HEWLETT hp PACKARD

BENCH BRIEFS

SPECIAL SAMPLE ISSUE

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TROUBLESHOOTING TRANSISTORIZED CIRCUITS FASTER

by George Stanley

Many books and articles have been written on transistors and transistorized circuits but very few have been written about troubleshooting transistorized circuits. This article is aimed at providing practical troubleshooting tips for those of you repairing transistorized equipment.

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

A conventional PNP or NPN transistor has three operating states:

A. *Off*, that is an open switch.

B. *Part way on*, bias voltage are set so the transistor can amplify, i.e. it can be turned further on or further off. This is the normal bias condition for amplifiers.

C. *Saturated*, behaves like a closed switch. Saturation is defined as where the IR drop across the emitter and collector resistors equals the supply voltage. The interesting thing about saturation is that both the base-emitter and base-collector diodes are forward biased. A saturated germanium transistor may have as low as 0.05 volts between its emitter and collector while a satured silicon transistor might have about 0.5 volts between these leads.

Saturated or *off* are the usual conditions found in digital circuits.

In troubleshooting transistor circuits, the most important area to examine is the base-emitter junction as this is the control point of the transistor. Remember that conventional PNP and NPN transistors are basically "off" devices and must be biased "on" to their operating point. This is done by forward biasing the base-emitter junction. Therefore, the status of the base-emitter diode tells exactly what the transistor *should* be doing. This diode is made out of either silicon or germanium. If the transistor is silicon and has approximately 0.6V forward bias between base and emitter, the transistor should be "on". The amount it should be on depends upon the current gain (β) of the transistor, the resistors in series with the collector and emitter, and the supply voltage. If the transistor were germanium and had approximately 0.2 volts forward bias between base and emitter, it would behave in the same general fashion.

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

This review leads us to our first troubleshooting tip.

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 0.6V 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.

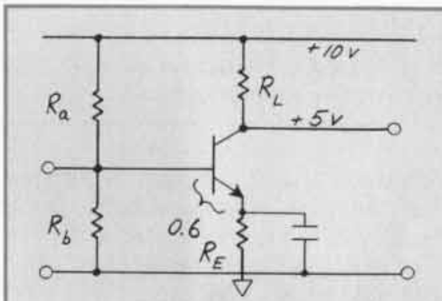

FIGURE 1. Properly biased transistor

For example, Figure 1 shows a normally biased NPN silicon transistor with the bias resistors adjusted to have the transistor turned on half way. Now remove the forward bias on the base-emitter diode junction by adding the short as is shown in Figure 2. When the short is added, the collector voltage should rise to within a few tenths of a volt of the supply voltage. If it doesn't, we've identified a bad transistor. This technique is perfectly safe in AC

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coupled circuits. In some DC coupled circuits we could cause damage if base-emitter shorts are applied around high power levels such as the output stage of a power amplifier.

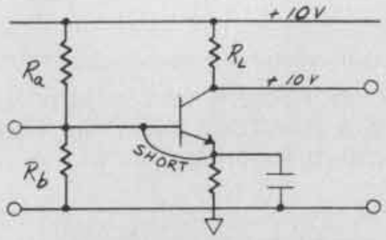


FIGURE 2. Amplifier with forward bias removed

When we use the above technique, the collector voltage would rise to exactly the supply voltage if there was no collector-base leakage current. Since all PNP and NPN transistors have some leakage let's review this area.

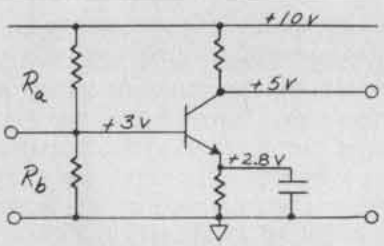


FIGURE 3. NPN germanium transistor with bias voltages

Figure 3 shows a properly biased transistor. Note the collector voltage is more positive than the base voltage — thus in normal operation 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 across the collector-base junction and part of it goes thru the base-emitter (control point) junction.

Since leakage current is extremely temperature sensitive we can use this to our advantage in troubleshooting:

TIP #3: When a transistor with excessive leakage is sprayed with coolant, it often starts behaving properly. Conversely, heating a leaky transistor will make the problem much worse.

