Repairing an ICOM IC-970A

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I have likely heard of the IC-970 at some point in the past, but it would have been WAY out of my price range, so I never would have given it a second glance. This isn't bad, it just IS. I don't like to shop for anything I can't afford. However, when the chance came along to obtain one for a steal, I jumped on it and agreed to purchase it sight unseen.

For one, I knew that the radio had to be capable and it also had the UX-97 module included, so it was all-mode on three bands. For another, it was broken and I am not one to refuse a challenge. I forgot to consider how deep down the rabbit-hole I might end up going.

Two problems were reported when I purchased the radio. The most prickly of the two (although, not by much) was that the tuning dial was seized. The other was that the 1296 band output was **very** low. I reasoned that I could always get a high-end encoder to replace the one that was seized up. This might require some machining, but that was no serious impediment for me. The low-output on 1296 is likely due to a bad PA module – hard to find, but not impossible (or so I hoped).

The "No-Tune" IC-970

Knowing that the tuning issue would be critical to the operation of the radio, I set about tackling the mechanism first, without even applying power to the radio. The individual from which I purchased the radio was a credible source whom I trusted (both ethically and technically), so I didn't see much value in re-verifying the radio symptoms at this point. Removing the encoder required that the tuning knob, radio covers, and front unit be separated from the main chassis. I left two loosened screws in the front unit to allow it to "pivot" which allowed access to the boards while reducing the stress on the wiring harness.

Four screws and two wiring connectors secure the tuning encoder (referred to as a "sensor" in the service manual). It was easily accessible, which was a relief. The sub-assembly consists of a cast metal frame, with a latching solenoid, a small circuit card, and the inner encoder mechanism. Two screws secure a sheet-metal cover that encloses the encoder mechanism (which consists of a shaft, a molded coarse wheel, a thin-metal fine wheel, and a thin-metal shadow mask), and four screws secure the small circuit card. In short order, I had disassembled the unit to its base parts.

I was surprised to find TWO encoders inside the sensor unit. I expected to see the fine-slot wheel (a quadrature encoder lashup), but the coarse wheel (a single channel encoder) presented a puzzle. The "why" of it would wait until later. The coarse wheel has 50 optical slots and 50 "teeth" around its periphery. The "teeth" rotate against a single metal ball (about the size of a "BB") that is either pressed with force, or no-force by the action of the latching solenoid. This allows the radio to control the tuning knob "detent" feature. Beware this "BB" as it will rest quietly in its "hole" and then suddenly leap for freedom under the watch of the unwary (as it did with me – luckily, I was able to find and retrieve it).

Another possible repair tactic I had considered up to this point was to re-bore the shaft bearing and place two collar ball bearings (likely at no small cost) to repair the galled bearing. However, the construction of the sensor precluded this. The bearing was essentially a tube, which wouldn't have supported the new bearings. Taking that route would mean machining a new sub-assembly from scratch. Not impossible, but a rather involved undertaking to say the least. Regardless, I needed to get the shaft out of the bearing before going any further.

I settled on tapping the shaft out with a small ball-peen hammer. GENTLY. I did so, but as careful as I tried to be with the tapping, I wasn't so careful with what was under the assembly while the tapping was ongoing. I managed to separate the shaft from the bearing, but rather than having one piece, I ended up with three. I broke the coarse wheel, which is an ABS-like plastic part molded directly onto the stainless steel shaft. Drat. So, now I had TWO things to fix on the sensor.

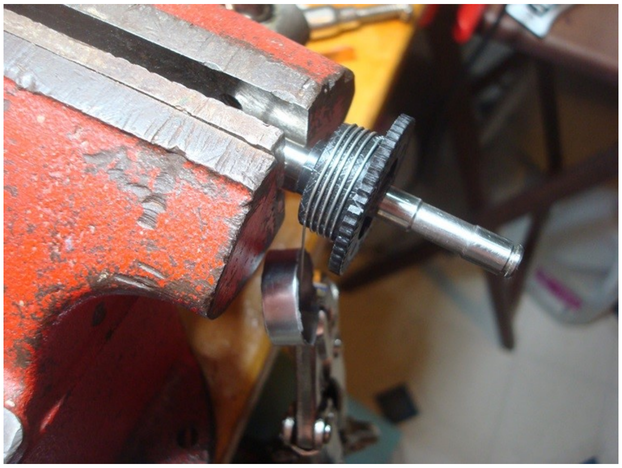
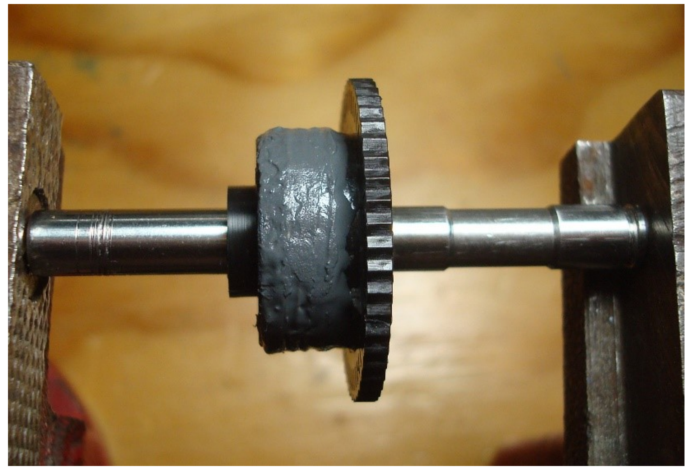
When I removed the shaft from the bearing, there was a distinct odor, one that is unmistakable to me. It is the odor I smell when I use (albeit, rarely) CA (Cyano-Acrylic) adhesive ("super-glue" to most folks). There was also a crusty, translucent material on the shaft. Curious. There was no evidence of CA outside of the shaft-bearing interface, and I was challenged to deduce how or why CA would be present inside this device. Truthfully, I wasn't SURE it was CA, it just looked and smelled like it. Could the grease used have somehow polymerized over time in a manner that was similar to CA polymerization? I'm not a chemist, so I have to say that anything is possible at this point.

While the how/why of it was a mystery, solving this conundrum was not a requirement for progress. So, I cleaned up the shaft and bearing. Prior to my work, someone had applied penetrating oil to the assembly, so that needed to be cleaned up as well. I found some evidence of galling on the bearing surface, but nothing on the shaft. I applied some fine grit (2000/sqin) sandpaper to the task and got the bearing and shaft to a reasonable state before turning my attention to repairing my mistake with the coarse wheel.

D'OH!

The good news with the coarse wheel is that it broke clean and into two pieces that were approximately the same size. The bad news: A LOT of pre-load was required to get the two pieces to mate properly. So much pre-load, in fact, that I worried at the efficacy of using adhesive since I felt that the pre-load force alone could cause the repair to fail with little provocation. I settled on a two-step approach. First, I used my favorite epoxy (JB-Weld) to secure the two pieces back onto the shaft. I had to use vise-grips with a bit of flashing to compress the pieces together (the flashing prevented the vise grips from gouging the plastic). I like to "bake" JB-Weld in my kitchen-oven at around 150F. This gives a rock-hard cure in 1-2 hours. However, since the part in question was plastic with unknown thermal limits, I decided against this which meant I had to give the parts a full 24-hour cure cycle. Queue the "Jeopardy" music...

