10K	7.5 V	60 μA	BLACK −
SIMPSON 269 (VOM)			
R × 1	1.5 V	74 mA	
R × 10	1.5 V	8 mA	RED −
R × 100	1.5 V	8 mA	BLACK +
R × 1K	**1.5 V**	**0.82 mA**	
R × 10K	24 V	1.3 mA	
R × 100K	30 V	13 μA	
TRIPLETT 630 (VOM)			
R × 1	1.5 V	320 mA	RED −
R × 10	1.5 V	32 mA	BLACK +
R × 100	**1.5 V**	**3.25 mA**	(Varies with
R × 1K	**1.5 V**	**325 μA**	serial
R × 100K	22.5 V	**70 μA**	number)
TRIPLETT 310 (VOM)			
R × 1	1.5 V	7.5 mA	RED −
R × 10	**1.5 V**	**750 μA**	BLACK +
R × 100	**1.5 V**	**75 μA**	(Varies with
R × 10K	1.5 V	75 μA	serial number)

* Numbers in bold type indicate safe range.

Tip #5

Measure the short-circuit current and open-circuit voltage for each resistance scale on your VOM's and VTVM's. Keep this information along with the polarity of the leads on a chart on the back of the ohmmeter.

Tip #6

If you are using a VTVM, make sure the range you are using has enough open-circuit voltage to overcome the 0.2V for germanium and 0.6V for silicon. Otherwise you will get an unsatisfactory reading.

Since leakage does not show up well on the transistor checker of Figure 6, nor on the ohmmeter tests, it is best to have an inexpensive beta/leakage tester on hand. There are many available and some of the best are in kit form. If a leakage current tester is unavailable, you can try shorting out the emitter-base junction while simultaneously measuring the voltage drop across the collector load resistor.

Tip #7

Measure I_{CBO} by shorting the emitter-base junction and monitoring the voltage across the collector lead resistor.

$$I_{CBO} = \frac{V_{RL}}{R_L}$$

For example, if you measured 30 mV across a 10K load resistor, your leakage current would be

$$I = \frac{E}{R} = \frac{30\text{mV}}{10\text{K}} = 3\mu\text{A}$$

This would be about right for a germanium transistor at room temperature, but a little high for a silicon surface-passivated transistor.

One of the most common mistakes in analyzing transistor circuits is to miscalculate the gain of one stage in a multi-stage amplifier. The error usually occurs in miscalculating the real value of the load resistor for that stage. Figure 11 shows a two-stage amplifier. The correct value for RL1 is not the actual listed value of the resistor, but rather the parallel combination of RL1, Ra, Rb and Rin of Q2. Usually the Rin of Q2 is the most dominant factor in this combination.

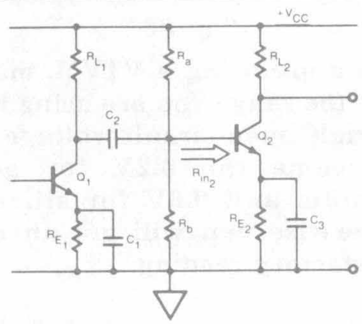


Figure 11. Two-stage amplifier

Tip #8

When calculating the gain of a stage, be sure and include the parallel loading effects of the next stage bias resistors and input impedance.

Summary

All of the above tips relate back to the fundamental characteristics of transistors described at the beginning of this article. To summarize, here is a list of important points relating to the troubleshooting tips and characteristics previously described.

- NPN and PNP transistors are basically "off" devices while vacuum tubes are basically "on" devices.
- Transistors are made up of two diodes: a base-emitter diode and a base-collector diode. In normal (amplifier) operation, the base-emitter diode is forward biased and the base-collector diode is reverse biased.
- Shorting the base to emitter turns off transistors while forward biasing base-emitter junctions turns on transistors.
- All transistors have leakage current across their reverse biased base-collector diodes. For surface passivated silicon transistors, this current is usually no more than several nanoamperes. Since germanium transistors cannot be surface passivated, this leakage current normally may be several microamperes.
- Leakage current increases with heat (a law of physics) and doubles about every 10°C.
- Leakage current may be easily measured by shorting the base-emitter junction and measuring between the transistor collector and the supply voltage. The leakage current then equals the voltage across the load resistor divided by its resistance. (Make sure the collector is not DC coupled to the next stage.)
- Abnormal increases in room temperature leakage current (e.g., 10 times normal) often indicate contamination of the base-collector junction (possibly due to a cracked or broken hermetic seal). The result is a shift in the normal bias operating point. Trouble will only be experienced if the driving signal drives the transistor to or near cutoff. The transistor will not properly turn off and the result may be clipping or distortion due to the residual leakage current flowing through the external resistors. Heating and cooling a transistor aggravates this condition and sometimes shows up marginal operation.
- Shorting collector to emitter simulates saturation as the transistor behaves like a closed switch.

