THE DRAKE TR7 RENEWED

By: DL/PA1HFO - Marc van Stralen

Date: 08/19/07

The TR7 is still a remarkably good transceiver compared with a lot of modern transceivers. Also the TR7 is very simple to operate, no complex menus, and easy to service and to maintain. It also has good intermodulation specifications. So I acquired via the internet in Germany and Holland some TR7 transceivers for approximately $150 each in working condition. Of course now, more than 30 years later the old TR7 has some disadvantages:

- The PTO is drifting continuously
- Ugly, very heavy and big power supply has same dimensions of TR7
- No Notch filter
- Sensitivity on the higher bands is some times to low
- No speech processor
- No DSP noise reduction
- No tune button on the front
- Key jack on the back of the transceiver
- Bulbs in s-meter and analog dial
- Phase noise VCO 116 dBc @ 10 KHz
- Power output is not flat over the 1.8 -30 MHz

Improvements Made:

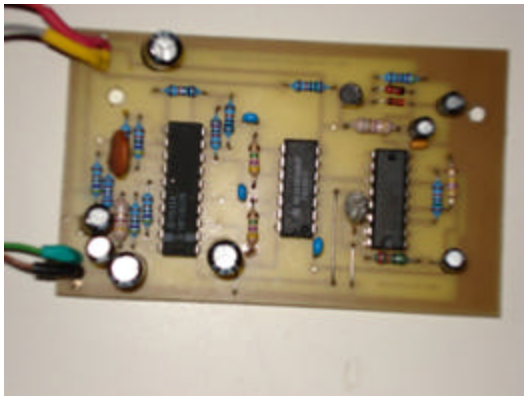
- New small power supply
- Built in Notch filter
- Built in speech processor
- Tune facility on the front
- Built in preamplifier like the R7
- Key jack at the front of TR7
- DAFC (drift correction for the PTO)
- Bulbs replaced by LED's
- Blower replaced with a very quiet 12 volts fan
- Temperature switch mounted on the heat sink to switch in the blower at 40 degrees Celsius
- Blower direction reversed for better efficiency
- Restyled modern and professional housing
- Mechanical changes front panel height increases with 15 mm
- New large LED display
- New top cover and under cover

POWER SUPPLY

I built a completely new housing for the power supply in the style as the new TR7 housing with built in loud speaker. The power supply unit itself is switching type, 22 Amp at 13.8 Volts from Mean Well. www.meanwell.com It is very nice fully screened power supply. I added a net filter and DC Output filter in the new housing to suppress any noise of the power supply. A blower controller was added. The blower in the power supply only runs very slowly when it is switched on and goes faster when its internal temperature rises.

NOTCH FILTER

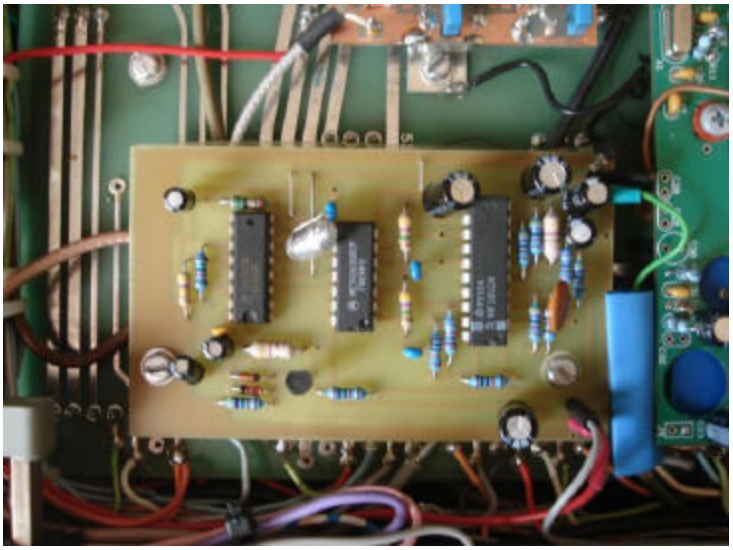
The simplest way to create a notch filter in the TR7 is to use an audio Notch filter. For the notch filter a dedicated PCB was designed. The notch filter can be easily mounted on the under side of the parent board of the TR7 with two small stand-off's and two little screws. There is no switch needed to switch it on and off. Only a small potentiometer on the front has to be installed at the front of the TR7 and is needed to control the notch filter. When the potentiometer is turned fully counter clock wise the notch filter will be off.