I've had very good luck with JB-Weld repairs on plastic when those repairs are reinforced with wire. Typically, I'll use a soldering iron to embed pieces of resistor lead (or bare bus) wire into the plastic bridging the fracture line. I then entomb the embedded wire and fracture in JB-Weld (the fracture joint is also secured with a thin layer of JB-Weld, which is applied prior to the reinforcing wire). This general idea is what I wanted here, but I decided to use a single piece of bus-wire wrapped around the plastic armature a number of turns. I would then tension the wire to provide it with some pre-load before entombing in JB-Weld. I secured one end of the wire by heating it with a soldering iron and then poking it into the armature (which is partially hollow). A sharp bend on the inside helps hold it until the epoxy can be applied and cured. I used about 1400g of deadweight to tension the other end of the wire during the cure cycle.

Coarse armature repair: during and after.

D'OH! (again)

I made it through the cleanup and repair. I didn't lose any of the pieces (well, not for long, anyway). Now I was ready to put the thing back together. The encoder shaft bearing surface is machined to have two journals with a gap in-between where the shaft was narrower than at the bearing surfaces. This "gap" serves well as a grease reservoir. I loaded this gap with Li grease and applied a thin film to the shaft journals and the mating bearing surfaces. Then I set about putting the rest of the pieces back together.

Of course, with the decision paralysis and waiting for JB-Weld to cure, it was several days since my initial dismantling. How all the pieces went back together was pretty easy to see, but there were some subtleties at play that I didn't realize in the beginning. The subtlety at play here being that there were three different orientations that one could use when attaching the fine-wheel to the coarse wheel (six, if you flip it over). This turned out to be important since the wheels had slots that were on a 5:1 relationship, but the fine wheel had three screws, set at 120 degree increments, which meant that for each possible orientation, the alignment between the coarse and fine wheels would shift by 1/3 of the angular slot spacing. This amounts to only 0.48 degrees, but it is apparently enough to throw-off the circuitry which uses the fine wheel to determine direction.

My first attempt showed initial promise, but once I got to playing with the tuning, I found that the frequency wasn't stepping properly. Sometimes it moved as it should, but other times it "dithered" – going up/down as the tuning wheel was moved smoothly in one direction. Luckily, the innards of the mechanism can be accessed without removing the sensor, so I was able to quickly rotate the fine wheel 120 degrees for another attempt. Try#2 was a success (so far, at least).

The Trouble with 1296

Having put the sensor repair behind me, I next turned to checking out the UX97 1296 UNIT. I was able to verify low output. Not zero, it was barely able to move the needle on my Bird but certainly not the 1W or 10W it was supposed to be. While the PA module was the obvious culprit, it is difficult to obtain (bordering on the verge of unobtainium) so before declaring that to be the issue, I would like to have some confidence that justifies the trouble and expense of finding (and hopefully, purchasing) a module.

I toyed with some ideas for troubleshooting the module. The bias is fixed, so the problem could be in the modulation circuitry. However, this is common to all bands, so it wasn't a likely possibility in this case as the 144 and 430 bands were working. I have several signal sources that can operate at 1296, so I thought it might be possible to un-solder the input to the PA and connect a signal source to allow the gain of the PA to be tested. At that time, I didn't have a datasheet for the module, so I wasn't sure what gain it should have, and thus was unsure of the signal level I should apply.

In the end, I decided to use a "current" probe and my spectrum analyzer (S/A) to look at the signal between the stages. I've used commercial probes in the past, but they are very expensive, so my probes simply consist of a short piece of coax with an SMA on one end, and a small coil, about 1/8" diameter, with 4 or 5 turns of wire-wrap wire soldered to the other. I probed the input to the driver module (the pre-driver transistor is on the bottom of the PCB, so I decided to put off looking at its input until seeing the outcome of the top-side tests) and noted the peak signal level. Then I repeated this at the output of the driver module. I saw over 30 dB of gain which is a reasonable figure. At the input to the PA module, I saw a level consistent with what I saw at the output of the driver which is another good validation point. However, at the output of the PA, I saw around 10 dB of LOSS across the PA. Not good.

QTY One, MARK-I, regulation current/magnetic probe.

I checked all of the DC voltages feeding the module and found them to be nominal. The only conclusion that seemed reasonable to me was that the PA was INOP, confirming my initial suspicion. This is also reasonable because these modules operate at really poor efficiency, usually around 20%. This means that a 10W RF output requires about 50W of DC power, in a space of about a couple of square inches. If you are having difficulty visualizing this, and you are old enough to have handled incandescent bulbs, consider what might happen if you were to grab a 60W lightbulb that had been on for several minutes (better have some serious burn first-aid handy). If the heat-transfer solution for these modules is compromised even just a little, they can be easily over-stressed. The cycling between transmit and receive would exacerbate the situation leading to early failure of the device. I saw this with one of my UX-129 modules for my IC-901.

Now the real difficulty: find a replacement. There are a couple of other linear PA modules for 1296 that are marginally available; I even have one for a transverter project. All of these modules are on the verge of unobtainum, so it boils down to what you can find. The gains and bias are different, so trying to adapt a different module requires some "tweaking" to get it to work correctly. I hoped to avoid this so when I was confronted by the 2x cost difference between "non-standard" module (cheaper) from RF Parts and the SC-1040 compatible replacement part I found on e-bay, I decided to spend the extra money so that I wouldn't have to engage in a science experiment to adapt the non-standard module. Now, more Jeopardy music while we wait for ebay in the midst of a COVID pandemic...

Let There Be Light (emitting diodes)!

Now that I'd gotten past the basic issues with the radio, I started to cast a more discerning eye at its state of affairs. I quickly noticed that of the 3 incandescent backlights for the LCD, only one was working. This is something that I generally like to tackle for my older radios: replace the incandescent bulbs with LEDs. I run the LEDs well within their specifications, so they should outlast everything else in the radio, and it also substantially reduces power dissipation and the resulting heat generated inside the radio. You can generally achieve a power reduction of 20:1 or so simply by replacing incandescent bulbs with LEDs. In this case, that meant going from 16W down to about 1 W.

The bulbs for the LCD in the IC-970 use small plastic holders and are removable without having to use soldering techniques. This makes the process pretty straightforward. The meter bulb was wired, so it took a bit more effort, but was still easy to accomplish (see the end of this document for a step-by-step account of the replacement technique). The holders passed the bulb leads through some grooves that ultimately provided a contact surface for a mating PCB trace. The holders were slotted and could be installed/removed with a quarter turn of a small flat-blade screwdriver. Using a DMM, I measured the voltage at the lamp "sockets". I wanted to know the voltage, and also the polarity. I marked a "+" next to the positive contact at each port.

Unmodified lamp holder (left). LED-modified lamp holder (right) – the resistor is the (+) terminal.

I first removed the silicone lamp cover and then un-threaded the incandescent bulb leads which allowed the bulb to slide out of the holder. If you are inclined to replace the bulb with another incandescent, you simply reverse the process, and re-install the lamp. For the LED, I used a leaded type that I have employed in other lighting applications. It is a high intensity red LED which meshes well with the amber background of the LCD display. Amber LEDs are available, but their intensity levels are usually pretty low. White can also be used, but I liked the red result better.

There are two main problems that one must confront when re-lamping an incandescent backlight with an LED. The first is current limiting and the second is viewing angle. The current limit is pretty easy to accomplish with a dropping resistor. While it would save some effort, “resist” the urge to use a single resistor for multiple LEDs in parallel. The slightly different characteristics of each LED can result in brightness variations. In this case, the resistor can be integrated into the bulb holder (it ends up looking a bit odd, but there is room enough behind the LCD). For the LED I chose, a 470 ohm resistor provides to proper current limit (20mA) at the brightest intensity setting (about 11V at the lamp terminals).

