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# GameRoom

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Rob Craig's

# Tales of the Silverball


## Fault Analysis: The Art of Tracking Down Pinball Problems

Rob Craig, hard at work repairing a pinball board

Never before has there been so much advice on how to restore or maintain a pinball machine. But no matter how much advice a person gets, it doesn't always translate into productive work on the machine. With those who have never had a basic electronics course (whether classroom or study-at-home) or some months of practice, the intuition of knowing what is working and what isn't working rarely exists. I've always found that there is a point in everything where you lose motivation and become quite counterproductive. Not knowing some basic fundamentals really frustrates rookies in electronic repair. Unless your free time resembles that of a retiree, you probably find a point when you're ready to throw in the towel. Hopefully this short article will help.

I need to point out that this article is simply a brief overview into a much deeper study in fault analysis and electronics repair as it relates to electronic computer controlled pinball. It is impossible to do anything more within the confinement of a few pages. Still, I bet you'll find something here to hold onto when you start to troubleshoot your next pinball problem.

Without going into all the nuts and bolts of every pinball system, you can pretty much summarize all solid state pinball machines as a collection of boards that interface with the systems CPU board. Knowing intimately what job they do helps speed up the process of narrowing down the problem. Advice that directs you to a particular portion of the system is usually helpful no matter what level of understanding you have about electronics.

### Breaking down the pinball machine

Zooming out a bit, let's start at the beginning with a look at the machine. What happens when you power on a typical solid state pinball machine? Power feeds through the line cord, into your switch and primary fuse, into a transformer which breaks down the voltage into usable levels (still alternating current). From there, most of it heads to a power supply where AC becomes DC, something that all integrated circuits (IC's) require. Supply voltages head to the 4 main systems in all pinball machines: the CPU board, the driver board, sound boards, & display drivers.

CPU boards (the brains of the system) have to kick everything off, right on time. A reset circuit starts the process of initializing individual sections within the CPU board. Usually game programs (stored in ROM chips) are checked, memory circuitry is tested (RAM chips), interfaces are reset and programmed (PIA's) for the switch matrix and lamp matrix, and finally the game specific program starts the attract mode.

The driver board usually contains all the switching circuits needed to trigger coils on the game and switch computer controlled lamps on and off. While in attract mode, the lamp driver transistors are busy handling orders from the CPU to make interesting waves of blinking lamps across the playfield. Once a game is started, the lamp drivers are still taking orders from the CPU as to what lamps to turn on or off, and the coil driver transistors are responding to more CPU orders to do things like reset drop targers, kickout balls in saucers, kickout a ball into the shooter lane, and open (or close) a mobile gate. Not all coils are CPU controlled and knowing which ones aren't can save you a lot of time looking in the wrong place for answers.

Sound boards are almost like their own independent computer. While some were quite simple – only generating belches and blurps, later boards contain large amounts

Left to right: Capcom CPU Board, Power Supply Board, and Sound Board

of compressed sound data that's mixed with FM generated tones, creating a very nice collection of sound. The complexity of any particular sound board is directly related to how easy it is to fix. I've repaired some of the earliest solid state sound boards in 5 minutes with simple electrolytic capacitor swapping, yet ran into hours of troubleshooting complex Williams DCS sound boards of the 90's.

Display drivers are similar to sound boards in that they can vary greatly from generation to generation. What was integrated into the CPU boards with early Gottlieb and Bally systems were not with early Williams systems. Again with latter DMD boards, Williams handled logic translations from the CPU through their dot matrix driver boards, while Data East / Sega / Stern / Capcom chose to dedicate a complete CPU driven board with it's own game specific ROM to draw DMD eye candy.

## Making Sense of It All

So how do you make troubleshooting and analyzing these various systems less complex? I've found that there is no complete substitution for real classroom electronics training and lab work. I seem to have gained a lot of permanent "memory burn in" on circuit analysis and simple component characteristics (resistors, capacitors, transistors, diodes, logic circuits, operational amplifiers, CPU characteristics) that would otherwise leave me only to the online manuals and advice of other pinball people.

Yet that advice and documentation is just the key to help anyone get up to speed and learn the ropes of pinball repair. Reading about other problems and their resolutions can keep you motivated even if plowing through schematic diagrams leaves you utterly disgusted.

