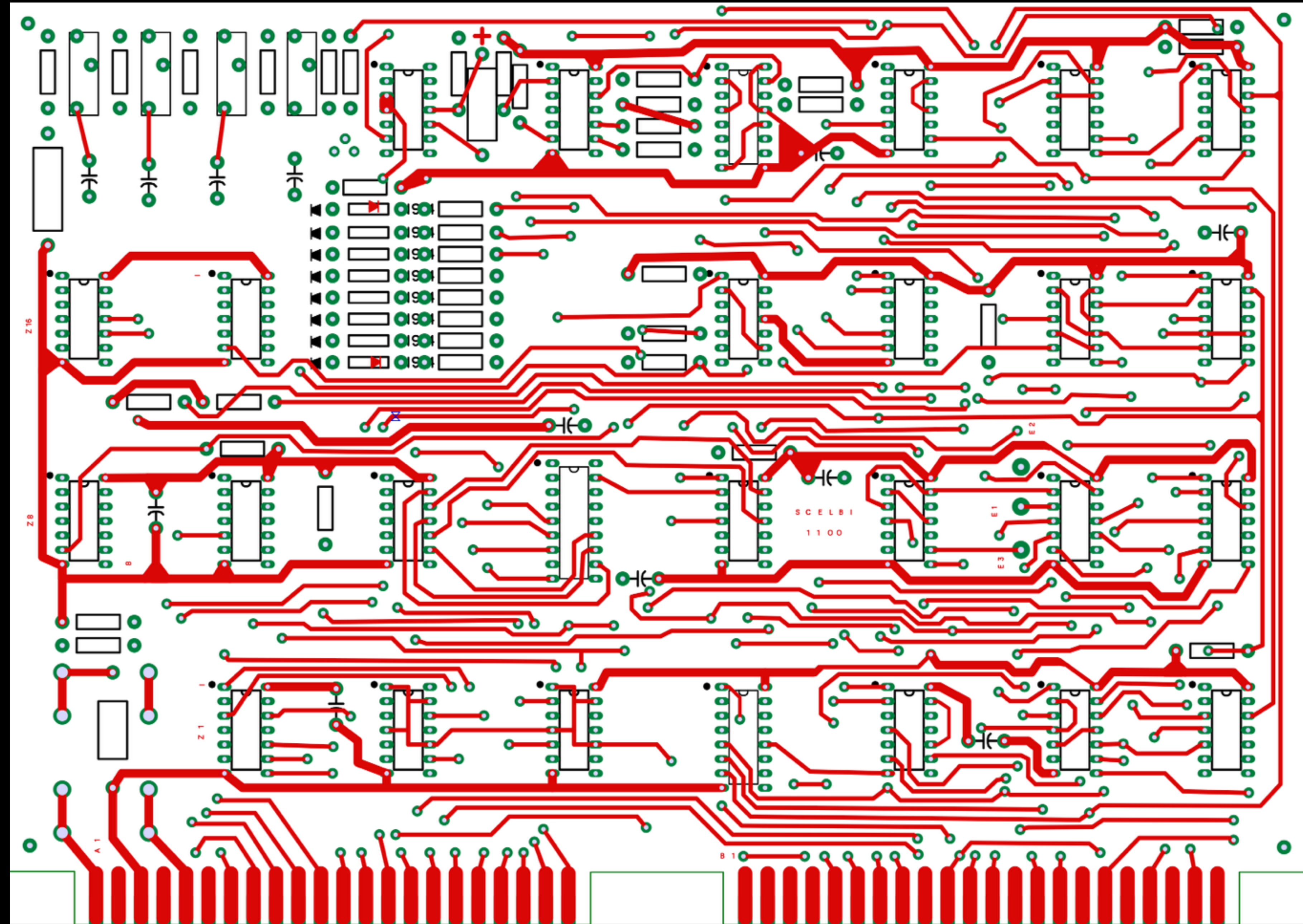


# Electronics Repair 101

Mike Willegal  
VCF east 9.1

SCELBI  
CPU  
LAYOUT



# Safety

- Remove metal jewelry
- When around high voltage, don't create a potential circuit from the high voltage to ground that might pass through your body
- A clean workspace
- Plenty of bench area

# Essentials

- Tools
- Knowledge
- Time/Patience
  - Put it aside for a while if you aren't making progress

# Tools

- Multimeter
- Oscilloscope
- Soldering iron
- Screwdrivers/wrenches/ect.



