**Turning on radio ProCabs / PowerCabs**

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December 9, 2007 (updated fix for older rev B and C ProCabs)

Overview

This paper will look into and explain why radio ProCabs / PowerCabs are hard to turn on. After explaining the cause of the problem a simple one resistor modification will be shown to fix the problem.

Problem Explanation

In order to explain what is going on one has to look at what is going on with the signals on the Estop key. The simplified schematic below shows a portion of the keyboard circuitry along with the radio board turn on circuitry.
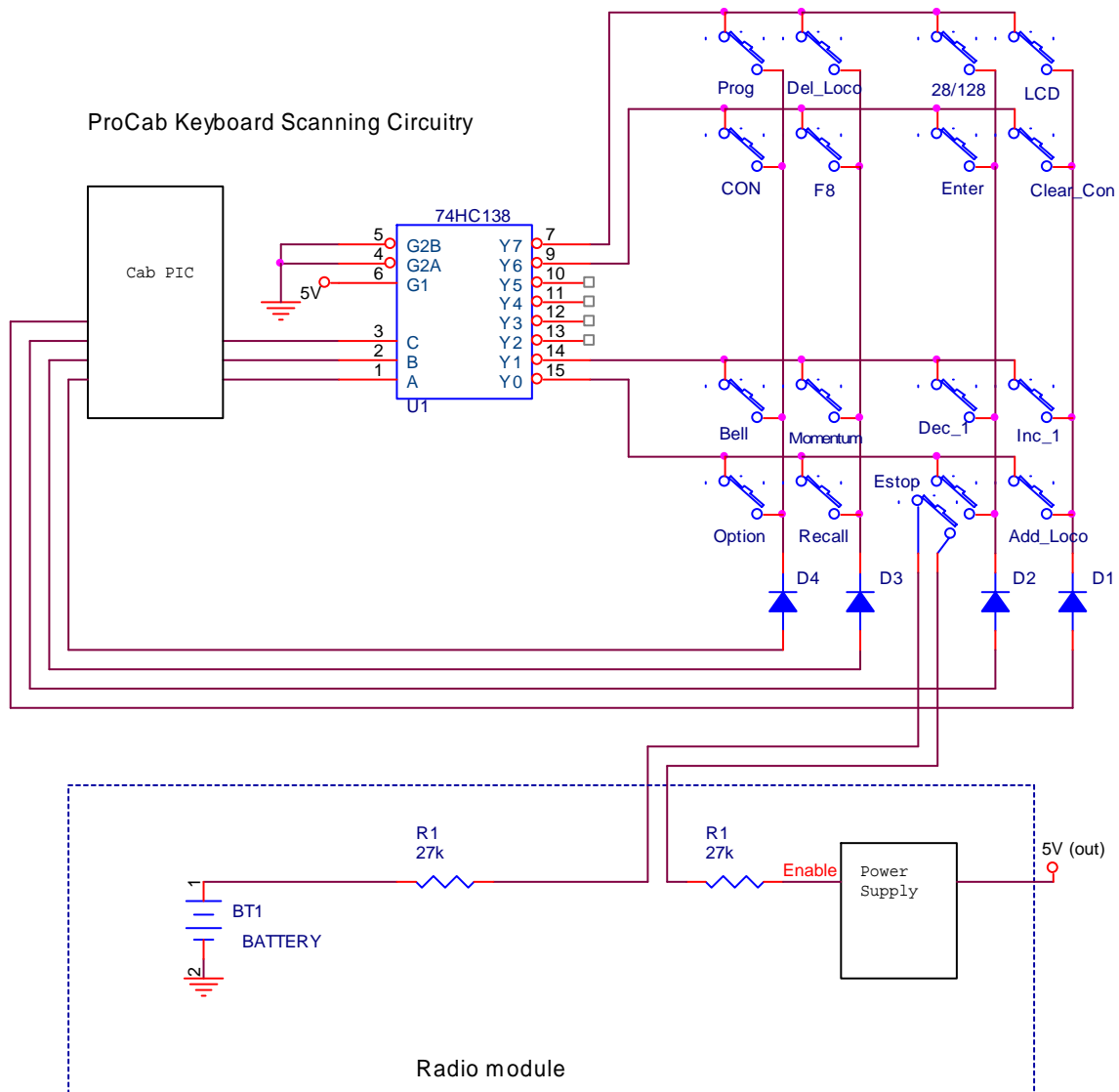
The schematic shows that the keyboard is electrically made of 8 rows and 4 columns of contacts that are scanned by the PIC processor in the cab. The keyboard is made up of 8 rows of keys and the PIC processor uses 3 address lines to access all of the rows. A 3 line to 8 line (74HC138) decoder sits between the PIC and the keyboard. As the PIC cycles through all the 8 addresses the corresponding output of the decoder will go low. For example if the row address from the PIC is 000 the Y0 output will be low and all the rest will be high. If the PIC outputs 111 then Y7 will be low and all the rest will be high.