Much information on transistors is available from HP on video tape in the *Practical Transistor Series*, HP Part Number 90100D, *Troubleshooting Transistor Circuits Faster*, HP Part Number 90030 683 and *Troubleshooting FET Circuits Faster*, HP Part Number 90030 726. Contact your local HP office for more information or call direct to Hewlett-Packard Video Products, (415) 857-2381.

For Selected HP-IB Instruments

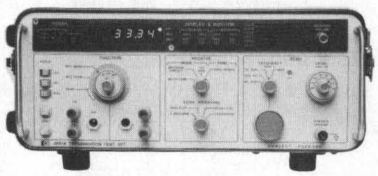
HP-IB VERIFICATION PROGRAMS

Many Hewlett-Packard instruments with HP-IB capability have calculator-controlled test programs available that can save you considerable time in verifying instrument operation. Each program is fully documented with instructions, listing, flow-chart, check points, etc. The verification programs listed below can be ordered from your local HP office.

INSTRUMENT MODEL		TAPE P/N	PROGRAM DOCUMENTATION
5150A	Thermal Printer	59300-10001 (9825A)	Service Note 5150A-4
5312A	ASCII Interface Module (5300B)	59300-10001 (9825A)	Service Note 5312A-2
5328A	Universal Counter (Opt. 011, 020, 021, 030, 031, 040, 041)	59300-10001 (9825A)	Service Note 5328A-17
5328A	Universal Counter (Opt. H99)	59300-10001 (9825A)	5328A/H99 Manual
5328A	Universal Counter (Opt. 096/H42)	59300-10001 (9825A)	5328A/H42 Manual
5335A	Universal Counter	59300-10001 (9825A)	5335A Manual
5340A	Frequency Counter (Opt. 011)	59300-10001 (9825A)	Service Note 5340A-11
5341A	Frequency Counter (Opt. 011)	59300-10001 (9825A)	5341A Manual
5342A	Microwave Frequency Counter (Opt. 011)	59300-10001 (9825A)	5342A Manual
5343A	Microwave Frequency Counter (Opt. 011)	59300-10001 (9825A)	5343A Manual
5345A	Electronic Counter (Opt. 011)	59300-10001 (9825A)	Service Note 5345A-9A
5345A	Electronic Counter (Opt. 012)	59300-10001 (9825A)	Service Note 5345A-12A
5353A	Channel C Plug-In	59300-10001 (9825A)	Service Note 5353A-1
5354A	4 GHz Frequency Converter	59300-10001 (9825A)	Service Note 5354A-6
5355A	Automatic Frequency Converter	59300-10001 (9825A)	5355A Manual
5358A	Measurement Storage Plug-In	59300-10001 (9825A)	5358A Manual
5359A	Time Synthesizer	59300-10001 (9825A)	5359A Manual
5363A	Time Interval Probes	59300-10001 (9825A)	Service Note 5363A-2
5363B	Time Interval Probes	59300-10001 (9825A)	5363B Manual
5370A	Universal Time Interval Counter	59300-10001 (9825A)	Service Note 5370A-1A
59301A	ASCII/Parallel Converter	59300-10001 (9825A)	Service Note 59301-2
59303A	Digital-to-Analog Converter	59300-10001 (9825A)	Service Note 59303A-1
59304A	Numeric Display	59300-10001 (9825A)	Service Note 59304A-1
59306A	Relay Actuator	59300-10001 (9825A)	Service Note 59306A-4
59307A	VHF Switch	59300-10001 (9825A)	Service Note 59307A-3
59308A	Timing Generator	59300-10001 (9825A)	Service Note 59308A-1
59309A	Digital Clock	59300-10001 (9825A)	Service Note 59309A-3
59313A	Analog-to-Digital Converter	59300-10001 (9825A)	59313A Manual
436A	Power Meter	00436-10006 (9830A) 00436-10007 (9825A)	436A Manual Service Note 436A-2
8409B	Automatic Network Analyzer	11863-10004 (9835/45)	11863D Manual 8409B Manual
8672A	Synth. Sig. Gen.	11712-10001 (9830A) 11712-10002 (9825A)	Kit Manual 11712-90001 Kit Manual 11712-90001
8409B	Network Analyzer	11863-10004 (9835/45)	11863D Manual 8409B Manual
8566A	Spectrum Analyzer	08566-60002 (9825A)	8566A Manual
8568A	Spectrum Analyzer	08568-60002 (9825A)	8568A Manual
8507A	Network Analyzer	85030-10002 (9830A)	85030A Manual 8507A Manual
8507B	Network Analyzer	85030-10007 (9825A)	85030B Manual 8507B Manual
3042A	Network Analyzer	03042-90211 (9825A)	3042A Manual
3045A	Spectrum Analyzer	03045-10001 (9825A)	3045A Manual
3582A	Spectrum Analyzer	03582-10001 (9825A)	3582 Manual
3585A	Spectrum Analyzer	03585-10001 (9825A)	3585 Manual
3050B	Voltmeter System	03050-90230 (9825A) 03050-90212 (9830A)	3050B Manual 3050B Manual
3052A	Voltmeter System	03052-90011 (9825A)	3052A Manual
3437A	System DVM	03437-10001 (9825A)	3052A Manual
3455A	System DVM	03455-10001 (9830A) 03455-10002 (9825A)	3052A Manual 3052A Manual
3495A	Scanner	03495-10001 (9830A) 03495-10002 (9825A)	3495A Manual 3495A Manual