# Multimeter

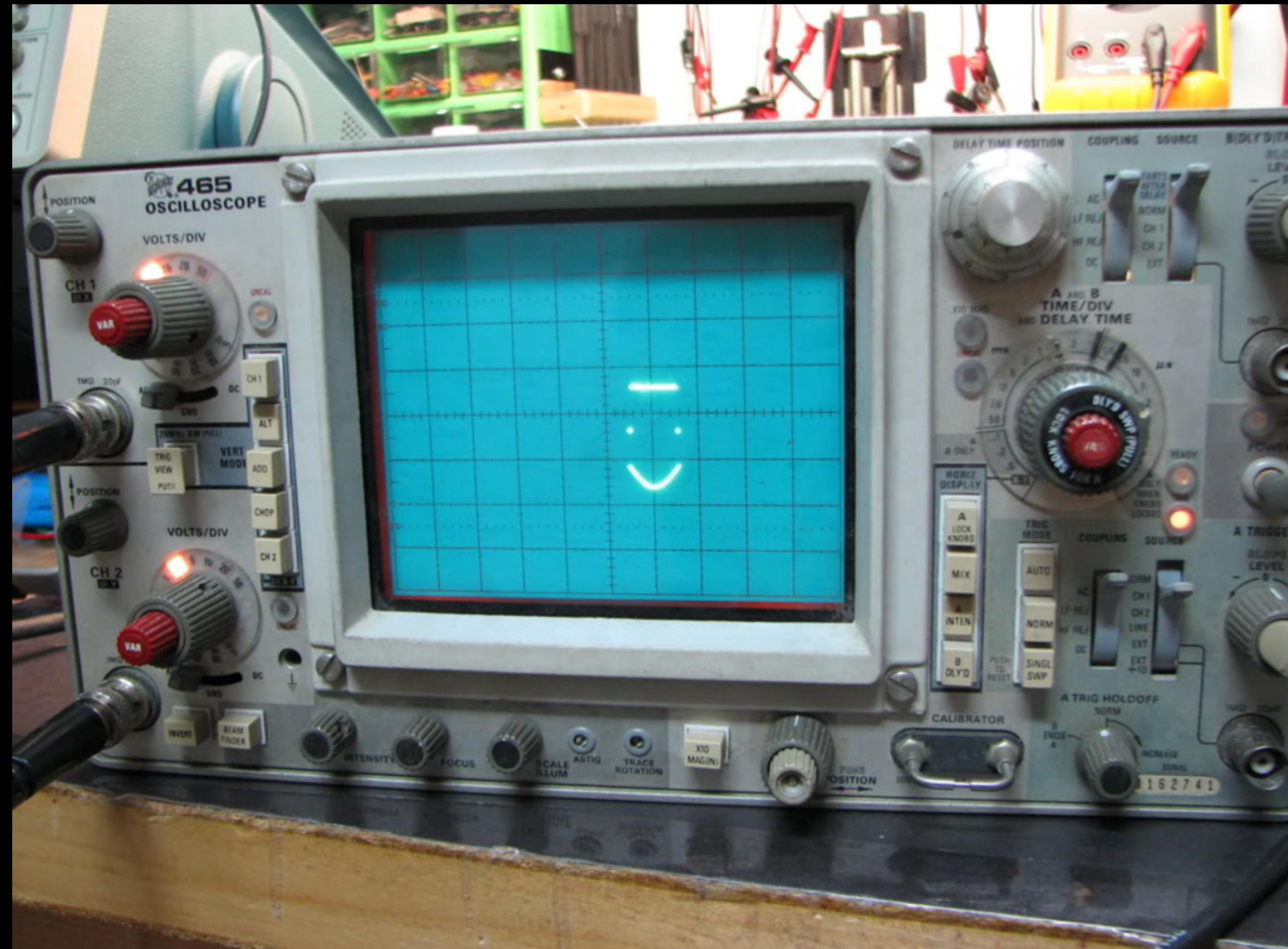
- High impedance input -10 megaohm minimum
- More digits/precision in ohms mode useful for tracking down shorts
- Quality probes helpful





# Oscilloscope

- 100MHz or higher
- 2 or more channels
- Newer digital can be easier to use
- Older analog may be less expensive