The viewing angle of LEDs is generally more difficult to address. The incandescent bulb (especially the “grain-of-wheat” types generally employed for back-lighting) are a very close approximation to an isotropic radiator. In other words, when suspended in space, they generally look equally bright in all directions. LEDs, on the other hand, are not isotropic at all. Most leaded types feature an encapsulated body that also serves as a lens, which serves to concentrate most of the light intensity into a spherical angle of about 100 degrees (more or less).

For most back-light applications, we don’t need a fully isotropic source, but we’d like to see angles approaching 180 degrees. The easiest way I’ve found to accomplish this is to grind facets into the LED lens area with a Dremel tool. I generally grind four of them at 90 degrees to each other to evenly cover the periphery of the LED. I like to angle them at about 30 degrees from the LED bore-sight to help throw more light to the sides. The facets should be clean but not really smooth. You want the light to scatter, so polishing the facets is counter-productive. I also re-used the silicone bulb covers, which added some scatter effect that was beneficial. I didn’t attach the covers with adhesive, but that might be worth consideration – at one point, I did have to fish out one of the covers from inside the LCD. While not impossible it also wasn’t easy.

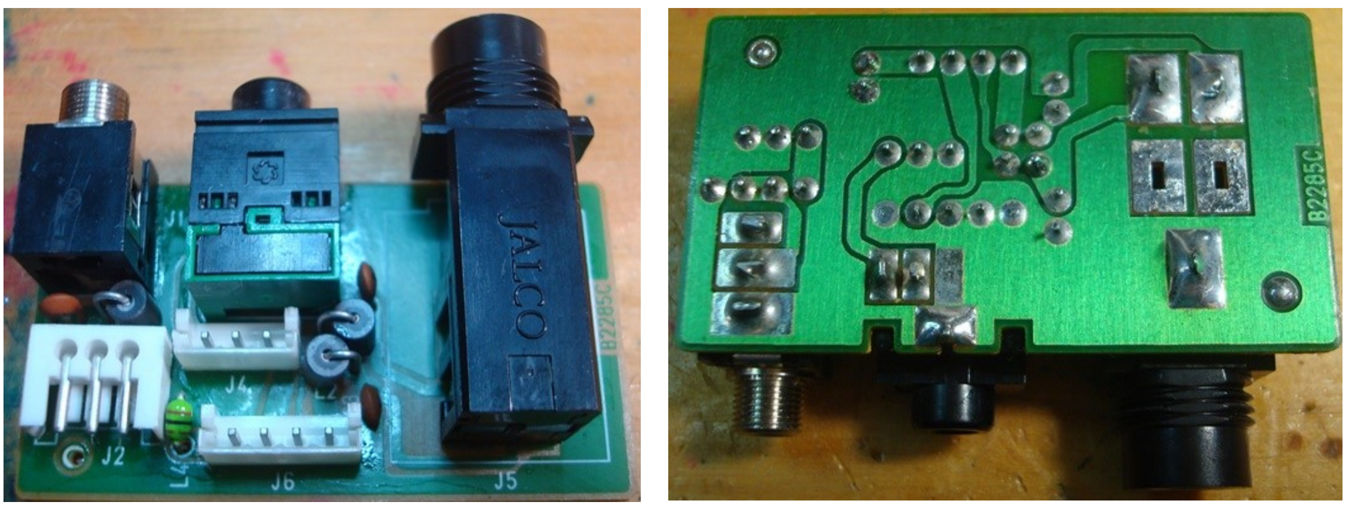
Electrically, the meter bulb received the same treatment. However, soldering tools were required to attach it to the radio. In addition, I re-wired the source of this bulb to use the same supply as the LCD back-light (it was originally connected to 13.8V). This would allow the meter back-light brightness to vary along with the LCD adjustment.

The CW Key Jack Situation

When I was troubleshooting the 1296 module, I wanted to key a CW signal to get a steady RF output. While I ended up using the FM mode to accomplish this, my first thought was to connect a switch to the key input and key the radio in CW mode. After some searching through my stash, I came up with a 1/4” stereo plug with a cable already attached. SWEET! However, when I went to plug it into the radio, it was a no-go. The plug wouldn’t fit into the jack. It would get about half-way in and then jam-tight. Fascinating.

I checked the documentation to see if a special plug was required, but the manuals didn't specifically state the size. It is just generally accepted (by me, at least) that this would be a 1/4" jack. I know that general aviation headset connections use a 0.21", three-terminal plug – while not likely, I wondered if that could be it? I happened to have one and it fit, but was sloppy. I was rushing to put in an order to Mouser for delivery the next day (Friday) to support my weekend projects so I took some measurements of the jack leads and after searching for a few minutes, I found a possible replacement (Kobiconn PN: 16PJ509). I got several because I have some plans for other keyer connections down the road.

In a rare turn of events, the Kobiconn part was a spot-on fit. The original jack featured switch terminals (I don't think it actually had internal switch contacts), but the radio doesn't use them. I placed the new part without soldering, then installed the board in the radio, securing all jam nuts. At that point, I soldered the connector to the board. This was a bit of extra trouble, but assembling in this way reduces the mechanical stress that might otherwise result from the inevitable misalignment that would likely result from soldering the connector otherwise. I also cleaned off much of the flux that ICOM is happy to slather on their PCBAs.



JACK-B Board with new 1/4" key jack (J5).

After looking at the original connector free of its installation, I determined that it had been previously broken and repaired with CA (so someone with CA is now known to have been in contact with this radio… curiouser). Unfortunately, they didn't do a good job of aligning the parts so any plug inserted would not likely be able to go all the way in. Points for trying, I suppose. A couple of minutes with a 1/8" round file and I now have a junk-box quality ¼" stereo jack.

Do You Have A License For That RCA Jack?

On top of everything, there were also some user-mods to this radio in the form of two 1/8" stereo jacks and an RCA jack. The stereo jacks connect to the CTRL UNIT. After some poking around in the schematic, it was clear that these jacks brought out the V and U preamp voltages. One was "OUT" and one was "IN". If you jumpered the two together, the radio behaved normally. Otherwise, you could get access to the two preamp power signals.

My inclination here is to keep the feature, but modify the implementation. I bought an 8-pin mini-DIN panel mount connector and two cable-end mates. One of the cable ends will be a loop-back connector, with no cable attached. Installing it into the panel connector would make the radio behave normally. If I ever want to get at those preamp signals, I could use a cable with the other connector. This would leave 3 other signal pathways available if I ever see the need. Since I have neither need nor intention of installing an IC-P35, I can use that opening (which is missing the cover panel) for the DIN connector.

The RCA jack was a bit harder to trace and actually turned out to be THREE RCA jacks. They were each connected to a length of RG-178 coax, and disappeared under the MAIN UNIT. This is the largest PCBA in the radio, so it took a moment of pause to decide to go ahead and lift it. It's not that I was "skeert" (for those not familiar with back-woods American euphemisms, this means "afraid") of the process, but with these older radios, little incidents can become big deals since most of the replacement parts are difficult to obtain and wires break more easily. After a bit of sleuthing, I found that the first one I traced was connected to pin 9 of U5 which is the unadulterated demod output of the "A" (main-band) FM receiver chip. I can imagine why someone might want that. For me, it is a doorway for crud to creep into the receiver so my inclination is to remove it.