Okay now let's look at how the radio board turns on in theory. Notice that the Estop key actually has four contacts. Two of these contacts are keyboard scanning contacts, and two of these contacts are separate and used to turn on power supply on the radio board module.

At the bottom of the schematic you can see that the batteries are connected to the enable pin of the power supply through two 27k series resistors and the Estop key. The idea of the turn on circuit is simple, when you press the Estop key the battery voltage is connected to the power supplies enable pin turning it on.

The power supply requires 0.9 volts minimum on the enable pin to turn fully on. The power supply actually starts to turn on at about 0.4 to 0.5 volts on the enable pin. When you have 0.4 to 0.5 volts on the enable pin the power supply will put out about 1.5 volts or so.

The Problem

The key to the problem is the Estop key and its contacts. As long as the key scanning contacts stay isolated and separate from the turn on contacts everything works as it should. Unfortunately all four contacts are connected to each other when one presses straight down on the Estop key. This is where the rocking the key comes in, as you rock the key to the 3 o'clock position on the ProCab, or the 6 o'clock position on the PowerCab you connect the turn on contacts by themselves and the cab turns on.

So the question is why doesn't it turn on when you connect all four contacts together. Well obviously one of the key scanning contacts is a lower resistance and it is dragging the voltage down so that the power supply never sees the 0.9 volts it needs to turn on.

Now let's look at the key scanning contacts on the Estop key. There are two key scanning contacts, the one connected to the row, and the one connected to the column. All the column contacts have isolation diodes on them so no current will flow into that contact.

That only leaves the row contact, and the row contact that connects to Estop is connected to Y0 of the 74HC138 decoder. Note that this corresponds to address 000 into the decoder.

Okay now let's look at the startup condition before the cab turns on. Every thing in both the cab and radio module is sitting at 0 volts except for the battery voltage going to the

power supply and the battery voltage going to the Estop key through the 27k series resistor.

The problem lies in that everything doesn't start up at the same time when the power supply starts to turn on.

Here is the sequence of events:

1. One presses straight down on the Estop key.
2. The battery voltage is applied to the enable of the power supply and the Y0 output of the decoder.
3. Because of the two 27k series resistors the current is limited and the voltage on the enable pin ramps up over a short finite time.
4. As soon as the enable voltage reaches 0.4 to 0.5 volts the power supply starts to turn on and puts out somewhere around 1.5 volts.
5. This 1.5 volts is applied to the entire 5 volt supply rail including the 74HC138 decoder. The decoder is CMOS and will start to run even at these low voltages.
6. The PIC processor has a voltage reset circuit and will not run at this low voltage so the voltage on the three address lines to the decoder is 0 volts, or 000 in binary.
7. Since the address to the decoder is 000 its Y0 output goes low and pulls down the voltage on the enable key.
8. Now it just sits here in this quasi on/off state as the power supply enable pin never sees the 0.9 volts it needs to turn on. As soon as it starts to turn on the decoder turns on and the Y0 output of the HC138 pulls the enable voltage low.
9. So to get it to turn on you end up rocking the Estop key back and forth to get the turn on contacts touch each other without touching the contact that is connected to Y0 of the decoder.

So the basic problem is that the decoder's address lines are at 000 before the PIC processor wakes up, and the lines need to be anything other than 000 to keep the enable voltage from being drug down.

To fix the problem a 10k to 100k pull-up resistor can be added between the 5 volt supply rail and any one of the three address lines. The pull up resistor will set the decoders address to something other than 000 when it is waking up. As soon as the voltage turns on, the PIC processor will start up and drive the address lines as it always does. The value of the resistor is high enough that it will not affect the PIC's ability to drive the lines.

The Simple Fix

A simple one resistor addition will fix the turn on problem so the radio ProCab, or PowerCab will turn on all the time when the Estop key is pressed.

