Basic Electronics Series

Electronic Troubleshooting

What Is Troubleshooting?

- *Troubleshooting* is the methodical exploration of an improperly functioning device or system to determine the gross and/or specific causes of the evident malfunction.
  - May be superficial – to isolate the fault to a basic subsystem or section
  - May be detailed – to isolate the fault to a specific component or set of components

Safety First

- Safety ALWAYS comes first…
  - Safety glasses or eye protection is a must!
    - Capacitors can explode
    - Clipped off component leads can go flying
    - Dust blown out of an enclosure goes everywhere
  - For older equipment especially…
    - The “trinity” is *highly* recommended:
      - Item #1 – an isolation transformer
      - Item #2 – an adjustable autotransformer or Variac™
      - Item #3 – a “dim bulb” current limiter
  - DO NOT work alone!

Tools Required

- The first set of tools required are those given to most of us at birth…
  - Sight…
    - Look for evidence of the fault
  - Smell…
    - Smell for burning or burnt components
  - Hearing…
    - Listen to the evidence of the fault
  - Touch…
    - On occasion, locate the fault by “feel”

Test Equipment - Basic

- Depending upon the fault type, some test equipment types can be very useful:
  - Multimeters – note the plural – more on that later
  - Continuity Tester
  - Infrared Thermometer
  - Universal Component Tester
  - Signal Generator/Sweep Generator
  - Signal Tracer – AF and RF
  - Oscilloscope
  - Frequency Counter
  - 50Ω 100W Dummy Load

Test Equipment - Advanced

- As your troubleshooting skills advance and the jobs get more complex, you might need (in no particular order):
  - Antenna Analyzer
  - Wattmeter
  - SWR Meter
  - NanoVNA
  - Spectrum Analyzer
  - Capacitance Meter
  - Inductance Meter
  - Capacitance Leakage Tester
  - ESR Meter
  - Logic Analyzer
  - Transistor Tester
  - Curve Tracer

Other Bench Equipment

- Isolation Transformer
- Current Limiter (dim bulb is OK)
- Adjustable Autotransformer (Variac™)
- DC Power Supplies
  - 5VDC @ 3A
  - 12VDC @ 3A
  - 13.8VDC @ 35A
- Battery Replacement Box
- Decade Resistance Box
- Decade Capacitance Box

The Old Setup

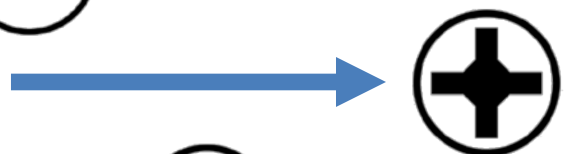
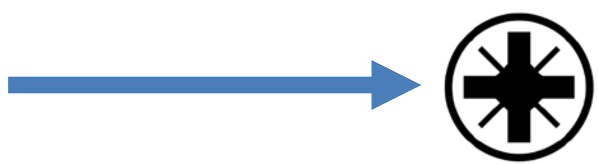
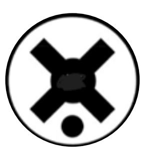
My Newer Version…

Tools

- Basic hand tools
  - Screwdrivers
    - Slotted, Phillips®, Allen, Torx®, Robertson®, PoziDriv®, JIS*
  - Pliers – several types, including
    - Needle nose
    - Diagonal cutting
    - Wire stripper/crimper
  - Small wrenches – Imperial and Metric
  - Socket set or nut drivers – Imperial and Metric
  - Knife
- Other needs
  - Digital Camera
  - Soldering and de-soldering equipment
  - Jumper leads with alligator clips
  - Magnifier
  - Tweezer
  - Good illumination

*JIS – Japanese Industrial Standard

Common Screw Drive Types

- Slotted 
- Phillips® 
- Robertson® 
- Allen 
- Torx® 
- PoziDriv® 
- JIS 

Many other screw slot formats exist – these are just the most common styles that you will encounter.

JIS vs. Phillips®

- JIS screws look like Phillips® screws, but have a tiny dot stamped into them
- Phillips® bits strip JIS screws
- JIS screws are found on everything manufactured in Japan

Schematic Diagrams

- When troubleshooting a piece of electronic equipment, and depending upon how deep the fault is, it usually helps to have a schematic diagram of the faulty equipment.
- Schematics are available online for *most* ham equipment, old or new.
- Of course, this means that some ability to read and understand the schematic is necessary as well.

Diagram Sources

- Online schematic resources:
  - The Schematic Man
    - https://theschematicman.com/
  - The Boat Anchor Manual Archive:
    - https://bama.edebris.com/
  - The Manual Man
    - https://www.manualman.com/
  - Resource Archive Listing
    - https://www.ve3kbr.com/op_aids/manuals.html

Diagram Sources

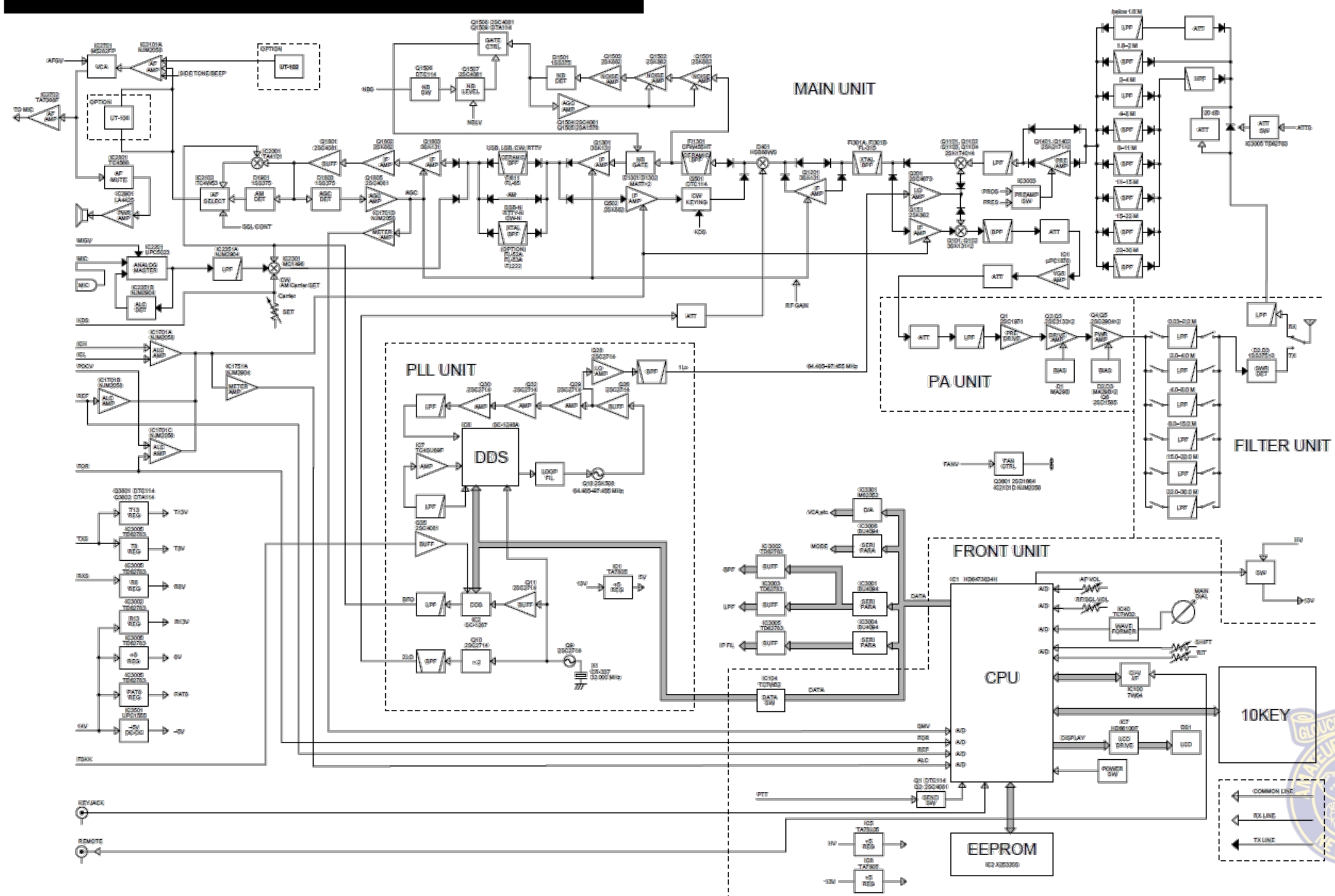
- In addition to the specific sites on the previous slide, most manufacturer sites will also have manuals and schematics available, including but not limited to:
  - Icom -- https://www.icomamerica.com/en/
  - Yaesu -- https://www.yaesu.com/
  - Kenwood -- https://www.kenwood.com/usa/com/
  - Elecraft -- https://elecraft.com/
  - …*and others – just Google it!*

Block Diagrams

- Sometimes, especially at the outset or when troubleshooting only at the gross level, a *block diagram* is more useful than is a schematic.
- A block diagram illustrates the functional sections or *blocks* of a piece of equipment, and shows how those blocks are interconnected and how they relate to each other.
- A block diagram helps to isolate the fault to a specific section or area of the device.