Safety-Related Service Notes

Service Notes from HP relating to personal safety and possible equipment damage are of vital importance to our customers. To make you more aware of these important notes, they are printed on paper with a red border, and the service note number has a "S" suffix. 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 back of *Bench Briefs,* each appropriate number is highlighted by being printed in color.



3551A Transmission Test Sets May Have Incorrect Line Fuse

Test sets with serial numbers 1550A05921 through 1550A06220 should be inspected as follows:

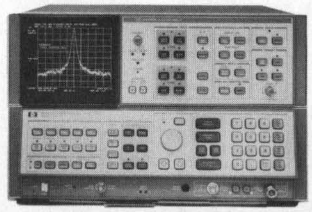
— Unplug the instrument.

— Slide the power module's plastic window to the left so that it covers the power cord receptacle.

— Pull the lever marked "FUSE" out from the instrument and remove the fuse.

The correct fuse will have the marking "250mA 250V" or "0.25A 250V" on one of the metal end caps of the fuse.

If you have an incorrect fuse, contact your local HP office for a free replacement. Specify HP part no. 2110-0201. For more information, please order Safety Service Note 3551A-12-S using the order form at the rear of *Bench Briefs*.



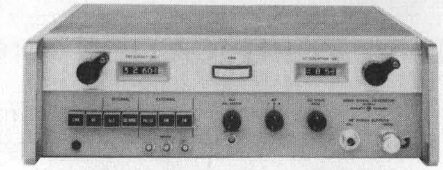
Recommended Line Fuses For 8568A Spectrum Analyzers

This Safety Service Note contains information concerning the proper *replacement* of line fuses in the 8568A Analyzer.

The following table lists the correct replacement fuses.

