Bringing an Early Solid State Transceiver into the 21st Century

Instead of replacing a basically sound transceiver, consider adding the features found in new gear.

Marc van Stralen, DK4DDS

This article describes changes I made to a Drake TR-7 transceiver to bring it up to date. Many could be applied equally well to other transceivers of the era. The Drake TR-7, a solid state HF transceiver manufactured by R. L Drake in Miamisburg, Ohio in the late '70s into the early '80s, has remarkably good performance specifications compared to many more recent transceivers. Its single conversion architecture and analog circuitry lend itself to straightforward operation. The TR-7 is very simple to operate, has no complex menus, and is easy to service and to maintain.

I acquired some TR-7 transceivers, all in working condition, via the Internet in Germany and Holland for prices far lower than current models.

What's Not to Like?

While the basic TR-7 performance is quite good, the 30 year old design does have some disadvantages compared to modern equipment:

- The permeability tuned oscillator (PTO) that controls the operating frequency drifts more than those of modern equipment.
- The original power supply is very heavy and has the same dimensions as the TR-7 itself.
- It has no notch filter.
- The sensitivity on the higher bands is too low for quiet bands.
- The TR-7 offers neither speech processor nor DSP noise reduction.
- The two VCOs of the first oscillator generate excessive phase noise.
- There is neither a front panel TUNE button nor a KEY jack.
- Displays suffer with an analog dial and incandescent bulbs in the S-meter.
- Power output is not flat over the operating range, 1.8-30 MHz.

This article will describe how I addressed each of these deficiencies, while updating the style of the equipment. I now have a radio that can be favorably compared to modern equipment. The modifications are straightforward and incremental, so others may select which are important to them. We will take them one at a time in the sections that follow.

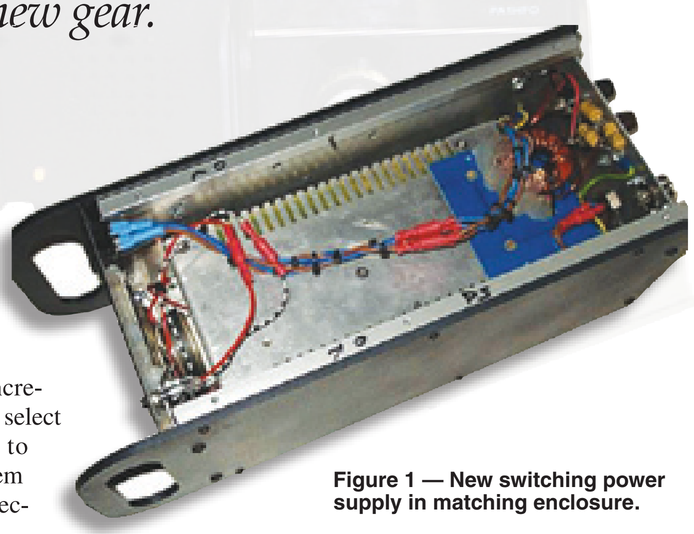

Figure 1 — New switching power supply in matching enclosure.

Power Supply

I built a completely new housing for the power supply in the style of my new TR-7 enclosure and included a built-in speaker. The power supply unit itself is switching mode 22 A/13.8 V supply I obtained from Mean Well (**www.meanwell.com**). This unit is a very nice, fully shielded lightweight power supply that offers a compact footprint (see Figure 1).

I added ac input and dc output filters in the new housing to suppress any switching noise from the power supply. I also added a blower controller so the power supply blower runs very slowly when it is switched on and goes faster only if its internal temperature rises.

Notch Filter

The simplest way to create a notch filter for the TR-7 is to use one that operates at audio frequencies. I designed a dedicated printed circuit board (PCB) that can be mounted on the underside of the parent board of the TR-7 with two small stand-off insulators the type normally used for PC serial and USB ports. The filter is controlled by a relay.

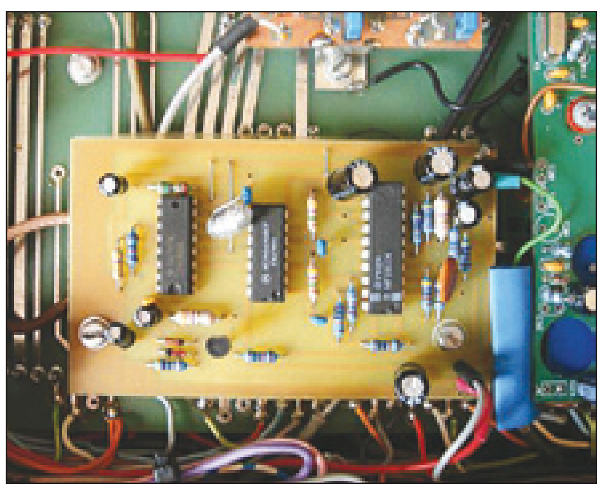

Figure 2 — Notch filter PCB assembled on to the parent board of the TR-7.

Only a small potentiometer has to be installed at the front of the TR-7 to control the notch filter. When the potentiometer is turned fully counterclockwise, the notch filter will be off. Table 1 lists the defined specifications. PCB artwork is available on the *QST* binaries Web site.[1] The notch filter installed in the TR-7 is shown in Figure 2 with the schematic and parts list in Figure 3.

DSP Noise Reduction

Most current transceivers offer digital signal processing (DSP) noise reduction.

[1] **www.arrl.org/files/qst-binaries/**.

As with the notch filter, I chose an audio frequency DSP to provide this function. I used a modified NES-5 DSP board from BHI in the UK (**www.bhinstrumentation.co.uk**). There are other products that could also be employed, however.

Table 1

Specifications of Added Notch Filter

Notch Frequency	*Notch Depth*
300 Hz	30 dB
500 Hz	35 dB
1000 Hz	42 dB
2000 Hz	45 dB

The NES-5 DSP noise reduction unit is intended to be connected to the loudspeaker output of a receiver or transceiver. It is built into a small enclosure and includes a built in speaker amplifier IC. I modified the unit by opening the enclosure and removing the PCB. I unsoldered the LM380, the 12 V regulator IC, input resistors R1and R2, and also the output resistors R7 and R8. I replaced the resistors with two 10 turn/50 kΩ potentiometers as shown in Figure 4. Mount the DSP board and a small 10 V reed relay on an empty piece of PCB board material so that the whole assembly can be mounted on the underside of the parent board as shown in Figure 5.