Icom IC-718 Block Diagram

SECTION 10 BLOCK DIAGRAM

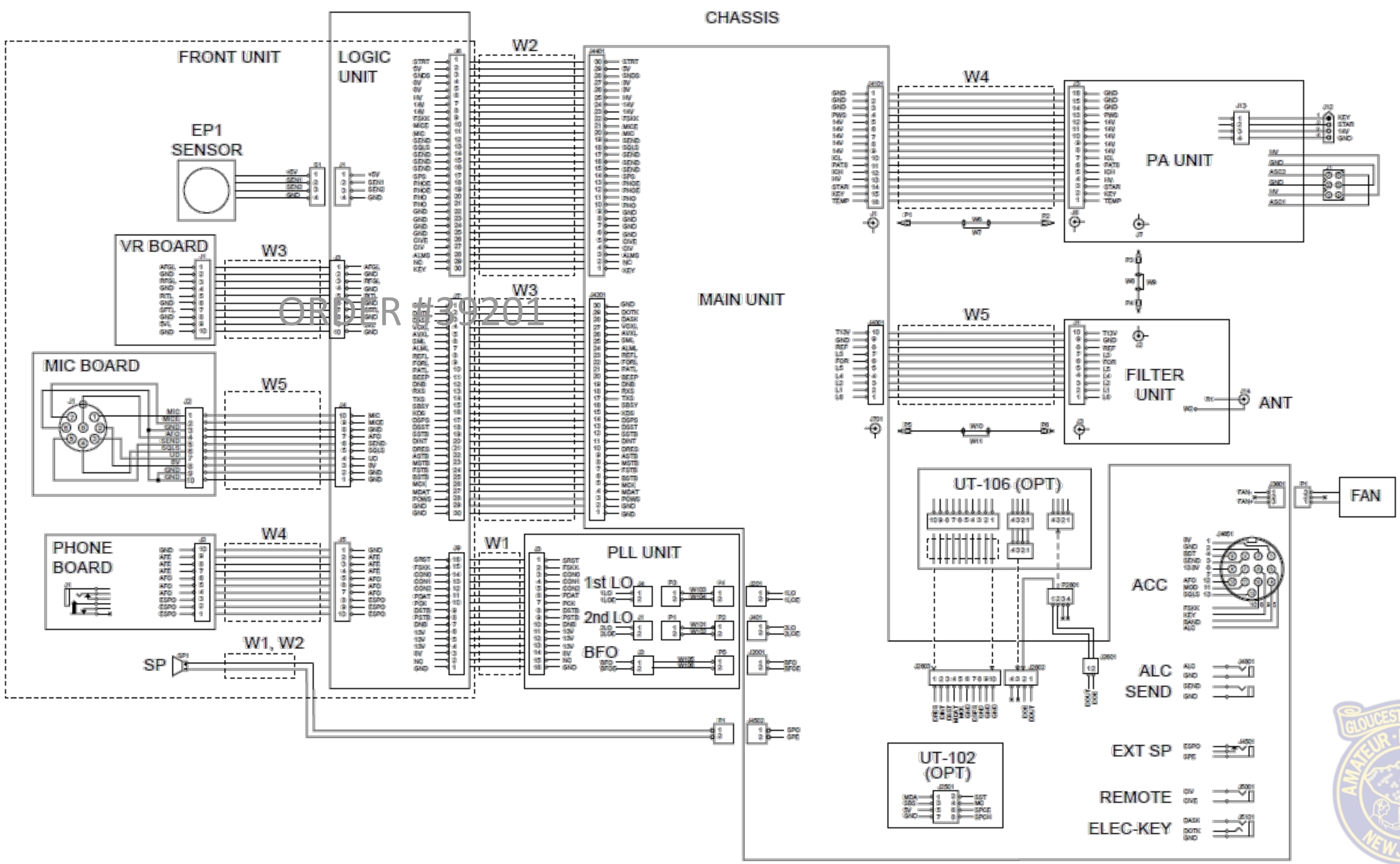


Wiring Diagrams

- At a first glance, any modern piece of electronic equipment can be daunting when it comes to the number and locations of connecting wires used to connect the sections and subassemblies together.
- A wiring diagram shows the physical wire structures and locations in a pictorial manner
  - Wire types and colors
  - Plug types and locations

Icom IC-718 Wiring Diagram

SECTION 11 WIRING DIAGRAM



Circuit Board Layout Diagrams

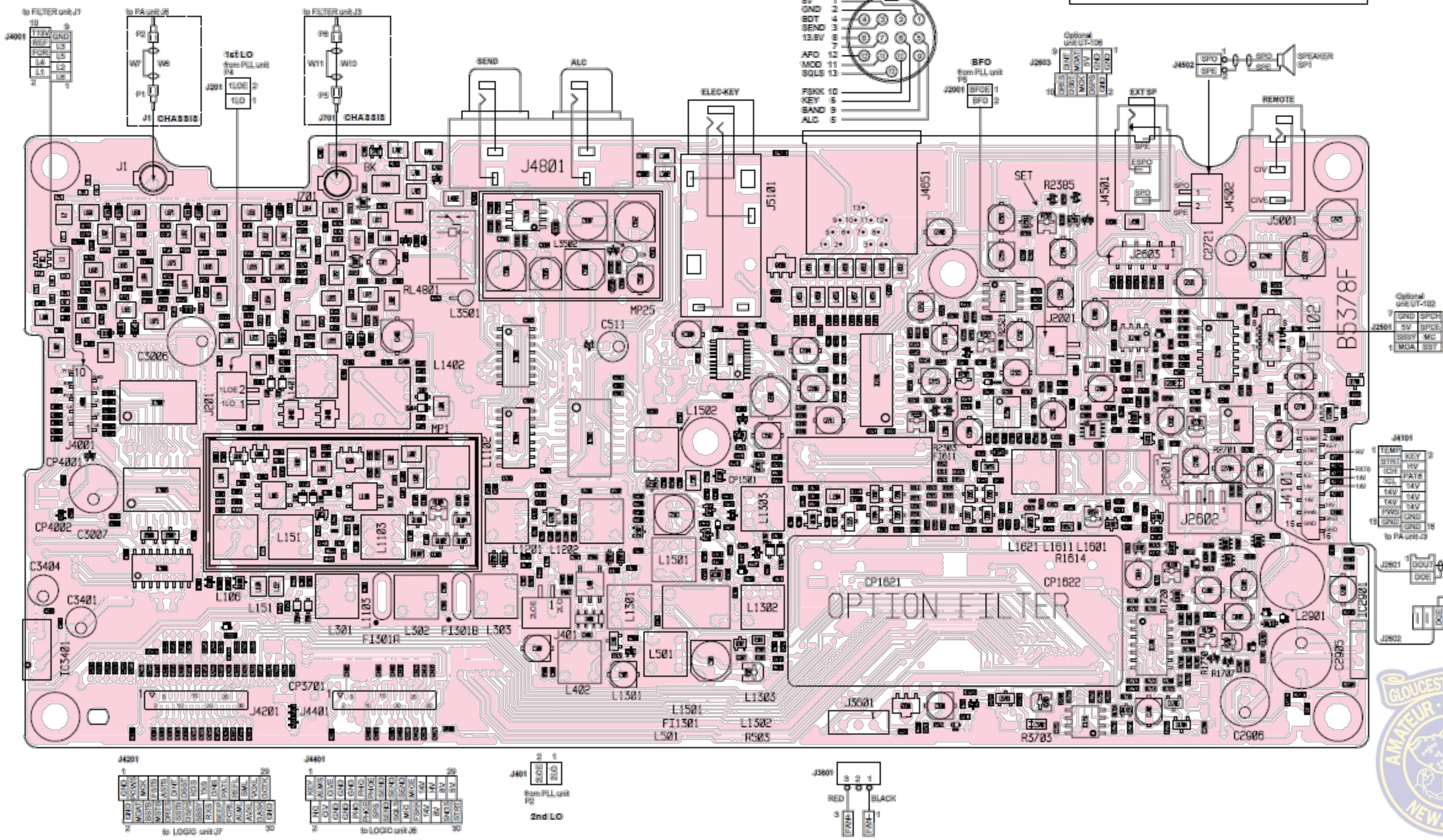
- A very useful diagram is one that identifies the specific locations of the various components on each of the circuit boards in a device.
- These diagrams are often shown as top-view “X-ray” diagrams, showing the components, and in a layer underneath them, the shapes and locations of the various inter-connecting PCB traces.