# Soldering Iron

- Temperature controlled
- Changeable tips



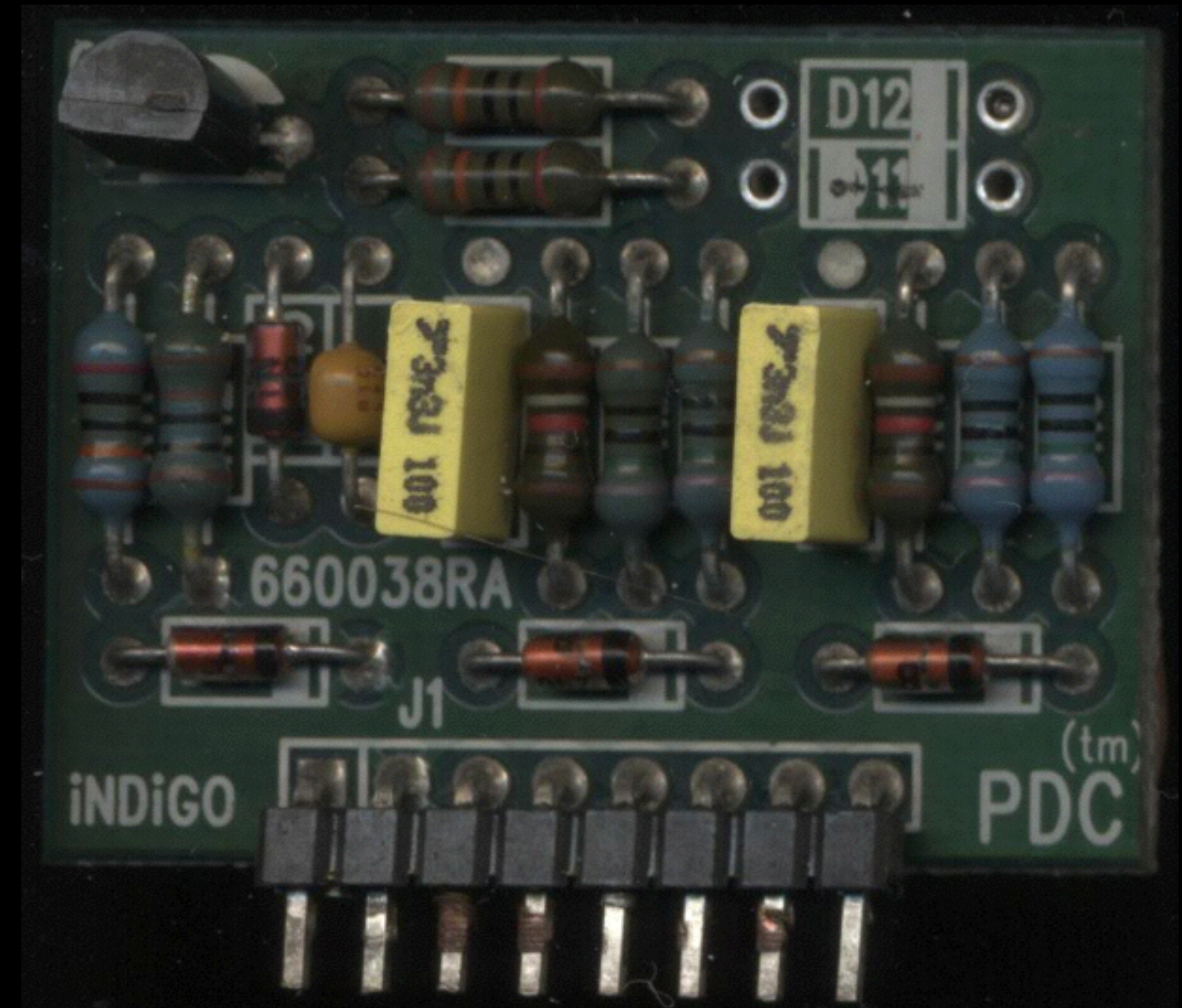
# Assumptions

- Connectors can degrade or fail
- Components can degrade or fail
- Cables can degrade or fail
- Start with the idea that the design is “correct”



# Case in Point

- My 4th subwoofer fails in 15 years
- Power FETransistors failed
- Replaced - failed again immediately
- Removed DIAC and tested with specially created test circuit
- Finally found issue



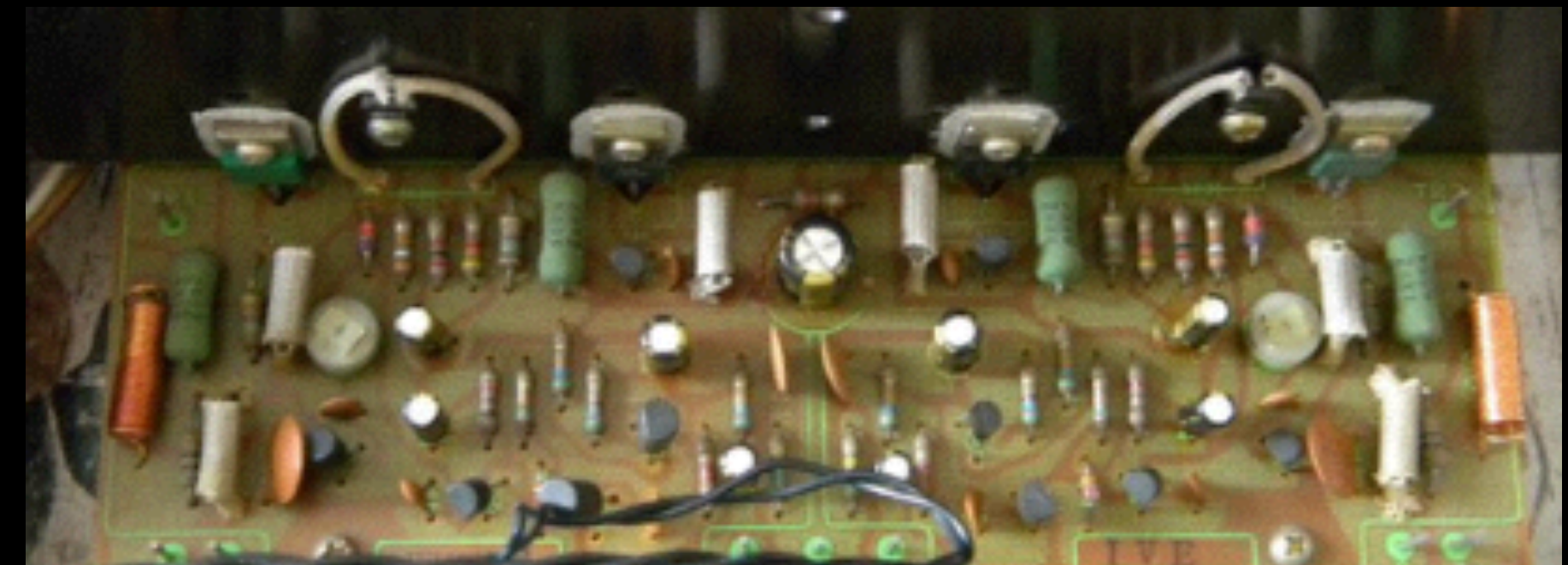
# Steps

- Research
- Check power supplies
- Look for obvious damage
- Check for hot parts
- Look for bad connections
- Compare duplicate/parallel circuits
- Component level troubleshooting



# Comparing Duplicate/Parallel Circuits

- Examples:
  - Working system of the same type
  - Individual Lines on a Bus Should Appear Similar
  - Duplicate Circuits (stereo)



[eetimes.com](http://eetimes.com)