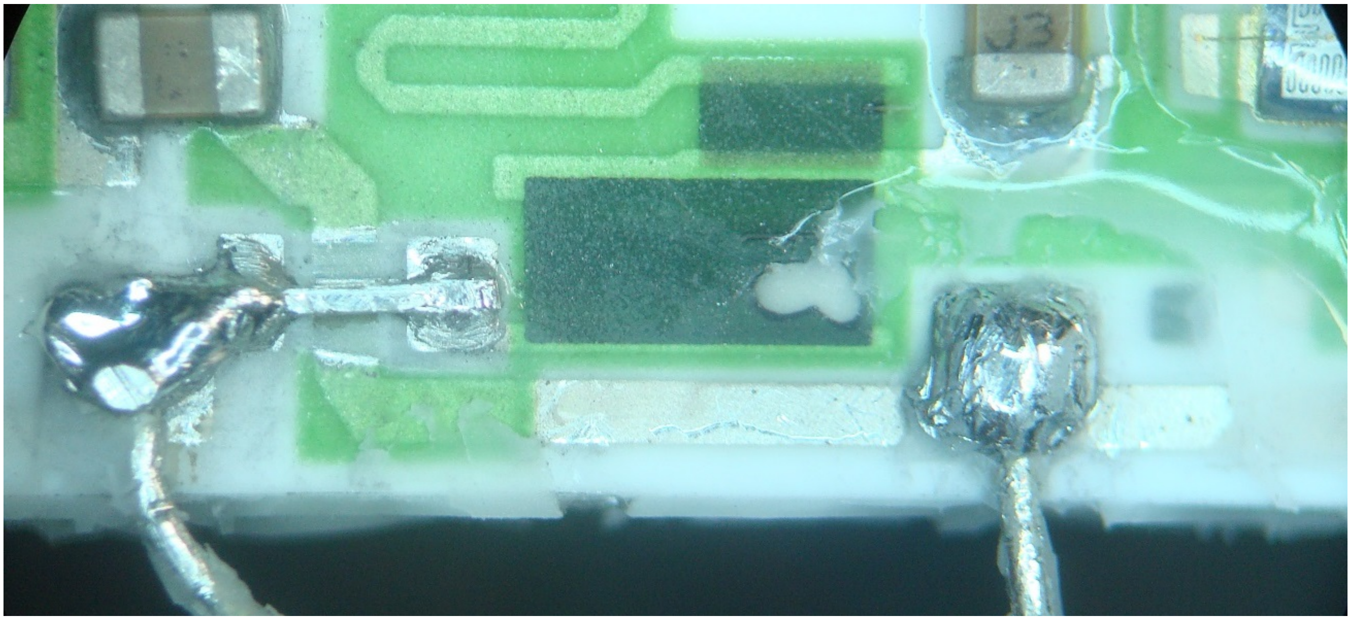
The other two jacks connected to U11-9 (the FM demod output of the "B" band) and to the varactor used for the FM modulation function. Again, I can see how someone might want these mods, but I can do without them for now. I abandoned the connectors in place. I'll remove them later if necessary. For now, they will be marked "INOP-AIP".

1296: The Redemption

After a time, and some nail biting, the 1296 PA finally arrived. Out with the old and in with the new...and...It WORKED! Hail Caesar! So, now what? Well, I figured that the old PA was trash, so why not crack it open and have a look-see at its innards. I am fascinated by chip level assemblies and constructs, so it was worth spending some time to remove the PA "cap". Turns out, it was worth quite a lot.

After looking over the landscape, I noticed something. Or rather, the LACK of something: no neon signs were seen. There were no burnt-out craters, no cracked components, nothing to signal why this module was not working. It could be that there was a small crack somewhere, but there was nothing OBVIOUS. So, I got to looking more closely. I also performed ohm meter checks to look for opens and shorts (cracked caps will sometimes become shorted). Everything looked good, except for the supply voltage path to the center amplifier stage.

I removed some more of the "pookey" (a technical term for any RTV-like adhesive which was used here to secure the PA cap) and saw a wire lying over a trace with a thin line of "black" residue. Something you might not even notice if you weren't looking for something wrong, but not quite a smoking gun either. As seen in the photo below, the power pin on the right connects to a trace which routes under the bias pin (left). The two conductors are only separated by a thin layer of "solder mask" and whatever air-gap resulted from the wire lying on top of the substrate. This seems like a recipe for disaster...and it most surely is.



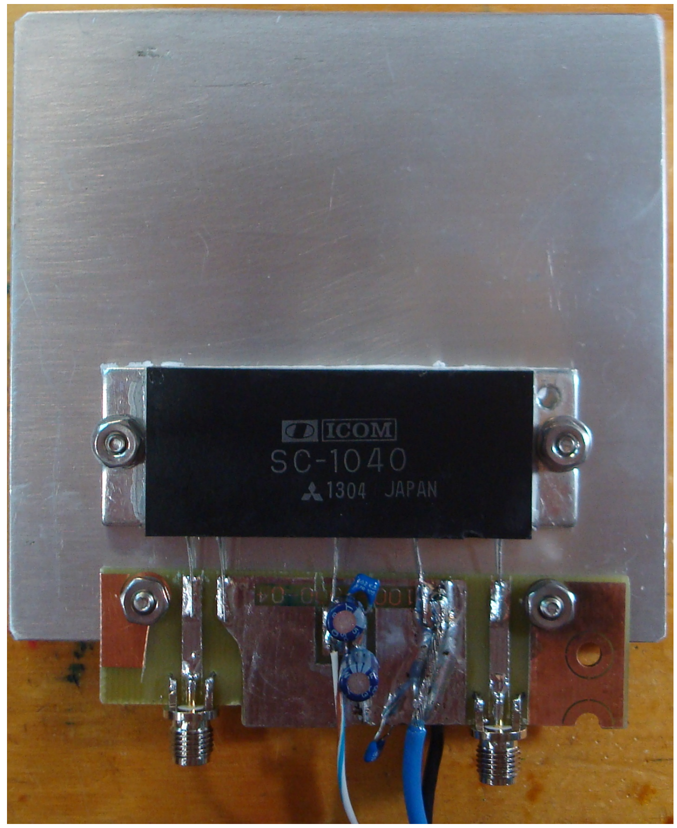
The bias pin (left) and the final stage power pin (right). The gap around the bias pin was cleared by the author.

The trace "looked" good, other than the narrow bit of residue, but an ohmmeter check told otherwise. The trace was open. With no connection, there is no power to operate the middle stage of the PA, which results in the "attenuator" behavior. There was no connection between either side of the trace and the bias pin. "Could it really be THAT easy?" I wondered. What do I have to lose?

So, I cleaned up the trace by carefully sanding the metalization on either side of the bias lead to ensure no future contact. I ran a small jumper wire between the power pin pad and the capacitor just above the bias pin pad. This required a pre-heater setup because the thermal behavior of the ceramic substrate makes it very difficult to solder. Then, I re-pookeyed (with "metal-safe" RTV) the whole smash and BOOMSKI! I have a re-manufactured PA module! Providing that it works, of course.

To answer that question, I had two basic options. One was to re-replace the PA in the IC-970. That was working and I wasn't anxious to risk the rework. This left the other option: build a test stand for the PA. Simple enough, I have lots of "blank" FR-4 PCB material. Using a razor knife, I "etched" a pattern on a piece of FR-4, then attached the minimum components and connected the input to the IC-970 1296 connector. The output of the PA test cell was connected to a 50 ohm load via my Bird wattmeter. The 970 was a good signal source as it was handy and its output could be easily controlled. The result was again a success (don't sound so excited, for crying out loud!). Yeah. So, NOW what? Now I have a spare 1296 PA module. Woohoo!

Right: The PA test cell with the repaired SC-1040 PA module.