Line Voltage	Fuse	HP Part Number	C D
100/120	2A FAST-BLOW	2110-0002	9
220/240	1A SLOW-BLOW	2110-0007	4

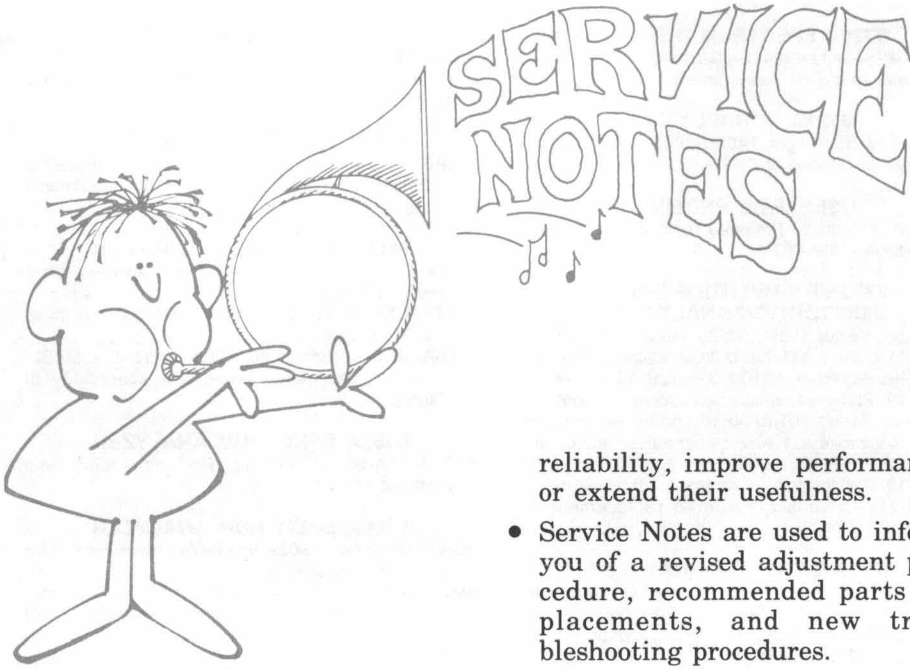
For more information, please order Safety Service Note 8568A-11A-S using the order form at the rear of *Bench Briefs*.



Check Front Panel Grounding On 8614A/B and 8616A/B Signal Generators

During the manufacturing process, some of the front panels on the 8614A/B and 8616A/B Signal Generators were painted on the backside. This may result in a poor ground connection for components mounted on the front panel *which could result in personal injury.*

To check the grounding on your generator, measure the resistance from ground to the SQ WAVE control shaft, the F control shaft, and the FM input jack outer shell. If the resistance of any shaft is greater than 0.1 ohm, remove the components and scrape the paint free from the area where the components seat against the backside of the front panel. For more information, please order Safety Service Notes 8614A-18-S, 8614B-10-S, 8616A-16-S, and 8616B-10-S using the order form at the rear of *Bench Briefs*.



What Are Service Notes?

For one thing they are free.

For another they provide an after-sales support link to Hewlett-Packard for a continuous flow of service-related information about your instrument.

What Do Service Notes Say?

- Service Notes recommend modifications to instruments to increase reliability, improve performance, or extend their usefulness.
- Service Notes are used to inform you of a revised adjustment procedure, recommended parts replacements, and new troubleshooting procedures.
- Safety Service Notes communicate potentially hazardous conditions related to the use of instruments.

What Are The Benefits To Me?
You can create a history file on each HP instrument you own. Service Notes describe modifications to instruments out in the field and are the only way you have of keeping your operating and service manual up-to-date.

Are Back Issues Available?
Yes! Copies of all service notes ever issued for an instrument are available in both hardcopy or microfiche. These notes are listed in model number sequence for all instruments (including obsolete models) in the "Service Note Index" — also available free of charge.

Please be aware that we can only supply free back issues on a limited basis. For those customers that require large numbers of Service Notes for many different instruments, HP has a complete microfiche library and automatic updating service available for a nominal charge.

How Do I Obtain Service Notes
Inside *Bench Briefs* is an abstract of all the current Service Notes issued over the last 2-3 months. At the rear of *Bench Briefs* is a Service Note order form.

1. Look in the abstract list for the model number of your instrument.
2. Read the abstract to get an idea of what the note is about.
3. If you want the note (or notes — many times there is more than one), check the appropriate numbers on the order form and mail it to one of the listed addresses.
4. If you want back issues of Service Notes (or notes that are not listed in the current issue of *Bench Briefs*), simply write the model number (or Service Note number if known) across the face of the order form.

---

supplement to BENCH BRIEFS SERVICE NOTE INDEX

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.