In an amplifier stage excessive leakage current will cause clipping distortion because of the shift in the quiescent operating point.

TIP #4: In an amplifier with clipping distortion try cooling each transistor. Quite likely you will find that when one transistor is cooled the clipping distortion disappears. That transistor probably has excessive leakage.

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 and examines each diode independently. The display is shown on an oscilloscope.

Figure 4 shows a simplified schematic of the transistor checker. *This tester was described in the September issue of* BENCH BRIEFS. *Key characteristics are repeated here for the sake of completeness.*

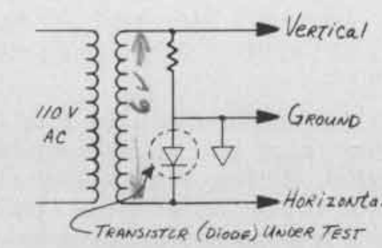


FIGURE 4. Transistor checker (simplified schematic)

With the tester connected as shown we would expect the following waveforms:

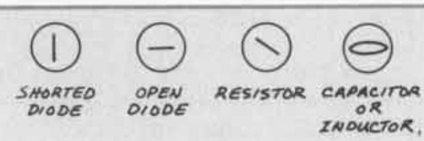


FIGURE 5. Tester waveforms

Since our 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 6.

FIGURE 6. Waveform of good diode

In actual practice the waveforms shown in Figure 7 are obtained because we do not care which lead is on the base and which lead is on the collector (or emitter).

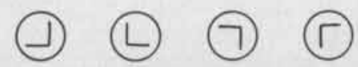


FIGURE 7. Possible waveforms for a good transistor diode junction

The above waveforms are typical of *out of circuit* transistor checks. Note in Figure 8, which shows

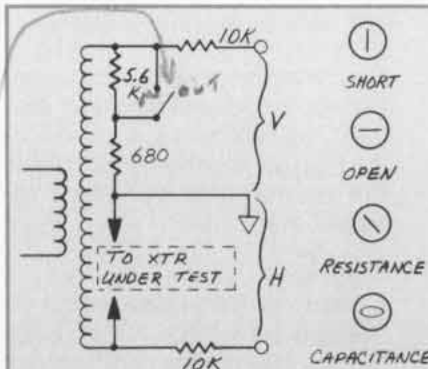


FIGURE 8. Transistor checker

a complete schematic, there is a switch for *"In-Circuit" and "Out-Of-Circuit"* operation. When performing *In-Circuit* tests there are usually resistors and capacitors associated with the transistor under test. The result is often a waveform such as is shown in Figure 9.

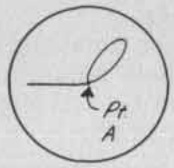


FIGURE 9. Typical in-circuit waveform for a good transistor

The loop in Figure 9 shows there is associated 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).

This transistor tester leads to our next troubleshooting tip.

TIP #5: 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 important thing 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 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 extra current.

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.

TIP #6: 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 #7: 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 8 nor on the ohmmeter tests, it is best to have an inexpensive beta/leakage tester on hand. There are many available for under $50.00 and some of the best are available in kit form. If a leakage current tester is unavailable you can always short out the emitter-base junction simultaneously measuring the drop across the collector load resistor. For example, if you did this and measured 30 mV across a 10K load resistor (with the emitter shorted) your leakage current would be $I = \frac{E}{R} = \frac{30mV}{10K}$ or 3μA which would be about right for a germanium transistor at room temperature but a little high for a silicon surface-passivated transistor.

TIP #8: Measure I_{CBO} by shorting the emitter-base junction and monitoring the voltage across the collector load resistor. $I_{CBO} = \frac{V_{RL}}{R_L}$ (see text).

One of the most common mistakes in analyzing transistor circuits is to miscalculate a stage gain in a multistage amplifier. For example, an excellent approximation of stage gain is $A_e \approx -\frac{R_L}{hi_b}$ where hi_b is 30Ω at 1MA of DC emitter current, 15Ω at 2MA, etc. The problem comes in plugging in the correct value for R_L. Figure 11 shows a two-stage amplifier. The correct value for R_{L_1} is not the actual value of this resistor but rather the parallel combination of R_{L_1}, R_a, R_b and R_{in} of Q_2. Usually the R_{in} of Q_2 is the most dominant factor in this combination.