The Straggler

While looking at the 1296 spectrum with the new PA installed, I noticed some significant spurs at about +/- 500 KHz from the carrier. I was a little concerned until I found these same spurs on 2m and 432 as well. Then, I was REALLY WORRIED. What could THIS be??? After a lot of combing through the block diagram and schematic, I couldn't identify any likely source of these spurs. It was becoming a real poser. However, I was rescued by Troubleshooting 101: Signal tracing.

I re-deployed my current probe connected to the S/A to see if I could find something that might shed light on these spurs. Find something I did, as Yoda might say. There was a series of spurs all over the cabling of the radio that started at about 350 KHz plus increasing harmonics. I suspected something from the logic board, but the strongest signal was located at one of the Main Unit connectors (J7). This connector has one of the few +13.8V supply pins for the Main Unit. Checking this pin with a scope showed a 350 KHz sine wave of a volt or so peak-peak superimposed on the +13.8V DC. Whoa!

Disconnecting J7 eliminated the noise. Whatever was causing it was on the Main Unit. Not far from J7 is a 7808 regulator (IC18). It has a couple of capacitors on the input and output (C247 & C248). Turns out, one was way out of spec (capacitance low and ESR very high) and the other was barely in-spec. I replaced the two caps and the problem was cured.

Turns out, this may have been what caused me issues with the encoder as I noticed that the encoder was "dithering" again. Once I fixed the noisy regulator, the dither was also cured.

The Home stretch

There are a couple of things I'd like to do with this radio, but chief among them is to "declare the repair to be complete". This is generally my greatest challenge. There were a couple more things to do, however. Since my radio was missing the inner chassis panel that installs above the Main Unit (this is where the PS-35, the keyer, and the decoder boards are installed) I wanted to fabricate a replacement. I also wanted to add an external reference lock capability so that I could lock the 30.2 MHz reference to an external (precision) 10MHz source. Finally, I wanted to install my HC705 processor-based keyer (which was currently homeless). The frequency lock was going to take a while, but in the meantime, I wanted to get the project "started" by completing any mechanical activities so that later, I could just "bolt-in" the components.

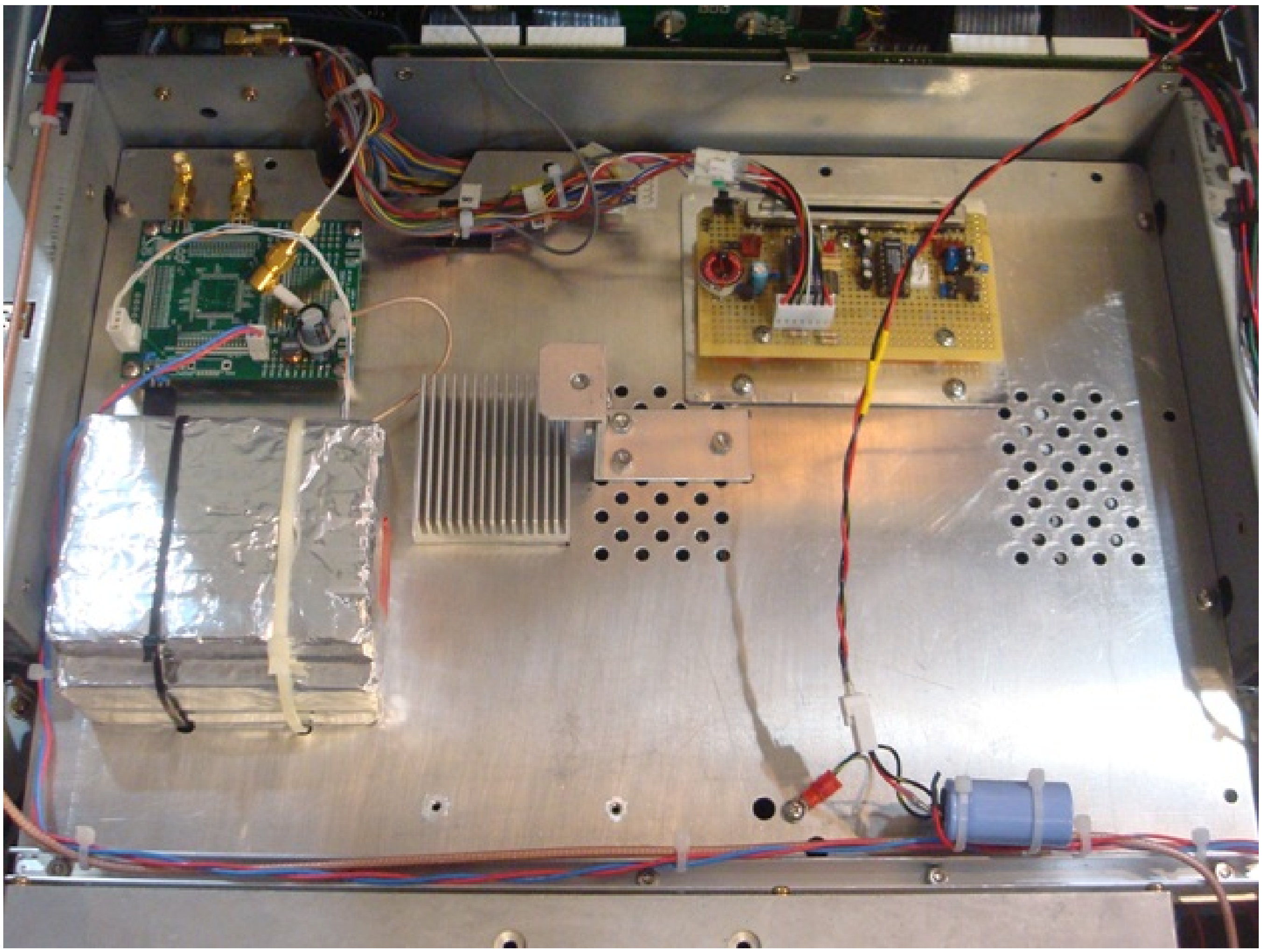


Photo of the Author's replacement internal chassis bay. The heatsink near the center helps reduce the temperature drift of the adjacent reference oscillator (in the foil box). The internal fan is not shown, but is powered by the cable that extends up from the capacitor located in the lower right of the image. The future frequency lock circuit will install where the (mostly) blank PCB is located in the upper left. The home-brew keyer is the remaining item in the frame.

To the right: The reference control panel installed at the rear of the IC-970 (the 10MHz input jack will be placed when the frequency lock installation is performed).

The photos above show the result. The large foil box enclosing the 30.2 MHz reference doesn't do a lot to stabilize the temperature, but it helps. I placed a toggle switch on the back panel (where the PS-35 connections install) to allow the reference to be powered on when the radio is off (STBY). This allows the reference to be stabilized so that the drift is minimized when the radio is turned on. Or, that was the plan. I had to add an internal fan and small heatsink to help mitigate the heat that comes from the rest of the radio. The result of this kludge is, given a constant room temperature, the 30.2 MHz reference will drift only about 2 or 3 Hz after the radio is turned on (assuming it was in STBY for at least an hour). Any greater level of stabilization will have to wait for the frequency lock circuit.

The Finish Line. Or, so...

The thermal stabilization efforts were more an exercise in boredom than a concerted effort. With the frequency lock modification on the horizon, it really isn't much needed and is only useful if the radio is operated at a temperature that is relatively constant. Still, it was an interesting science experiment that may prove useful in the future, if only to illustrate what NOT to do.

