

The PA1HFO PIN Diode Attenuator for the Drake TR-7

Objective

A couple of years ago, Mark van Stralen (PA1HFO) published a paper in which several TR7 improvements were described. In this paper, I document my implementation of one part of Mark's project – the PIN Diode Attenuator.

After replacing the bad final transistors in my PA stage a while back, I found that it was impossible to get reasonable output on 10 meters without the PA oscillating in some cases on 40 meters. The only way around the problem was to reduce the pre-driver gain pot on the PA brick to a point where the output on 10 meters was around 60-65 watts. I also found it bothersome that the PA brick gain varied widely from band to band, necessitating fiddling with the Carrier control on the TR-7 with each band change. Mark's solution to these problems was a PIN diode-based attenuator (placed in the RF feed to the PA brick) which sensed the TR-7 bandswitch position and provided an individual adjustment to control the signal level fed to the PA for each position of the bandswitch.

The Bandswitch Dilemma

While the solution addressed my needs perfectly, implementing it was not as simple as I'd first thought. For one thing, the original schematic was just about unreadable and the method of sensing the bandswitch position was not documented. Emails to Mark didn't reveal how that was accomplished. The design required that one input of the attenuator be grounded for each position of the TR-7 bandswitch. I wasn't able to find anywhere on the TR-7 motherboard where the needed ground was available, but I did find that a couple of the TR-7 bandswitch wafers were used to produce a four bit BCD value for each position. The TR-7 service manual describes how the Digital Control Board uses that BCD value by decoding it to a decimal value, and then uses that value to send the proper signals to the synthesizer for each band. I needed a way to duplicate that logic using only pins on the motherboard.

The solution was to use a SN7445 BCD to Decimal decoder IC on the attenuator board to duplicate the decoding done on the Digital Control Board. The BCD value is picked off at Digital Control Board pins 1, 2, 3, and 4 on the motherboard and routed to the new PIN attenuator board with a four-wire cable. This IC is very inexpensive (25 cents) and is capable of switching the 12V leads in the attenuator to ground.

How The Attenuator Works

The design uses a pi attenuator with three PIN diodes. The PIN diodes function as resistors in this network, with their resistance value controlled by varying the forward bias on all three diodes. The bias is derived from a set of 8 identical transistor pairs that provide a bias voltage to a common buss depending on the setting of 8 small pots. The bandswitch position is decoded and the resulting value selects one of the 8 transistor pairs with the other pairs being essentially disabled. So, the pi attenuator can be set for a different level of attenuation for each band by adjusting the appropriate pot. That allows you to set up the TR-7 for maximum output on the 10 meter band, and to reduce the signal fed to the PA on the other bands to avoid over-driving the PA stages.

A Second Benefit

I can now adjust the pre-driver pot to provide maximum output on 10 meters and set the ALC pot so that the ALC LED just comes on as the maximum power is reached. I can also set the Carrier level control at one point and leave it there on every band. To achieve that, I set the Carrier knob position for 10 meters (where the LED just comes on), and then adjusted each of the attenuator band pots so that the ALC LED just came on. Note that I used single-turn pots, and these provided very smooth and easily controlled setting of the attenuator.