Before I go on to describe the fix I should point out that the fix involves soldering a small surface mount component and this should only be attempted by those skilled in soldering small components. And as with any modification to the cab this may impact your warranty status. *Proceed at your own risk!*

Newer style ProCabs and PowerCabs (Part No. 10157, Rev. A through E)

On the newer style ProCab and PowerCab boards the fix is neat and clean. See the two photos below:
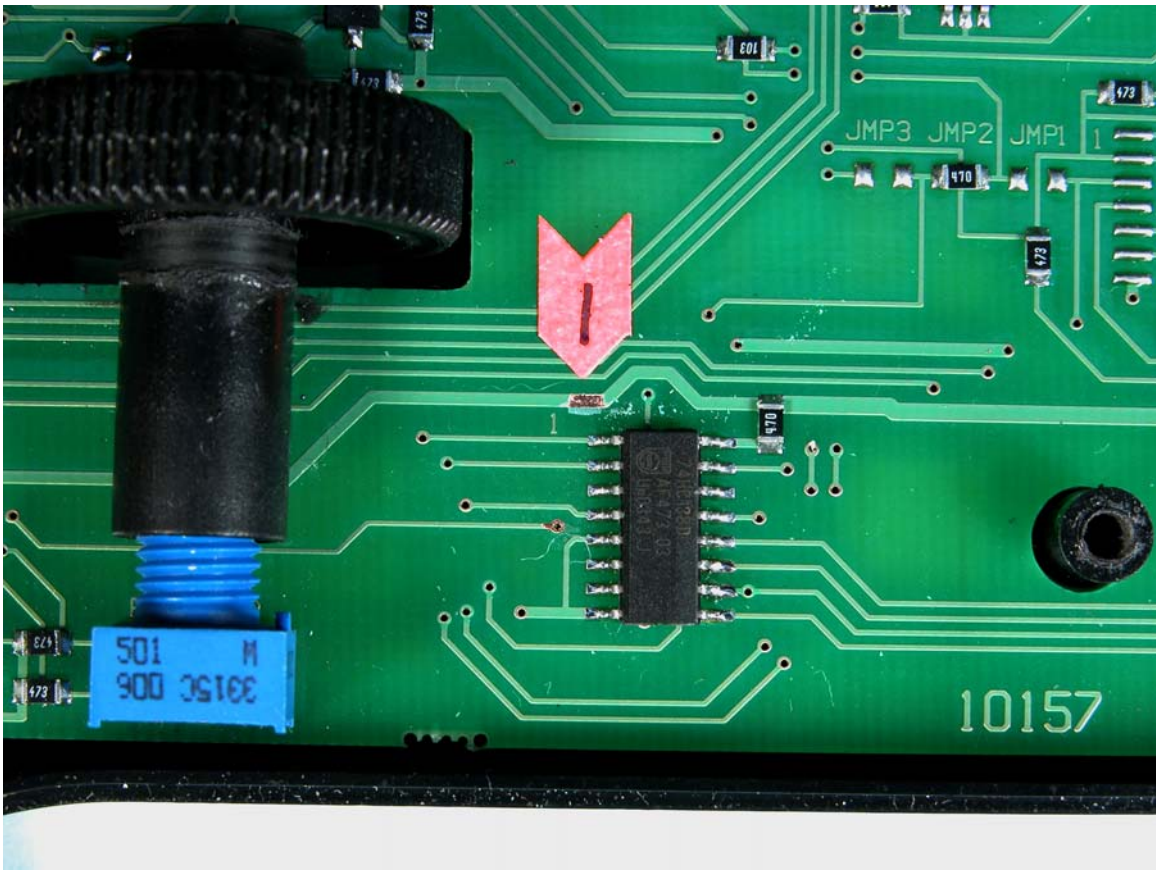
This photo applies to a current radio ProCab or a PowerCab, this portion is the same on both cabs. The 74HC138 decoder is the black chip in center of the picture. The rework will connect a resistor between 5 volts and pin one of the decoder.