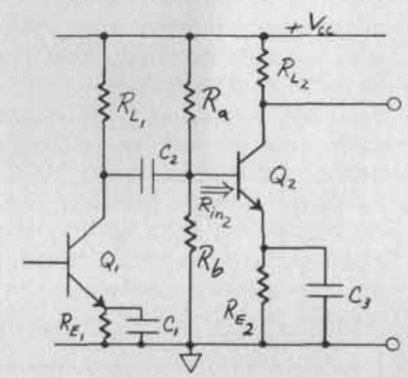


FIGURE 11. Two-stage amplifier

TIP #9: When calculating the gain of a stage, be sure and include the parallel loading effects of the next stage bias resistors and input impedance.

All of the above tips relate back to important characteristics of transistors. Of course, there are many other tips that are common to NPN and PNP transistors as well as to FET's and vacuum tubes but that may be good material for another article.

In summary, here is a list of important points relating to transistors which you may find useful in coming up with troubleshooting tips of your own.

A. NPN and PNP transistors are basically "off" devices while vacuum tubes are basically "on" devices.
B. 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 reversed biased.
C. Shorting the base to emitter turns off transistors while forward biasing base-emitter junctions turns on transistors.
D. All transistors have leakage current across their reversed 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.
E. Leakage current increases with heat (a law of physics) and doubles about every 10°C.
F. Leakage current may be easily measured by shorting the base-emitter junction (diode) and measuring between the transistor collector and the supply voltage. The leakage current then equals the voltage across the load resistor (R_L) divided by R_L. (Make sure the collector is not DC coupled to the next stage.)
G. Abnormal increases in room temperature leakage current, say 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, of course, will not properly turn off and the result may be clipping or distortion due to the residual leakage current flowing thru the external resistors. Heat- and cooling a transistor aggravates this condition and sometimes shows up marginal operation.
H. Shorting collector to emitter simulates saturation as the transistor behaves like a closed switch.

Essentially the same material is covered in a service video tape which you can purchase from Hewlett-Packard. This tape is entitled *Troubleshoot Transistor Circuits Faster* (17 minutes), I.D. #800683.

If you have some good troubleshooting ideas, send them in and we will share them with all the readers.

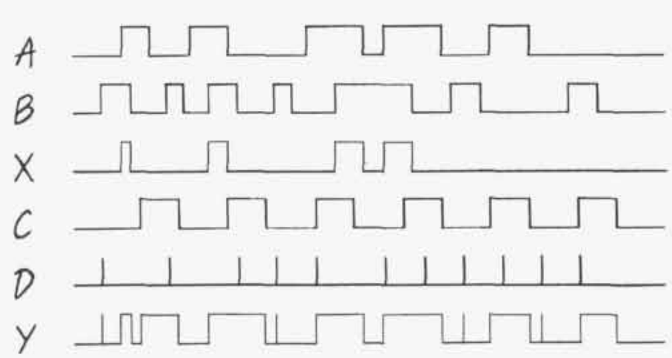
This material is printed with the permission of the Hayden Book Co., Inc., Rochelle Park, N.J. It will appear along with other troubleshooting material in a revised edition of George Stanley's well-known book, TRANSISTOR BASICS: A SHORT COURSE. *Watch for it.*

George Stanley, a member of I.E.E.E., received his B.S.E.E. degree from Stanford University. He is very interested and active in the area of technical education, and is the author of Transistor Basics: A Short Course, *Hayden Book Co., and* A Casebook of Basic Circuits for Electronics Instrumentation, *Rhinehart Press. He also created a fifteen-part video tape series entitled* "Practical Transistors" *for Hewlett-Packard.*

Prior to becoming involved in technical education, George was a microwave development engineer and holds a patent in the area of control circuitry. He lives in Los Altos, California with his wife and their three children.

QUIZ SOLUTION

Here's the solution to the logic quiz that was in the last issue.