The relay will be used to direct the audio signal either through the DSP processor or directly to AF input.

You have to unsolder the wire at point 11/131. That is the AF gain control line of the second IF and AGC board. Rewire this wire to the middle contact of the relay. Solder a new wire from 11/131 to the input of the DSP board and also to the contact of the relay. The output of the DSP is wired to the other contact of the relay. The relay will be switched in by using the 10 V from the NOISE BLANKER switch. By switching in the noise blanker you can adjust the DSP for the right level by using the 50 kΩ input and output potentiometers.

Digital Automatic Frequency Control

The PTOs of my TR-7s seem to drift continuously. To overcome this problem I built in a digital automatic frequency control (DAFC) controller. The DAFC PCB is also mounted to the underside of the parent board.

It uses the 500 kHz reference signal of TR-7 digital frequency readout and the receive incremental tuning (RIT) voltage variable capacitor (varicap). The TR-7 is stable as a rock following this modification. RIT control is still possible. This design, an update of a 1980's design by Juergen Schaefer, DF8FD, is that of Konrad Dienel, DL1SDQ, and can be found at **www.conny-dl1sdq.de**. He will provide a complete unit including an instruction manual in English or German. If you want to construct this DAFC unit yourself, the circuit diagram is shown in Figure 6.

Speech Processor

The speech processor is a design of Ulrich Graf, DK4SX, who also used it for his modified TR-7. The processor is based on the SSM2166 IC from Analog Devices (**www.analog.com**). I designed a dedicated single sided PCB for the speech processor, to allow it to fit on the underside of the parent board. Some small modifications of the exciter board are needed to switch the processor on or off. The whole unit was built in a complete enclosed metal box, as shown in Figure 7 with the schematic and parts list provided in Figure 8.

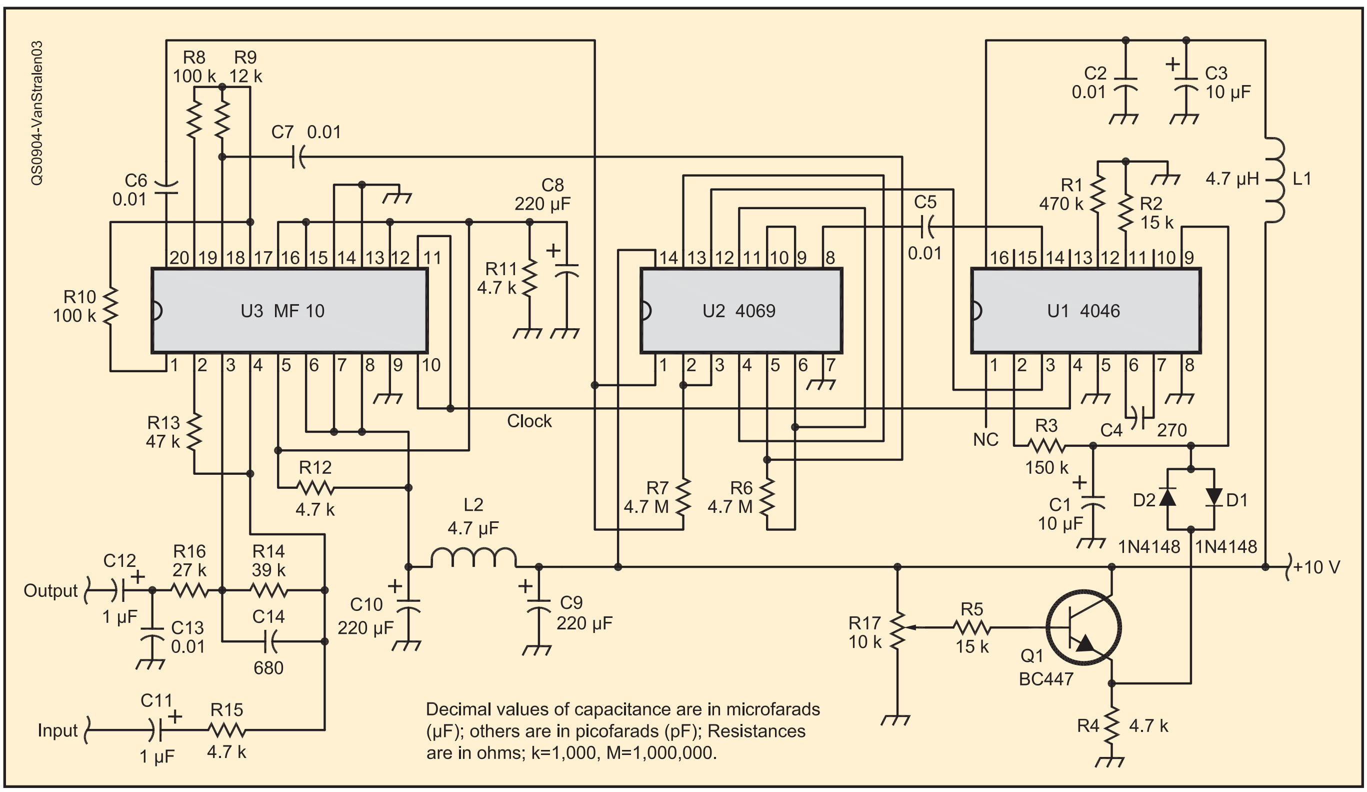

Figure 3 — Notch filter schematic diagram and parts list.

C1 — 10 µF, 16 V electrolytic capacitor.
C2, C5-C7, C13 — 10 nF ceramic capacitor.
C3 — 10 µF, 16 V electrolytic capacitor.
C4 — 270 pF, 2% capacitor.
C8-C10 — 220 µF, 16 V, 3.5 mm electrolytic capacitor.
C11, C12 — 1 µF, 16 V electrolytic capacitor.
C14 — 680 pF ceramic capacitor.
D1-D3 — 1N4148 silicon diode.
L1, L2 — 4.7 µH SMMC RFC.
Q1 — BC 547 transistor.
R1 — 470 kΩ, ⅛ W resistor.
R2 — 15 kΩ, ⅛ W resistor.
R3 — 150 kΩ, ⅛ W resistor.
R4, R11, R12, R16 — 4.7 kΩ, ⅛ W resistor.
R5 — 15 kΩ, ⅛ W resistor.
R6, R7 — 4.7 MΩ, ⅛ W resistor.
R8, R10 — 100 kΩ, ⅛ W resistor.
R9 — 12 kΩ, ⅛ W resistor.
R13 — 47 kΩ, ⅛ W resistor.
R14 — 39 kΩ, ⅛ W resistor.
R15 — 27 kΩ, ⅛ W resistor.
R17 — 10 kΩ linear potentiometer.
U1 — HEF 4046.
U2 — HEF 4069.
U3 — MF 10.