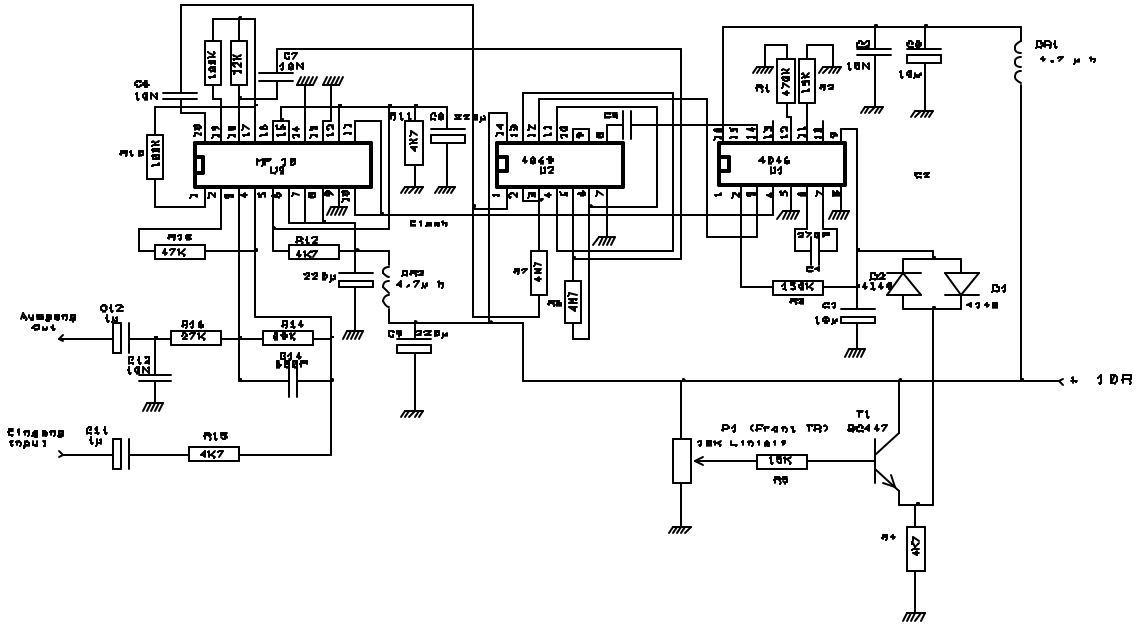
Specifications notch filter

Notch depth

300 Hz	**30 dB**
500 Hz	**35 dB**
1000 Hz	**42 dB**
2000 Hz	**45 dB**



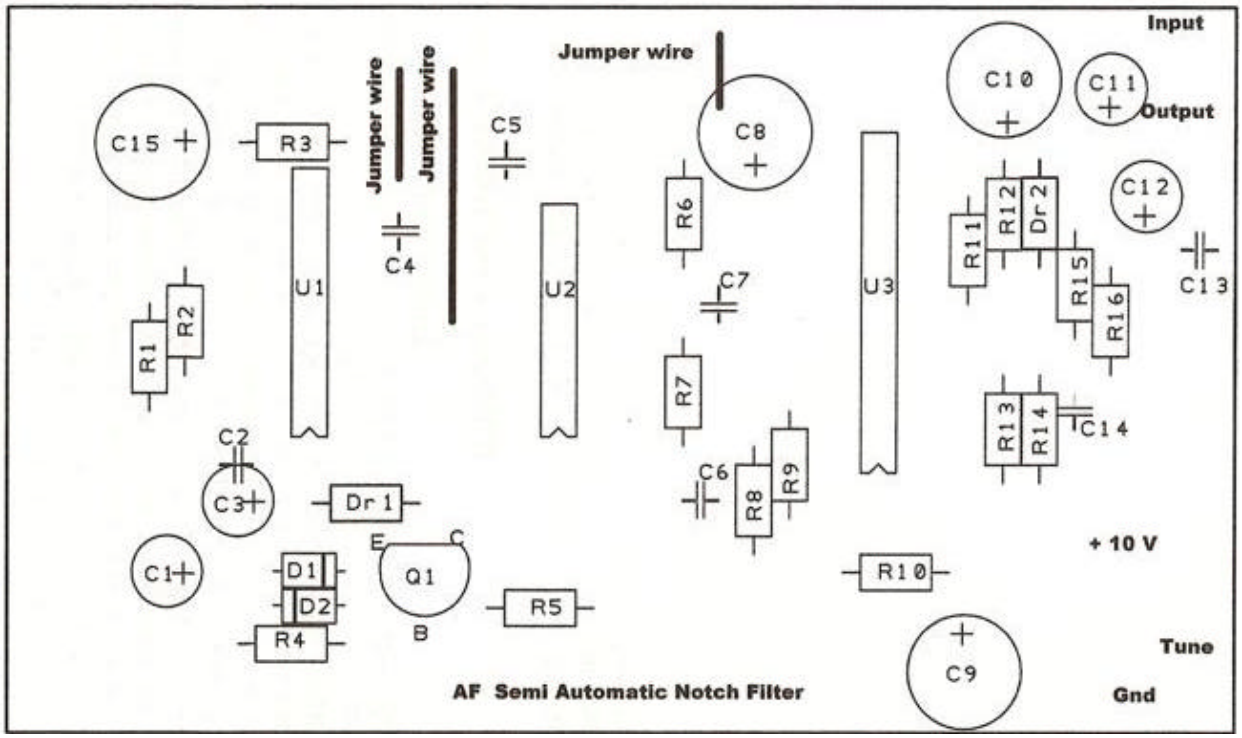
Notch filter assembled on to the parent board of the TR7



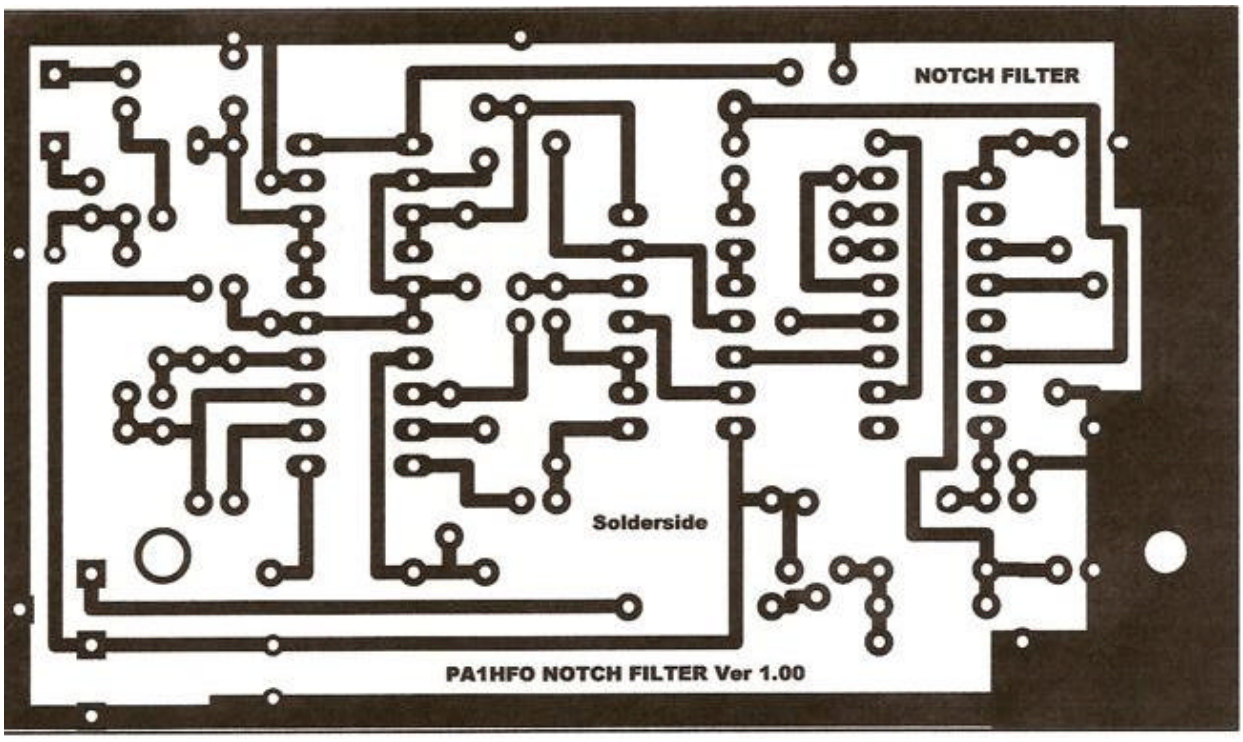
E	D	C	B	A	Drawn	Check	Projection Do Not Scale	DL/PA1HFO
Drn	Drn	Drn	Drn	Project TR7 Renovation			Client	
Chk	Chk	Chk	Chk	Title Semi Automatisch Notch Filter			Filename Notch_Filter_14_09_2007	Drawing No. / Sheet 1 of 1

NOTCH FILTER PCB

Component Layout Notch Filter (Scale 2:1)