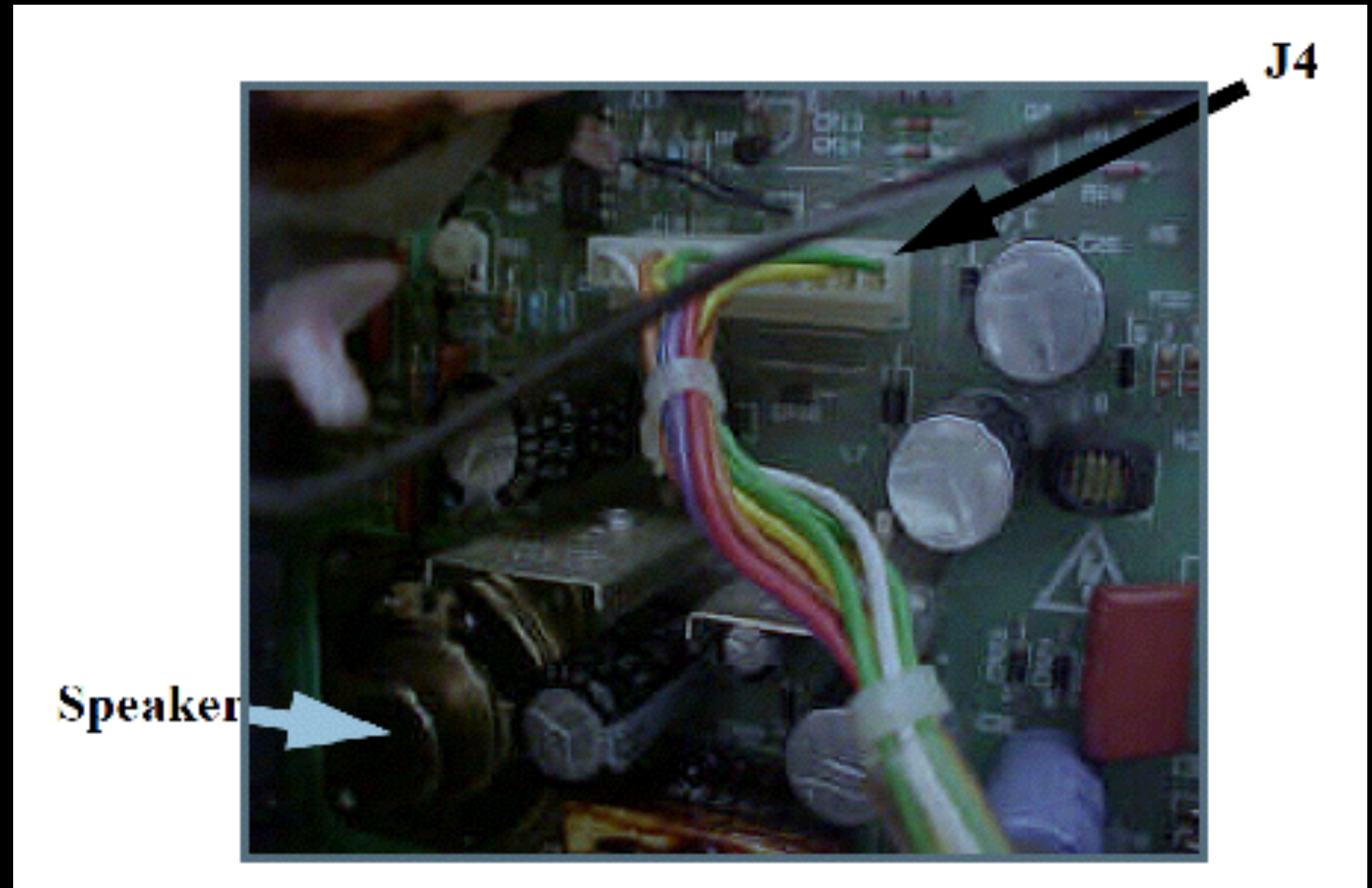
# Research

- The Internet is your friend
  - Wrong answers probably outnumber right answers
- Manuals/Schematics
- Might find exact same problem and solution
- Might find similar, but different problem
- Might not find anything comparable
- Component knowledge can be more useful than system knowledge



# Macintosh 128K Intermittent Blank Screen

- Several sources describe common problem with bad solder joints on J4 on analog board
- Wiggling cable showed that the problem seemed likely to match
- Tried re-soldering several times to no effect
- Finally determined problem was actually connector on digital board