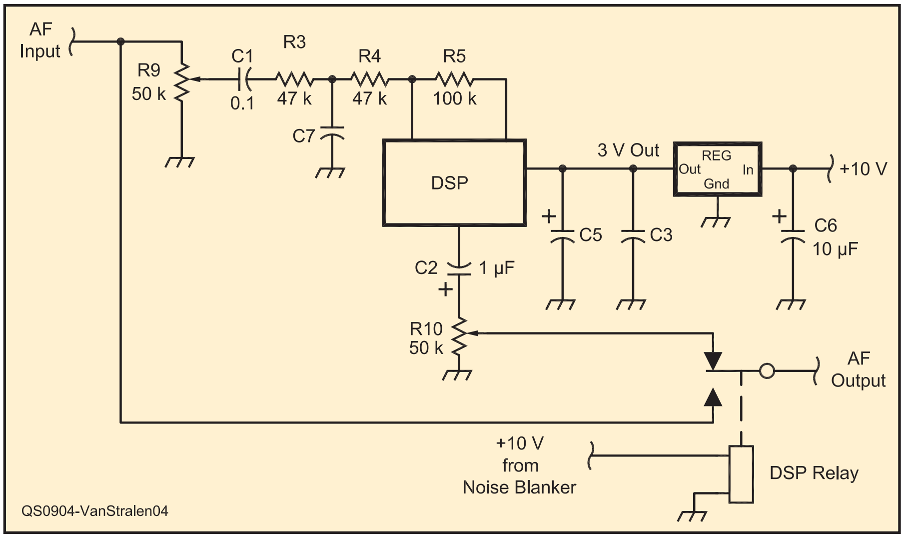

Figure 4 — Schematic of modified DSP including control circuitry.

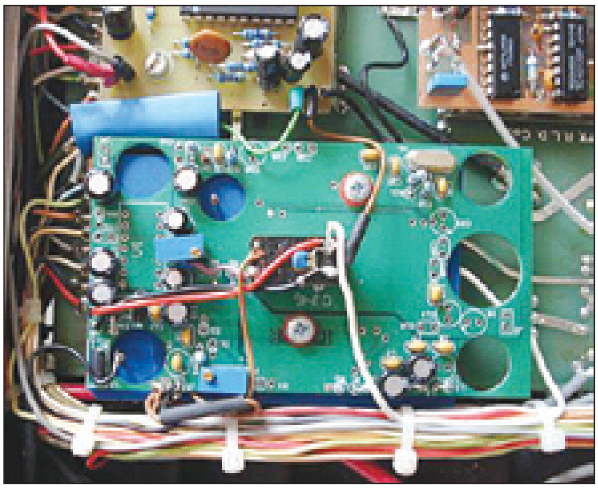

Figure 5 — DSP mounted on the underside of the TR-7 parent board.

Table 2
Component Changes in TR-7 Exciter Section

Part	*New Value*
C307	47 nF
C310	220 nF
R330	3300 Ω
R333	470 Ω

TR-7 Exciter Modifications

The speech processor will be inserted between the two microphone amplification stages. The processor will be connected between the collector of Q301 and capacitor C310. Some modifications are needed with the values of the following components changed as shown in Table 2. A partial circuit diagram of the TR-7 showing the changes is provided in Figure 9.

A 12 kΩ resistor is needed between the collector of Q302 and the microphone gain control.

New LED Display

The 100 Hz digit of the digital readout of the TR-7 I was renovating was no longer 100%. I decided to replace the complete light emitting diode (LED) assembly with a new one. I found, by comparing specifications, that a direct replacement is no longer available. I started to design a new LED-display PCB, but was informed that Willi Rass, DF4NW, (**www.df4nw.de**) supplies complete display units using standard LEDs. These are available in red, green, blue, yellow or a combination of these colors.

I ordered the display and after I received it, I needed less than an hour to remove the old display and to install the new one. The enhanced display is shown in Figure 10.

Mechanical Changes

The original TR-7 envelope does not provide much space to integrate additional electronics or circuit boards. The only places are on the underside on the parent board and a little space in the high pass filter compartment. There is also very little additional front panel real estate for additional switches or controls. I decided to increase the transceiver and front panel height by about 5/8 inch to accommodate additional jacks and control functions.

I first replaced the large fuses and holders with 5 × 20 mm fuses and their more compact holders. I then replaced the two rear mounting screws of the power amplifier assembly with longer ones. The longer screws will be used to secure one of the spacer strips.

Front Panel Extension

An aluminum extrusion with a U cross section was used for the front panel expansion. It fits below the TR-7's front panel. The one I used was supplied in the metric dimensions of 330 × 15 × 1.5 mm or approximately 13.2 × 0.6 × 0.06 inches.

Holes must be drilled for the KEY jack, TUNE switch, PROCESSOR ON/OFF switch, processor LED, LNA ON/OFF switch and LNA LED. Also two small holes have to be drilled to screw the front panel extension onto the TR-7. The same piece profile is used for the rear side of the TR-7. Only two screws have to be drilled to screw the rear extension onto the transceiver. A bottom view of the front addition is shown in Figure 11, with the rear extension shown in Figure 12.

Side Panels

The new side panels are made from aluminum and are 350 × 130 × 5 mm or approximately 13.8 × 5.1 × 0.2 inches. Two pairs of panels were made, one for the TR-7 and the other for the power supply.

Spacers for Side Panels

To assemble the two side panels on to the transceiver, four spacer strips made of 0.17 inch (4.3 mm) thick aluminum or brass are required.

Top and Bottom Cover Plates

Top and bottom plates are made from 0.06 inch (1.5 mm) aluminum. Ventilation holes are drilled as necessary. The top cover plate slides on top of the front of the TR-7 as did the original cover. At the left rear and right rear side two aluminum support blocks are mounted. In each block there is a tapped hole for the appropriate screw thread. At the underside two aluminum support blocks, each 10.6 × 0.4 × 0.4 inches (270 × 10 × 10 mm) will be mounted on to the left and right side panel as shown in Figure 13. In the top side of each support block three additional tapped holes are made to fix the bottom cover plate on to the transceiver. The support blocks are also used to align the front and rear extension on to the transceiver. The completed expansion with the added boards are shown in Figure 14.