Photos

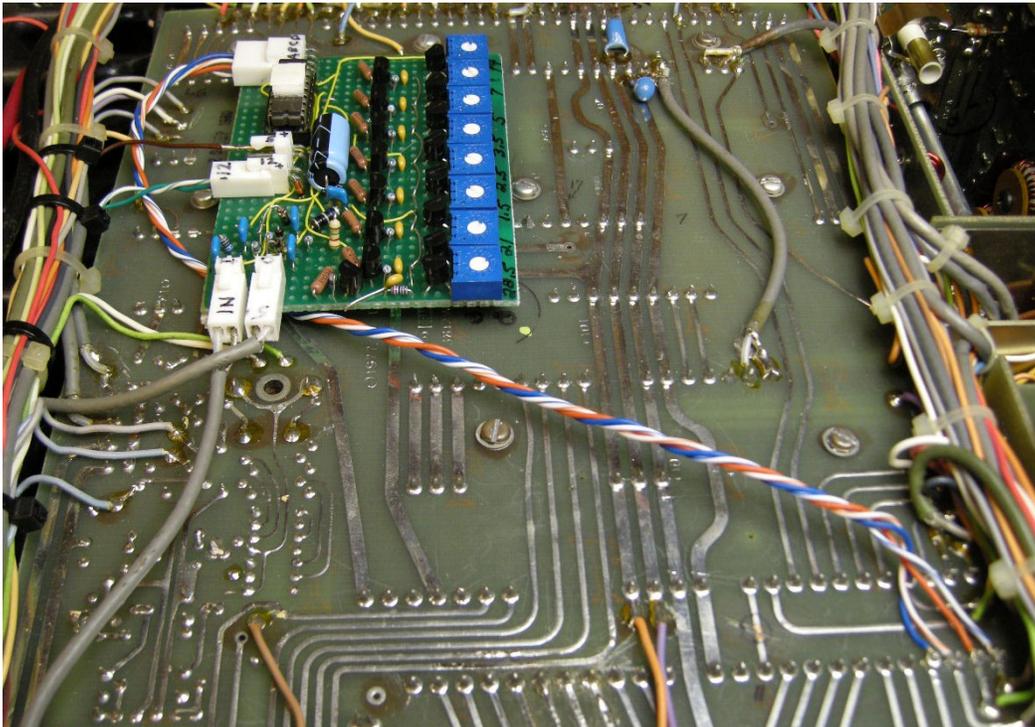


Illustration 1: - PIN attenuator board mounting and bandswitch sensing

The attenuator was built on a piece of Velleman prototype board with a copper land joining groups of three holes. I decided not to bother making a printed circuit board since the board layout provided by PA1HF0 would have to be modified to include the SN7445 decoder IC.

The board is mounted to the motherboard using 2 stacked pieces of double sided foam tape (about 1/8" thick each), one on each corner. Before mounting the board, I snipped off the card socket pins that protruded through the motherboard under the attenuator board as short as I could. With a single piece of the foam tape on the top of the IC, the board just fits under the bottom chassis cover.

The coax that feeds the RF signal to the PA input was freed from the wire bundle and cut at a point that allowed the ends to reach to my connectors. Note the four twisted wires that connect to pins 1-4 of the second card position (lower right in photo) and run to the attenuator board connector. Those pins are from the Digital Control board and provide the BCD information indicating the bandswitch position.

Here's a closeup shot of the attenuator board:

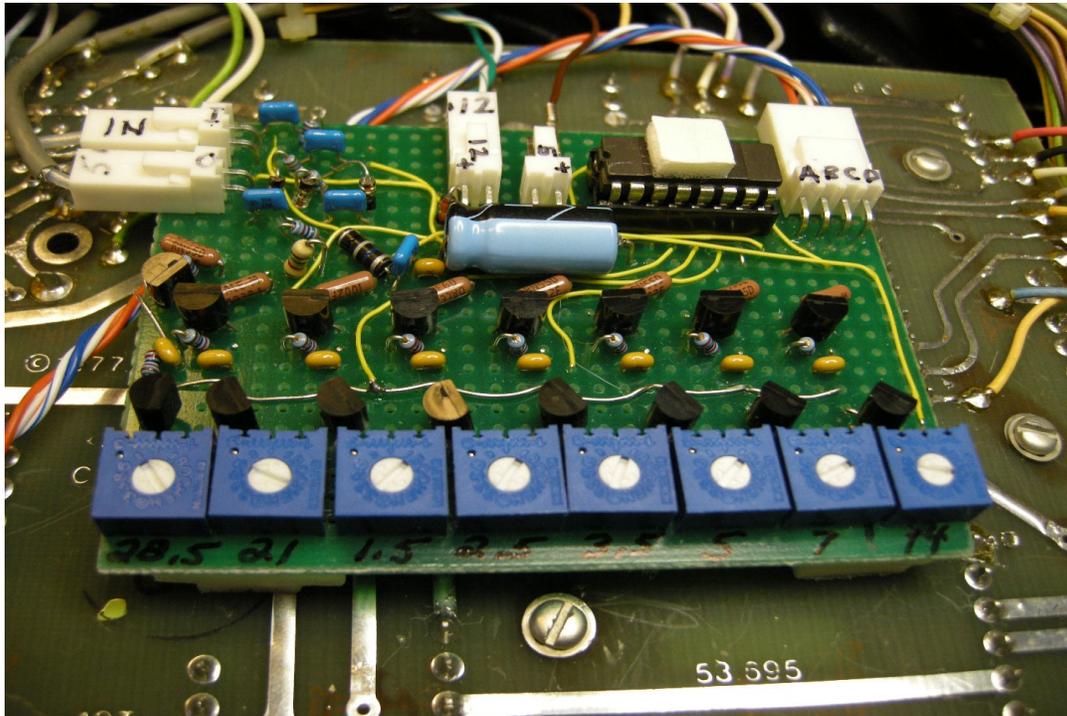


Illustration 2: Closeup of PIN attenuator board and mounting

You can see the double-sided tape under the corners.