# Components

- Integrated Circuits
- Capacitors
- Transistors and Diodes
- Resistors

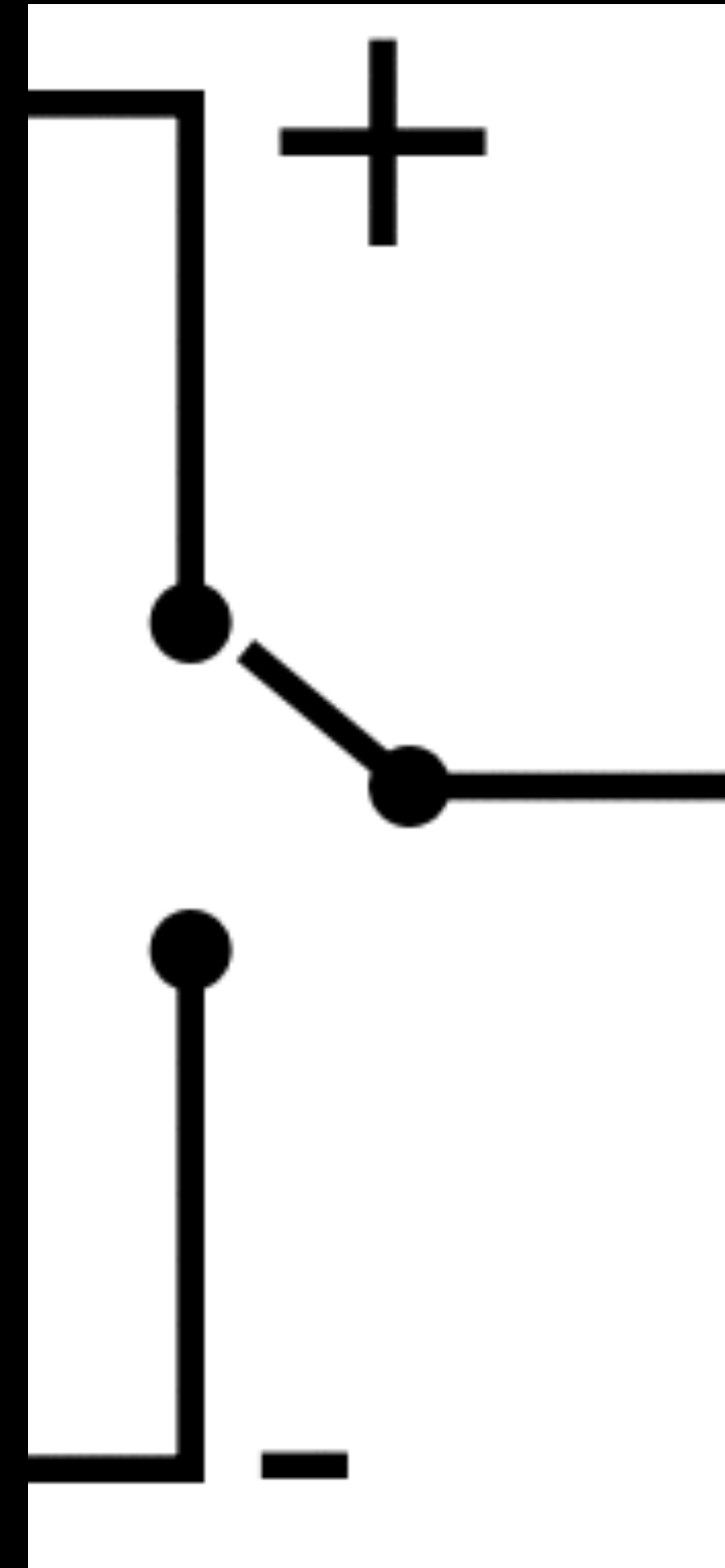


# Integrated Circuits

- Logic types
  - normal TTL
  - open collector
  - tristate
- When you detect a bad signal with a lot of parts connected to a bus
  - lift transmitters leg and recheck signal on lifted leg and receivers

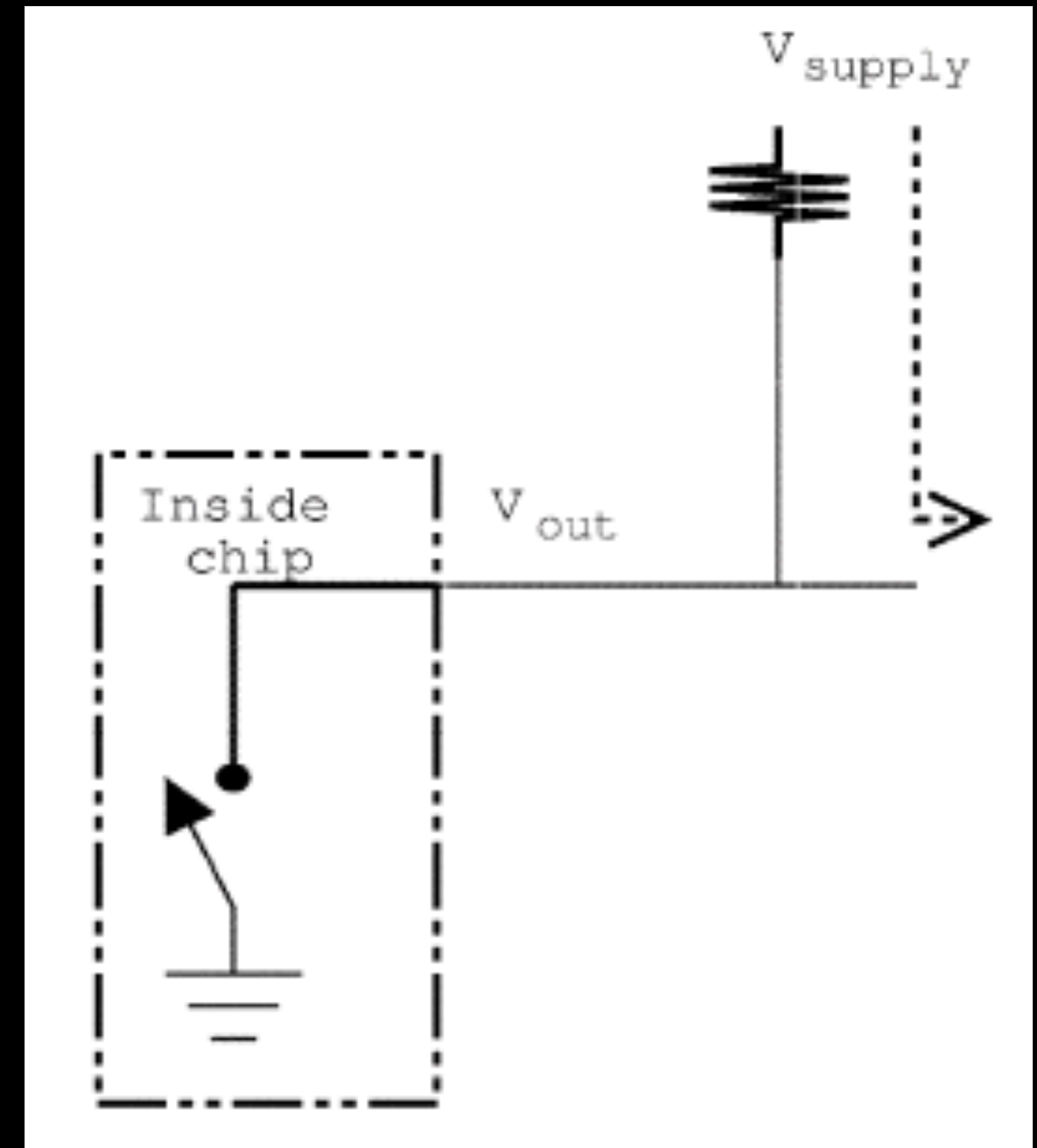
# Normal TTL Output

- One transmitter
- One or multiple receivers
- Common failure mode - transmitter fails, signal will float at around 2 volts
- Receiver can also fail and prevent source from driving signal to correct level
- Shorts and opens on PCB can also disrupt signal integrity