435A/436A POWER METERS

435A-5. Serials Prefixed 1629A and below, and serial numbers 2004U-05330 and below. N connector modification to allow POWER REF OUTPUT compatibility with 8481B and 8482B.

436A-3. Serials 1629A01131 and below, and 1943U00880 and below. N connector modification to allow POWER REF OUTPUT compatibility with 8481B and 8482B.

546A LOGIC PULSER

546A-1. Serials 1732A and below. Modification to improve performance.

1302A/1304A DISPLAYS

1302A-3. Serials 1721A and below. Preferred replacement for astigmatism potentiometer.

1304A-3. Serials 1715A and below. Preferred replacement for astigmatism potentiometer.

1610A LOGIC ANALYZER

1610A-8. Serials 1836A01319 and below. Modification to improve reliability.

1610A-9. Serials 1940A-01704 to 1940A-01764. Modification to improve power supply regulation.

1611A LOGIC ANALYZER

1611A-8A. Serials 1837A-02232 and below. Modification to eliminate bright spot on CRT after turn off.

1615A LOGIC ANALYZER

1615A-2. Serials 1937A-03487 and below. Modification to eliminate bright spot on CRT after turn off.

1822A TIME BASE AND DELAY GENERATOR

1822A-2A. Serials 0907A- and below. Modification to improve reliability.

3325A SYNTHESIZER/ FUNCTION GENERATOR

3325A-5A. Serials 1748A02350 and below. Modification to improve square wave phase control.

3325A-7. Serials 1748A02350 and below. Adjustment to mixer driver to improve reliability.

3325A-8. All serials. Relay cleaning procedure.

3330A/B SYNTHESIZER
3330A/B-11A. Serials 1313A02622 and below. Modification to improve power supply reliability.

3335A SYNTHESIZER/ LEVEL GENERATOR
3335A-4. Serials 1640A-00703 and below. Modification to prevent locking failures of summation VCO.
3335A-5. Serials 1640A-00703 and below. Modification to improve sweep output reliability.

3336A/B/C SYNTHESIZER/ LEVEL GENERATOR
3336A/B/C-2. Serial numbers:
3336A—1930A00103-1930A00112
3336B—1931A00101-1931A00110
3336C—1932A00101-1932A00107
Replacement of front panel key caps.

3455A DIGITAL VOLTMETER
3455A-17A. All serials. Modifications to reduce AC drift.
3455A-18. Serials 1622A06990 and below. Preferred replacements for FET's A10Q1, Q2, Q13, and Q14.

3465A/B DIGITAL MULTIMETER
3465A-5A. All serials. Replacement part numbers for batteries.
3465B-2A. All serials. Replacement part numbers for batteries.

3551A TRANSMISSION TEST SET
3551A-12-S. Serials 1550A05921 through 1550A06220. Possible incorrect power line fuse rating.
3551A-9B. Serials 1550A04325 and below. Replacement procedure for A3 input amplifier assembly, front panel, and front subpanel.
3551A-13. All serials. +12 volt regulator replacement instructions.

3555B TRANSMISSION AND NOISE MEASURING SET
3555B-2E. Serials 0992A06760 and below. Improved power supply reliability.

3570A NETWORK ANALYZER
3570A-10. Serials 1331A01615 and below. Modification to improve performance during HP-IB operation.
3570A-11. Serials 1331A01595 and below. Modification to improve low amplitude phase measurements.

3585A SPECTRUM ANALYZER
3585A-3. Serials 1750A00570 and below. Modification to improve 75Ω input return loss.

3702B IF/BB RECEIVER
3702B-42. All serials. Preferred replacement for NPN transistor (1854-0071).

3703B IF/BB RECEIVER
3703B-6. All serials. Preferred replacement for NPN transistor (1854-0071).

3705A IF/BB RECEIVER
3705A-7. All serials. Preferred replacement for NPN transistor (1854-0071).

3710A IF/BB RECEIVER
3710A-22. All serials. Preferred replacement for NPN transistor (1854-0071).

3712A IF/BB RECEIVER
3712A-3. All serials. Preferred replacement for NPN transistor (1854-0071).

3715A IF/BB RECEIVER
3715A-2. All serials. Preferred replacement for NPN transistor (1854-0071).

3716A IF/BB RECEIVER
3716A-11. All serials. Preferred replacement for NPN transistor (1854-0071).