I still need to do a full cal-check of the radio. There are a lot of oscillators that need to be checked and likely netted. For now, the radio hasn't much to do as I live in an HOA restricted home. That isn't likely to change for some time, tho there is a plan. For now, it may see some service in my microwave rover, tho it is not well suited to portable operation. If I do deploy it, I'll likely only hit one or two grid squares near my home. Just enough to give it some service time every now and then.

Not bad for a total investment of less than $400.

IC-970 LCD Re-lamping details

This is a series of images and instructions for modifying the lamp holders for the IC-970 LCD backlights.

Materials needed:

QTY	PN/MFR	Description
4	HLMP-LG75-XY0DD, Broadcom	LED, 4mm, radial-lead, red
4	MFR-25FTE52-470R, Yageo	Resistor, ¼ W, axial-lead, 470 ohm
AR	R30W-0100, Jonard	Wire-wrap (WW) wire, 30AWG, Ag plated (13")
AR	Personal preference	Solder
1.5	(inches)	Heatshrink tubing, 0.125" DIA (pre-shrink)

Mouser, DigiKey, and others are a good source for the above items. *Note, you may have to substitute some items depending on future stocking trends and supplier.*

Note: This instruction is dependent on the LED noted above. The choice of a different LED may require some adjustments to the resistor value and process details. Use great care when handling the holders, they are likely very brittle from age and the heating of the incandescent bulbs.

LED preparation: Secure the leads of the LED in a vise and use a Dremel tool with a standard cutoff wheel to grind 4 facets into the sides of each of the LEDs (see the image below for a detail of the facets). Be careful, you basically only need to lightly "kiss" the LED with the wheel moving at low RPM.

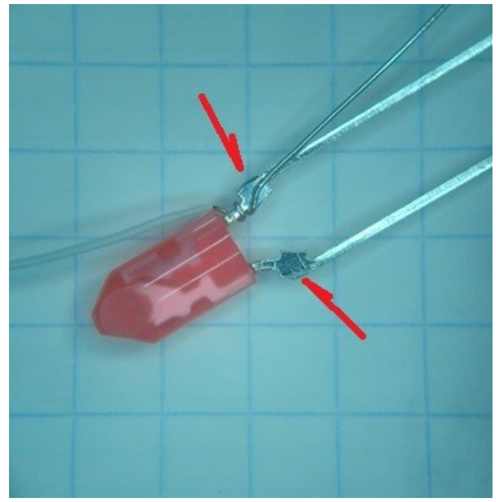
Note: If a Dremel tool is not available, use 300 grit wet/dry sandpaper to create the facets (use a small amount of water to help carry away the plastic tailings). This will be a rather tedious chore, so try to get hold of a Dremel tool if at all possible.

Three (3) of these LEDs are used for the following steps to modify the LCD backlights. The fourth LED (optional) is for the S-meter backlight.

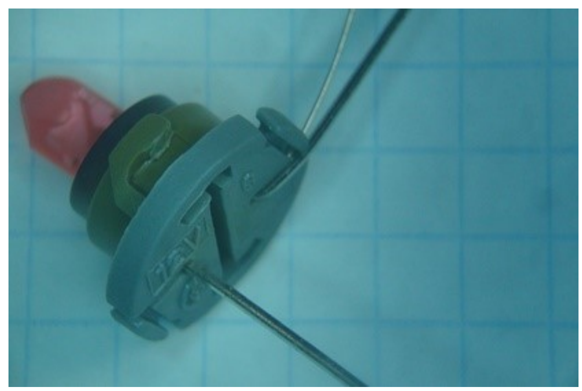
Note: These steps are written from the standpoint of a single lamp holder. Repeat the process for the other two holders. It is recommended to do one holder from start to finish before attempting the remaining holders.

Step1: Remove the lamp-holders from the IC-970 and inspect for damage. This will require that the top and bottom radio covers be removed, and the front unit (4 screws: remove the top two and loosen the bottom two) be tilted forward to allow access to the lamps. Use a small flat-blade screwdriver to gently turn the holders CCW about 1/8 turn. If the holders appear usable, gently remove the silicone cover from the lamps and set aside. Use a pair of fine point tweezers to "unwind" the lamp leads from the socket. After unwinding, they should both be reasonably straight and sticking straight out the back-side of the holder. At this point, the lamp should slide out. Set the lamps aside or discard. Use an air-duster can to clean out the holder and set it aside.

Step 2: Bend the LED leads as shown in the image below. Carefully trim the outside corner of the PCB stops (2 places, indicated by the arrows). Strip 2" of WW wire and tightly wrap around the cathode lead of the LED as shown. Apply a small amount of solder to the area between the PCB stop and the LED body. Avoid getting solder on the main part of the LED lead.



Step 3: Trim the spool side of the WW wire and align the attached bare wire to run parallel with the LED lead. Carefully guide the LED leads into the lamp holder making sure that the WW wire is on the outside edge of the LED lead. I use the hole nearest the "12V" embossed text as the anode (+) lead. Bend the WW wire and then the LED cathode lead at a 90 degree angle as shown.



Step 4: Prepare the ¼ W resistor as shown below. First bend both leads 90 degrees next to the resistor body. Then, strip 2" of WW wire and tightly wind 2 or 3 turns on one of the resistor leads as close to the body of the resistor as possible. Apply a small amount of solder to the WW wire joint and carefully trim the spool side of the WW wire and then trim the resistor close to the soldered connection. There should be about 2" of bare WW wire in place of one of the resistor leads.

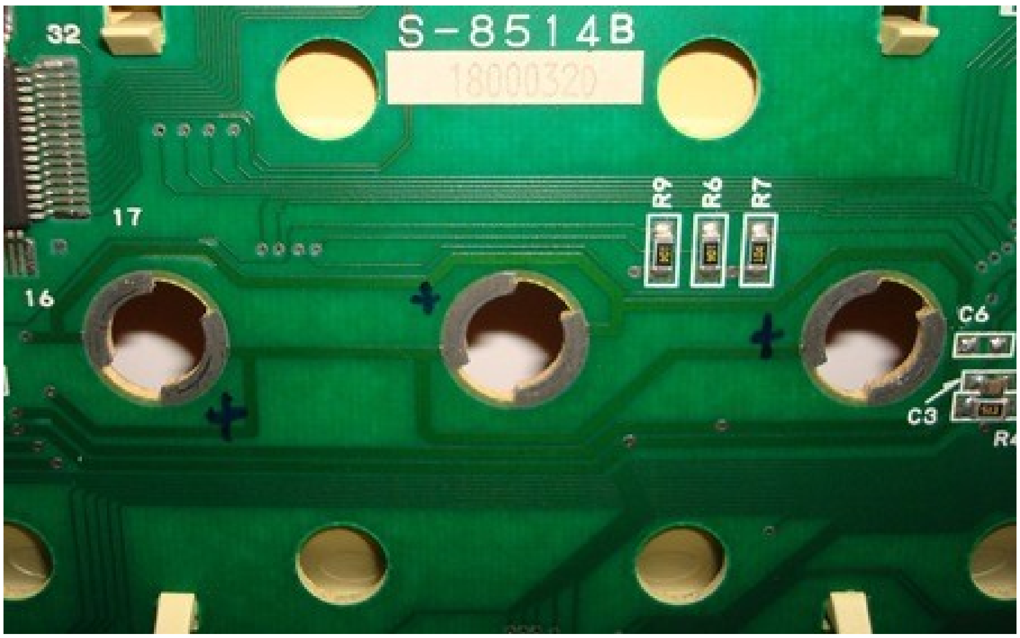
Step 5: Bend a 180 degree loop in the remaining resistor lead (NOT the WW wire lead). This loop is then positioned to wrap around the LED anode lead that is sticking straight out of the holder while the bottom of the resistor and the WW lead rest in the groove in the side of the holder as shown at the right. Carefully crimp the resistor lead loop onto the LED lead and solder. Trim the leads.