# Open Collector Output

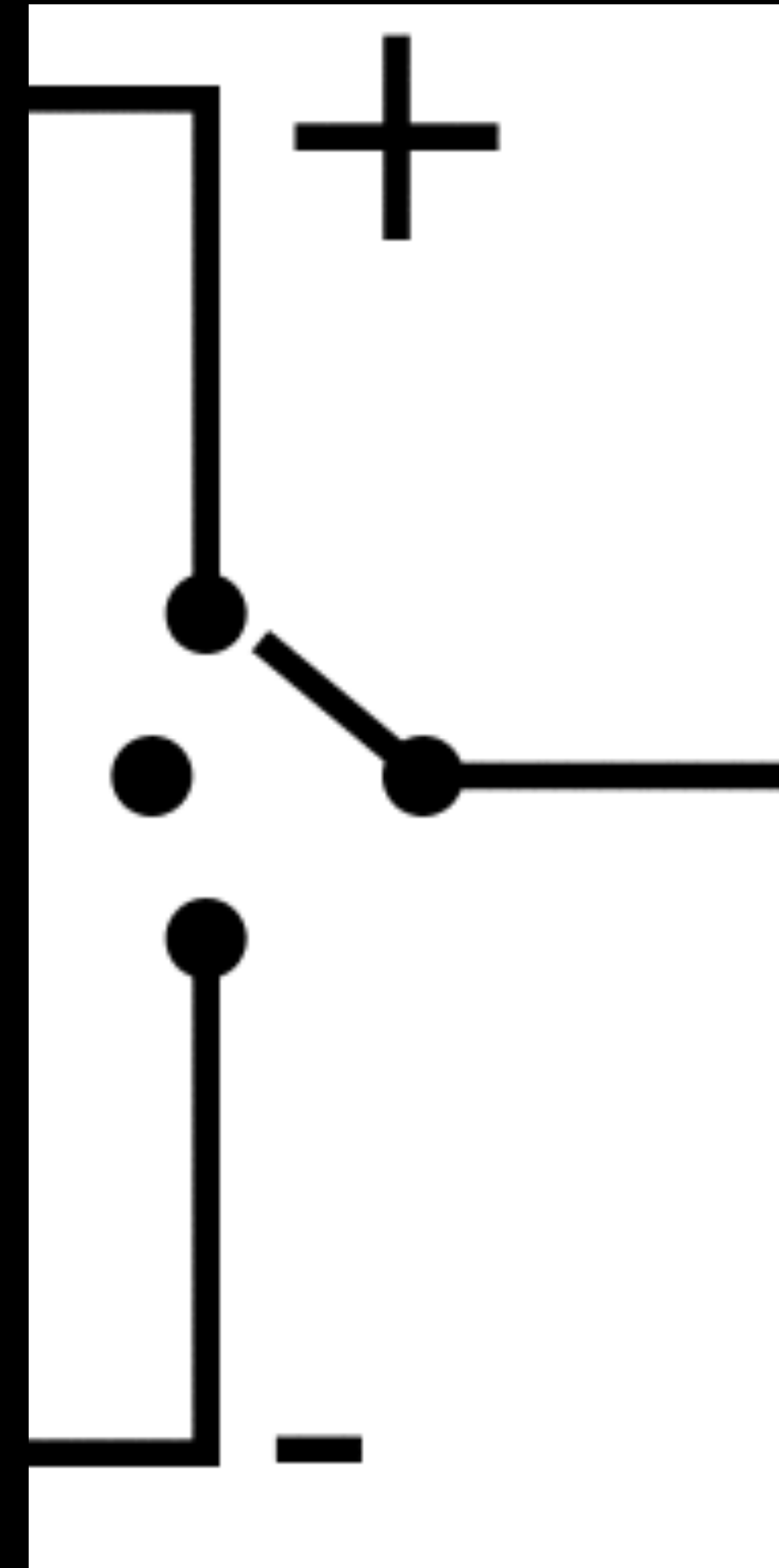
- Multiple transmitters
- Multiple receivers
- Uses an external resistor tied to power supply to set default signal to high
- Outputs will drive signal down to indicate low state
- Multiple outputs on same or different ICs can be connected to same signal
- Will not “float” unless resistor is bad
- Shorts or opens on PCB can also disrupt signal integrity





# Tristate Output

- Multiple transmitters used on “busses”
  - three states high/low/off
- Multiple receivers
- Frequent failure mode - transmitter fails, signal will “float” at around 2 volts
- Receiver can also fail and prevent source from driving signal to correct level
- Transmitters can fight, looks similar to float
- Shorts and opens on PCB can also disrupt signal integrity



# Capacitors

- Capacitors
  - Many types
  - Decouple power planes (often ceramic usually small values)
  - As small sources of power (usually larger value electrolytic)
  - In RC timing (in combination with resistors)