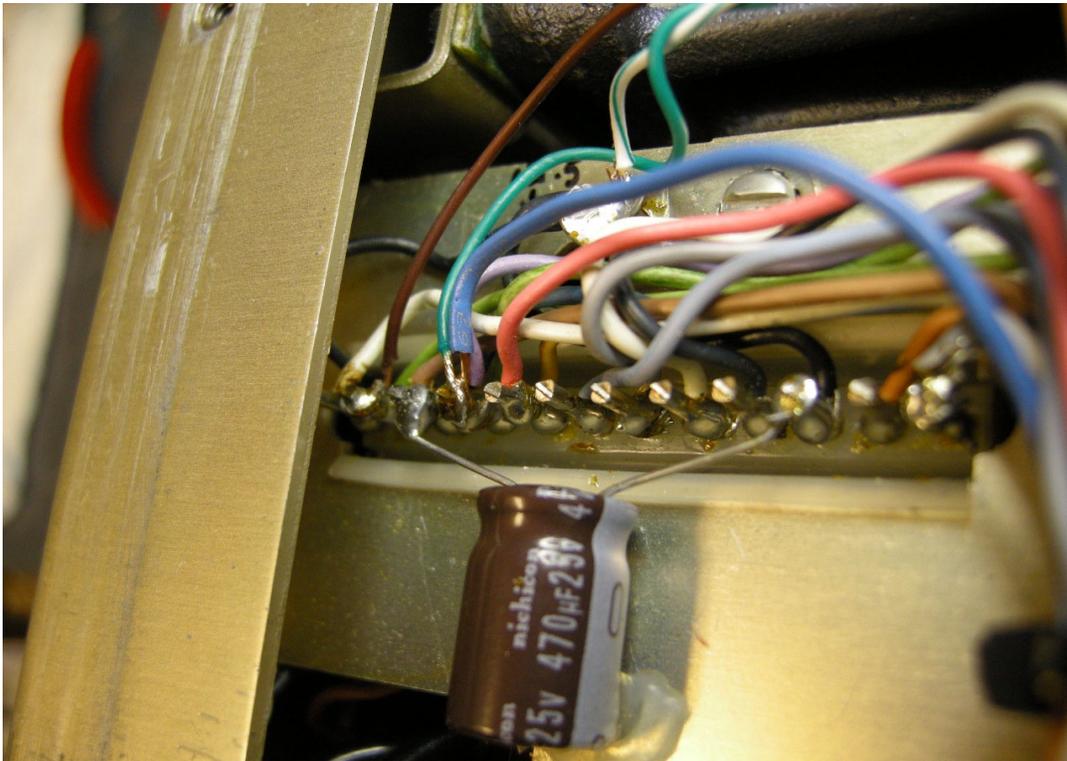
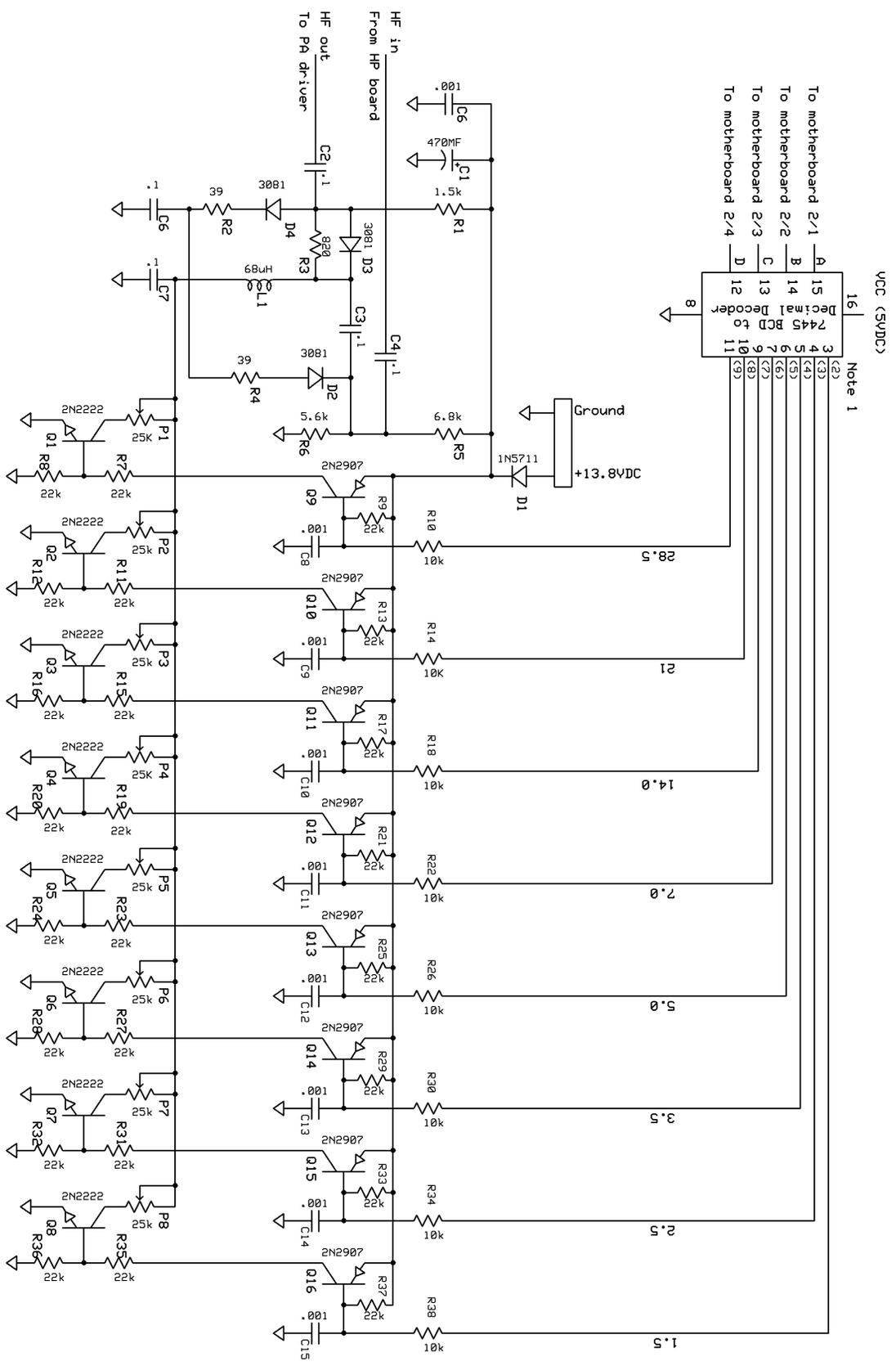