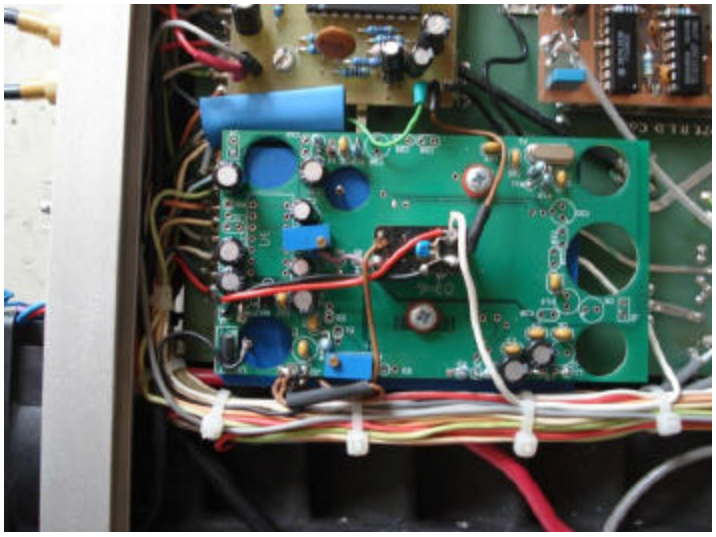


Solder Side Notch Filter PCB (Scale 2:1)



Parts List Notch Filter

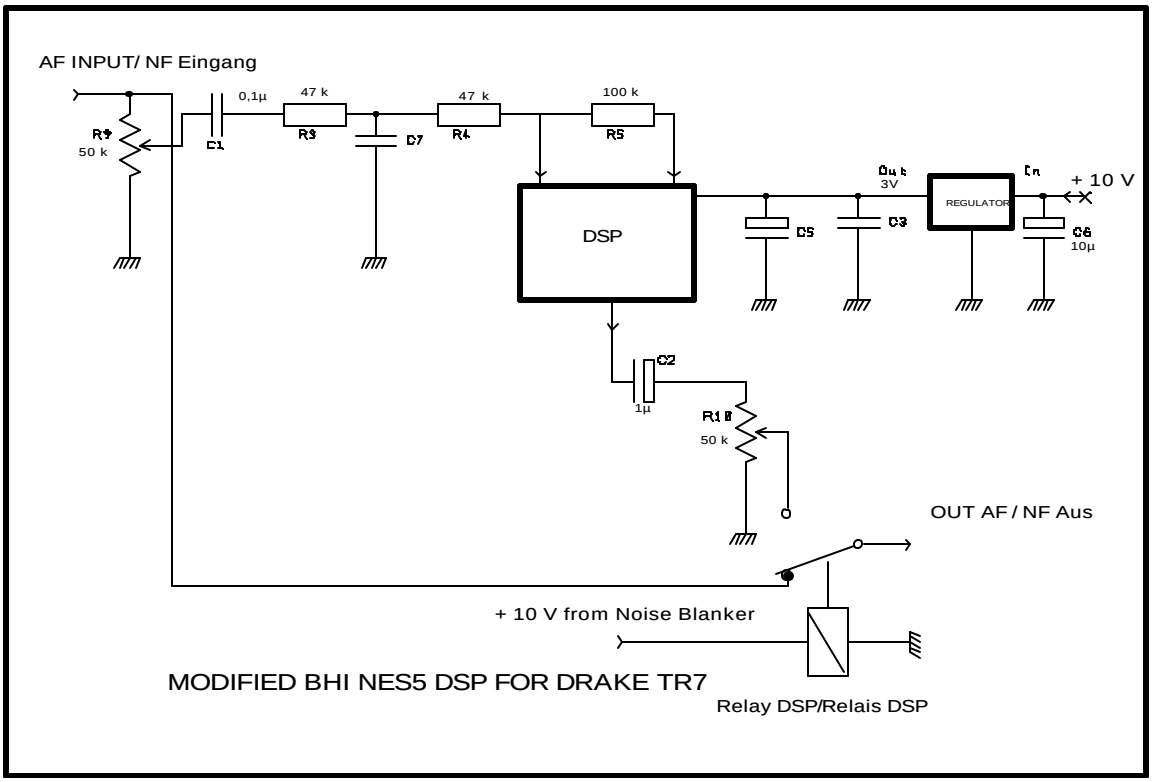
Ref. Desinator(s)	Qty	Description	Grid
R1	1	470 K Widerstand,Resistor 1/8 watt,	
R2	1	15K Widerstand,Resistor 1/8 watt	
R3	1	150 K Widerstand,Resistor 1/8 watt,	
R4	1	4K7 Widerstand,Resistor 1/8 watt	
R5	1	15K Widerstand,Resistor 1/8 watt	
R6	1	4M7 Widerstand,Resistor 1/8 watt	
R7	1	4M7 Widerstand,Resistor 1/8 watt	
R8	1	100 K Widerstand,Resistor 1/8 watt	
R9	1	12 K Widerstand,Resistor 1/8 watt	
R10	1	100 K Widerstand,Resistor 1/8 watt	
R11	1	4K7 Widerstand,Resistor 1/8 watt	
R12	1	4K7 Widerstand,Resistor 1/8 watt	
R13	1	47K Widerstand,Resistor 1/8 watt	
R14	1	39 K Widerstand,Resistor 1/8 watt	
R15	1	27 K Widerstand,Resistor 1/8 watt	
R16	1	4K7 Widerstand,Resistor 1/8 watt	
Dr1	1	4 µ 7, RFC, SMMC	
Dr2	1	4 µ 7, RFC, SMMC	
D1	1	1N4148, Diode	
D2	1	1N4148, Diode	
C1	1	10 µF/16V Rad.	1 E
C2	1	10 nF Kondensator, Capacitor/Keramisch, Ceramic	1 E
C3	1	10 µF/16V Rad.	1 E
C4	1	270 pf Kondensator, Capacitor/ 2 % Styroflex/mica	1 E
C5	1	10 nF Kondensator, Capacitor/Keramisch, Ceramic	1 E
C6	1	10 nF Kondensator, Capacitor/Keramisch, Ceramic	1 E
C7	1	10 nF Kondensator, Capacitor /Keramisch, Ceramic	1 E
C8	1	220 µF/16V Rad.	3.5 mm
C9	1	220 µF/16V Rad.	3.5 mm
C10	1	220 µF/16V Rad.	3.5 mm
C11	1	1 µF/16V Rad.	1 E
C12	1	1 µF/16V Rad.	1 E
C13	1	10 nF Kondensator, Capacitor/ Keramisch, Ceramic	1 E
C14	1	680 PF Keramisch	1E
U1	1	HEF 4046	1 E
U2	1	HEF 4069	1 E
U3	1	MF 10	1 E
Q1	1	BC 547	
P1	1	Pot1 10 K Liniar	
PCB	1	PCB Notchfilter TR7 -Ver15_08_07	