Icom IC-718 Main Circuit Board Layout Diagram

SECTION 9 BOARD LAYOUTS

9-1 MAIN UNIT
• TOP VIEW

The combination of this page and the next page shows the unit layout in the same configuration as the actual P.C. Board.



Icom IC-718 Board Set

- The diagram shown on the previous slide is just one of eight such circuit board diagrams for the Icom IC-718 radio…
  - Main Unit
  - PLL Unit
  - Logic Section
  - Phone Section
  - Microphone
  - VR
  - Filter
  - PA

Diagram Types Compared

- Block diagram – shows the logical relationships of functional sections of the device
- Wiring Diagram – shows the physical connections between all of the various subassemblies of the device
- Schematic Diagram – shows the logical electrical connections between all of the various components that make up the device
- Board Layout Diagram – shows the physical location of the various components on the circuit boards that comprise the device

Diagram Breakdowns

- Often, large complicated diagrams – of any of the four basic types – will be broken down into smaller and easier to understand "sectional" or "modular" diagrams.
  - Diagrams are often drawn with lettered and numbered rows and columns, forming a grid system used to locate specific components on the diagram.
- Some manufacturers will only field-service a device to the sectional or modular level – known as *board-level* servicing. This was a scheme that was popular in the past, but most manufacturers have gotten away from this methodology and gone back to component-level servicing.

The Process

- OK – now that all of the housekeeping is out of the way, we can get down to what we are here for… the process.
- The first step in any diagnosis is to verify that the fault actually exists, and that the problem is not something simple like an improperly set or adjusted control.
  - For example, a radio that will not transmit in phone mode because the mode switch is not set to phone mode…

- The first thing to do is to duplicate the operating conditions that caused the complaint to begin with.
  - The is somewhat simplified when the problem is that the device will not power up at all.
  - In that case, verify that the correct operating voltage is being delivered to the device…
    - A failed power supply will cause *all* devices connected to that supply to fail simultaneously.
    - Consider the circumstances and look for any commonality that would help to identify the fault.
    - Do not forget about the return side of the power supply. Applied power must have both legs intact.

Case History #1

- The complaint was that the radio, a Yaesu FT-736R, would not power up at all. It has an integrated power supply, *i.e.,* the power supply is built into the radio.
- 120VAC line voltage was properly applied to the radio
- There was absolutely no response to turning the power switch on – no sounds, no lights, nothing at all…

- The radio has a six-pin plug with two red wires and two black wires coming from the power supply unit and going into the rest of the radio chassis.
- Measuring the voltages at this plug showed no voltage present at all, either between the red and black wires or between either of these wires and the chassis.
- Connecting an external power supply to the plug, with +13.8VDC on the red wire, allowed the radio to power up and operate normally in all ways.

- What this showed was that the fault was within the integrated power supply unit (PSU).
- Removal of the PSU from the radio, and subsequent removal of its cover, allowed a cursory visual inspection of the internal components of the PSU.
- A darkened area of the PSU printed circuit board (PCB) was evident underneath a pair of 33Ω 5-watt resistors, in close proximity to a 56µF and a 220µF electrolytic capacitor.
- This is a prime example of using your senses to diagnose a fault.

- Of course, some thinking and reasoning skills are necessary, as well.
- Thinking about the effect of the heat from the resistors on the PCB, it was not a big leap to the realization that the capacitors were probably dried out from the heat.
- Removal of the suspect capacitors allowed accurate measurement of their capacitance.
- This showed one of them to be around 4µF, while the other was about 25µF.
- Replacing these capacitors solved the problem and fixed the power supply, and thus repaired the radio as well.

Back to the Process

- Verify the complaint conditions…
  - Ascertain what works and what does not work.
  - Do the panel illuminating lamps or LED's come on?
  - Is there any sound at all from the speaker?
  - Do front panel indicators (frequency, LCD, waterfall, etc.) work?
  - If a transceiver, does it switch between RX and TX? (use a dummy load…)

- How is the device powered?
  - Battery only?
  - DC from an external power supply?
  - AC from the mains powering an internal DC power supply?
- Is the device solid state, or does it utilize vacuum tubes?
- With the device unpowered and switched off, open the enclosure and do a thorough inspection for anything obviously burned, blown fuse, pinched wire, and so forth.

- Take several detail-revealing photos before disturbing anything so that you can re-position leads etc. as the factory had placed them.
- Take note of the apparent age and condition of the various problematic capacitors in the unit – particularly polarized capacitors.
- ***Starting at this point, anything found to be other than correct during any of the testing done must be tracked down and corrected before moving on. For example, if an immediate short is indicated on power-up, that short MUST be located and cleared before any further steps are taken.***

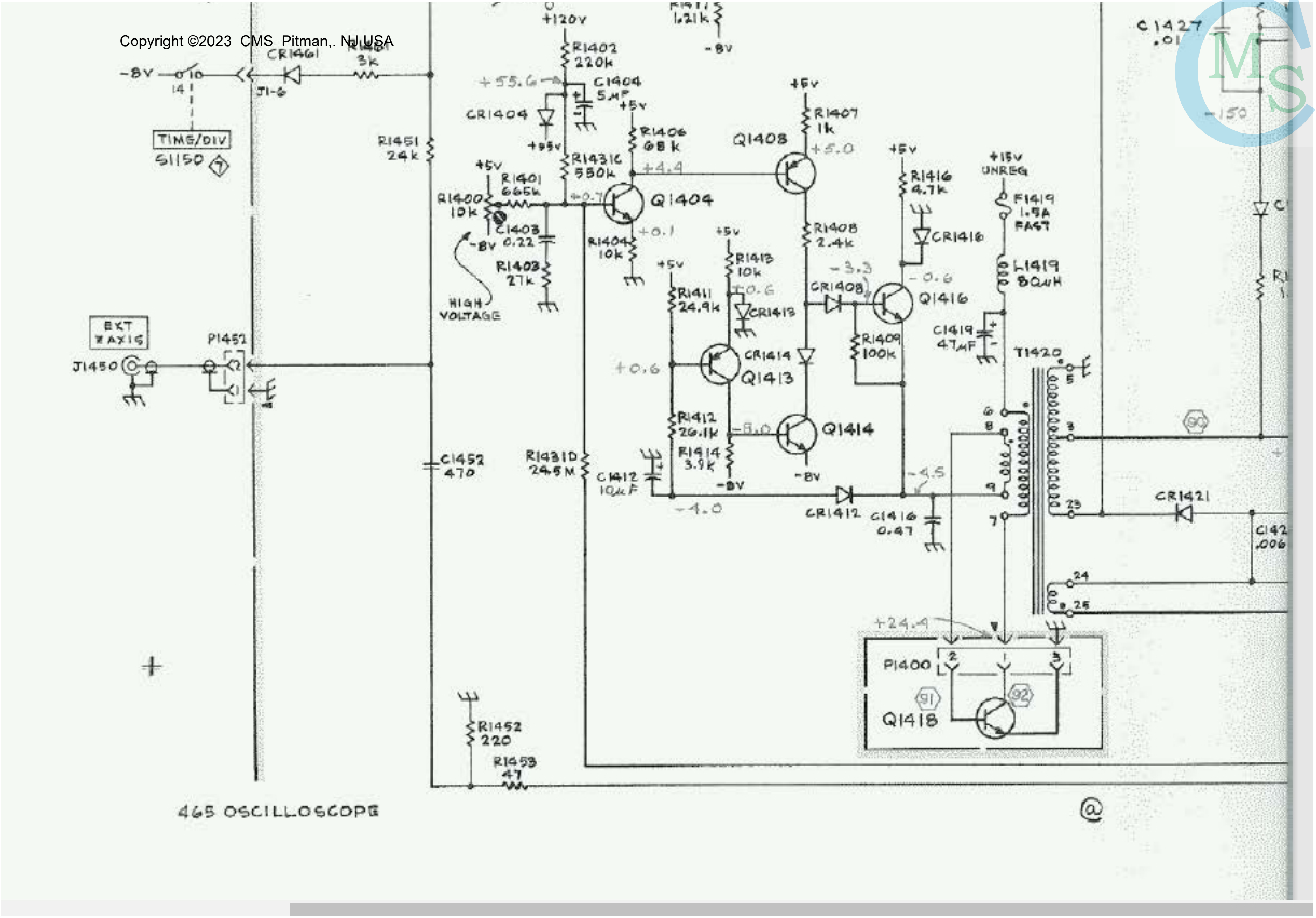
- Using proper precautions – isolation transformer and current-limited variable AC supply, slowly bring the voltage up on the unit. Watch the current drawn by the device. An immediate HIGH draw will usually indicate a direct short in the unit, though tube equipment will initially draw high and then settle down as the tube filaments heat up.
- Assuming all is OK on startup, bring the unit to full line voltage and check the LOW VOLTAGE supplies for proper output. DO NOT ATTEMPT TO MEASURE HIGH VOLTAGES! Any low-voltage supply found to be dead or off by more than ten percent of its specified value MUST be corrected before continuing. Thus, a 5 volt supply reading 4.4 volts is too low and must be corrected. However, if the service manual provides different advice on this issue, the service manual values should prevail.