Step 6: Bend the WW wire from the LED cathode another 90 degrees so that it is pointing the same direction as the LED. Trim the LED cathode lead (the square lead that is part of the original LED package) at the edge of the LED holder. Grip the WW lead for the LED cathode with needle-nose pliers and apply a moderate amount of tension. Then wrap the lead in a the direction roughly tangential to the round holder edge then loop it up into the groove on the back side of the holder. Trim the WW lead to approximately the length of the groove. Repeat this step with the WW wire attached to the resistor on the anode side.

Step 7: Place the silicone boot over the LED and carefully tuck it inside the hole in the holder where the LED is located. If desired, tack the boot with a small drop of RTV at 2 or 3 spots where the boot meets the holder. Be careful to avoid having any adhesive extend out over the outer diameter of the LED arbor.

Note: If the boot is missing or damaged, it might be possible to use some translucent RTV to get the same effect. Apply a thin coat to the surface of the LED and allow to fully cure (at least 24 hours, more is better) before installing in the LCD module.

Step 8: Install the LED holders back into the LCD module. The figure below indicates the anode (+) connections for each lamp (be sure to verify these orientations for your radio). Re-assemble the front panel and apply power. It should be easy to see light emitted from the back of each holder to verify it is operational. Of any of the LEDs are not illuminated, try removing and re-installing rotated 180 degrees. If none of the LEDs are illuminated and reversing doesn't change the issue, use a DMM to make sure that there is voltage present at the PCB pads for the lamps.



This is a view (with subdued ambient light) of the back of the LCD with the lamps operating:

S-Meter Re-lamp procedure

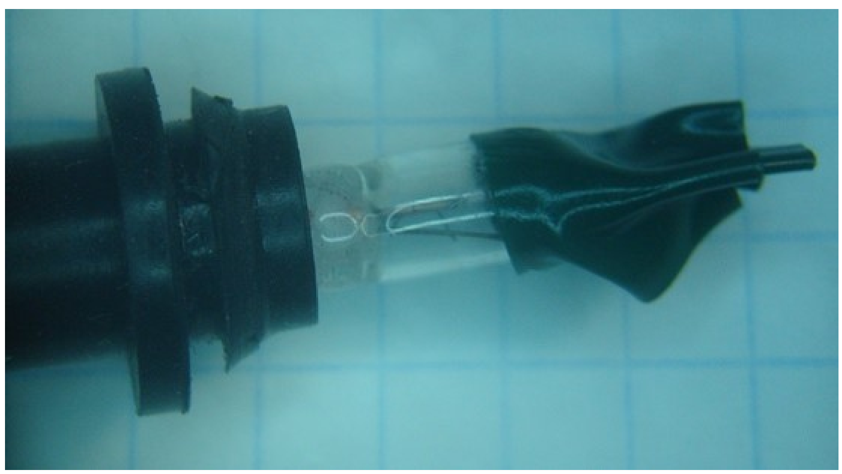
This procedure uses the same LED and current limit resistor as for the LCD backlights. The S-Meter features a different holder, however, and has fewer steps to modify. There are two options to this procedure, one uses the existing supply scheme, which provides 13.8V to the S-meter lamp. There is no brightness adjustment for this scheme other than changing the value of the limiting resistor. It does use the existing wire and is easier to perform.

The alternate procedure connects the S-meter lamp supply to the same supply used by the LCD backlights. This requires that the LCD module be removed from the front panel, and a longer wire must be installed to reach the voltage point for the LCD backlight supply. The advantage is that the S-meter backlight will adjust along with the LCD brightness using the accessible pot on the bottom of the FRONT UNIT.

The two procedures are similar except for the wire preparation. When using the existing source, one may use the existing wire, but care must be taken to get the polarity correct since the two wires are generally of the same color. For the adjustable brightness option, I recommend using a new pair of wires of differing color (cut the ground wire to 7.25", and the positive wire to 12.5" - strip and tin each end 0.25").

Step 1: Remove the lamp holder from the back of the S-meter. A small flat-blade screwdriver is useful, but be careful not to damage the rubber lamp holder or S-meter housing.

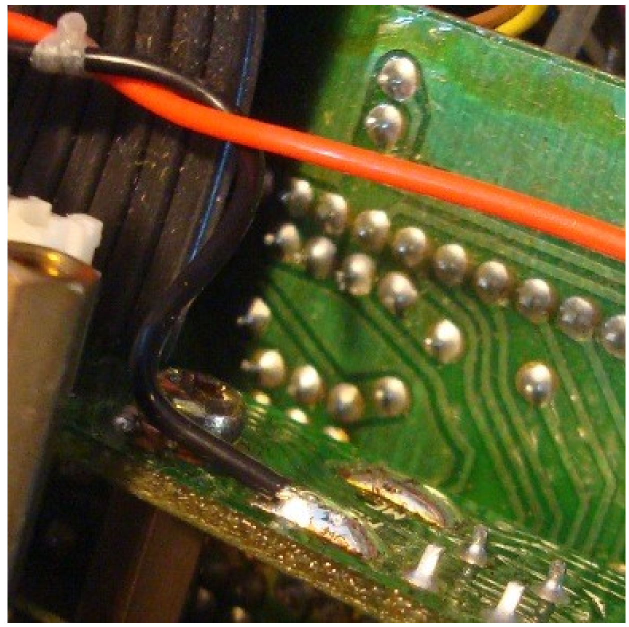
Step 2: Cut the wires at the lamp holder. Wrap a small piece of electrical tape around the exposed portion of the glass bulb. Carefully grip the bulb with pliers and gently twist the base back and forth while also gently tugging at the bulb. It may require several tries and several pieces of tape to remove the bulb.



Step 3: Insert the prepared LED into the housing. Bend the anode lead of the LED, and the resistor leads as shown to the right. Crimp the resistor and LED leads together and solder. Bend the cathode lead in the same fashion as the anode lead. Cut heatshrink sections long enough to cover the two leads plus at least 0.25".

Step 4, Existing wiring: Strip and tin the previously cut wires 0.25". Using a DMM Ohmmeter, determine which lead is the ground lead (less than 5 ohms to the chassis). Place the appropriate piece of heatshrink on this lead, bend the exposed conductor into a hook, and crimp onto the LED cathode lead, and solder. Repeat the process for the anode (resistor) lead. Push the heatshrink tubing for each lead over the exposed connections and carefully shrink with a heatgun.