DSP NOISE REDUCTION

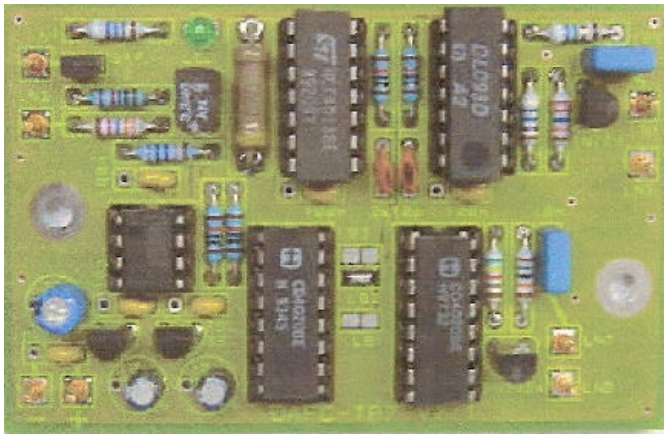
Component Side Notch Filter PCB

For the DSP noise reduction a modified NES 5 from BHI (UK) was used. www.bhinstrumentation.co.uk The NES 5 is original DSP Noise reduction unit which must be connected to the loudspeaker output from a receiver or transceiver. It has a built-in small enclosure and has a built-in speaker amplifier IC. To modify the unit open the enclosure of NES5 and take out the PCB board. Desolder the LM380, the 12 Volts regulator, the input resistors R1, R2 and also the output resistors R7 and R8. Replace the resistors with two 10 turn 50 k potentiometers. Mount the DSP board and small 10 volts reed relay on an empty piece PCB board so that you can mount the whole assembly at the under side of the parent board. The relay will be used to switch the audio signal through the processor or direct to the AF input. You have to desolder the wire at point 11/131, that is the AF gain control line of the 2nd 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 to the contact of the relay that is activated when the relay is not activated! The output of the DSP is wired to the other contact of the relay. The relay will be switched in by using the 10 volts of the Noise Blanker switch. By switching in the noise blanker you can adjust the DSP for the right levels by using the 50k input and output potentiometers

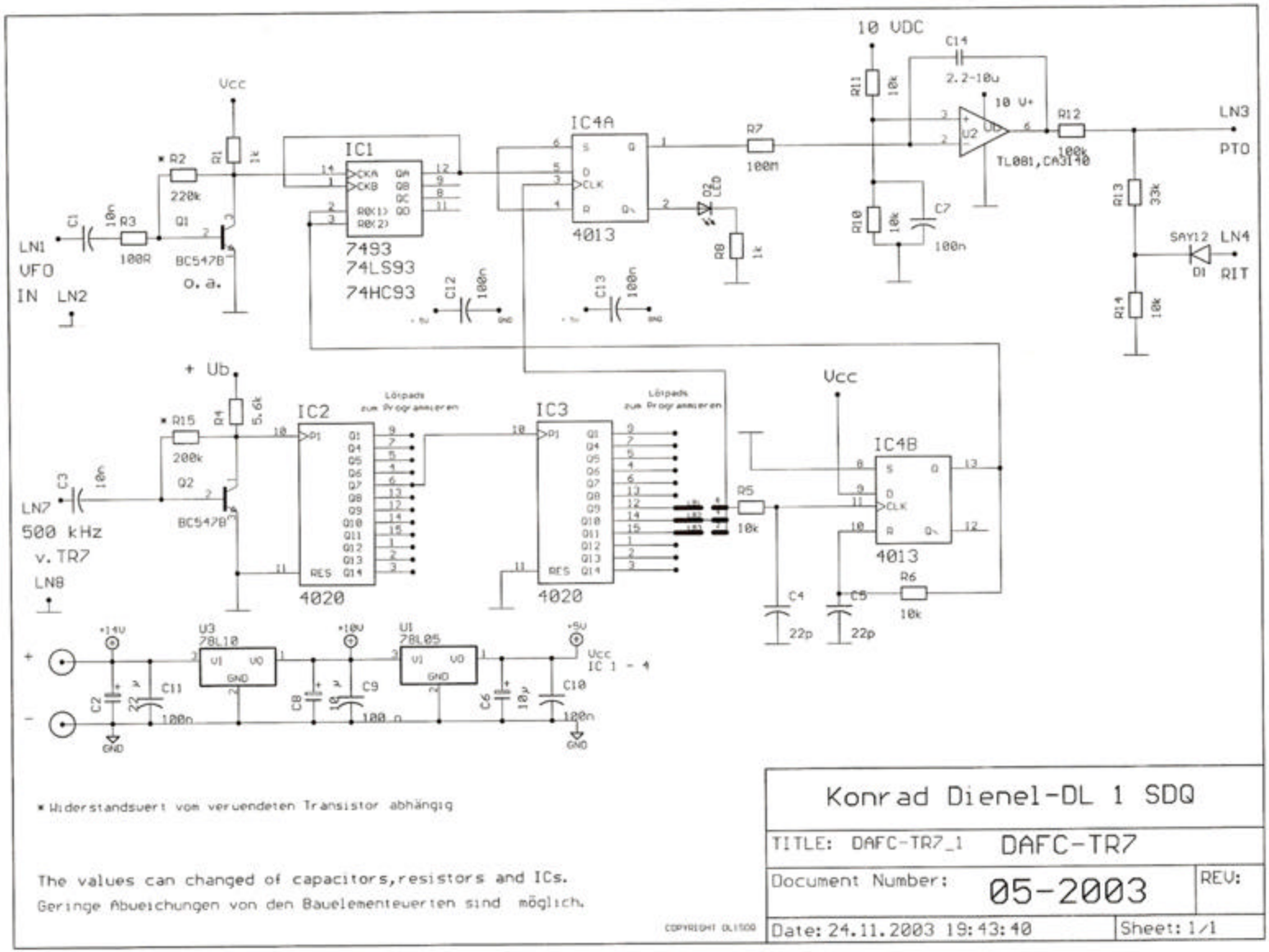


DIGITAL AUTOMATIC FREQUENCY CONTROL
THE PTO

The PTO of the TR7 is continuously drifting. To overcome this problem a DAFC controller was built. The DAFC PCB is mounted to the underside of the parent board. It is using the 500 KHz reference signal of TR7 digital frequency read out and the RIT varicap. The TR7 is stable as a rock now after this modification. RIT control is still possible of course. The design is of DL1SDQ. www.conny-dl1sdq.de You can buy a complete unit including an instruction manual in English or German.



If you want to construct this fine DAFC unit your self, you will find the circuit diagram below.


10 VDC
Vcc
IC1
7493
74LS93
74HC93
IC4A
4013
TL081,CA3140
LN1
VFO
IN
LN2
LN3
PTO
LN4
RIT
SAY12
LED
+ Ub
IC2
IC3
4020
Lötpads zum Programmieren
LN7
500 kHz
v. TR7
LN8
IC4B
+14V
+10V
+5V
U3 78L10
U1 78L05
GND
Vcc IC 1 - 4
* Widerstandswert vom verwendeten Transistor abhängig
The values can changed of capacitors,resistors and ICs.
Geringe Abweichungen von den Bauelementenwerten sind möglich.
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Konrad Dienel-DL 1 SDQ
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DAFC-TR7
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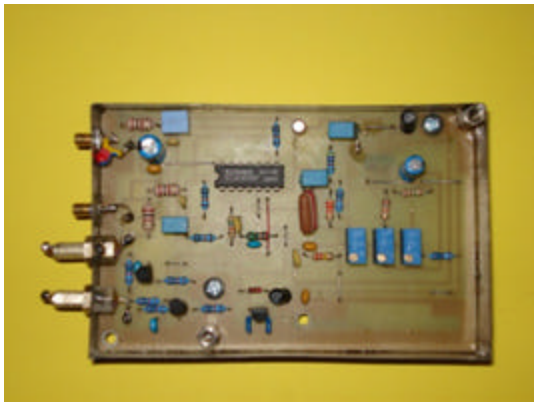
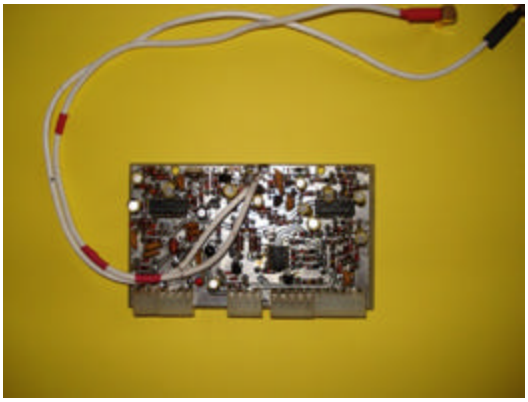
Sheet: 1/1

