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POOGE for eBay Test Gear

By Charles Hansen

How to test bargain equipment you might find on eBay or from surplus equipment dealers.

Heathkit, Eico, and other test equipment kit manufacturers had their own part numbers for commercial electronic components. In their heyday they had such huge purchasing power that they could afford to have component manufacturers silk-screen their house part numbers on otherwise standard components (the company I worked for most of my engineering career had the same policy). There are at least four reasons for going to the trouble of making house part numbers: source control to weed out unreliable vendors; spec control to tighten a device parameter, such as the gain for a transistor; inventory control for spare parts orders; or security control to hide the parts selection details from potential competitors.

Fortunately, a few generous hobbyists on the Internet have listed the cross-references between these "house" part numbers and the manufacturers' part numbers. We should be grateful for their uncompensated hard work. The Heathkit part cross-reference I used is at www.d8apro.com. Click on the Heathkit page (you might want to download a copy—it may not be there forever).

Heathkit had over 1,900 distinct electronic parts of all kinds. Many of these parts are now obsolete, although you might luck out and find new old stock (NOS) being offered by companies that specialize in that service.

I once needed to locate a MPSU45 high-frequency Darlington NPN transistor to fix a Tektronix item. I tried to locate a modern substitute, but nothing I could find met all the device parameters. There was no listing for the transistor in the NTE online catalog. The manual listed only a Tek part number, but fortunately the device itself had the Motorola MPSU45 part number. Sometimes you just get lucky!

The few suppliers that had NOS parts also required minimum orders of $100. However, an Internet search turned up a pinball machine service company that was happy to sell me just one.

This brings up another requirement for upgrading or repairing old test equipment. Unless the equipment is extremely basic, don't even think about modifications or repairs without the operating/service manual. There are websites that provide .gif scans of Heathkit and EICO schematics for use in working on the simpler equipment.

Fortunately, eBay and companies such as AG Tannenbaum, Manuals-Plus, Hi Manuals, and others have complete manuals for older equipment. More and more you see these manuals being offered for less cost on CD-ROM, although I prefer a written manual for its convenience on the test bench. There are times when I have had to reverse-engineer the pc board in order to make a schematic, but this is a tedious and error-prone process that still tells you nothing about the required calibration procedures.

You also need proficient troubleshooting skills and an understanding of the detailed circuit operation for the equipment which you are modifying or repairing. In terms of test equipment[1], I would not tackle a complicated project without a good digital multimeter, a two-channel scope, a Variac to control the power-up of older equipment, a sine-square-triangle function generator, solder and de-soldering irons, and so on.

MODIFICATION UPGRADE EXAMPLES

I'm going to present two examples showing how you can improve the performance and reliability of older Heathkits. The general concept applies to most electronic equipment, and I have used the same basic approach to repair or upgrade test items from HP, Tektronix, Fluke, Boonton, B+K, and Sound Technology[2,3,4]. I purchased an IM-4100 counter-timer and an IG-4505 oscilloscope calibrator. Fortunately, the original kit builders appeared to have experience and did a fine job on the wiring and soldering. This is one advantage to used test equipment kits—rank beginners are not likely to tackle this genre of projects.

While Heathkit generally used quality parts, one exception was their aluminum electrolytic capacitors, which were seldom from vendors such as Sprague, Cornell-Dubilier, Mallory, or the other premier companies. Even if they were, if the unit you obtain is more than ten years old or hasn't been powered up for a few years, I would not waste my time trying to re-form old electrolytics. All the ones I removed from equipment built in the 1970s and 80s were made in Mexico, with the "Temple" brand name. The negative lead wire was riveted rather than spot-welded, and the positive insulator was a disc of fiber material that readily leaked electrolyte.

Make sure you use 105° C replacement electrolytics rather than the cheaper 71° C or 85° C parts. They cost about 30% more, but the higher operating temperature buys you twice the reliability and a 25% surge voltage margin. These 105° C electrolytics are readily available from Mouser (www.mouser.com).