- Using voltage indications from the schematic or service manual, begin checking voltages across the functional sections of the unit, testing the LOW voltages only.
- Think about the symptoms. For example, does the unit consistently blow a fuse? If so, find the fuse on the schematic diagram and look to see what is protected by the fuse. The fault must lie somewhere in the protected circuit(s) after the fuse. Of course, if the fuse is a main fuse, there's a lot of ground to cover – the entire device.

Case History #2

- Let's take a break for another bench-top repair tale. I was presented with a Tektronix 465 scope – an early one, with a low serial number.
- On power-up through the current limiter and the isolated transformer/Variac™ combination, all was well, except that there was no hint of activity on the CRT face.
- The beam finder on the scope failed to find any trace or even a dot – absolutely nothing. Everything else on the unit appeared to be OK. Graticule illumination worked, the indicators in the voltage select switches worked, and all other front panel indicators seemed to work just fine. I powered it down and opened it up.

- Just for peace of mind, I checked all of the low voltage supplies – the +5V, the -8V, the +15V, the +55V, the +110V – all checked out OK.
- I then looked at the fuse on the +15V unregulated supply rail and found that it was blown. This was fuse F1419, in the charge pump circuit for the CRT (schematic next slide).
- Downstream from this fuse were an inductor L1419, a capacitor C1419, and a transistor Q1418, as well as the primary of a transformer T1420.
- This capacitor is a 47µF Tantalum type of polarized capacitor – notorious for failing shorted.


TIME/DIV
S1150
EXT
Z AXIS
J1450
P1452
CR1461
R1461
3k
R1451
24k
C1452
470
R1452
220
R1453
47
+120V
R1402
220k
C1404
5μF
CR1404
R1406
68k
R1431C
550k
R1401
665k
R1400
10k
C1403
0.22
R1403
27k
HIGH VOLTAGE
Q1404
R1404
10k
R1431D
24.5M
C1412
10μF
Q1408
R1407
1k
R1408
2.4k
R1413
10k
CR1413
R1411
24.9k
Q1413
CR1414
R1412
26.1k
R1414
3.9k
Q1414
CR1412
CR1408
R1409
100k
Q1416
R1416
4.7k
CR1416
C1416
0.47
+15V UNREG
F1419
1.5A
FAST
L1419
80μH
C1419
47μF
T1420
CR1421
C1427
.01
P1400
Q1418
465 OSCILLOSCOPE

- I decided to play the odds and start there, removing the blown fuse and measuring resistance to ground from the “out” or protected side of the fuse holder.
- I found a direct short to ground, as expected – the fuse blew, after all.
- Next I removed the suspect capacitor and measured to ground again from the fuse holder. No more direct short!
- I replaced the capacitor with something a little bit beefier – a 100µF 50V aluminum electrolytic – and put a new 1.5A fuse into the holder. *Note that care must be taken when substituting capacitors in terms of functionality and suitability in the particular circuit at hand.* When in doubt, install same type and value. An increased voltage rating is generally OK.
- Now, on power up I got a beam immediately after CRT warm-up. Success!

- The point of that story is that sometimes you have to play the odds and go after the common failure items.
- In older equipment, capacitors are often a weak area, especially polarized capacitors. ESR creeps up, caps go open or short, or capacitance varies from its nominal value.
- In equipment of any age at all, capacitors should be early suspects, especially in cases of short circuits or signal loss.

Back to the Process

- If all operating voltages seem to be correct, you may be looking for a failed component that is not affecting the operating voltages – in other words, what I call a “quiet” fault.
- Now might be a good time to start checking temperatures, using either a very accurate non-conducting thermometer probe or an infrared thermometer.

- Check for the part that is cold by comparison to all the others on the board.
  - When integrated circuits or even discrete actives operate, heat is produced as an unavoidable side effect.
  - Therefore, if you find no heat on a component while everything else around it shows some degree of heat, you probably found an inoperative component.
  - Be sure to put the unit through all of its operating modes and/or to fully understand the circuit before condemning a part due to no sensible heat in it.

- How about popping static noise in a receiver?
  - Sometimes the source of these problems can be found by physically tapping on the various components – capacitors and resistors especially.
  - The popping noise often comes from a tiny fracture or intermittent inside a component.
  - By tapping on the component, you will aggravate that open, increasing the popping noise.
- Don’t overlook odors.
  - Failing electronic components will often emanate foul or harsh odors, making them easier to find.
  - Sniff around the board if you can do so safely.

- Another tool in your arsenal is *thermal change.*
  - You can try heating components slightly by bringing a hot soldering iron near the part and watching for a change in status.
  - The same thing can be done with cooling sprays made for just this purpose – you spray it on the chips to cool them and watch for a change.
  - Any component that exhibits wild operational fluctuations with relatively minor temperature changes should be considered suspect.

- Signal tracing through a device is done using either a signal tracer or an oscilloscope.
- Remember that oscilloscopes are ALWAYS connected with respect to chassis ground. Thus, it is very important to have an isolation transformer when diagnosing mains-powered equipment. A hot chassis can blow the ‘scope ground lead clip right off the lead!
- Furthermore, when using a signal tracer, it is usually advisable to couple the signal via a capacitor to maintain isolation of the tested circuit from the test equipment.

- The signal source used for signal tracing can come off an antenna or may be injected into the device under test.
- It is also possible to couple a signal into the antenna or antenna jack using a two- or three-turn coil around the signal generator output lead.
- Alternatively, capacitive coupling may be necessary to maintain isolation.
- It is always best to use the lowest amplitude signal that you can to get the job done.
  - Too much signal can overdrive circuits and can activate automatic level controls, distorting the test results.