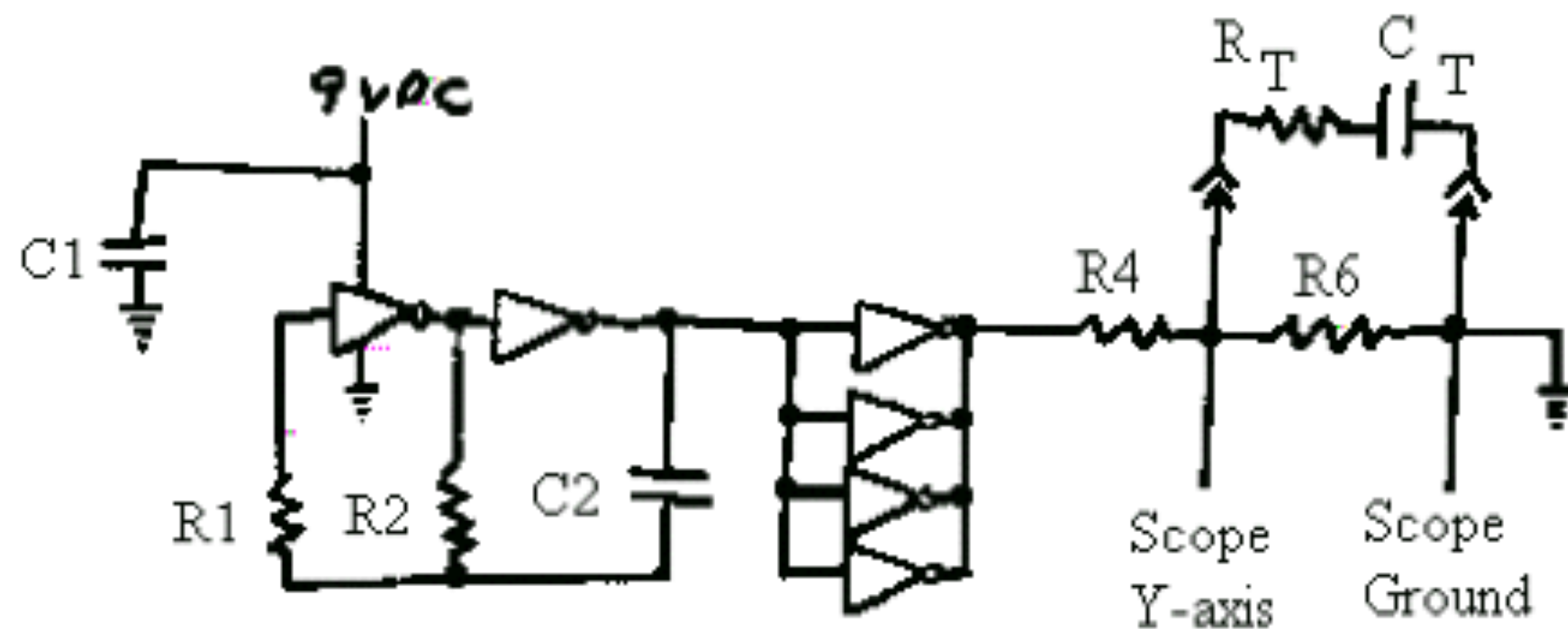
# Capacitor Failure Modes

- Capacity Degrades
  - ripple on power rails
  - timing off
- Internal Short
  - in power circuits, often results in physical damage



# Testing

- Capacitance - many multimeters can test capacitance
- ESR (equivalent series resistance)
  - ESR can be tested with an oscilloscope and a 555 timer or a CMOS 4049
  - [http://members.ozemail.com.au/~bobpar/99\\_Cent\\_ESR.pdf](http://members.ozemail.com.au/~bobpar/99_Cent_ESR.pdf)