3720A SPECTRUM DISPLAY
3720A-3B-S. Serials 1349U-00221 thru 1534U-00286. Installation of CRT safety shield.

3721A CORRELATOR
3721A-14B-S. Serials 1405U-00496 thru 1544U-00596. Installation of CRT safety shield.

3736A IF/BB RECEIVER
3736A-3. All serials. Preferred replacement for NPN transistor (1854-0071).

3770A/B AMPLITUDE/DELAY DISTORTION ANALYZER
3770A-39. Serials 1905U-00528 and below. Modification to improve A21 40kHz timer adjustment range.
3770A-40. All serials. A31Q2, 3, 5, 7, 9, 10, 12, 14, 16, 17, 19. Preferred replacements for transistors.
3770B-19. Serials 2010U-00506 and below. Modification to improve A21 40kHz timer adjustment range.
3770B-20. All serials. A31Q2, 3, 5, 7, 9, 10, 12, 14, 16, 17, 19. Preferred replacements for transistors.
3770B-21. All serials. Preferred replacement for capacitor A11C7.

3771A DATA LINE ANALYZER
3771A-2A. All serials. Recommended procedure for retrofitting for option 001 (+10dBm switch).
3771A/B-11A. All serials. Retrofitting instructions for Option 002 (loop holding).
3771A/B-17. All serials. Preferred replacement of phase-locked loop integrated circuits.

3779A/B PRIMARY MULTIPLEX ANALYZER
3779A-15A. Serials 1919U-00175 and below. Modifications to prevent intermittent single channel interface operation while running A-D measurements.
3779B-15A. Serials 1933U-00206 and below. Modifications to prevent intermittent single channel interface operation while running A-D measurements.
3779B-18. All serials. Field installation of 3779B Option 002 into 3779B Option 001 instruments.

4140A pA METER/DC VOLTAGE SOURCE
4140A-3. Serials 1917J00270 and below. Modification to improve operation of key controls.

4942A TIMS
4943A-5. Serial numbers affected:
4942A — All serials:
4943A — Serials 1731A00290 and below:
4944A — Serials 1737A00570 and below:
A6 or A17 RF cable replacement compatibility.

4943A TIMS
4943A-5. Serial numbers affected:
4942A — All serials:
4943A — Serials 1731A00290 and below:
4944A — Serials 1737A00570 and below:
A6 or A17 RF cable replacement compatibility.

4944A TIMS
4943A-5. Serial numbers affected:
4942A — All serials:
4943A — Serials 1731A00290 and below:
4944A — Serials 1737A00570 and below:
A6 or A17 RF cable replacement compatibility.
4944A-6. Serials 1737A00481 and below. Modification to prevent intermittent level dropout.

5315A/B UNIVERSAL COUNTER
5315A/B-2. All serials. Replacement part numbers for yellow LED displays.

5342A MICROWAVE FREQUENCY COUNTER
5342A-9A. Serials 1812 and below. Procedure to correct A2 false frequency readout, and to eliminate ground at U19(8).

5391A FREQUENCY STABILITY ANALYZER SYSTEM
5391A-1. All serials. Software bugs and fixes.

5500C LASER HEAD
5526A-5A. Serials below 1920A and below. Preferred replacement of the high voltage and PZT power supplies.

8558B SPECTRUM ANALYZER
8558B-6A. Serials 1420A and below. Modification kit to install serviceable seven segment LED digital panel meter.

8566A SPECTRUM ANALYZER
8566A-5. Serials 1842A through 1950A. External 321.4 MHz IF modification kit.
8566A-6. Serials 1842A through 1950A. External mixer modification kit.
8566A-7A. IF section serials 1928A and below. Modification to decrease magnetic susceptibility of display.

8568A SPECTRUM ANALYZER
8568A-11A-S. All serials. Recommended fuse replacement.