IG-4505 OSCILLOSCOPE CALIBRATOR

These calibrators are going for $20-$40 on eBay, compared with over $100 for the higher-precision IG-4244 model. The X2 and X5 time-base functions did not work on the unit I bought. I found the 5V supply for the TTL time-base logic was only 4.3V. TTL logic requires a power supply of 4.75V to 5.25V to work properly.

The 5V power supply uses a TO-220 regulator power transistor fed from a 7V raw DC supply. The transistor base is connected to a 5.6V zener diode, which should provide the proper 5V at the transistor emitter. The zener had degraded to 4.8V, so the power-supply voltage was insufficient for 7490 decade counter IC2 to operate properly.

Before tackling the logic problem, I installed four new 105° C electrolytic caps. I always mark the chassis near the replaced parts (**Photo 1**) so the next owner will know about the modifications.

I decided to redesign the power supply to use a 78T05 5V regulator IC. This allowed me to remove the power transistor and two extraneous zeners and resistors (R102, R103, ZD101, and ZD102; **Fig. 1** and **Photo 2**). This brought the logic supply up to 4.95V and allowed all the time-base functions to operate properly with a worst-case timing error of 0.2%. However, the raw 7.1V supply at the input to the new 78T05 regulator IC was less than the minimum 7.5V required for good regulation.

My final modification was to replace the power-hungry standard TTL gates with low-power Schottky (LS) equivalents. Circuit Specialists (www.web-tronics.com) has NOS LS gates at nice low prices. I used a 74LS74A in place of the 7474 data flip-flop (IC1) and 74LS90 decade counters in place of the 7490 chips (IC2-IC7). This dropped the total logic supply current from 42mA to 15mA, a savings of almost 900mW. More important, with less load the raw supply to the 78T05 increased to the required 7.5V.

The most difficult part of replacing the TTL chips is working around the rotary switches (**Photo 3**). Heathkit rarely made the construction of their kits maintenance-friendly. Many times the final wiring to the circuit board was done after it had been mounted in its final location. This required unwiring the board if you had to even move it a bit for parts replacement.

There was just enough slack in the IG-4505 pc board wiring to allow me to remove the mounting hardware for the three front panel switches, slide the pc board back from the front panel, and access the TTL chips. You must also push the attached Time Out coax line through its rubber grommet to allow the pc board to move back. I had to lube it with silicone spray before it would slide through the grommet.

When I re-installed the pc board, I noticed one lead of the power line fuse was nearly touching the shield on the Volts Out switch coax. I repositioned the coax to prevent a short circuit. The fuse may not have protected the pc board circuitry because it was the line side of the fuse that was near the coax. I also put electrical tape over the exposed bit of coax shield from the 5V supply to the pc board to prevent it from shorting to the board. Be sure to tighten the BNC plug connector hardware at the end of the Time Out coax line after you pull the slack back through the grommet.

The voltage output circuit was working perfectly, but needed calibration. Q2, ZD103, and D2 needed to operate for at least 15 minutes to achieve thermal stability before I could calibrate the IG-4505. The IG-4244 has active regulation of the voltage output circuit. I could have modified my calibrator in a similar manner, but once it was warmed up the voltage output was stable within 0.3%. This is more than sufficient for most scopes, which have 3% tolerance on their voltage measurements.


PHOTO 1: IG-4505 capacitor replacement.


PHOTO 2: IG-4505 power supply redesign.

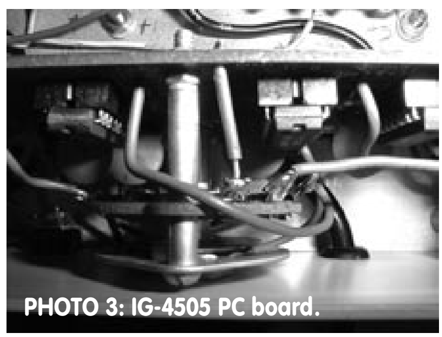
PHOTO 3: IG-4505 PC board.