SPEECH PROCESSOR

The speech processor is a design of DK4SX who used it for his modified TR7. The processor is based on the SSM2166 IC from Analog Devices. I designed a dedicated single sided PCB for the speech processor so it fits to the under side of the parent board. Also small modifications on the exciter board are needed to switch on or off the processor. The whole unit was built into a complete closed metal box.



Speech Processor Board

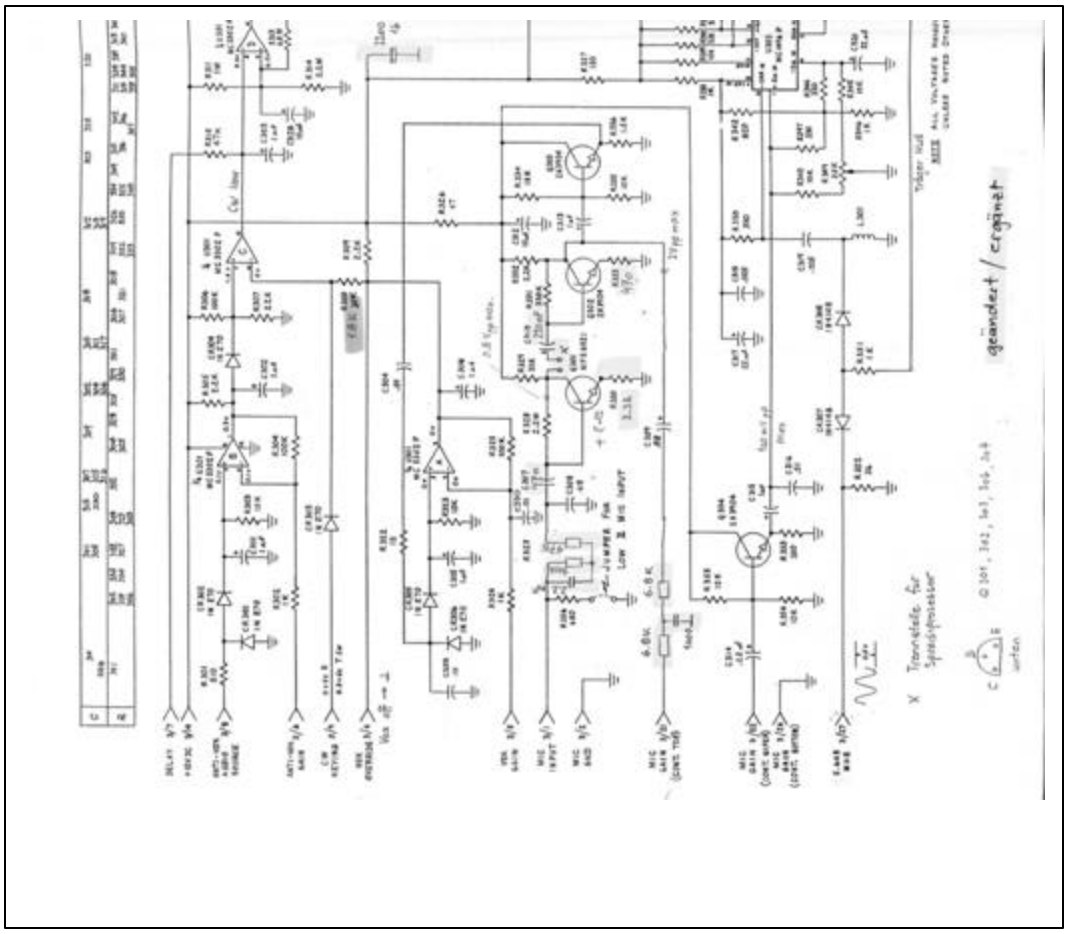


Modified TR7 Exciter board

TR7 Exciter Modifications

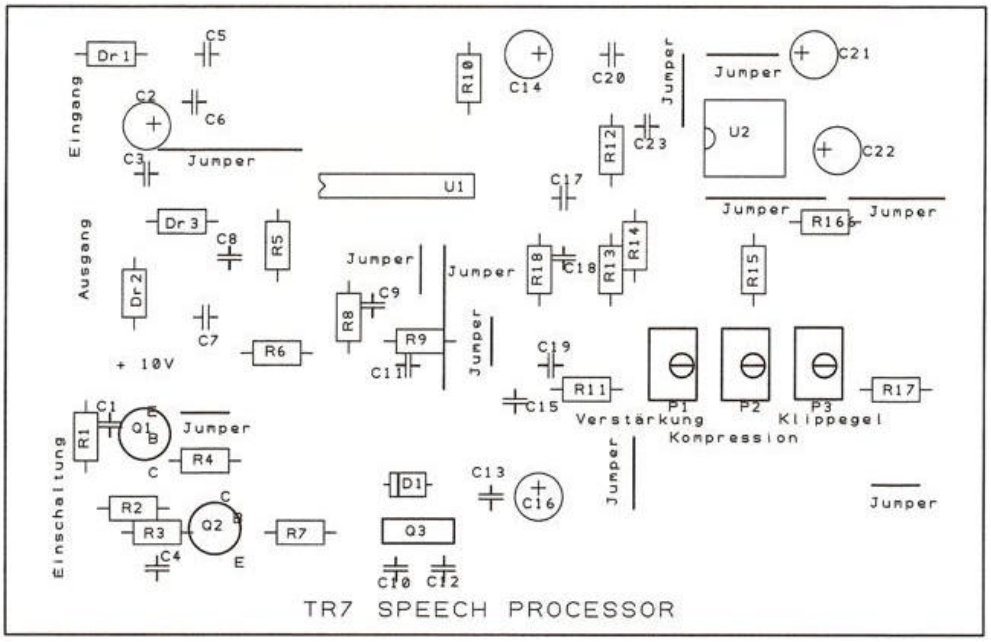
The speech processor will be installed between the two microphone amplification stages. The processor will be connected between the collector of Q301 and capacitor C310. The two cables, one from the collector Q301 and the 12K resistor between the collector Q302 and the microphone gain control.