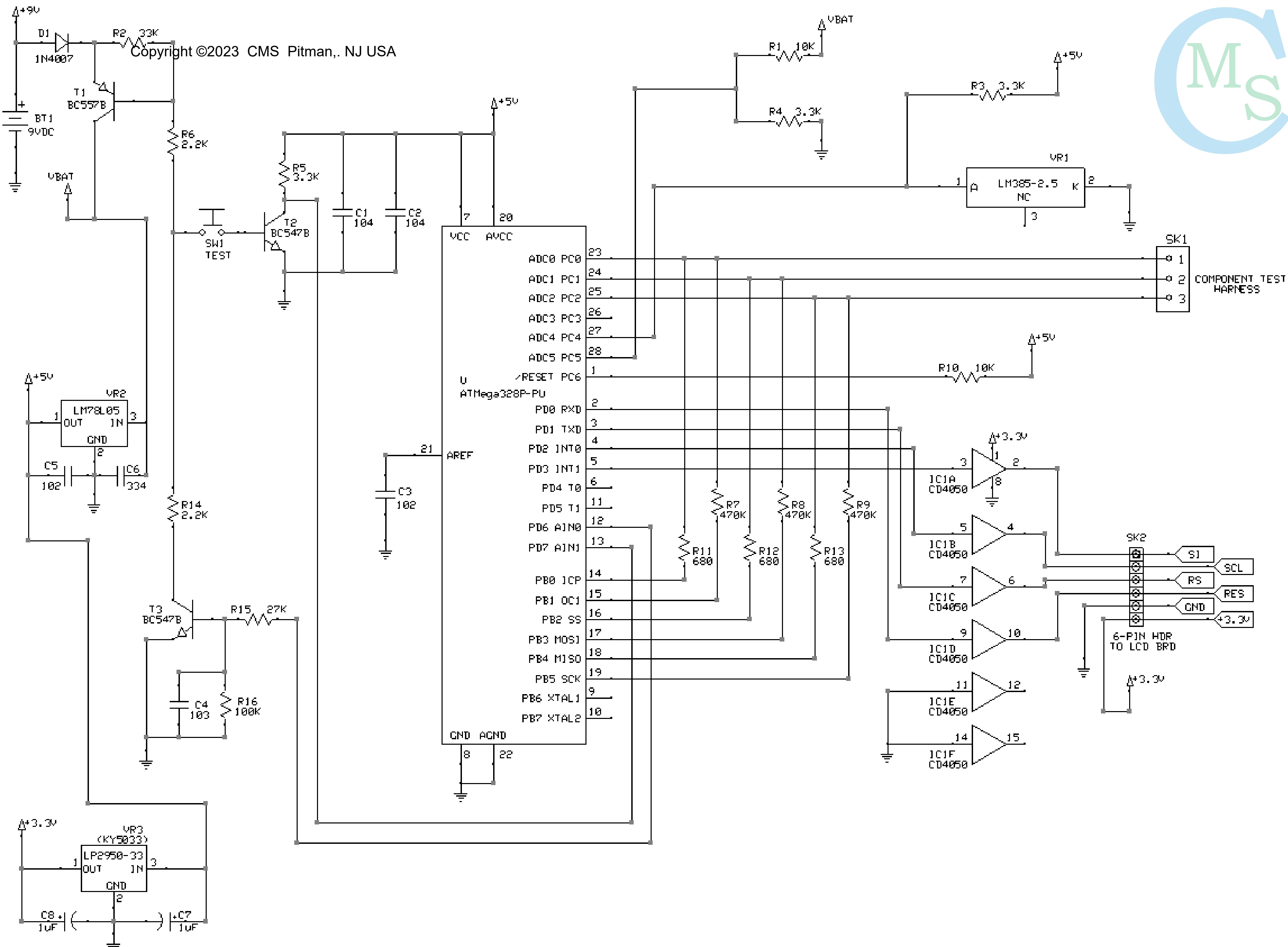
Case History #3

- Time out again for another anecdotal repair…
- Very recently, I was working with one of my universal component testers when it quit in the middle of the job.
- This particular tester is a Velleman K8115 unit that I had assembled from a kit.
- It is a two-board open design with the PCB’s stacked and spaced.
- The upper PCB is a display board, carrying an LCD display, a single current limiting resistor for the LCD backlight LED, ten 1µF monolithic capacitors, and a six-pin inline header socket for interconnection to the main board.

- The main PCB incorporates two voltage regulators (3.3VDC, and 5.0VDC) in TO-92P packages and a nine-volt battery as the power source.
- The remaining semiconductors include a 2.5VDC voltage reference diode in a TO-92P package, a pair of TO-92P BC547 NPN transistors, a single TO-92P BC557 PNP transistor, a CD4050B CMOS non-inverting hex buffer in a DIP-14 package, and an Atmel ATmega328P microcontroller in a DIP-28 package.
- The whole foil side of the lower PCB is exposed, as there is no enclosure on this device.
- There are five rubber feet on the lower PCB to keep it elevated off a possibly conductive bench or table top.
- Now, on to the failure…


Camelion
Plus Alkaline
Component Tester
TEST
Velleman Projects

- I was holding the tester in my left hand, with a transistor attached to the rest lead mini-clips, and I had pressed the "Start" pushbutton switch with my right hand.
- The test began as it normally would, but then, just as the LCD screen began to display the results, the screen went white and began flickering slowly.
- Obviously, some component went bad during the test.
- Now… I had previously tested and characterized this same type of transistor (a 2N3904) on numerous occasions, so I knew that the problem was not any sort of overload or error due to the device type under test.
- How does one even begin to troubleshoot something like this? I started out with the schematic diagram, as usual…



+9V
D1
1N4007
R2 33K
T1
BC557B
BT1
9VDC
VBAT
R6
2.2K
R5
3.3K
SW1
TEST
T2
BC547B
C1
104
C2
104
+5V
VCC
AVCC
ADC0 PC0
ADC1 PC1
ADC2 PC2
ADC3 PC3
ADC4 PC4
ADC5 PC5
/RESET PC6
U
ATMega328P-PU
PD0 RXD
PD1 TXD
PD2 INT0
PD3 INT1
PD4 T0
PD5 T1
PD6 AIN0
PD7 AIN1
PB0 ICP
PB1 OC1
PB2 SS
PB3 MOSI
PB4 MISO
PB5 SCK
PB6 XTAL1
PB7 XTAL2
GND AGND
AREF
C3
102
R1 10K
R4 3.3K
R3 3.3K
VR1
LM385-2.5
NC
SK1
COMPONENT TEST HARNESS
R10 10K
+3.3V
IC1A CD4050
IC1B CD4050
IC1C CD4050
IC1D CD4050
IC1E CD4050
IC1F CD4050
R7 470K
R8 470K
R9 470K
R11 680
R12 680
R13 680
SK2
SI
SCL
RS
RES
GND
6-PIN HDR TO LCD BRD
VR2
LM78L05
OUT IN
GND
C5
102
C6
334
R14
2.2K
T3
BC547B
R15 27K
C4
103
R16
100K
VR3
(KY5033)
LP2950-33
C8
1uF
C7
1uF

- I knew that the battery was good, because as a part of the initialization routine, this tester displays available battery voltage on-screen, and it had shown 8.97 volts.
- The initialization routine also displays the output level of the 5VDC regulator, which had shown as 5.03 volts.
- However, the voltage regulator could have failed, so I looked a bit more closely at the schematic diagram.
- The fact that the LCD backlight was operational meant that both the 5.0VDC and the 3.3VDC voltage regulators were operational, as the backlight is supplied off the 3.3VDC rail, and the 3.3VDC regulator takes its input directly from the output of the 5.0VDC regulator.

- A quick check of the operating voltages showed that the VCC (pin 7) and AVCC (pin 20) of the ATmega328P µC were at the nominal 5VDC supply voltage with respect to device ground (pin 8 for GND and pin 22 for AGND) of the ATmega328P, and that the VCC pin (pin 1) of the CD4050B hex buffer was at the nominal 3.3VDC supply voltage with respect to device ground (pin 8) of the CD4050B.
- These are normal operating voltages for this piece of equipment.
- With normal operating voltages present on the IC's and all other active devices, where do we turn from here?

- Using the equipment that I had available to me at the time, I did something that might seem strange, but really is not.
- Using my infrared thermometer, I took a quick temperature reading on the µC and the hex buffer IC's, which showed that the hex buffer IC was running at a temperature (63°F) that was 22 degrees Fahrenheit colder than the temperature at which the µC IC was running (85°F).
- This indicated to me that the hex buffer IC was either not working at all or was working poorly.

- The next step was to test the signals through the hex buffer, of which only four of the six buffers onboard the IC were in use in this circuit design.
- Another quick look at the schematic showed the following signal paths:
  - µC pin 2 runs directly to hex buffer pin 9, which outputs non-inverted to hex buffer pin 10, which then runs directly to pin 4 of the 6-pin header to the LCD screen;
  - µC pin 3 runs directly to hex buffer pin 7, which outputs non-inverted to hex buffer pin 6, which then runs directly to pin 3 of the 6-pin header to the LCD screen;
  - µC pin 4 runs directly to hex buffer pin 5, which outputs non-inverted to hex buffer pin 4, which then runs directly to pin 2 of the 6-pin header to the LCD screen; and
  - µC pin 5 runs directly to hex buffer pin 3, which outputs non-inverted to hex buffer pin 2, which then runs directly to pin 1 of the 6-pin header to the LCD screen.

- Thus, whatever signal is present on pin 2 of the µC should also appear at pin 10 of the hex buffer, and so forth through µC pins 3, 4, and 5.
- This, however, was not the case.
  - For example, a high level signal at pin 7 of the buffer produced a low level signal at pin 6 and thence also at pin 3 of the LCD connector.
  - In fact, when tested with a logic probe, all four of the individual buffer sections in use in the CD4050B were outputting logic low signals.
  - This validated the temperature test and proved conclusively that the CD4050B had failed.

- The most likely failure cause was a zap of static electricity into or across the CD4050B hex buffer IC.
  - As with all CMOS devices, this IC is extremely sensitive to static electricity, and is easily damaged or destroyed by static hits.
  - There is a high probability that this could have been avoided had the entire foil side of the PCB been covered with a layer of insulating tape, which has now been done.
- Replacing the CD4050B IC repaired the tester, and it now works as designed.

Back to the Process

- OK – we have talked all around the process, and we've listed the basic steps. Now let's discuss some details…
- It was mentioned earlier that multimeters – plural – were needed.
  - At least one each of a digital and an analog type are to be preferred.
  - Get the highest input impedance meters that you can afford
    - The higher the input impedance, in ohms per volt, the more accurate the meter will be and the less circuit loading will occur.