Since this article can't ever be an exhaustive analysis on all things problematic in pinball, I'll hit general electronics fault analysis hard and hope that some of this will stick with you.

## Making Big Problems Out of Little Ones

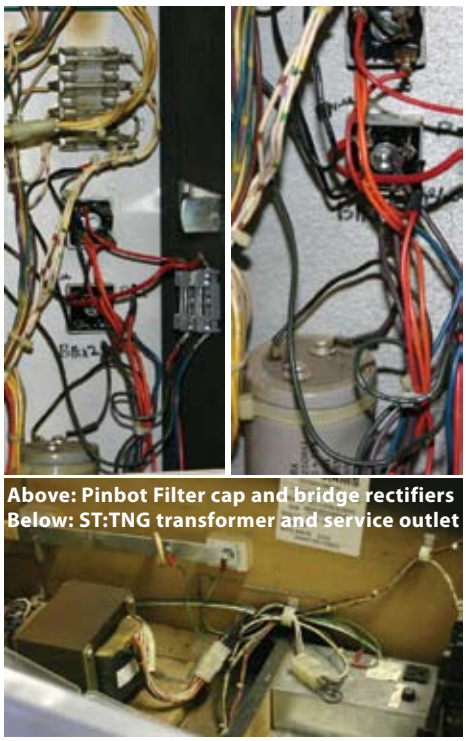
The way you analyze your pinball problems (and any electronic device) really should be a consistent, streamlined process. Think about what you already know about the system. While this will vary with everyone, it doesn't change the fact that most simple problems can quickly be inflated to monumental proportions in short time, simply by overlooking the obvious.

For example, I spent hours analyzing a Capcom CPU board, convinced that I had something that was locking up the program before it was totally up and running. I focused on that CPU board for days, learning all the quirky things that Capcom did differently than any other manufacturer. I then worked over the unique switch board, even replacing it with a NOS board only to find no solution.

After total frustration, I decided to recheck all of my power supply voltages. It turned out that the 12V opto supply was running about 3 volts low. Replacing capacitors in this area of the board fixed the voltage problem. Upon power-up, the machine completed its boot up sequence and was finally in attract mode. As tempting as it may be to blame Capcom for not allowing my game to at least report the lack of opto voltage as the problem, it was my own fault for not starting at the beginning with the fault analysis — I didn't analyze the entire system from the ground up.

## Simple Visual Inspection

Perhaps the hardest problem to locate is the easy fix that was overlooked. I have bought a lot of "left for dead" operator machines that I can't power up and test when I have to make the deal. When I get them into the shop, the first thing I do is spend a lot of time looking around inside. With visual inspection alone you can find all types of issues. Disconnected cables, missing PCB mount screws, bad repair work (note these as potential problems areas), wrong boards installed, missing boards, missing fuses, cut wires, shorted diodes on switches, stuck tilts, disconnected ground straps, missing coils, battery acid damage... the list goes on and on. Whether it's a dead machine that you bought cheap or a nice one that just quit working, you really



Above: Pinbot Filter cap and bridge rectifiers
Below: ST:TNG transformer and service outlet