KEY Jack

A 3 mm phone jack was mounted on to the

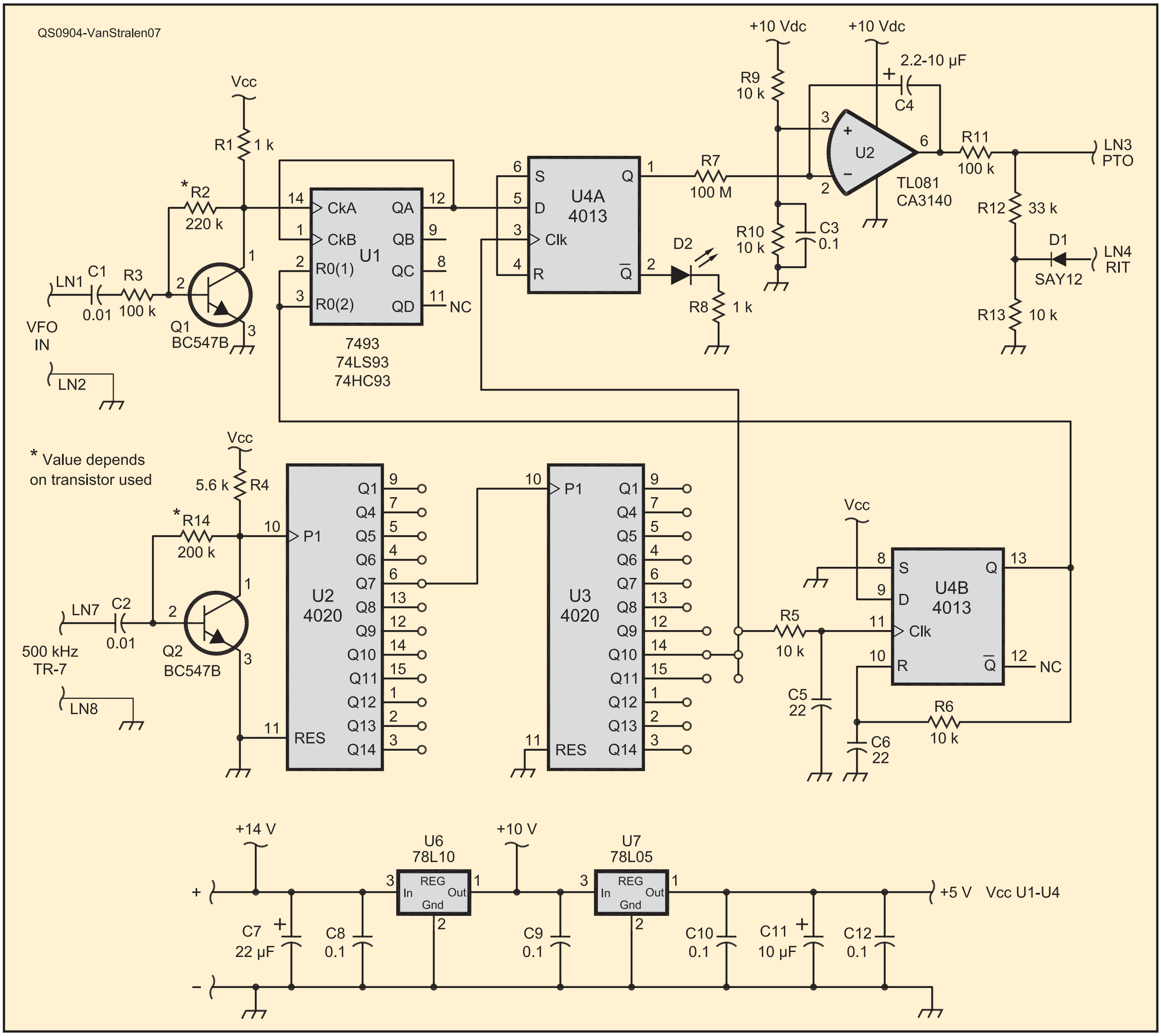

Figure 6 — Schematic diagram of digital automatic frequency control (DAFC) controller. For R7, if 100 mΩ not available, use 10 each 10 mΩ SMD1026 resistors in series.

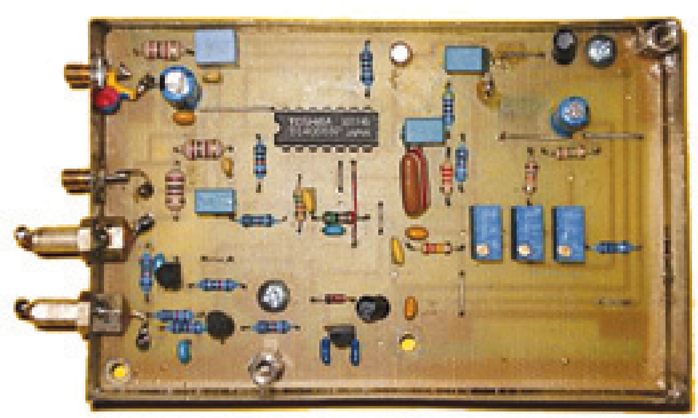

Figure 7 — Added speech processor board.

front panel extension. This is wired in parallel with the original KEY jack on the rear.

TUNE Button

The TUNE push button was also mounted on front panel extension. This is also wired in parallel with the KEY jack on the rear. Tuning is very simple now — switch the TR-7 to CW mode and activate the push button.

Speech Processor Button and Indicator LED

This push button and its indicator LED are also mounted on the front panel extension. They will be wired to the speech processor unit. No relays are required. See the circuit diagram of the speech processor and exciter modifications.