Some modifications are needed and values of the following components has been changed:
C307= 47 uF
C310=220 uF
R330= 33k
R333= 470

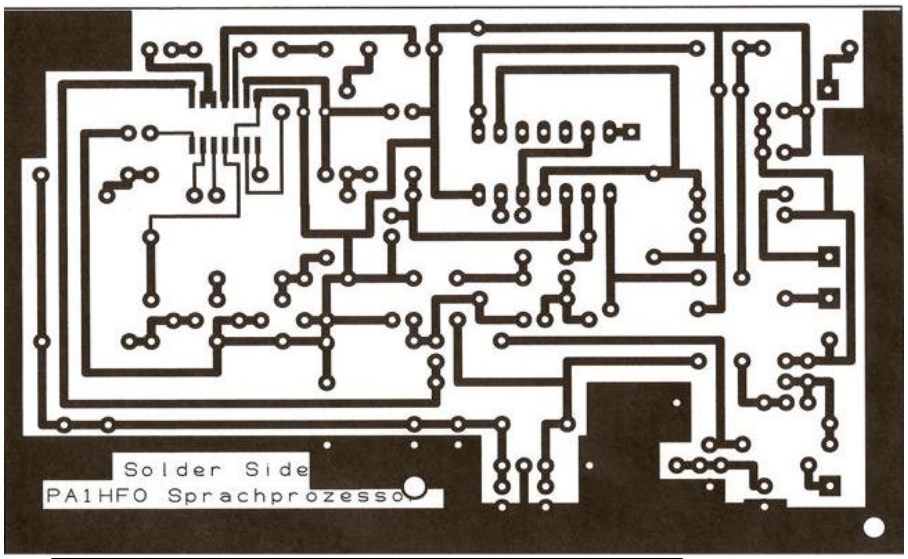


TR7 SPEECH PROCESSOR PCB

Component Layout Speech Processor PCB



Solder Side Speech Processor PCB Scale 1:1



Parts List Sprachprozessor / Speech Processor

Parts List Sprachprozessor / Speech Processor

Ref. Desinator(s)	Qty	Description	Grid
R1	1	10 K Widerstand, Resistor 1/8 watt,	
R2	1	10 K Widerstand, Resistor 1/8 watt,	
R3	1	10 K Widerstand, Resistor 1/8 watt,	
R4	1	10 K Widerstand, Resistor 1/8 watt	
R5	1	100 K Widerstand, Resistor 1/8 watt	
R6	1	100 K Widerstand, Resistor 1/8 watt	
R7	1	10 K Widerstand, Resistor 1/8 watt	
R8	1	56 K Widerstand, Resistor 1/8 watt	
R9	1	150 K Widerstand, Resistor 1/8 watt	
R10	1	100 K Widerstand, Resistor 1/8 watt	
R11	1	330 K Widerstand, Resistor 1/8 watt	
R12	1	47 K Widerstand, Resistor 1/8 watt	
R13	1	33 K Widerstand,Resistor 1/8 watt	
R14	1	1 K Widerstand, Resistor 1/8 watt	
R15	1	18 K Widerstand, Resistor 1/8 watt	
R16	1	1 M Widerstand, Resistor 1/8 watt	
R17	1	1 K Widerstand, Resistor 1/8 watt	
R18	1	100 K Widerstand, Resistor 1/8 watt	
P1	1	10 K Spindel-Trimmpotentiometer	
P2	1	220 K Spindel-Trimmpotentiometer	
P3	1	50 K Spindel-Trimmpotentiometer	
L1	1	100 µH, RFC, SMMC	
L2	1	100 µH, RFC, SMMC	
L3	1	100 µH, RFC, SMMC	
L4	1	100 µH, RFC, SMMC	
D1	1	1N4148, Diode	
C1	1	1 nf Kondensator, Capacitor/Keramisch, Ceramic	1 E
C2	1	100 µF/16V Rad.	3.5 mm
C3	1	100 nF Kondensator, Capacitor/Keramisch, Ceramic	1 E
C4	1	1 nf Kondensator, Capacitor/Ceramic, Keramisch	1 E
C5	1	1 µ Kondensator, Capacitor/MKT, Foil	2 E
C6	1	470 pf Kondensator, Capacitor/Keramisch, Ceramic	1 E
C7	1	1 µ Kondensator, Capacitor/ MKT,Foil	2 E
C8	1	470 pf Kondensator, Capacitor/ Keramisch, Ceramic	1 E
C9	1	3n3 Kondensator, Capacitor/Keramisch, Ceramic	1 E
C10	1	220 nF Kondensator, Capacitor /Keramisch, Ceramic	1 E
C11	1	1n8 Kondensator, Capacitor/ Keramisch, Ceramic	1 E
C12	1	220 nF Kondensator, Capacitor/Keramisch, Ceramic	1 E
C13	1	100 nF Kondensator, Capacitor/ Keramisch, Ceramic	1 E
C14	1	10 µF/16V Rad.	1 E
C15	1	3n3 Kondensator, Capacitor/ Keramisch, Ceramic	1 E
C16	1	10 µF/16V Rad.	1 E
C17	1	1 µ Kondensator, Capacitor/MKT, Foil	2 E
C18	1	1 n Kondensator, Capacitor/ Keramisch, Ceramic	1E
C19	1	330 pF Kondensator, Capacitor/ Keramisch, Ceramic	1E
C20	1	1 µ Kondensator, Capacitor/ MKT, Foil	2E
C21	1	10 µF/16V Rad.	1E

C22	1	22 µF/16V Rad.	1 E
C23	1	10 nf Kondensator, Capacitor/ Keramisch, Ceramic	1 E

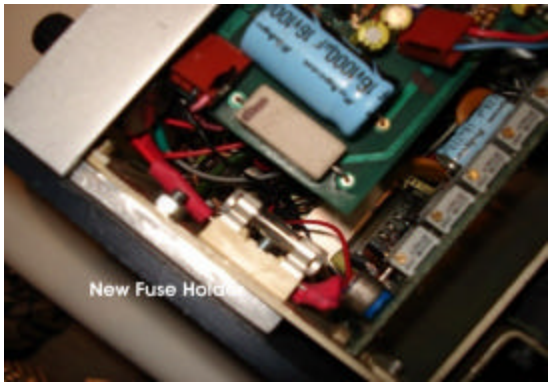
Ref. Desinator(s)	Qty	Description	Grid
U1	1	4066	
U2	1	SSM2166	
Q1	1	BC 557	
Q2	1	BC 547	
Q3	1	78L05	

PCB	1	PCB Sprachprozessor TR7 -19-08-2007	

NEW LED DISPLAY

The 100 Hz digit of digital read out of the TR7 I used for this renovation was not 100 % any more. So I had to replace the complete LED assembly by a new one. By evaluating the specifications I found out it was not available any more. I started to design a new LED display PCB. But someone informed that DF4NW supplies complete display units using standard LED's available in red, green, blue, yellow or a combination of these colours. I ordered the display and after I received I needed less than one hour to remove the old LED display and to assemble the new one. www.df4nw.de

MECHANICAL CHANGES



In TR7 has not much space to integrate additional electronics and circuit boards. The only place is the under side on the parent board, and there is some space available in the high pass compartment. Also there is very little space for additional buttons on the front panel of the TR7. To overcome those problems I decided to increase the total front panel height and the transceiver by 15mm. So I have created enough space for the modifications I wanted to implement without rebuilding the complete TR7.