The first step is to take a sharp Xacto knife and carefully scrape off the green soldermask from the 5 volt trace as shown above at the tip of the orange arrow.
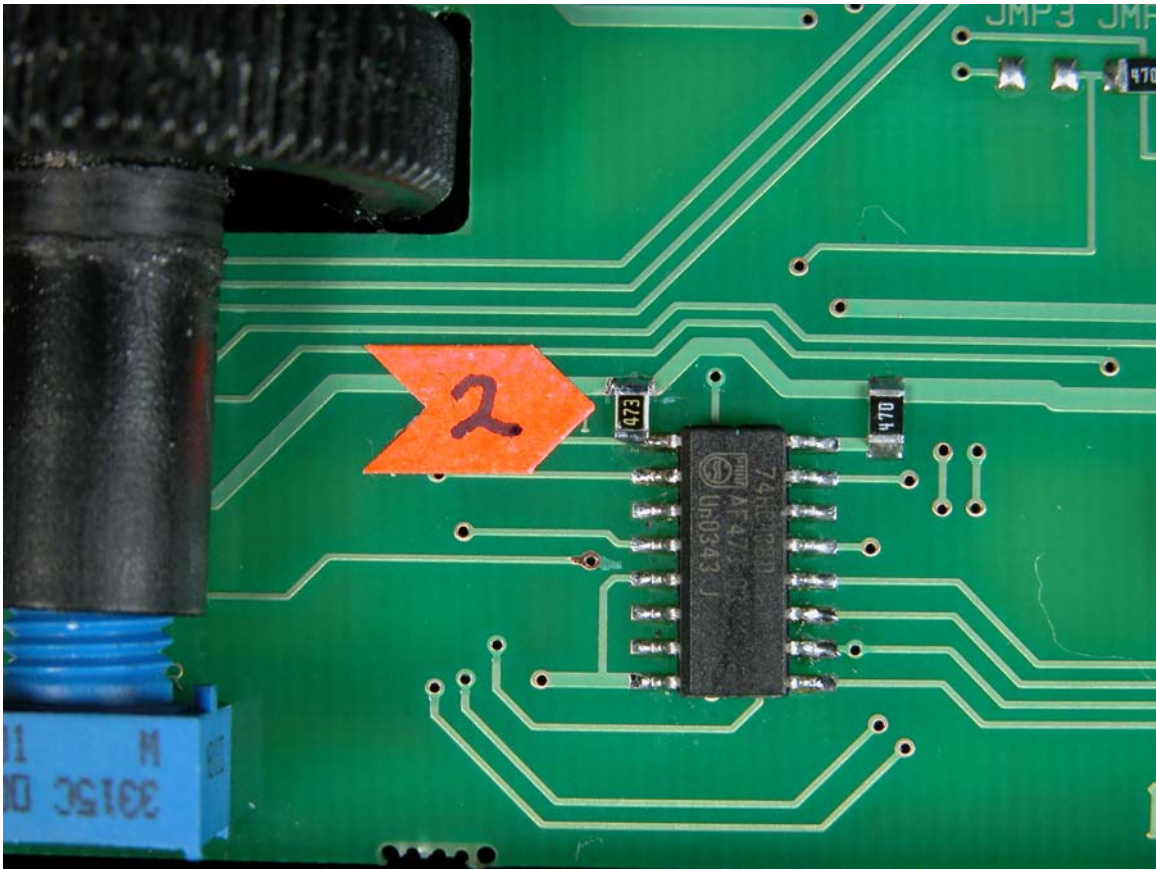
Next carefully solder a 0805 size chip resistor between the 5 volt trace and pin one of the 74HC138 decoder. This photo above shows a 47k resistor that I soldered in place. The ideal value is about 47k, but anything in the range of 10k to 100k will work fine.

That's it you're done, the cab will now turn on every time as this resistor is sets the address to 001 at turn on, so output Y0 will be high and the enable voltage will be allowed to go to 5 volts.

Older Style ProCabs (Part No. 10050, Revision B & C PC boards) (updated fix)