Multimeter Use

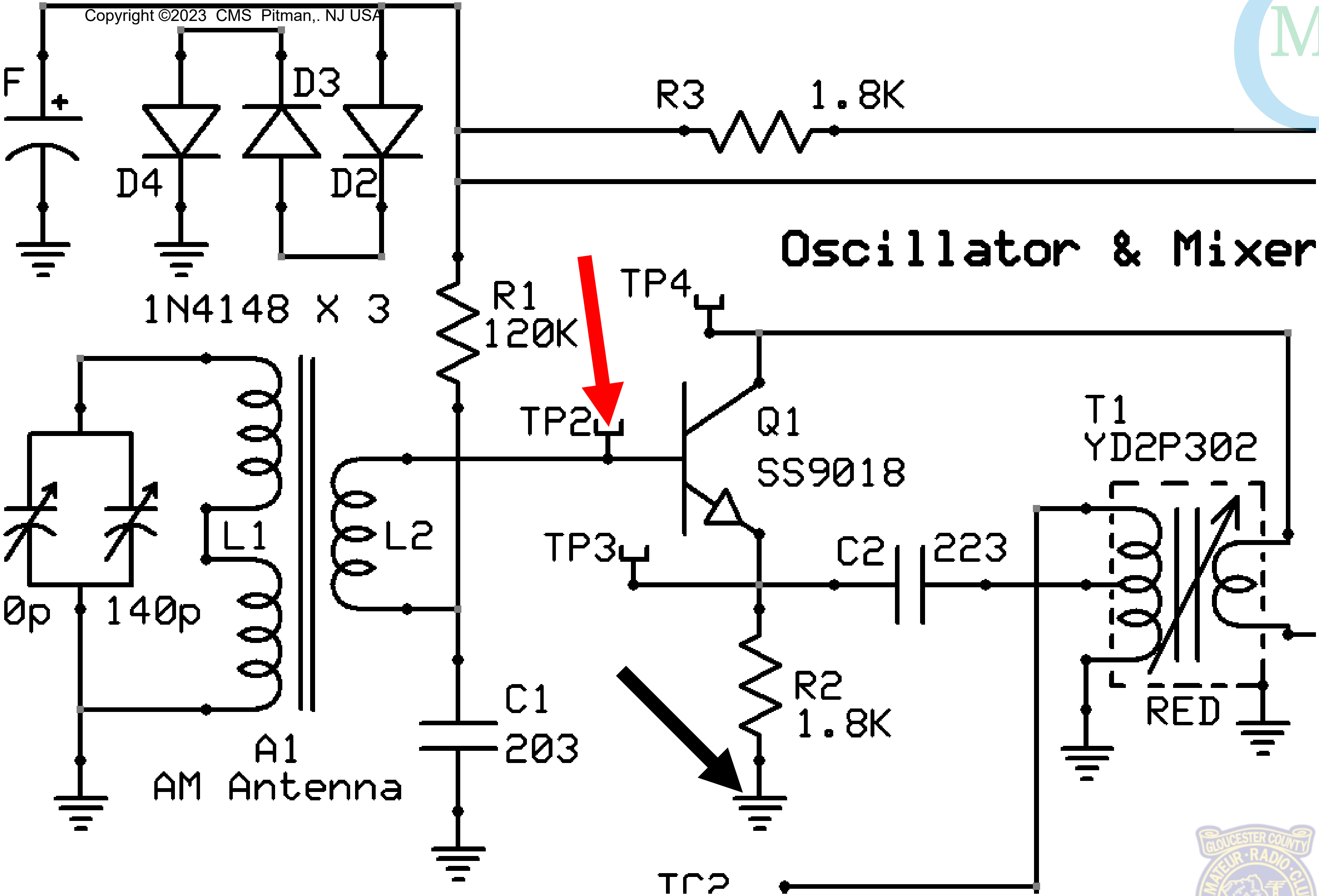
Voltmeter	Ohmmeter	Ammeter

Analog vs. Digital

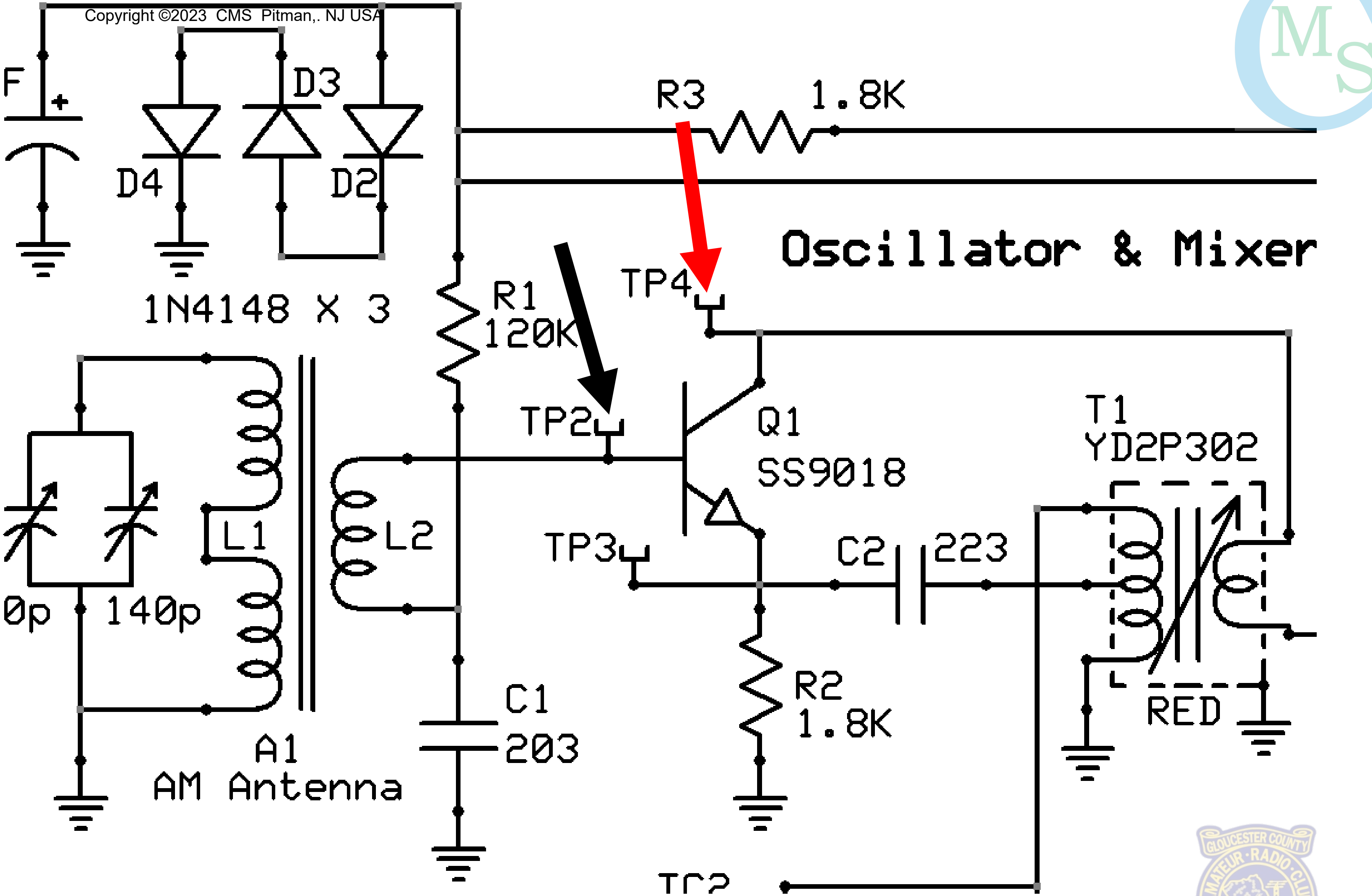
- When observing or looking for a trend, an analog meter is generally better suited to the task than is a digital meter.
- If looking for specific value accurate to *x* decimal places, a digital meter is better suited to the task than is an analog meter.
- When using an analog meter, beware of parallax error…
  - Purpose of the mirror behind the sweep needle