To mount the notch filter potentiometer on the front panel, and for easy assembly of spacers for the new side panels, we have to do some small modifications in the TR7 itself. First the large fuse and fuse holder will be replaced by smaller type 5mm x 20mm fuse.

The second change is to replace the two rear mounting screws of the power amplifier unit with longer ones. The longer screws will be used now to fix one of spacer strips.

FRONT PANEL EXTENSION

To increase the front panel I am using a 330mm x 15mm x 1.5mm aluminium “U” profile. Holes must be drilled for the key jack connector, tune switch, processor switch, processor LED, LNA Switch, and LNA LED. Also two small holes are drilled to screw the front panel extension to the TR7. The same piece profile is used for the rear side of the TR7, only two holes are drilled to screw the rear extension to the transceiver.

Front panel extension installed

TR7 with rear side extension installed

SIDE PANELS

The new side panels are made from aluminium 350mm wide, 130mm high and 5mm thick. Two pair of panels are made, one pair for the TR7 and one pair for the power supply.

Example of a side panel

SPACERS FOR THE SIDE PANELS

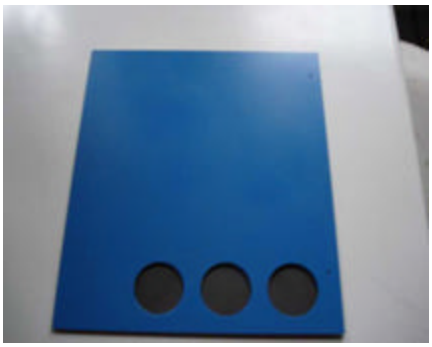
To assemble the two side panels to the transceiver four spacer strip are made of 4.3mm thick aluminium or brass.

Spacer strips at the right side of TR7

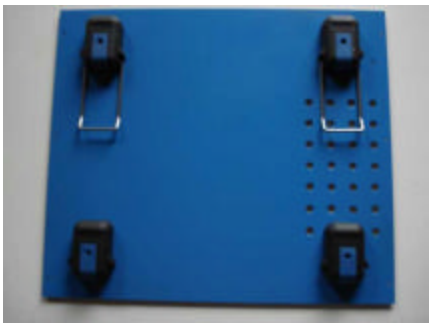
Spacer strips at the left side of TR7

TOP AND BOTTON COVER PLATES

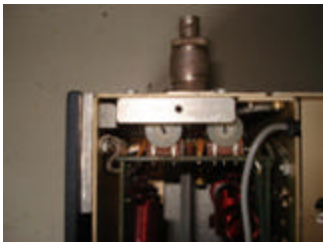
A top plate and bottom plate are made from 1.5mm aluminium and adequate holes are drilled for the necessary ventilation. The top cover plate slides into the front of the TR7 like the original metal cover. At the left rear and right rear sides two aluminium support blocks are mounted. In each block there is a hole with 3mm screw thread. At the under side two support aluminium support blocks (270mm x 10mm x 10mm) are mounted to the left and right side panels. In the top side of the each support block three holes are made with 3mm screw thread to fix the bottom cover plate to the transceiver. The support blocks are used to fix the front and rear extensions to the transceiver.



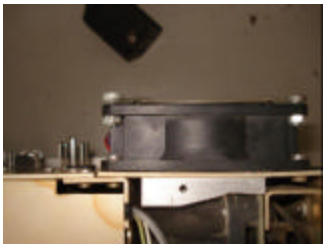
Top cover plate



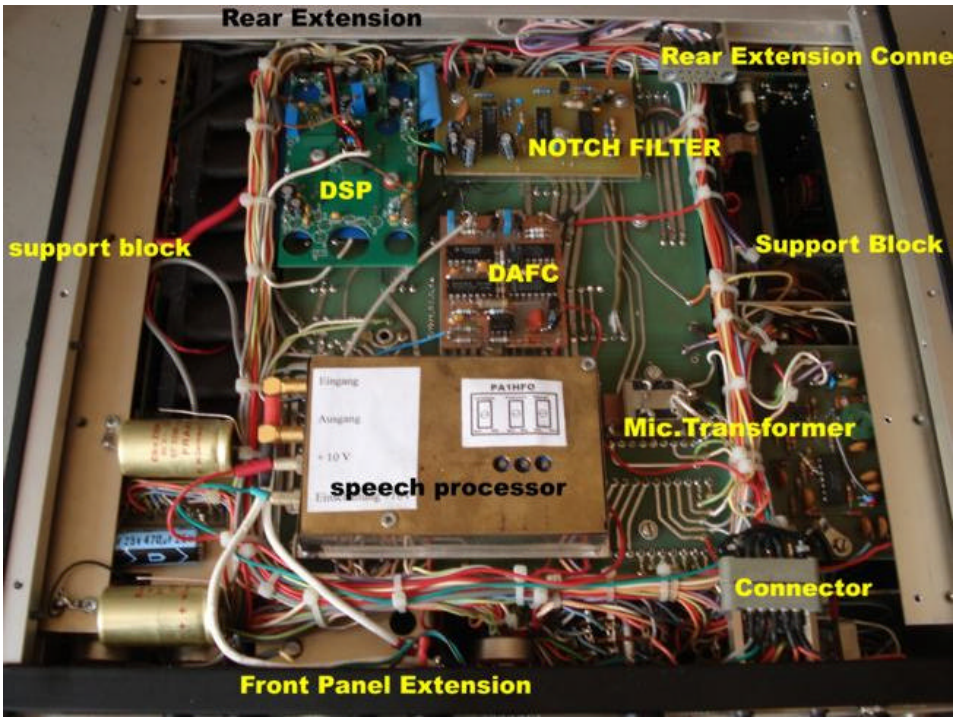
Bottom cover plate



Left side support block



Right side support block



KEY JACK

A small 3mm phone jack is being used and mounted to front panel extension. This is parallel wired to large CW jack at rear side.

TUNE BUTTON

The tune push button will be mounted to the front panel extension, and is wired to the CW jack at rear side of the transceiver and to ground. Tuning is very simple now, switch the TR7 in CW mode and activate the push button.