SPECTRUM ANALYZER USE

If your job entails measuring analog signals for such things as modulation, harmonic mixing, spectral purity and other related items, you may be interested in investigating spectrum analysis. An application note is available that discusses what a spectrum analyzer is, how it works, and other related items. For a free copy of AN150 Spectrum Analyzer Basics, please contact your local HP office.

CATV—PERFORMANCE VERIFICATION

Community Antenna Television personnel may be interested in the method of verifying the performance of CATV systems to U.S., Canadian, and Japanese CATV specifications by using a spectrum analyzer. Measurements can be made easily and accurately. Details are available in a free application note AN 150-6 which is available by calling your local HP office.

NEW VIDEO TAPE

AMPLITUDE MODULATION

(90221—) 16 minutes. Color. This tape explains the characteristics of four types of AM (single and double sideband, suppressed carrier and vestigial sideband). Both frequency and time domain representations are covered, as well as explanations of modulation index, bandwidth and power distribution in AM signals. It is recommended as viewing support for any of the HP Spectrum Analyzer Operation series of videotapes. Students in technical fields will find this program of particular interest. To increase viewer retention, this program ends with a short review and quiz.

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.

Memo to Dick Gasperini:

Re: *BENCH BRIEFS* pp 5 and 6.
"SUPERSEDES" supersedes "SUPERCEDES."

Elsam Products Co.
Brockton, Mass.

Are you implying that we make spelling misteaks and occasionally do not catch typograpihc errors?

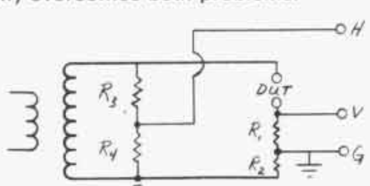
Editor

Dear Editor:

The diode/transistor checker shown in the Sept-Oct 1974 issue of *BENCH BRIEFS* (Figure 3) has two drawbacks:

1. The curves are in the wrong quadrants. A diode, for instance, shows forward conductance in the second or fourth quadrant, rather than the first or third, as would be preferred.
2. If the scope horizontal input impedance is less than infinity (100K is common), the "open circuit" curve will have a tilt, rather than being perfectly horizontal. This could be 8% for the values shown.

The circuit shown here (original, as far as I know) overcomes both problems:



Note that when the Device Under Test (DUT) is a short, the H and G leads are in a bridge configuration. If $\frac{R_1}{R_2} = \frac{R_3}{R_4}$, there is zero voltage to the horizontal input, as desired, regardless of the input impedance of the scope. If the DUT is zero since no current can flow through R_1. As long as these two conditions are met, the circuit must work correctly under all intermediate conditions.

Also note that the H and V leads are on the same side of ground, in effect, rather than on opposite sides like the circuit in *BENCH BRIEFS*. This puts the curves in the proper quadrant. Without the bridge arrangement, this configuration requires an impractically small vertical sampling resistor to avoid tilt in the short circuit case. The bridge, however, allows any convenient value to be chosen for R_1.

I use the following resistor values: R_1 = 1K, R_2 = 10K, R_3 = 10K, R_4 = 100K.

If more current is needed, an appropriate resistor can be shunted from V to P without upsetting the bridge. Also, for real precision work R_3 and R_4 can be replaced by a 100K pot, which allows exact nulling.

Sincerely,

James J. Davidson
Davidson Consultants
Overland Park, Kansas

The diode waveform can appear in any *quadrant depending on which way the diode is connected and whether the scope vertical input switch is in the "+ up" or "- up" position.*

You are correct about the slight tilt. If your input is 10 megohms, the tilt is hardly noticeable. If you have a 100K scope input impedance, you will have about 8% tilt when in the out-of-circuit *position. When using the* in-circuit *position, it is about 1%.*

Of prime importance in any transistor check of this type is its behavior when actually testing transistors. When doing in-circuit testing (see article this issue), note there is tilt produced by in-circuit resistors and "looping" produced by in-circuit capacitors — see Figure 9. These characteristics are probably secondary to whether or not the diode has the telltale diode "knee" — again, see Figure 9. If it does, then the diode is good; if not, then it is shorted or open.

Many people do not bother with an in-circuit/out-of-circuit *switch and do everything in the* in-circuit *position. This works fine in about 99% of the cases and the only place you might get into trouble is with very high-speed or very high-frequency transistors.*

George Stanley

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.