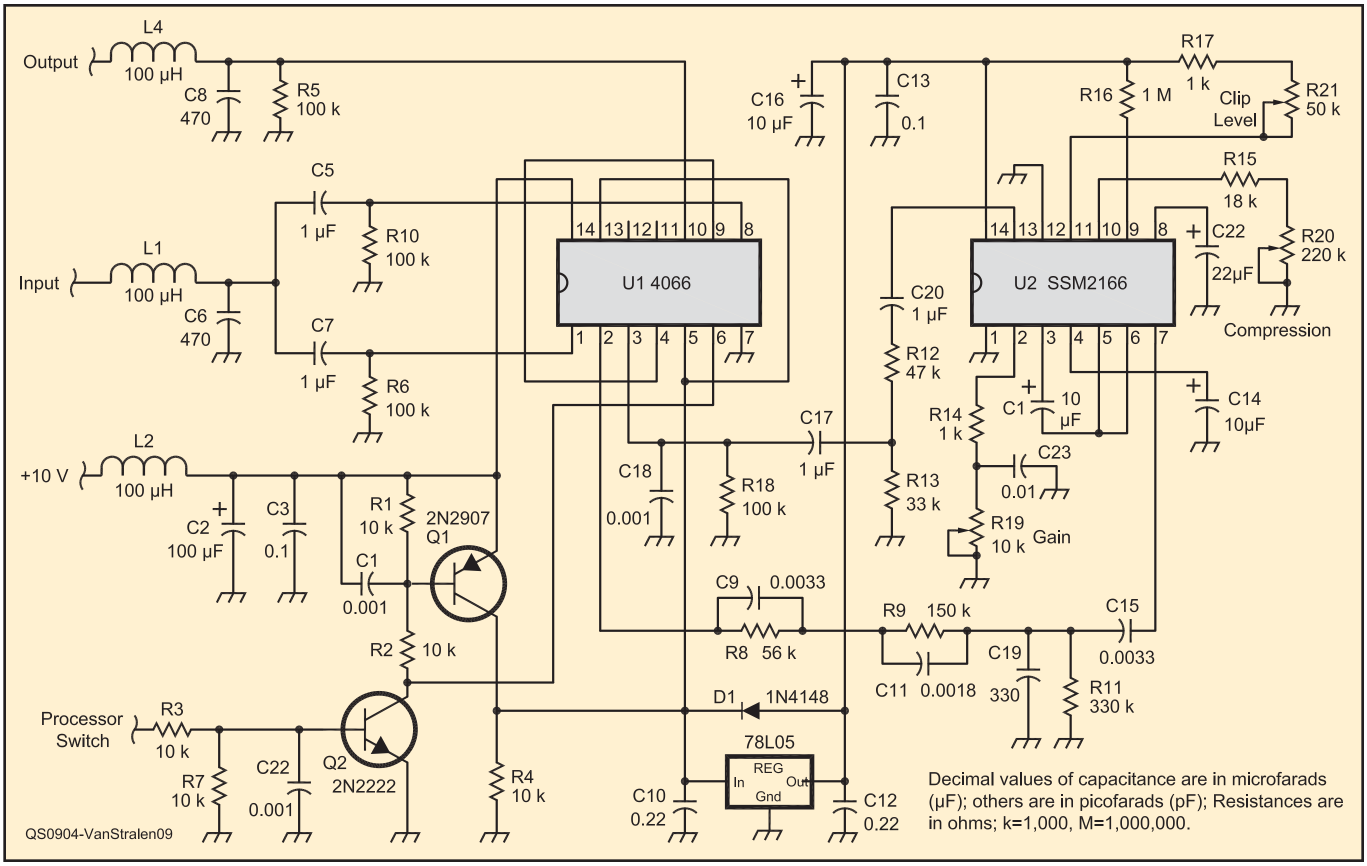

Figure 8 — Schematic diagram and parts list of speech processor board.

C1 — 1 nF ceramic capacitor.
C2 — 100 μF, 16 V electrolytic capacitor.
C3, C13 — 100 nF ceramic capacitor.
C4, C18 — 1 nF ceramic capacitor.
C6 — 470 pF ceramic capacitor.
C5, C7, C17, C20 — 1 μF foil capacitor.
C8 — 470 pF ceramic capacitor.
C9, C15 — 3.3 nF ceramic capacitor.
C10 — 220 nF ceramic capacitor.
C11 — 1.8 nF ceramic capacitor.
C12 — 220 nF ceramic capacitor.
C14, C16, C21 — 10 μF, 16 V electrolytic capacitor.
C19 — 330 pF ceramic capacitor.
C22 — 22 μF, 16 V electrolytic capacitor.
C23 — 10 nF ceramic capacitor.
D1 — 1N4148 silicon diode.
L1-L4 — 100 μH SMMC RFC.
Q1 — BC 557.
Q2 — BC 547.
Q3 — 78L05.
R1-R4, R7 — 10 kΩ, ⅛ W resistor.
R5, R6, R10, R18 — 100 kΩ, ⅛ W resistor.
R8 — 56 kΩ, ⅛ W resistor.
R9 — 150 kΩ, ⅛ W resistor.
R11 — 330 kΩ, ⅛ W resistor.
R12 — 47 kΩ, ⅛ W resistor.
R13 — 33 kΩ, ⅛ W resistor.
R14, R17 — 1 kΩ, ⅛ W resistor.
R15 — 18 kΩ, ⅛ W resistor.
R16 — 1 MΩ, ⅛ W resistor.
R19 — 10 kΩ trimming potentiometer.
R20 — 220 kΩ trimming potentiometer.
R21 — 50 kΩ trimming potentiometer.
U1 — 4066.
U2 — SSM2166.

Preamplifier Button and Indicator LED

This push button and its indicator LED are also mounted on the front panel extension. It will be wired to the preamplifier PCB mounted in the high-pass compartment. No relays are required.

Bulbs Replaced by LEDs

The bulbs of the S-meter and analog dial light are replaced by high intensity LEDs. I used simple defective bulbs, removed the glass and internal wiring and soldered a resistor and LED into the bulb base as shown in Figure 15. By using this method you don't need to replace the sockets in the transceiver.

Selectable Preamplifier

The sensitivity of the TR-7 on the higher bands is sometimes too low. A preamplifier can improve the sensitivity of the receiver section. I wanted to preserve the high dynamic range of the TR-7 during times the preamp wasn't needed, so I made the preamp selectable from the new front panel extension. I decided that a preamplifier with a gain of approximately 10 dB and high dynamic range would be a good addition.

I decided to build my own using the circuit in Figure 16. If you don't want to build a preamplifier yourself, you can buy one from Willi Rass, DF4NW at **www.df4nw.de**. It is a completely assembled externally selectable preamplifier.