The circuit board on the older ProCabs (with the radio cable connection at the bottom) is a different layout so the physical implementation of the fix is different. On the 10050 printed circuit boards there are some unused part pads that can be used to make the fix nice and clean. See the photos below:
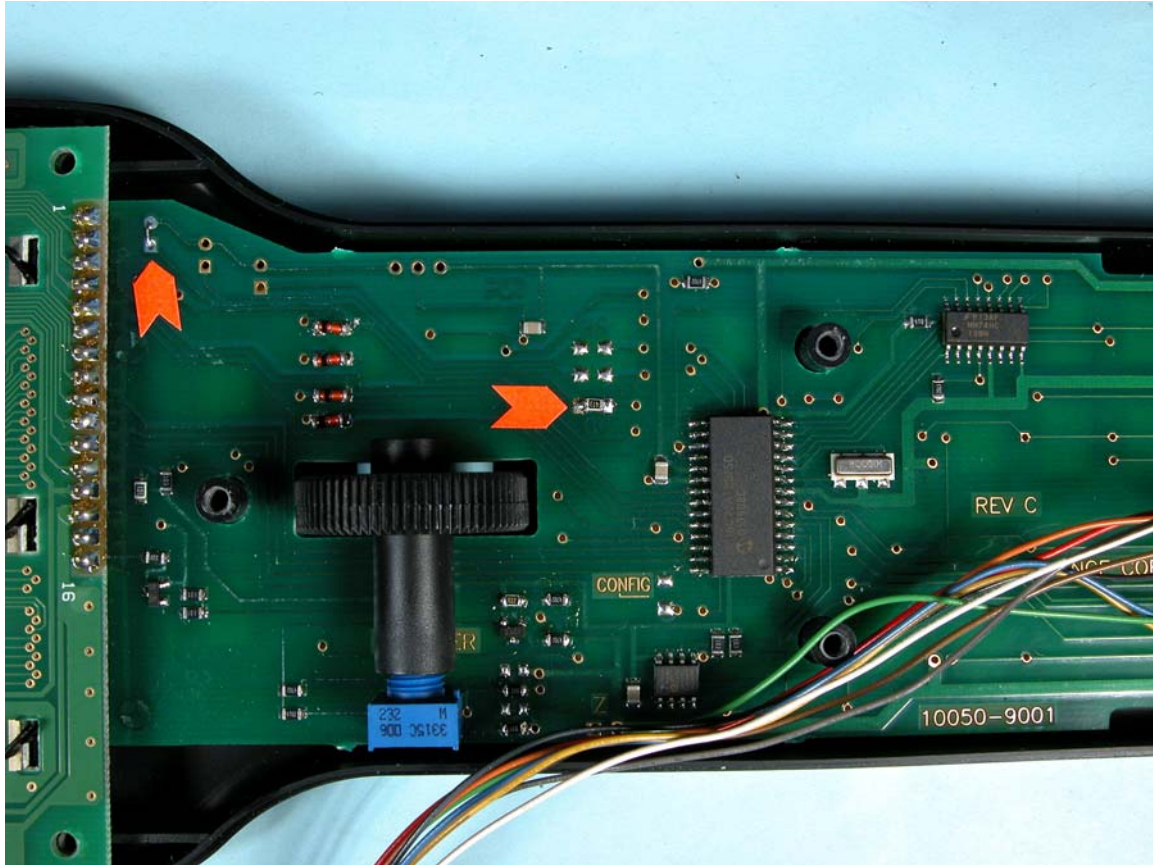

The photo above shows the fix installed in a revision C ProCab. The orange arrows show the location of the pull up resistor (orange arrow on the right), and the location of a jumper wire to connect to 5 volts (orange arrow on the left).