8568A SPECTRUM ANALYZER
8568A-19. Serials 1903A and below. Improvement for line related sidebands.
8568A-20A. IF section serials 1928A and below. Modification to decrease magnetic susceptibility of display.
8568A-21. IF section serials 1918A and below; RF section serials 1912A and below. Modification to improve 40 — 80 kHz residuals.
8568A-25. Using the 8444A tracking generator with the 8568A spectrum analyzer.
8568A-28. IF section serials 2005A and below; RF section serials 1921A and below. Modification to improve 3 MHz resolution bandwidth.
8568A-29. RF section serials 1943A and 1948A. Modification to improve third order intermodulation performance.
8568A-30. IF section serials 2003A and below. Modification to improve third order intermodulation performance.
8568A-31. RF section serials 1943A and below. Recommended component changes to prevent signal level fluctuations.
8568A-32A. All serials. Adjustment procedure to improve amplitude drift vs. temperature.
8568A-34. All serials. Procedure to select A13C22 capacitor whenever IC A13U13 is changed.

8614A/B SIGNAL GENERATOR
8614A-18-S. Serials 1748A and below. Procedure for checking front-panel grounding.
8614B-10-S. All serials. Procedure for checking front-panel grounding.

8616A/B SIGNAL GENERATOR
8616A-16-S. Serials 1739A and below. Procedure for checking front-panel grounding.
8616B-10-S. All serials. Procedure for checking front-panel grounding.

8620C SWEEP OSCILLATOR
8620C-5. Serials 1933A and below. Elimination of frequency shift in 8620C HP-IB Option 001 plug-ins.

8671A SYNTHESIZER
8671A-1. Serials 2006A and below. Modification to improve performance of Reference Oscillator.

8672A SYNTHESIZED SIGNAL GENERATOR
8672A-2A. Serials 1719A and below. Preferred replacement for 1853-0050 transistor.
8672A-8. Serials 2006A and below. Modification to improve performance of Reference Oscillator.
8672A-9. Serials 1831A thru 2007A. Modification to improve amplitude recovery time.

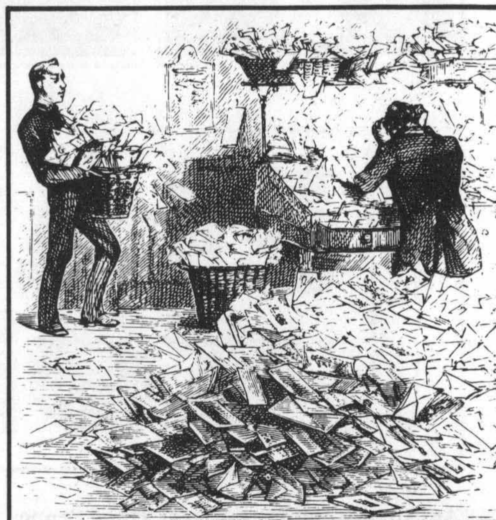
9571A DTS-70
9571A-10. All serials. Recommended replacement for 62605J Power Supply.

Service Note Order Form

Instructions

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

2. If you want a printed copy of the service note index, please mark the box below and return this form to one of the following addresses.



Our highly trained staff and modern tabulating equipment are anxiously awaiting your reply.

For European customers (ONLY)

Hewlett-Packard
Central Mailing Dept.
P. O. Box 529
Van Hueven Goedhartlaan 121
AMSTELVEEN—1134
Netherlands

All other customers

Hewlett-Packard
1820 Embarcadero Road
Palo Alto, California 94303

NAME______________________________

COMPANY NAME______________________________

ADDRESS______________________________

CITY______________ STATE______________ ZIP__________

Service Note Index

☐ Yes, I want a printed copy.