Voltmeters

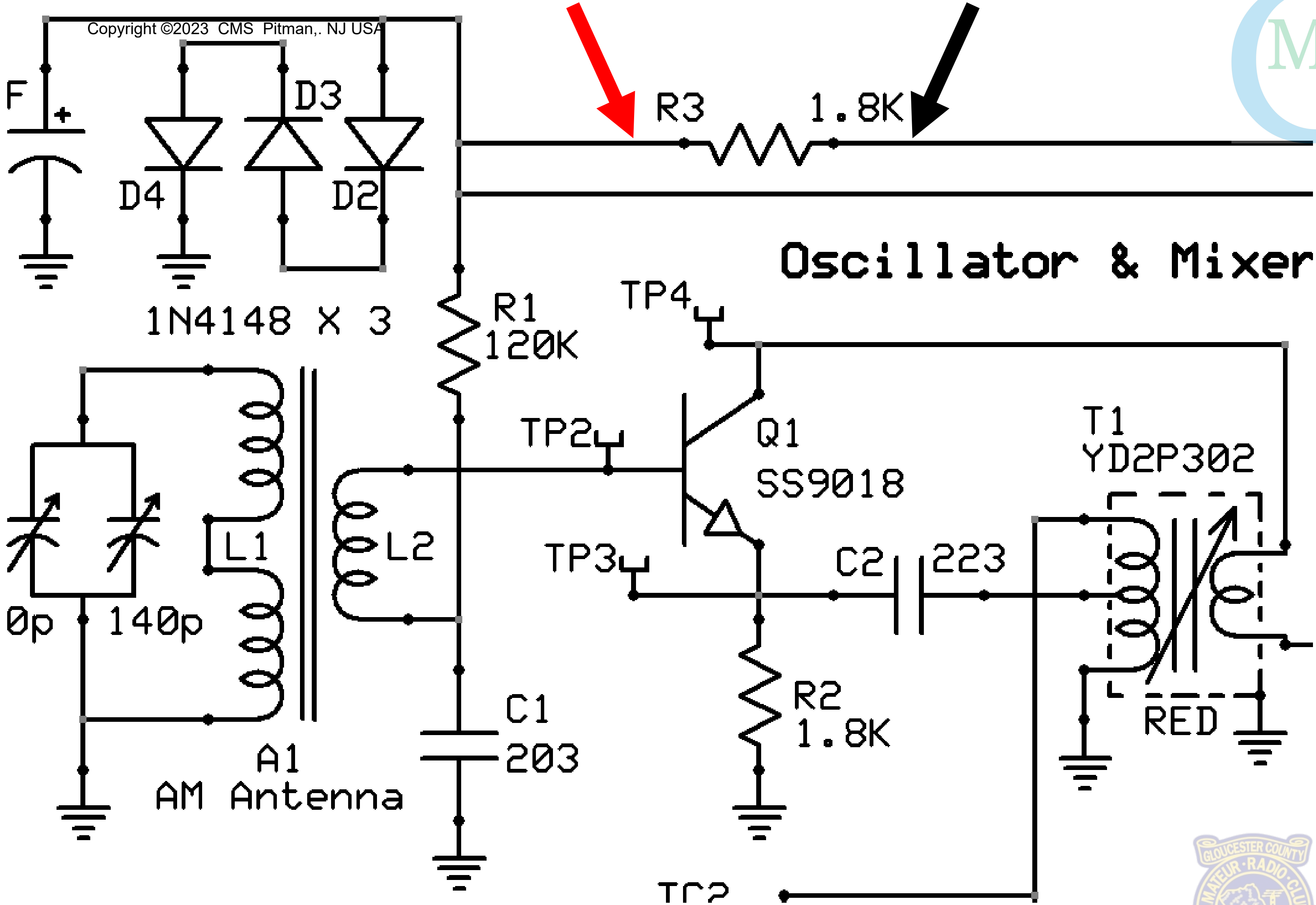
- Voltmeters are connected between two points in the circuit
  - Measuring the difference in potential between those two points
- Voltage is frequently measured with respect to ground…
  - One lead on chassis, and the other at the point of interest
- Voltage is also measured across a given component
  - One lead at each end of the component



Measures voltage at Q1 Base with respect to ground…

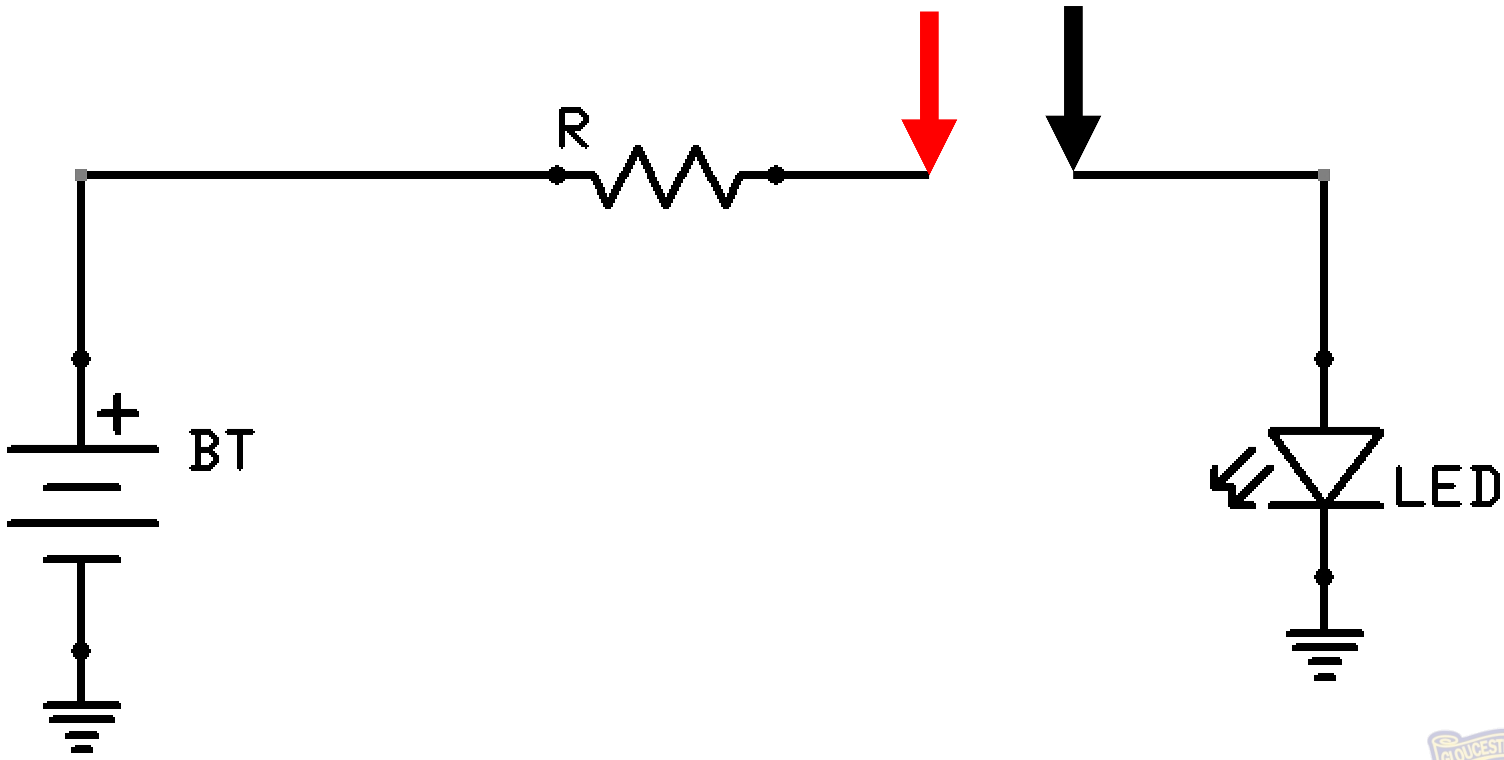


Measures voltage across Collector-Base junction…



Measures voltage across 1.8KΩ resistor R3…

Ammeter



Measures current through series circuit…

Ammeter as Diagnostic Tool

- Having the equipment to measure current draw – a capable ammeter – can also be useful for diagnostics.
  - Suppose you have a radio that you suspect is not transmitting at all. You can somewhat verify that premise through the use of an ammeter.
  - Connect the ammeter to measure the current drawn by the radio – *e.g.,* on the incoming DC power line and note the current drawn in RX mode.
  - Key the mic and watch the current draw.
  - If it does not increase at all, or increases by an almost imperceptible amount, you can conclude that the radio is in fact NOT transmitting.

Ammeter Usage

- An ammeter must be placed in series with the circuit or branch under test.
- Ammeters are polarity-sensitive – the + lead goes to the more positive side of the circuit.
  - Voltmeters are polarity sensitive too – though many digital meters today will read a negative value if connected backwards
  - A voltmeter is a calibrated ammeter under the skin…

Method of Halves

- When tracking down a fault, another useful method is the “method of halves”.
- Suppose you are troubleshooting a radio with a “dead” receive function – no sound at all comes from the speaker.
- After eliminating the simple and obvious things like a volume level adjustment or a headset jack with a plug in it, we have to dig into the circuit.