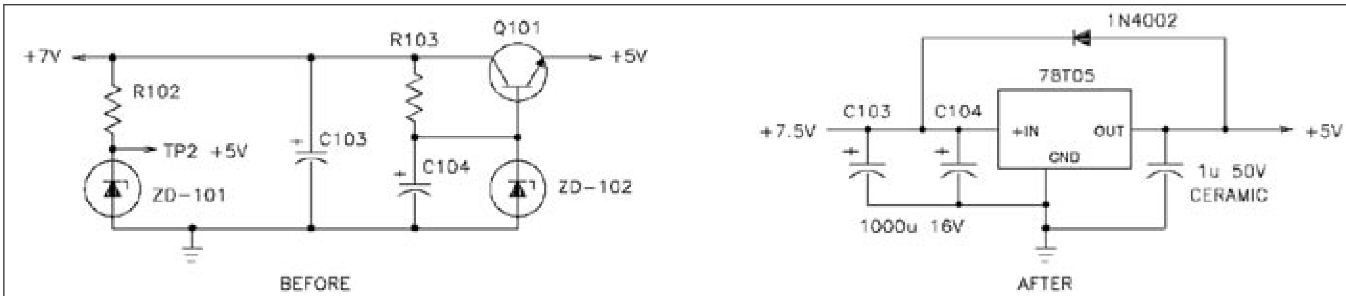

FIGURE 1: IG-4505 5V power supply redesign.

AE-2647-1

IM-4100 COUNTER-TIMER

The IM-4100 was working perfectly, but ran very warm. After 15 minutes, the temperature at the bottom of the case was 45° C. Clearly this unit could also benefit from a power-reducing LS TTL upgrade.

I replaced the ancient 6000µF 15V power-supply filter cap C16 with a new 6800µF 16V 105° C electrolytic (**Photo 4**). Fortunately, this unit already had a 78T05 regulator IC for the 5V logic supply. You will not be able to find any replacements for the MC10116 Schmitt trigger (IC1) or the UA9368 display drivers (IC8–IC12). You could probably redesign the unit to use modern CMOS display driver chips if necessary, but that requires major pc board surgery.

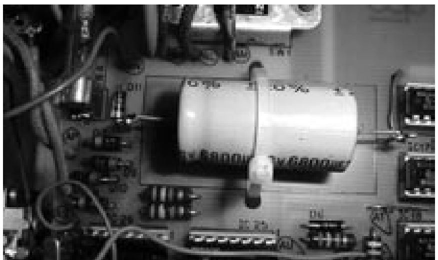

PHOTO 4: IM-4100 capacitor replacement.

My next step was to replace the TTL gates. There is no LS equivalent for the 7450 (IC15) or 74S64 (IC2) so those parts remained in place. I replaced the 7400 (IC14, IC17, IC26), 7476A (IC13), 7490A (IC3-IC7, IC19-IC25), 74122 (IC16), and 74132 (IC18) with their LS equivalents.

When I powered up the modified IM-4100, it did not work. The gate LED did not flash and all the digits were "0" with the over-range dot lit. The unit does this briefly on power-up to verify that all the displays work, but this one was stuck there.

I used my scope to troubleshoot the unit. If you want to follow along, I suggest first downloading the two-part schematic from the Tech-Systems Labs Heathkit website (www.tech-systems-labs.com/heath_schematic.htm).

The clock oscillator was working and there was a 10MHz clock input to pin 1 of the first 74LS90 (IC24) in the decade counter time-base scaler, but there was no 1MHz output at pin 12. When I pulled out the next chip (IC23, after first turning off the AC power), the 1MHz output appeared. This occurred all down the line—when I pulled IC22, IC21, IC20, and IC19, the divided output from the previous stage was present.