Additional Enhancements

Updating the RV-7 VFO

An external VFO is very handy if it is desired to operate on split frequencies. The Drake RV-7 is designed for the purpose and I had one in working condition. Its frequency stability was not satisfactory, however. I attempted to eliminate drift using digital automatic frequency control (DAFC), but did not find the results satisfactory.

Instead I replaced the existing VFO with a homebrew direct digital synthesis (DDS) oscillator designed by Steven Weber, KD1JV. It has a programmable frequency range of 4.55 to 5.55 MHz with tuning steps of 10, 100 and 250 Hz as well as 5 kHz. The push button below on the front panel is the RIT control for the remote DDS, such as the synthesized RV-75 has. It allows the receiver to be offset from the receiver in ±25 Hz steps over the full 1 MHz VFO range of the transmitter. Also the DDS output, 4.55 to 5.55 MHz, is available on a BNC connector at the rear side of RV-7.

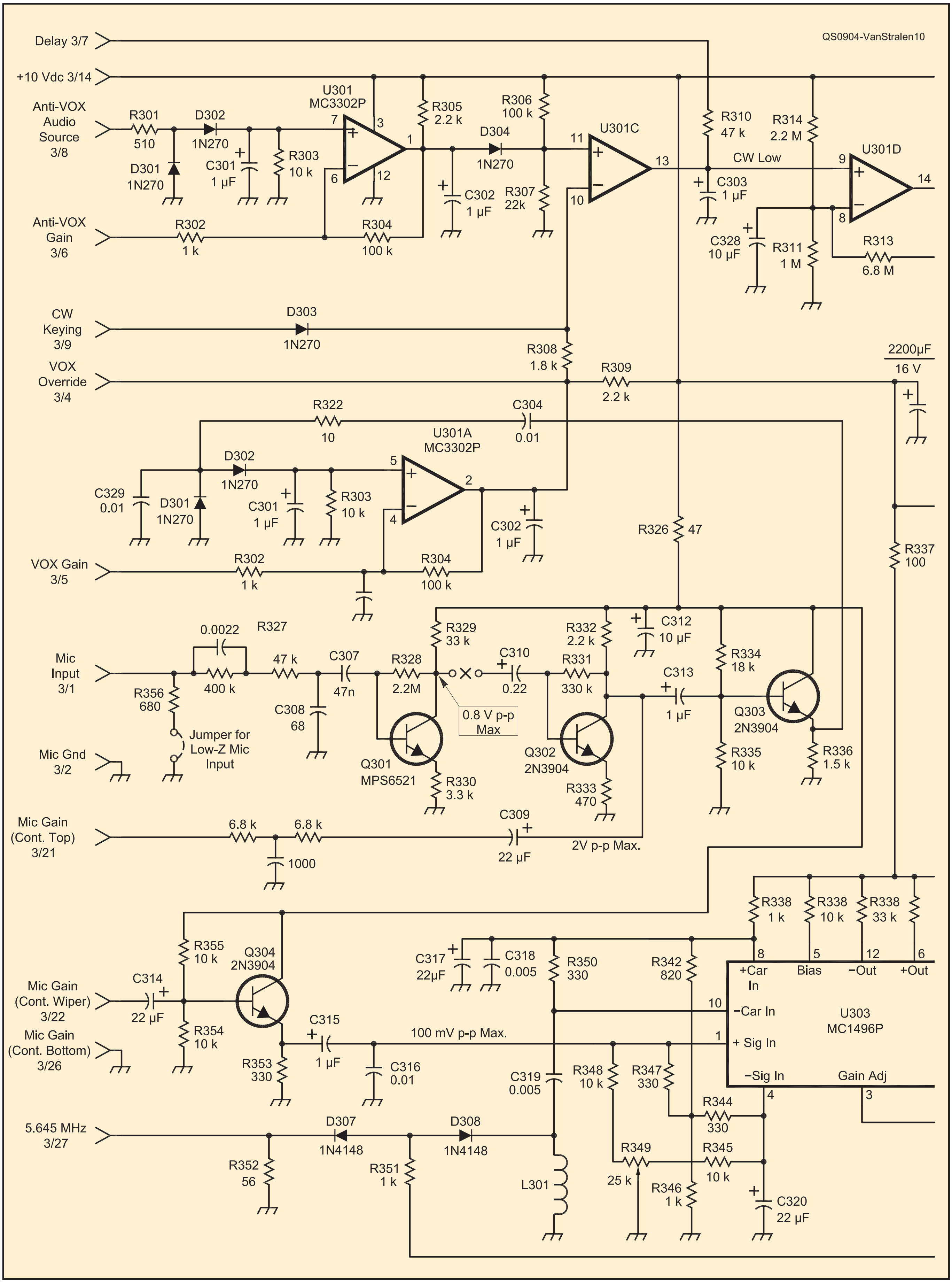

Figure 9 — Schematic diagram of modified portion of TR-7 exciter board.

Figure 10 — The new LED display is shown installed in the TR-7.

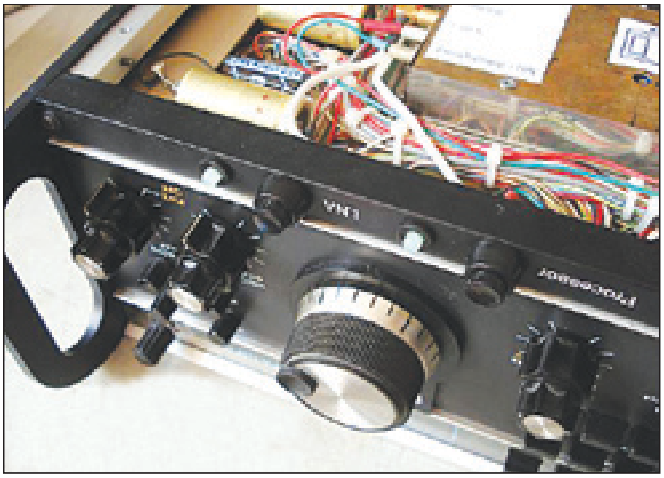

Figure 11 — Installed front panel extension, as seen from the bottom.

Figure 12 — TR-7 with rear extension installed.