- Armed with the schematic and a board layout diagram, we can check the power supply voltages to be sure that all power supplies are operating.
- Next, using a signal generator, we can inject a 1 kHz audio tone (sine wave) into the audio circuit at the wiper of the volume control potentiometer.
- If we hear the tone in the speaker, we can safely assume that circuit is intact from the volume control downstream to the speaker, meaning that the fault lies somewhere upstream of (or before) the volume control.

- Consulting the schematic or the block diagram, select an accessible point roughly half way between the antenna connection and the volume control, and move the signal generator input to that point.
- Again, listen for the tone in the speaker.
  - If the tone is not heard, the fault lies between that point and the volume control.
  - If the tone is heard, the fault lies somewhere upstream of that point.
- Continue splitting the remaining circuitry in half like that until you have narrowed the fault location to the smallest possible area.

- Once you have narrowed down the fault location to the smallest possible segment, it is time to begin working at the component level.
- At this point, some critical thinking is due.
  - Apply reason to the problem, looking at the various remaining components in the fault area.
    - As an example, if a signal injected just after a capacitor can be heard, but that same signal injected just before the capacitor cannot be heard, the chances are good that the capacitor is open
    - If operating voltages are missing, look for possible failed electrolytic or tantalum capacitors – especially in older equipment.
    - If operating voltages are abnormal, look for shorted coupling capacitors before suspecting resistors.
    - Look carefully, under a bright light and a magnifier, for failed solder joints.

- If your equipment is older (read *"antique"*), and if it uses carbon composition resistors like the one shown below, don't be at all surprised to find the resistor values to by widely divergent from their nominal values.
  - These resistors are notorious for value changes as the resistors age.
  - Replace them with a modern type.

- Also, if the piece of equipment uses any wax and paper capacitors such as that shown at right, they should probably be replaced just as a matter of course, as they are well past their “best by” dates.

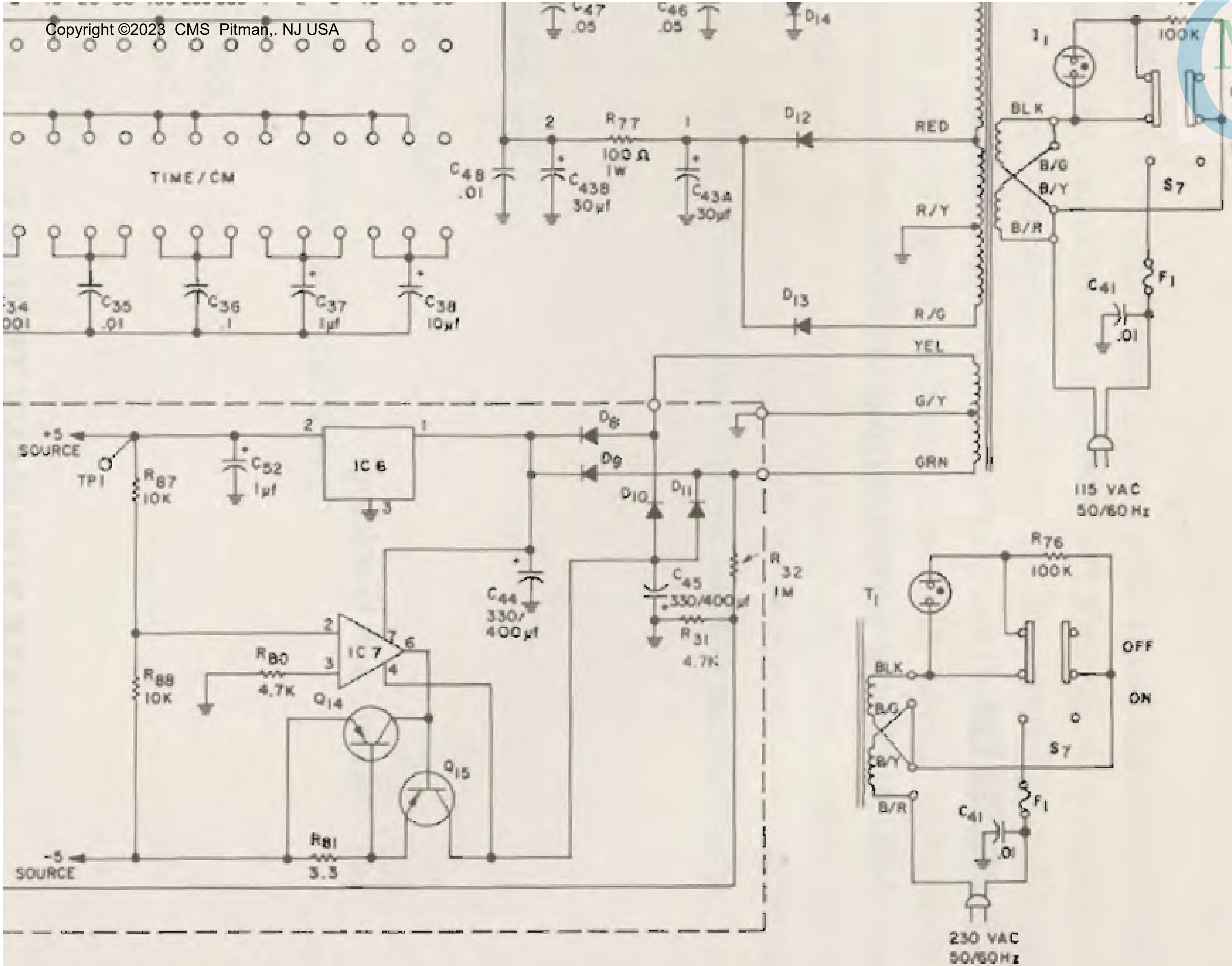
- These are best replaced by modern metallized plastic film capacitors.

- If you have any older capacitors that are marked with “OUTSIDE FOIL”…
- It makes a difference how the replacements are installed in the circuit.
- The outside foil or shielded end should be connected to the lower impedance side of the circuit – usually to ground.
- This is because the outside foil provides a shielding effect for the capacitor, preventing it from picking up stray signals, shunting them to ground instead.

Case History #4

- Time for the last repair story…
- This time, the equipment was an analog oscilloscope, an old Conar Model 255.
- This scope is a kit-built 6MHz CRT ‘scope from the mid- to late-1970’s.
- The failure indication was the lack of a trace, though the (neon) pilot lamp illuminated and the CRT filament lit up.

- The next slide shows the relevant portion of the unit schematic diagram.
- A quick check of the operating voltages showed that the +5VDC source was missing.
- Investigation of the +5VDC regulator, IC6 (LM7805) showed that the input voltage of +12VDC was present.
- This leads to either one of two places… IC6 itself, or a short after the regulator IC.
- Looking at the schematic, the most likely components after IC6 are R67 and R68, a pair of 10K resistors, or C52, a 1µF electrolytic.


TIME/CM
C35 .01
C36 .1
C37 1µf
C38 10µf
C48 .01
C43B 30µf
R77 100 Ω 1W
C43A 30µf
D12
D13
D14
C47 .05
C46 .05
RED
R/Y
R/G
YEL
G/Y
GRN
BLK
B/G
B/Y
B/R
I1
100K
S7
C41 .01
F1
115 VAC 50/60 Hz
+5 SOURCE
TP1
R87 10K
C52 1µf
IC 6
D8
D9
D10
D11
C44 330/400µf
C45 330/400µf
R32 1M
R31 4.7K
IC 7
R80 4.7K
R88 10K
Q14
Q15
R81 3.3
-5 SOURCE
R76 100K
T1
OFF
ON
230 VAC 50/60Hz

- Measuring from TP1 (the +5VDC supply point) to ground with an ohmmeter showed a direct short.
- This meant that the problem was either C52, the 1µF electrolytic capacitor at the voltage regulator output, or the regulator itself.
  - R67 and R68 could reasonably be eliminated because *both* resistors would have to have been shorted, an unlikely occurrence.
- Removal and testing of the capacitor was easier than the IC, so that's what I pulled.

- It turned out that the capacitor was shorted, and replacement of the capacitor restored operation of the +5VDC supply and thus the ‘scope.
- *However… due to the fact that the capacitor was shorted, and although the IC is overload-protected,* I went ahead and replaced the voltage regulator IC anyway.
- It was cheap – at fifty-nine cents – insurance against a repeat failure in a short time, as the regulator was surely stressed.

Conclusions

1. Troubleshooting *does not* have to be complicated.
2. Most faults can be tracked down with a little bit of investigation and some application of logic or reasoning.
3. Some component types are more prone to failure than are others.
4. Not all short circuits will blow fuses!


Any
Questions