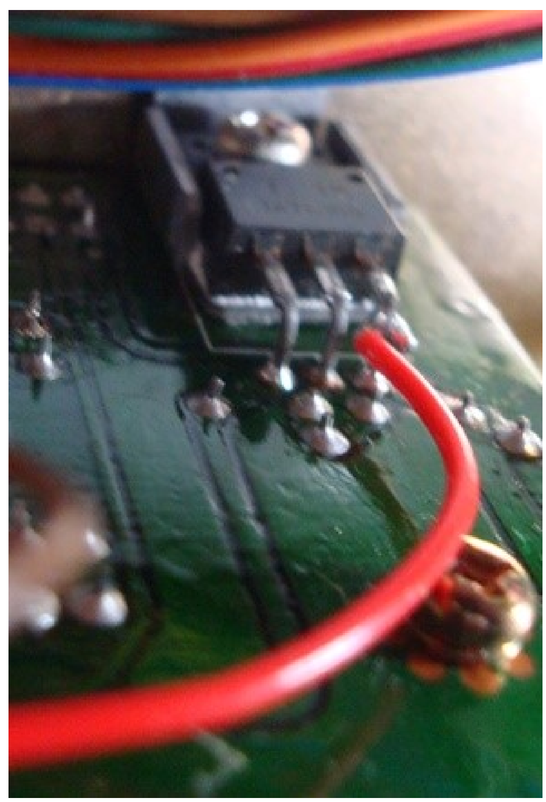
Step 4, Adjustable source wiring: Form the exposed leads on one end of each new wire into hooks. Crimp the appropriate wire onto each LED lead and solder. Thread heatshrink tubing over the exposed connections and shrink with a heatgun. Twist the wires together.



Remove the LCD module by removing the screws at the four corners of the LCD. Carefully remove the module and disconnect the two electrical connections. Set aside.

De-solder the existing S-meter backlight cable and discard. Thread the new cable in its place and solder the ground lead to the pad indicated in the image to the right.

Form the exposed positive conductor into a tight hook and trim any excess lead. Hook the lead over the LCD backlight regulator pin and solder (this regulator is located to the far right of the solder pads for the S-meter backlight). Pre-tin the regulator lead to ease the soldering operation and pre-load the positive lead with solder.

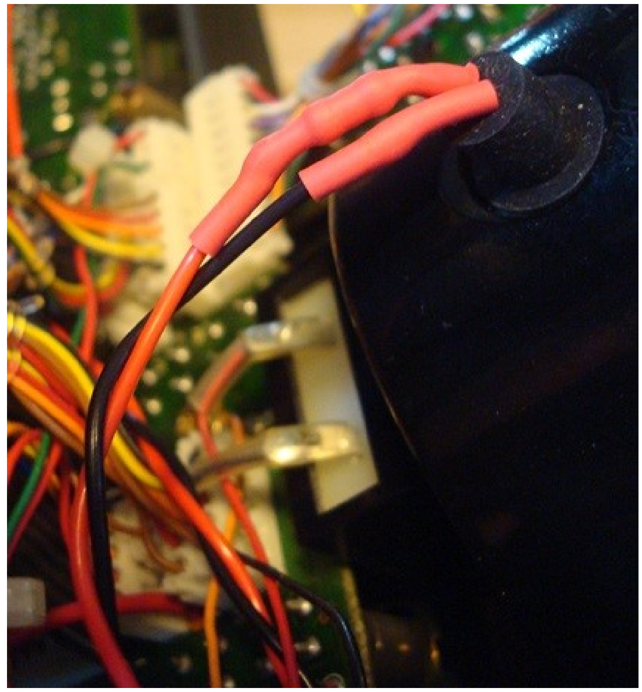


Note: Make sure there is ample clearance between the positive lead and the center regulator pin. See image to the right.

If desired, use a lint-free cloth to clean the LCD and inside of the LCD lens.

Retrieve the LCD assembly and re-attach the electrical connections. Carefully replace the assembly in the FRONT UNIT and re-attach the four screws.

Step 5: Re-install the lamp holder into the back of the S-meter. Ideally, you should simply need to firmly press the grommet back into place while twisting slightly back and forth (I had to "help" mine with a small screwdriver). When properly installed, the holder should remain in place with a gentle tug.



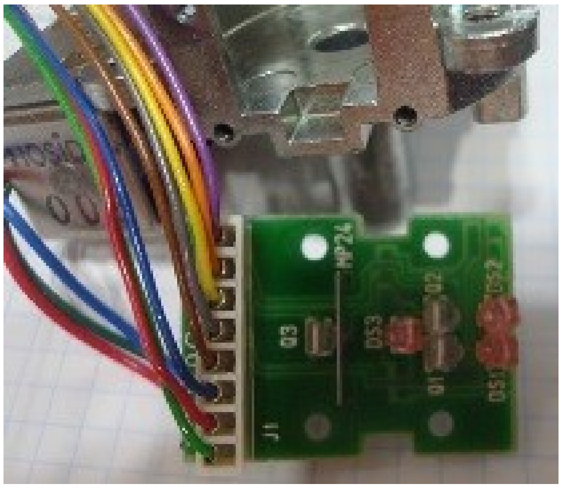
This is my result:

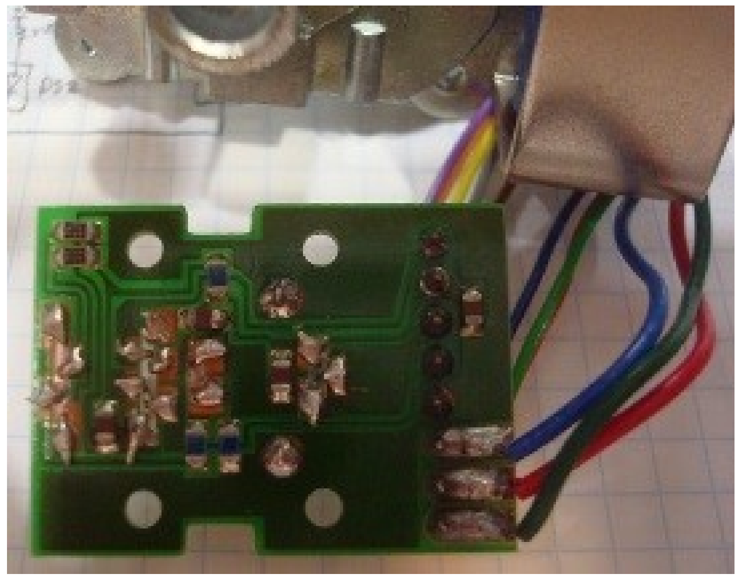
The image was "staged" a bit (I had to shine some ambient light onto the LCD to get a decent image, which serves to wash-out the backlight somewhat) and is not as representative of the actual appearance as I'd like. However, my photography skills and equipment are rather limited and this represents the extent of my capabilities in this regard.

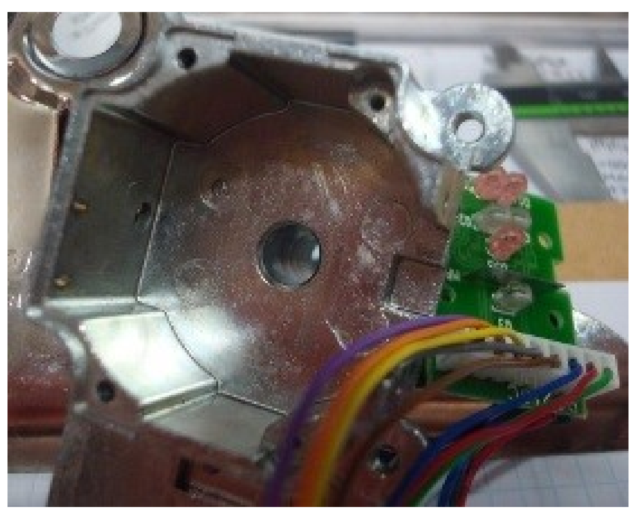
The three "hot-spots" from the LCD backlights are slightly more pronounced than the image above suggests. I found full brightness to be most preferable as the relative brightness of these "hot-spots" was such that they appeared less pronounced than at the dimmer settings. I am pleased enough that I don't feel compelled to put any more effort into the task. A better diffuser at each LED would be the goal for the those with a more discerning eye.

Image Gallery

Sensor Images







Sensor Images (cont)

1296 PA Repair