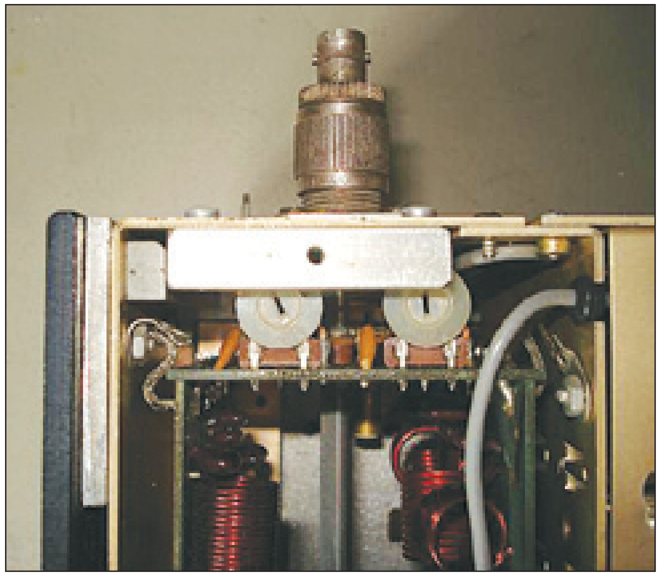

Figure 13A — Left side support block in place.

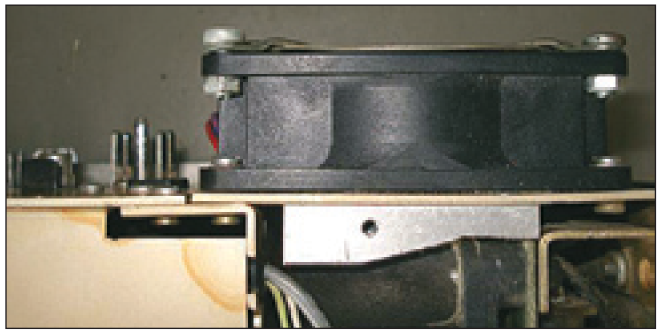

Figure 13B — Right side support block installed.

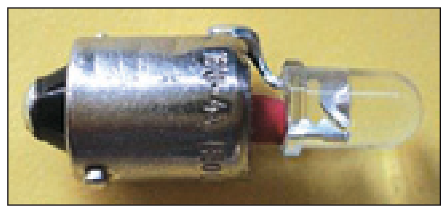

Figure 15 — LED built into base of dial light bulb.

I made the enclosure the same style and color of the TR-7 and its power supply. An inside view is shown in Figure 17.

Cooling Fan

The existing fan of the power amplifier (PA) was replaced by a silenced 12 V version. I have also reversed the airflow direction of the rear PA fan. The air is now blown in to the PA to increase the cooling efficiency. I added a dust filter mounted on the fan. A thermocouple driven switch is mounted on to the heat sink to activate the fan whenever the heat sink reaches a temperature of approximately 40° C.

Indicator Lamps

All the indication lamps have been replaced by LEDs in the manner described for the S-meter.

Improvement of PA Frequency Response

The gain of the PA of TR-7 is not flat over the full operating frequency range. The result is that the power output fluctuates on the different ham bands. I have solved this problem by using an adjustable PIN attenuator.

The attenuator is placed between the high pass transmitter output and the driver input of the PA. It has eight different selectable ranges controlled via the digital control board corresponding to the eight frequency ranges of the TR-7 amplifier.

You are now able to use the maximum gain of the PA over the whole range from 1.8 to 29.7 MHz without oscillation on the lower bands. The design of this attenuator is