140A OSCILLOSCOPES

140A-15. Serial prefix 747 and below. Recommended replacement of Q602.

141A OSCILLOCOPES

141A-20. Serial prefix 815 and below. Recommended replacement of Q602.

184A/B HIGH SPEED OSCILLOSCOPE MAINFRAME

184A/B-2. Serial prefix 1433A and below. Modification to correct CRT crossover.

412A/AR DC VACUUM TUBE VOLTMETER

412A/AR-4. Offsets on current ranges.

412A/AR VACUUM TUBE VOLTMETER

412A-7B. All serials. Supersedes 412A-7A. Replaceable parts for voltage probe assembly.

465A GENERAL PURPOSE AMPLIFIER

465A-4. Serial number 0970A03785 and below. Harmonic distortion.

1200A/B DUAL TRACE OSCILLOSCOPE

1200A/B-4A. 1200A serial numbers below 1047A01396; 1200B serial numbers below 0931A00973. Increased protection for input preamplifier boards when making power measurements. Supersedes 1200A/B-4.

1201A/B DUAL TRACE STORAGE OSCILLOSCOPE

1201A/B-3A. 1201A serial numbers below 1117A00616; 1201B serial numbers below 1120A00296. Increased protection for input preamplifier boards when making power measurements. Supersedes 1201A/B-3.

1202A/B 500 kHz OSCILLOSCOPE

1202A/B-1A. 1202A serial numbers below 1044A00631; 1202B serial numbers below 0931A00491. Increased protection for input preamplifier boards when making power measurements. Supersedes 1202A/B-1.

1220A/1221A OSCILLOSCOPES

1220A-6/1221A-3. All serials. TV Sync separator check.
1220A-7. Serial numbers 1416A02341 and below. Astigmatism adjustment.
1220A-8/1221A-4. All serials. Servicing information.
1220A-9. Serial numbers below 1416A-02340. Triggering at low amplitudes.
1220A-10. All serials. DC trace shift.
1220A-11. All serials. Replacement of A3R1.
1220A-12. All serials. Replacement of capacitors A1C40, A1C401, A1C402 and A1C407.

1310A COMPUTER GRAPHIC DISPLAY

1310A-8B. Serial prefix 1406A and below. Supercedes 1310A-8A. Modification to reduce coupling between the Z-axis input and the X/Y inputs.
1310A-12. All serials. Replacement part numbers for power indicator lamp and front mask assemblies.

1311A COMPUTER GRAPHIC DISPLAY

1311A-8B. Serial prefix 1405A and below. Supercedes 1311A-8A. Modification to reduce coupling between the Z-axis input and the X/Y inputs.
1311A-12. All serials. Replacement part numbers for power indicator lamp and front mask assemblies.

1331A/C X/Y DISPLAY

1331A/C-10. 1331A serial prefix 1424A and above; 1331C serial prefix 1426A and above. New instrument configuration.
1331A/C-11. 1331A serial prefix 1319A and below; 1331C serial prefix 1318A and below. Addition of heat sink on A5Q41.

1331C-3. Serial prefix 1426A and below. Intermittent erasing.

1415A AND 1415A OPTION 14 TIME DOMAIN REFLECTOMETERS

1415A-12. Serial numbers 816-01911 and below. Recommended replacement of Q602.

1720A OSCILLOSCOPE

1720A-2. All serials. Modification kit for probe power jacks.
1720A-3. Serial numbers below 1425A00350. Improved contrast ratio for main intensified sweep.
1720A-4. Serial numbers 1405A00200 and below. Chop mode sweep baseline irregularities.

1905A RATE GENERATOR

1905A-2. Serial prefix 1209 and below. Preferred replacements.

LEEDS AND NORTHRUP 2740 SCANNER/PROGRAMMER 2741 SCANNER EXTENDER FRAME

3050A-2. L and N scanner interconnections.
3050A-4. Part numbers for 2740 scanner.
3050A-5. -hp- to L and N part number cross reference.
3050A-6. Leeds and Northrup offices.

3431A DIGITAL PANEL METER

3431A-4. Troubleshooting procedure.