☐ 435A-5
☐ 436A-3
☐ 546A-1
☐ 1302A-3
☐ 1304A-3

☐ 1610A-8
☐ 1610A-9
☐ 1611A-8A
☐ 1615A-2
☐ 1822A-2A

☐ 3325A-5A
☐ 3325A-7
☐ 3325A-8
☐ 3330A/B-11A
☐ 3335A-4

☐ 3335A-5
☐ 3336A/B/C-2
☐ 3455A-17A
☐ 3455A-18
☐ 3465A-5A

☐ 3465B-2A
☐ 3551A-9B
☐ 3551A-12-S
☐ 3551A-13
☐ 3555B-2E

☐ 3570A-10
☐ 3570A-11
☐ 3585A-3
☐ 3702B-42
☐ 3703B-6

☐ 3705A-7
☐ 3710A-22
☐ 3715A-2
☐ 3716A-11
☐ 3720A-3B-S

☐ 3721A-14B-S
☐ 3736A-3
☐ 3770A-39
☐ 3770A-40
☐ 3770B-19

☐ 3770B-20
☐ 3770B-21
☐ 3771A-2A
☐ 3771A/B-11A
☐ 3771A/B-17

☐ 3779A-15A
☐ 3779B-15A
☐ 3779B-18
☐ 4140A-3
☐ 4943A-5

☐ 4944A-6
☐ 5315A/B-2
☐ 5342A-9A
☐ 5391A-1
☐ 5526A-5A

☐ 8558B-6A
☐ 8566A-5
☐ 8566A-6
☐ 8566A-7A
☐ 8568A-11A-S

☐ 8568A-19
☐ 8568A-20A
☐ 8568A-21
☐ 8568A-25
☐ 8568A-28

☐ 8568A-29
☐ 8568A-30
☐ 8568A-31
☐ 8568A-32A
☐ 8568A-34

☐ 8614A-18-S
☐ 8614B-10-S
☐ 8616A-16-S
☐ 8616B-10-S
☐ 8620C-5

☐ 8671A-1
☐ 8672A-2A
☐ 8672A-8
☐ 8672A-9
☐ 9571A-10

READERS' CORNER

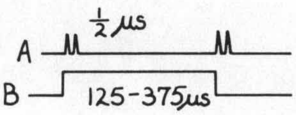
An Application For A Dual Trace Scope

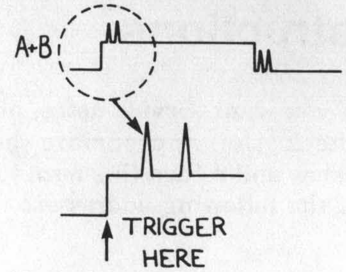
Dear Editor:

When measuring two very fast signals on a scope, the user is generally forced to go to a dual beam model or use the alternate trace mode of a dual trace model. However, the alternate trace mode will not maintain the correct time relationship between the two displayed traces since they are not displayed simultaneously. For accurately timed signals this poses no problems. But for real-time signals that have a random component (noise) in them, it is more desirable to see both signals simultaneously. What follows is a method to do this with a single beam dual trace scope.

I have found that the HP 1223 Variable Persistence Oscilloscope can measure two pulse trains (see Figure) without loss of time relationship by using the A + B mode. Channel A and B are summed rather than alternated or chopped. The resulting signal vastly speeded by time in debugging a tape-head design which involved two very different but synchronized signals: a dual 1 μsec pulse train occurring at the beginning of a variable width pulse train)125 μsec to 375 μsec).

USUALLY NOT MEASURABLE (REAL TIME) ON DUAL TRACE MACHINE.





Hugh Macdonald
Psychology Department
Stanford, CA

As Part 2 of the scope article pointed out, in Alternate mode and triggering on A or B, the correct time relationship between the two signals will be maintained.

When the technicians at HP's repair center in Mt. View measure head skew on our digital tape recorders, they use the Alternate mode and Trigger View. This allows them to observe the two input signals and trigger signal at the same time. This option visualizes the time relationship of the two inputs to the trigger point and each other.

Editor

Puzzle Answer

After making up your matrix and filling in all the blanks, the answers appear that the Frenchman drinks water and the Italian rides the bus.

	1	2	3	4	5
Color	yellow	blue	red	black	green
Nationality	Frenchman	German	Englishman	Spaniard	Italian
Drink	water	tea	milk	orange juice	coffee
Inst.	DVM's	scopes	signal generators	counters	distortion analyzers
Trans.	car	motorcycle	bicycle	walks	bus

HEWLETT-PACKARD COMPANY
1820 Embarcadero Road
Palo Alto, California 94303

BENCH BRIEFS
JULY-AUG 1980
Volume 20 Number 4

Service information from Hewlett-Packard Company

To obtain a qualification form for a free subscription, send your request to the above address.

Reader comments or technical article contributions are welcomed. Please send them to the above address, attention Bench Briefs.

Editor: Jim Bechtold, HP Mt. View California

Bulk Rate
U.S. Postage
PAID
Sunnyvale, CA.
Permit No.
317

Address Correction Requested

Printed in U.S.A.