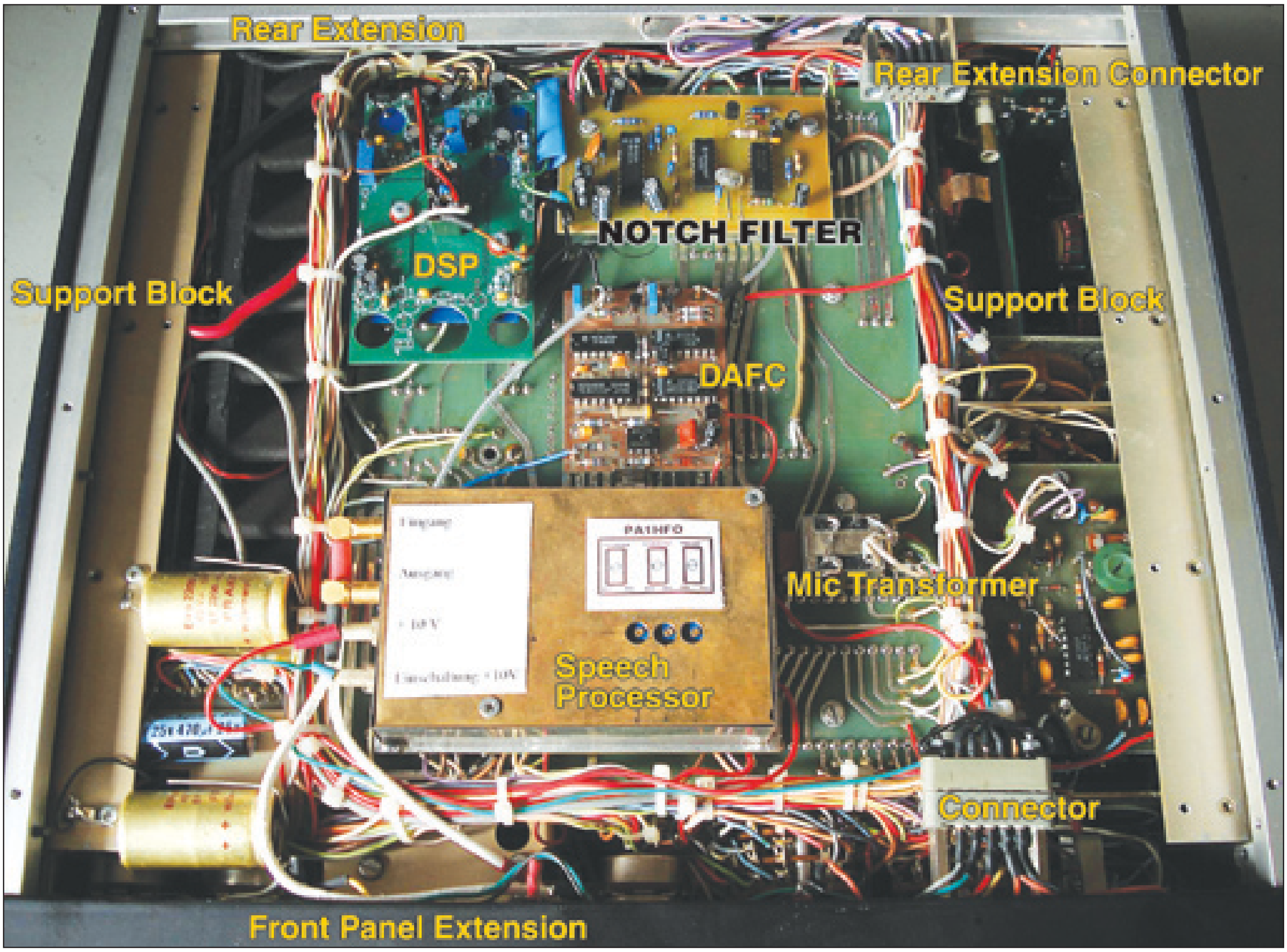

Figure 14 — Bottom view of the TR-7 showing modifications installed.

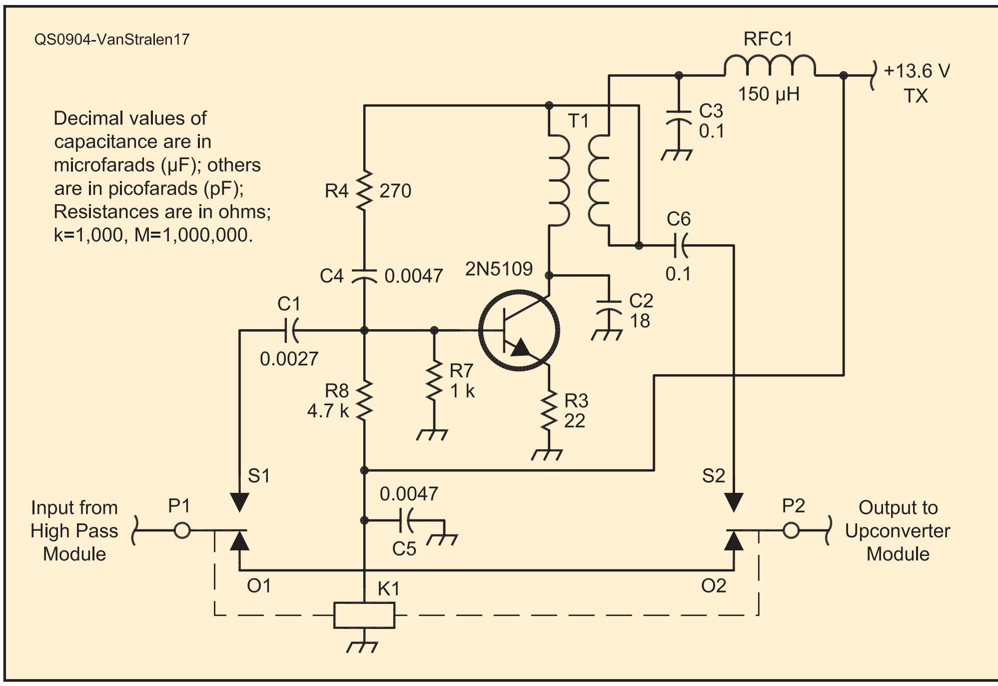

Figure 16 —Circuit diagram of the home brew switchable 10 dB preamplifier. K1 is a miniature DPDT relay (Maluska M4-12H, Restar BTS 12-150 or equivalent).

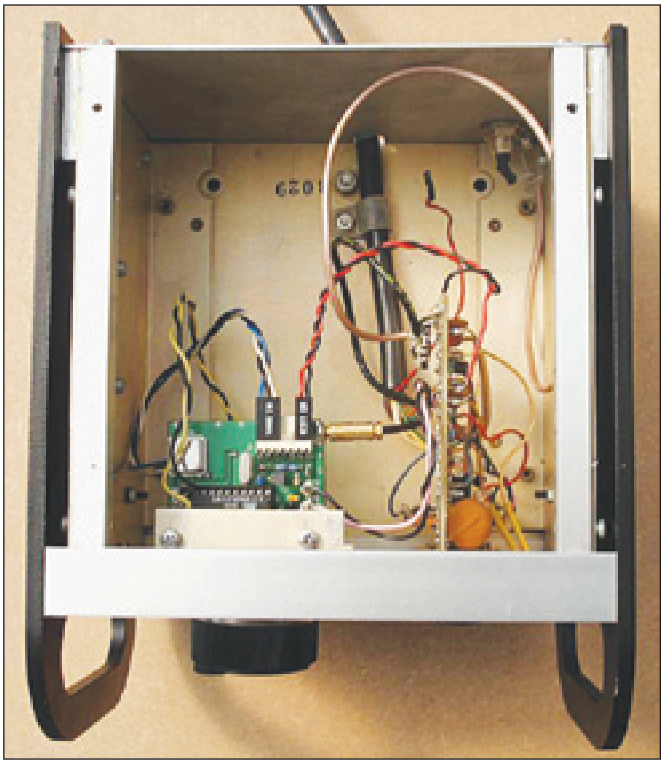

Figure 17 — Updated RV-7 showing DDS synthesizer board.

from Ulrich Graf, DK4SX. I have designed a dedicated PCB for the attenuator that fits exactly into the left side frame of the TR-7, on the underside above the PA.

Conclusions

The additions and changes to the TR-7 that I have described add the modern conveniences we have come to expect to a radio that has been around for more than a quarter century. The result is a radio that is fun to operate and a good performer in any time period.

Marc van Stralen, DK4DDS, has been licensed since 1970 at age 18 first as PAØMJY, later as PA1HFO. He received his present call letters on his move to Germany in 2004.

Marc has studied electronics and telecommunications and had his own business refurbishing and selling used electronic manufacturing equipment such as soldering machines and placement equipment. Marc retired in 2008.

His interest in electricity and electronics started early and when he was 3 years old he could screw connectors on to electrical wire. At 12 he made his first attempt at building radios, starting with a germanium diode crystal set.

His first Amateur Radio project was the construction of fully transistorized (solid state) 10 W, 2 meter SSB transceiver. After earning his A license, he focused on HF homebrew and kit radios.

You can reach Marc at Schulstrasse 21, D-48455, Bad Bentheim, Germany or at **dk4dds@t-online.de**.