3469A MULTIMETER

3469A-4. All serials. Replacement for A3 DC amplifier assembly.

3480A/MULTI-FUNCTION DIGITAL VOLTMETER

3480A/B-7. All serials. Bottom cover shorted to guard.

3482A CD RANGE UNIT

3482A-1B. Serial number 1133A00775 and below. Supercedes 3481A-1A. Compatibility problem with 3480C/D.

3484A MULTI-FUNCTION UNIT FOR 3480A/B

3484A-2. Serial number 1124A01494 and below. Intermittent false triggering.

3490A MULTIMETER

3490A-8A. Serial number 1211A02555 and below. Recommended replacement for power supply capacitors C101 thru C107.

5326/5327 COUNTERS

5326A/5327A-9B, 5326B/5327B-9B, 5326C/5327C-9B. 5326A serial numbers 1312A01906 to 1312A03980; 5326B serial numbers 1312A02141 to 1312A03015; 5326C serial numbers 1312A00451 to 1312A00675; 5327A serial numbers 1312A00396 to 1312A00590; 5327B serial numbers 1312A00546 to 1312A-00945; 5327C serial numbers 1312A00546 to 1312A00895. Added protection to prevent the +175 volt fuse from blowing.

5451A FOURIER ANALYZER SYSTEM

5451A-8. All serials. Field preventive maintenance procedure.

5451B FOURIER ANALYZERS

5451B-9. All serials. Improved Fourier transform accuracy.

7040A/7041A X-Y RECORDER

7040A-4/7041A-2. Serial prefix 1416A and below. Improved Y-axis wiper assembly kit.

7044A/7045A X-Y RECORDER

7044A-1/7045A-1. Serial prefix 1414A and below. Improved Y-axis wiper assembly kit.

7200/7201/7202/7203A GRAPHIC PLOTTER

7200A-5/7202A-5. All serials. Pen time delay adjustments with EIA interface boards.
7200A-6. All serials. Baud rate conversion kit.
7200A-7. All serials. Current to EIA RS232C interface conversion.
9862A-14, 9125A/B-1, 7210A-11, 7203A-8, 7202A-7, 7201A-4, 7200A-8. All serials. Converting one plotter model to another.
9862A-12/7210A-8/7203A-5/7202A-8/7201A-2/7200A-9. All serials. PC board numbering conventions.
9862A-13/7210A-9/7203A-9/7202A-9/7201A-3/7200A-10. All serials. New plotter hood latch.
7200A-11/7202A-10. All serials. Replacing the EIA RS232C interface board with a current interface board.
7202A-6. All serials. Current to EIA RS232C interface conversion.
7203A-6. All serials. Service manual corrections — test tape.
7203A-7. All serials. Interface and mother board schematics.
7203A-12. Serial prefixes below 1440A. Component change on interface board.

7210A DIGITAL PLOTTER

7210A-7. All serials. DOS III drivers for use with HP 2100 systems.
9862A-12/7210A-8/7203A-5/7202A-8/7201A-2/7200A-9. All serials. PC board numbering conventions.
9862A-13/7210A-9/7203A-9/7202A-9/7201A-3/7200A-10. All serials. New plotter hood latch.
7210A-10. All serials. 2100 Computer plotter driver and library compatibility.
9862A-14, 9125A/B-1, 7210A-11, 7203A-8, 7202A-7, 7201A-4, 7200A-8. All serials. Converting one plotter model to another.

7260A OPTICAL MARK READERS

7260A-8. Serial prefix 1422A. New serial I/O board.

7402A OSCILLOGRAPHIC RECORDER

7402A-3. Serial prefix 1402A and below. Improved event marker operation.
7402A-4. Serial prefix 1421A and below. Improved -15V regulator fuse protection.

8407A NETWORK ANALYZER

8407A-6. All serials. Phase locked oscillator troubleshooting.

8640A/B SIGNAL GENERATORS

8640A/B-13A. 8640A serial prefix 1244A and below; 8640B serial prefix 1243A and below. Installation of FM gain compensation circuit and potentiometer. Supercedes 8640A/B-13.
8640A/B-21. 8640A serial prefix 1415A and below; 8640B serial prefix 1423A and below. Recommended fuse replacement for 220/240V operation.
8640A/B-22. All serials. Alternate method for FM linearity adjustment.
8640A/B-23. All serials. Correcting intermittent RF divider/filter switching.
8640A/B-24. All serials. RF oscillator end stop adjustment.