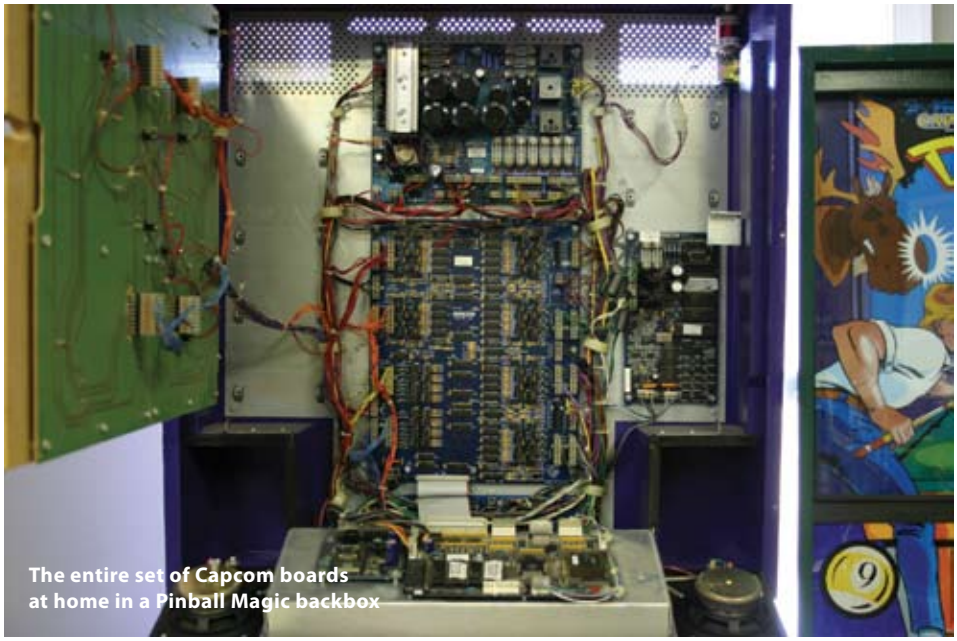
should do a visual first. Take your time and note anything that doesn't seem right. As your knowledge of the machine grows, your ability to quickly distinguish the obvious will get better and better.

## Starting from the Ground Up

Ground up analysis is very important. It's like an upside-down pyramid of sorts. In order to get the final result, all of the supporting systems must be functional. If any one system shows fault, the systems before it need to be analyzed. Translated into pintech, if your game is dead, start at the line cord and work your way up to the boards in the head. I would hate to hear about someone sending boards off for repair when their problem was a broken wire from their line cord or a blown line fuse. Yet I've assisted a few that have had this exact issue and had somehow turned the problem into a complete mess. From AC to transformer to power supply to system (CPU, driver, DMD, sound), keep focused on isolating the particular system that's at fault. When you have that handled, zoom in further into the specific area of that system that's failing. At minimum, you'll have expanded your own mental database of pinball electronics technology, and perhaps you'll reward yourself with the correct diagnosis and repair.

## Component Reliability

Electronic components have their own history when it comes to reliability. Silicon based components should be considered active devices. They include diodes, bridge rectifiers, transistors, and all IC's. With things switching on and off inside of these components, the opportunity for breakdown is high. The odds increase when you add higher voltages and currents. That's why you see coil driver transistors and bridge rectifiers dying earlier than almost all other silicon based components. Capacitors follow this same model. Although they don't contain a switching silicon element, capacitors are very busy charging and discharging. As a rule, the larger they are, the quicker the internal die-electrics breakdown. While small ceramic caps seem to last forever, larger electrolytic caps need to be checked for increasing ripple voltages. For CPU board voltages, dying capacitors are the leading cause of supply voltage drop. Resistors on the other hand rarely die on their own, being the least active of the bunch. Essentially converting electricity to heat, a resistor only seems to suffer from... (you guessed it) too much heat. You can see this in early Williams driver boards and Bally power supplies where the heat has either burnt off the component casing, or perhaps de-soldered itself from the board. While this is such a general overview, I admit that I've kept this component information tucked away since my school days. In the shop, it helps me make think a bit clearer about which component could be problematic.



The entire set of Capcom boards at home in a Pinball Magic backbox

## Wrapping It Up

While I'm tempted to drop another 10 pages into this topic, I realize that I need to wrap this up. So I'll end with perhaps the most important item. There is no greater tool in my shop than the Digital Multimeter (DMM). With this alone, you can check every fuse, transistor, diode, switch, and wire (to name the most common). Voltage inputs and outputs of power supplies can be checked against manuals or other documentation online. I've been through at least a dozen meters over the years, and I think every one of them came with a short manual on how to properly measure voltage, current, and resistance and how to test diodes and wiring and/or traces for continuity. That manual alone could be one of the most important first-steps for anyone wanting to learn more about pinball electronics.

Lastly, online documentation is better now than it's ever been. And there is no better site for exhaustive pintech education than Clay Harrell's Coin-Op Game Repair Guides site (www.marvin3m.com/fix.htm). Not only does Clay discuss problems and solutions, but there is an education inside that will help you learn how things work and why they fail. You should print out the guide that applies to your type of game, and write down plenty of notes as you work. GR

Rob always keeps a sharp eye out for pinball problems