Illustration 3: Source of power for the PIN attenuator

The blue-green wire coming in at the top of the photo attaches to pin 9 of the power supply board which provides 5V for the attenuator. The brown wire connects to pin 11 for 13.8V and the blue/white striped wire connects to the ground lug, providing a ground for the attenuator board.

On the next page you'll find the schematic diagram for the attenuator. The diagram was produced using ExpressSCH, so if you're interested in getting a PC board made, please contact me and I'll forward the .sch file to you. I corrected an error in the original schematic, involving the line from the collector of Q9 to R7.



Notes
 1 - One of these pins is pulled to ground for each BCD value.
 The BCD values produced by the bandswitch do not map to decimal 0 and 1.

Conclusions

If you are happy with the way your TR-7 operates now and you're satisfied with the power out on all the bands, then there's probably no reason to consider building the attenuator board. If you've had to replace the PA transistors and are not happy with the power output on the highest bands, then maybe the attenuator is for you.

If you're careful about the height of components used, you can easily fit the attenuator board inside the bottom of the TR-7 with no mechanical modifications required. Prior to installing the attenuator board and adjusting the ALC and pre-driver to work with the attenuator, my maximum power out on 10 meters was 60-65 watts without running into oscillation problems on 40 meters. (Running into a dummy load was no problem, but with an antenna that had a bit of reactance, oscillation frequently occurred). I now get a solid 93 watts out on 10 meters, with no oscillation on the lower bands and I no longer need to fiddle with the Carrier control when changing bands. Yes, I'm aware that there's little difference between 60 and 90 watts at the receive end, but this project was about improving the TR-7 overall and it was a worthwhile and interesting exercise.

The table below shows the power output observed after installing and adjusting the attenuator. I set the Carrier control at the eighth mark where the LED just comes on at full brilliance. Power was measured using an N8LP LP-100 wattmeter and a 50 ohm oil-cooled dummy load. The adjustments for the bands below 10 meters were NOT made for maximum power, but rather so that the ALC LED just came on at full brilliance at the same Carrier control setting as for 10 meters. I can now change bands without having to adjust the Carrier level.

Frequency	Output power
28.300	93.3 watts
24.925	95.2
21.025	98.4
18.125	101.7
14.025	120.6
10.105	122.4
7.025	119.7
3.525	119.1
1.825	112.4

On my Version 2 pre-driver board, the adjustment pot is set at 3 o'clock.

73, Floyd Sense – K8AC

January 7, 2010