8660B SYNTHESIZED SIGNAL GENERATOR

8660B-22. All serials. Display flicker modification.

9125A CALCULATOR PLOTTER

9125A-2. All serials. 17127A retrofit kit installation instructions.
9862A-12/7210A-8/7203A-5/7202A-8/7201A-2/7200A-9. All serials. PC board numbering conventions.
9862A-13/7210A-9/7203A-9/7202A-9/7201A-3/7200A-10. All serials. New plotter hood latch.
9862A-14, 9125A/B-1, 7210A-11, 7203A-8, 7202A-7, 7201A-4, 7200A-8. All serials. Converting one plotter model to another.

11661A FREQUENCY EXTENSION MODULE

11661A-4A. Serial prefix 1412A and below. YIG pretune driver protection. Supercedes 11661A-4.

MODELS 34721A/B AND 34703A

34721A/B-1, 34703A-3. All serials. Compatibility between the 34721A BCD module and the 34703A DCV/DCA/Ω meter.

HEWLETT hp PACKARD

195 Page Mill Road, Palo Alto, California 94306

I hope you have enjoyed reading this sample issue of BENCH BRIEFS. This is another one of the after-sales services available from Hewlett-Packard. BENCH BRIEFS is published six times a year and gives details about recommended modifications on HP electronics products, mentions new tools available for service personnel, gives help with replacement parts, and offers suggestions on trouble-shooting techniques. BENCH BRIEFS also includes listing of new Service Notes. These are recommendations from the HP factories on modifications or other recommended procedures for specific HP products.

BENCH BRIEFS is recommended reading for service personnel repairing HP instruments. Calibration, periodic maintenance, and incoming inspection personnel, as well as service managers, find it a source of helpful information.

To start your free subscription to BENCH BRIEFS, please complete and mail the form below.

Regards,

Richard E. Gasperini
Editor, BENCH BRIEFS

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- 40 ☐ Petroleum Products
- 44 ☐ Chemicals/Plastics/Synthetics/Rubber
- 92 ☐ Other Processed Materials
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- 56 ☐ Radio/TV/CATV Broadcasting
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- (J) ☐ Automatic Test Systems
- (U) ☐ Mini Computer Systems
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MERRY CHRISTMAS

It's hard to believe that the end of the year is here again.

I thought it may be interesting to review the past year and take a look at the upcoming issues.

BENCH BRIEFS was started 14 years ago to provide service information about HP products to customers involved with repair, calibration, maintenance, performance verification and related area. *BENCH BRIEFS* evolved from the HP tradition of providing top quality support services along with a top quality product. That tradition continues today.

The problems of today are a little different than those of 1960. Electronic products are more powerful and complex, creating more of a challenge for service personnel. It is even more important today to stay abreast of new advances in technology.

In 1975 we plan to continue featuring articles that will help you be more effective in your job. There will be more emphasis on digital electronics—tips to diagnose and isolate a failure, tools available that will speed troubleshooting, methods of unsoldering IC's, etc. We hope you find this series interesting and worthwhile.

I hope 1974 proved to be challenging and rewarding for each of you. Best wishes for an even better year in 1975.

Dick Gasperini
Editor

WHO'S DICK GASPERINI?

Dick joined HP in 1969 after receiving a BSEE from Michigan Tech and immediately began working with service people and service-related problems.

In addition to editing *BENCH BRIEFS*, Dick spends a good deal of time teaching a course for service personnel - "Digital Troubleshooting Techniques". This course, which will soon be available on HP Videotape, is intended for people needing an understanding of digital circuitry.

Dick is single and enjoys photography, camping, and woodworking.

MEET CHRISTINA FREEMAN

Christina is in charge of art production for *BENCH BRIEFS* and spends her time compiling service note listings, getting material typeset, working on drawings and layouts, and coordinating printing and distribution.

Christina enjoys the outdoors and camping, in addition to drawing and sewing.

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