The 1Hz output from IC19 and the 1kHz output from IC22 is fed through the IC2 and IC15 gating chips, which respond to the Mode and Range switches, to the display counters. These two ICs also provide logic signals to supply narrow clear and reset pulses to the display counter circuitry. While the decade dividers were all working properly, the ICs after IC2 and IC15 were suspect.

I removed the LS chips in the Clear/Reset pulse circuitry one at a time and replaced them with the original standard TTL parts. When I replaced IC18 (74132), the counter resumed normal operation, although the left "0" and its over-range dot were flashing at each gate LED on-off.

Heathkit did some analog cheating with IC18. The positive output level from flip-flop (F-F) IC13 is capacitively coupled to the input of quad NAND Schmitt-trigger gate IC18D, with a 470Ω resistor to ground. This is supposed to produce a narrow positive pulse that is inverted to a negative pulse at the output of IC18D that feeds monostable IC16. This was the case with the standard 74132 gate, but the 74LS132 produced only a slight dip on the positive output level that was insufficient to trigger IC16.

Looking at the input to IC18D again, I could see the pulse was being differentiated into low-level positive and negative spikes by the LS gate that did not toggle the Schmitt-trigger input. The same situation occurs with IC18A, which receives a capacitively coupled positive pulse from the output of monostable IC16 and did not produce a negative pulse at the output. The time-base scaler counters could not divide down the clock because IC17D could not generate a negative level from IC18A. This kept the resets high, inhibiting the count function.

There is a difference in the input circuitry between standard TTL and LS TTL. The standard gate inputs are connected to the emitter(s) of the NPN input transistor, with diode clamps to ground that clamp negative input spikes. The LS input circuit feeds the base of an NPN Schottky transistor through Schottky diodes, with Schottky diode clamps on the input. The input-high voltage and current requirements are roughly the same, but the input-low current is only –0.1mA for LS compared with –1mA for standard TTL.

I'm not sure why the LS gate did not respond properly to the capacitive-coupled pulse, but the results were the same for all three 74LS132 gates I tried for IC18. LS gates are much faster than standard TTL, and may be more sensitive to glitches on the less-stringent power supply and ground track layouts in this older design.

After I replaced IC18, I turned my attention to the left-most "0" and over-range display blinking. The over-range output of display decade counter IC7 is sent via IC13 to a gated R-S F-F comprised of the four NAND gates of IC14. Gates IC14B and IC14C are cross-connected as an R-S F-F that latches the display driver overflow and drives the over-range dot of the left 7-segment display.

IC18C drives the input gate section of IC14A and IC14D, and transistor Q6 is connected to the same input signal to transfer the display decade counter data to the 7-segment display drivers. IC18B provides the reset pulse to the display decade counters. Some kind of transient was making IC14 briefly respond during the transfer signal and blink the over-range dot. Replacing IC14 with the standard TTL gate package cured the glitch.

After replacing IC14 and IC18 with the original TTL parts, the IM-4100 worked perfectly. All those other LS chips helped save 380mA of supply current (1.9W) and dropped the case temperature from 45° C to 31° C. Finally, I calibrated the 10MHz clock oscillator using the beat-frequency method against the carrier frequency of WWV as described in the manual. WWV is the NIST shortwave AM radio station that broadcasts time and frequency information 24 hours per day.

CONCLUSION

Older test equipment provides a low-cost means to add to your test lab. Be sure to check the specifications before you buy, and check the eBay photos to be sure the cosmetic condition is good. I will sometimes even buy the manual ahead of time for test equipment that I am considering. This lets me assess the degree of difficulty in obtaining replacement parts for making repairs. Sometimes units that don't work at all can be real bargains if they are relatively easy to repair. *aX*

REFERENCES

1. You can find out more on the topic of test equipment on pages 54 and 66 of my book "The Joy of Audio Electronics" published by Audio Amateur Press.

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