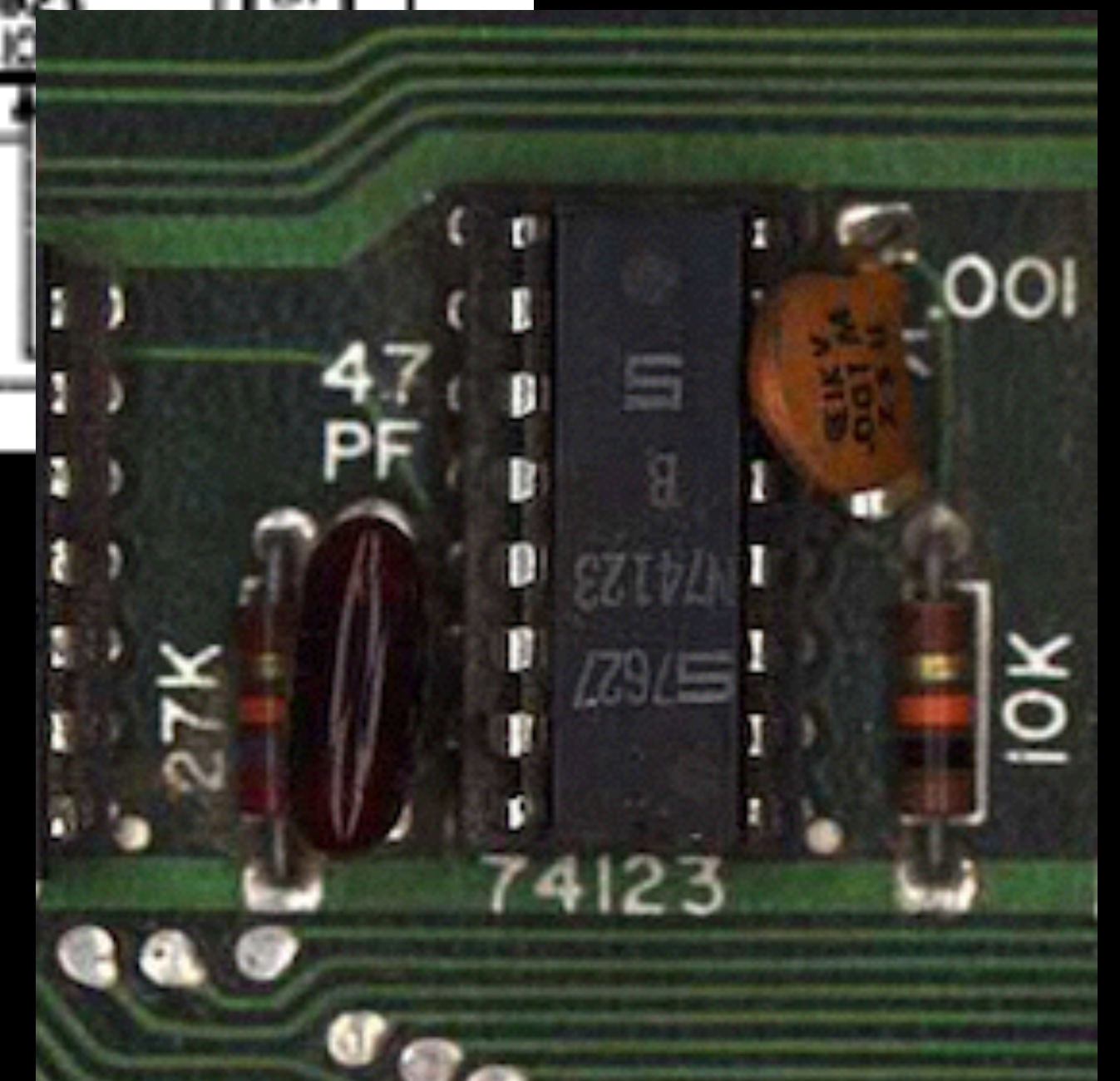
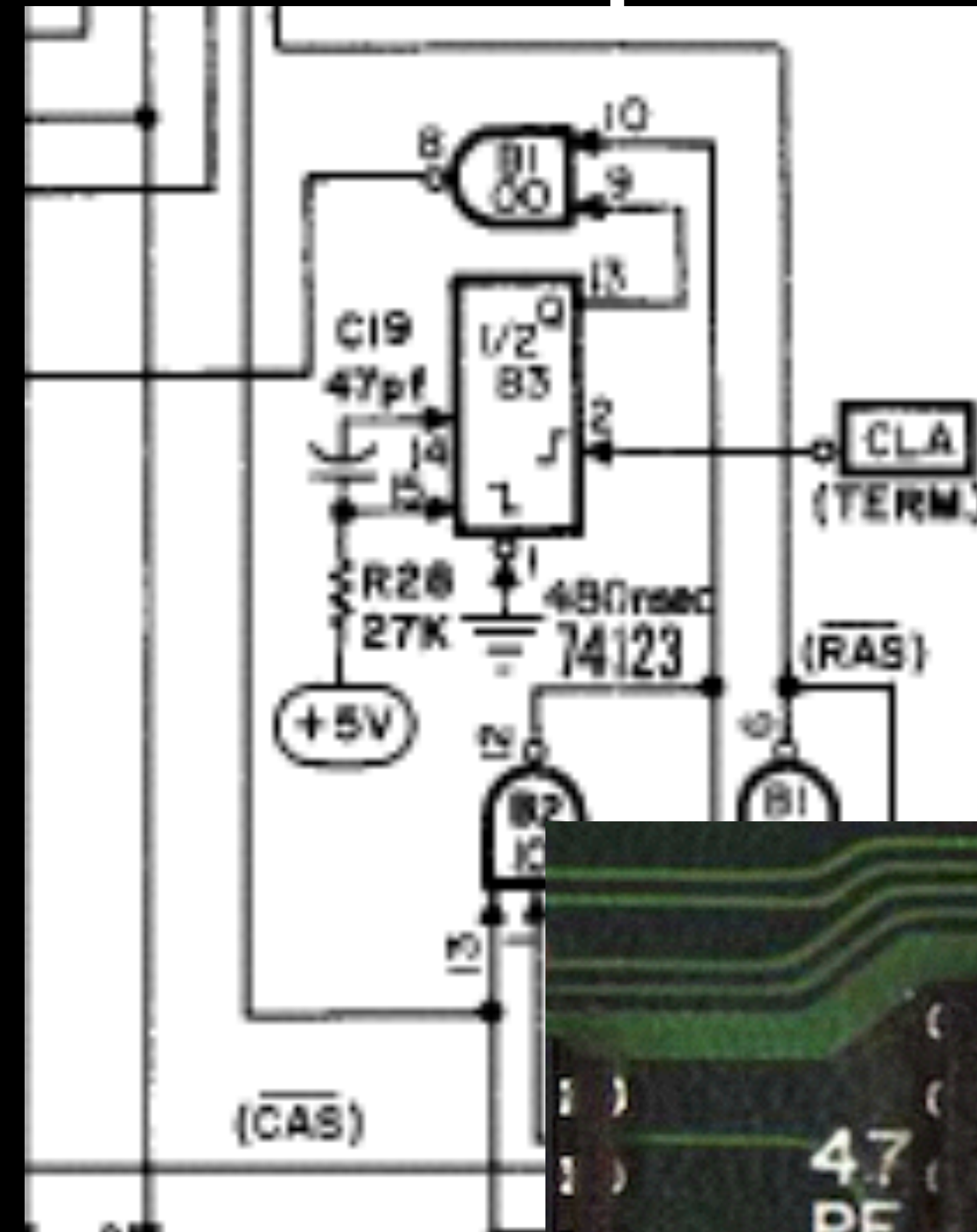
Simple Version of ESR Scope Adapter

## Bread Board parts for 100 kHz

- IC 4049 Hex Inverter
- R1 10K
- R2 1.6K
- R4 700 ohm
- R6 5 ohm
- C1 1uF
- C2 1nF
- $C_T$  Capacitor Under Test
- $R_T$  ESR

# Marginal Cap Example

- Apple 1 intermittent DRAM test failure
- First checked all signals going to/from 6502 and DRAM for integrity
- Determined RAM timing off do to 74123 one shot circuit not generating correct 480 nsec pulse do to out of spec 47pF mica capacitor



# Transistors and Diodes

- Bipolar transistors are essentially back to back diodes
- Check with DMM diode check function
  - Instructions: <http://www.vetco.net/blog/?p=184>
- FET type transistors checked differently
  - Simple sanity check: <http://www.utm.edu/staff/leeb/mostest.htm>



# Resistors

- Rarely fail when used within spec
- When they do fail, they will normally show it
- Color code for value and tolerance
  - <http://www.digikey.com/us/en/mkt/calculators/4-band-resistors.html>

# Replacement Components

- If possible, replace with exact type
- Save broken part and document if you have a rare collectors piece
- “A”, “B”, or “C” revision parts usually work, but not always
- DRAM and CPU component speed important,
  - Faster is often OK



# Component Sources

- Digikey, Mouser, Jameco
- Unicorn Electronics
  - <http://www.unicornelectronics.com>
- Surplus vendors
  - Minimum quantities
  - May need to generate a purchase order
- Donor systems



# Sometimes it is a Long Forgotten Design Issue

- Apple 1 cassette interface
  - <http://www.willegal.net/appleii/aci.htm>
- Apple II rev 0 video flagging
  - <http://www.willegal.net/appleii/applesync.htm>
- Brain Board Ground
  - <http://www.willegal.net/blog/?p=1880>

# Questions?

- This document posted to:
- [www.willegal.net/appleii/troubleshooting](http://www.willegal.net/appleii/troubleshooting)