Electrically this is the same fix as pin 1 of the decoder is connected to one (right pad) of the pads where the resistor is installed, and the jumper connects 5 volts to the other (left) pad where the resistor is connected.
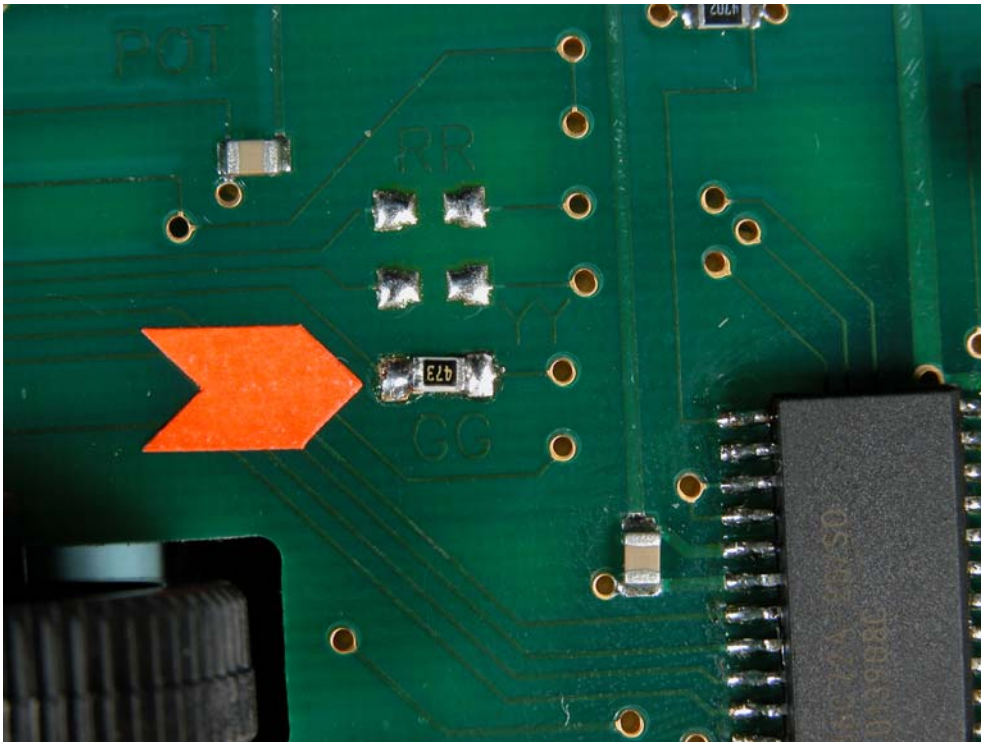
Step 1: Install a 0805 size chip resistor in location "GG" as shown above. The value of the resistor should be in the range of 10k to 100k. The photo above shows the 47k resistor that I have installed.
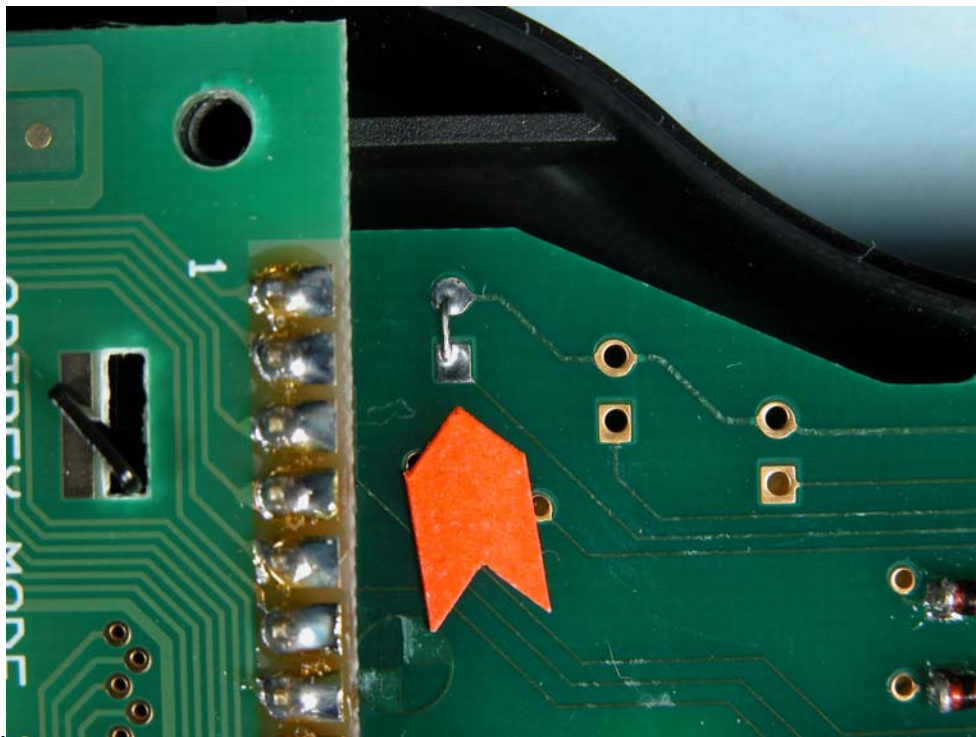
Step 2: Solder a short jumper wire between the pair of holes as shown above.

That's it you are done, now just reassemble your cab.

Conclusion

The problem with the radio ProCab turn on is really because there is an undefined state on the address lines of the 74HC138 decoder. This decoder drives one set of the contacts on the Estop key. Most of the time the decoder sees a 000 address at start-up enabling its Y0 output which essentially shorts the power supply enable signal to ground. This leaves the cab in a quasi on/off state and it never wakes up.

By adding a pull up resistor on one of the decoder's address lines the address selected at turn on is something other than 000 so the Y0 output is high, and this allows the enable signal to turn on the power supply.