SPEECH PROCESSOR BUTTON AND INDICATOR LED

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

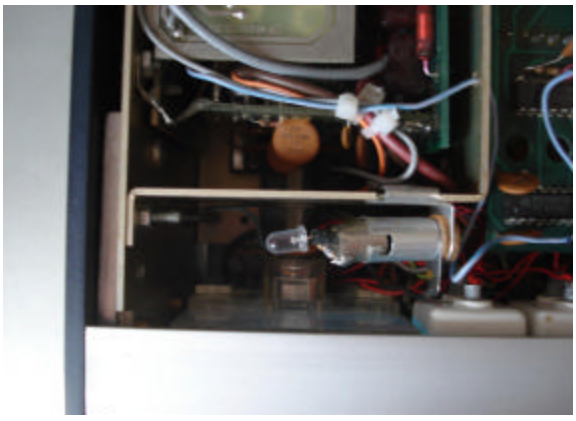
PREAMPLIFIER BUTTON AND INDICATOR LED

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

BULB's REPLACED WITH LED's

The bulbs in the S-meter and analog VFO dial are replaced with high density LED's. I used defective bulb sockets, removed glass and internal wiring, and soldered a resistor and LED into the socket. By using this method you don't need to replace the sockets in the transceiver.

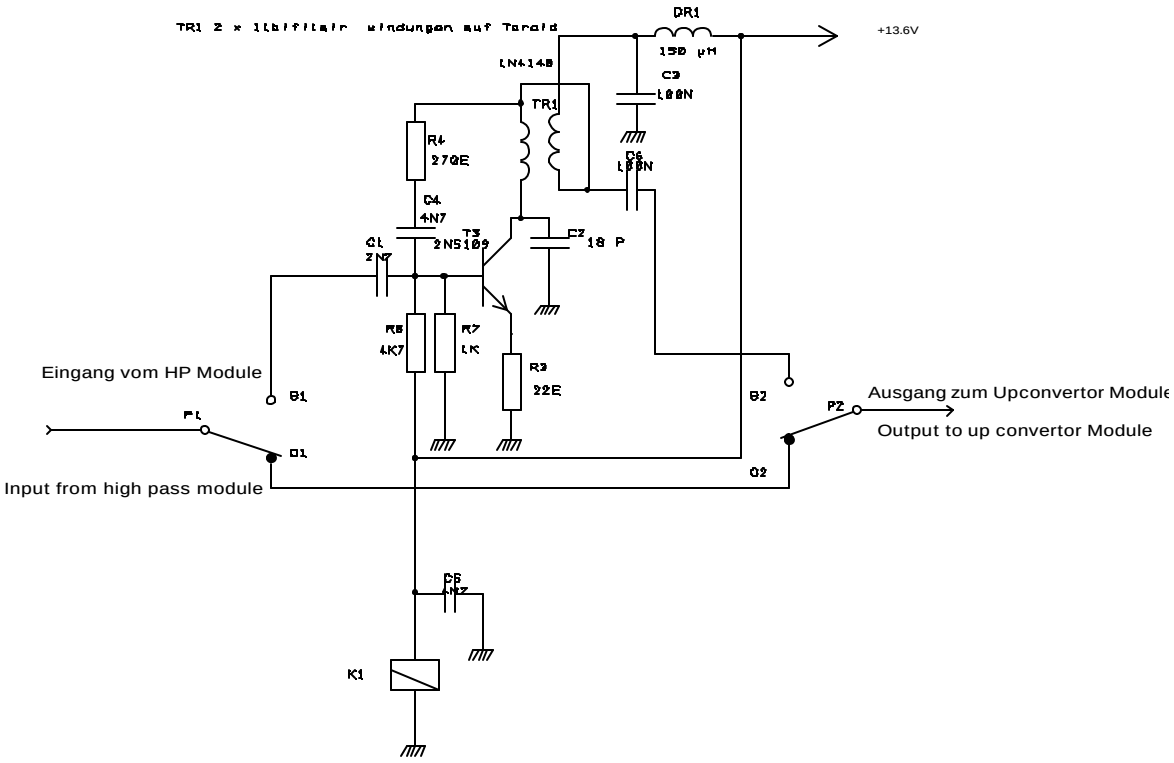
LED built into a bayonet socket



S-meter LED light

SELECTABLE PREAMPLIFIER

The sensitivity of the TR7 on the higher bands is sometimes too low. A preamplifier can improve the sensitivity of the receiver section. The best method is to use a selectable preamplifier with an gain approximately 10dB and high interception point.



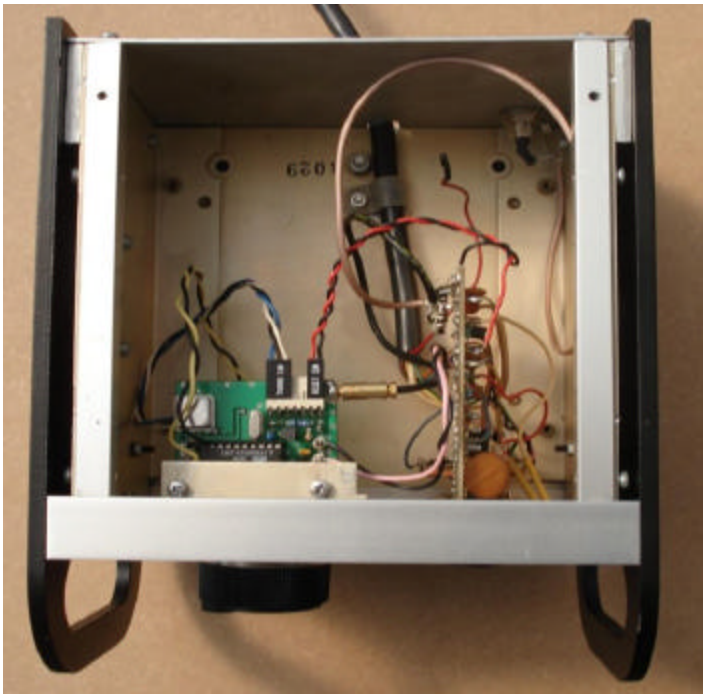
Circuit diagram of the home brew pre-amplifier

If you don't want to built the preamplifier yourself you can buy one from DF4NW. It is completely assembled selectable preamplifier. www.df4nw.de

RV7 RENEWED

I also renewed the remote RV7 VFO. It became the same styling and color of the renewed TR7 and power supply. Electricaly the RV7 was in working condition but was very unstable. Some experiments with a DAFC to compensate the drift didn't satisfy me at all.
I replaced the existing PTO with a homebrew DDS, (design by KD1JV) with a programmed frequency range from 4 .55MHz to 5.55MHz, and has tuning steps of 10Hz, 100Hz, 250Hz and 5 KHz. The push button, see below, on the front panel is the RIT control for the remote DDS, like the synthesised RV75. It allows the receiver to be offset from the receiver in +/- 25Hz steps over the full 1 MHz VFO range from the transmitter. Also the DDS output, 4.55MHz to 5.55MHz is available via a BNC connector at the rear side of RV7.

The renewed RV7



OTHER IMPROVEMENTS

Fan

The existing fan on the PA was replaced by a silent 12 volt version. I have reversed the flow direction of the fan for the PA at rear side. The air is now blown into the PA, this increases the efficiency. A dust filter is mounted to the fan. A thermocouple switch is mounted to the heatsink and activates the fan when the heatsink reaches the temperature of approximately 40 degrees Celsius.

Indicator Lamps

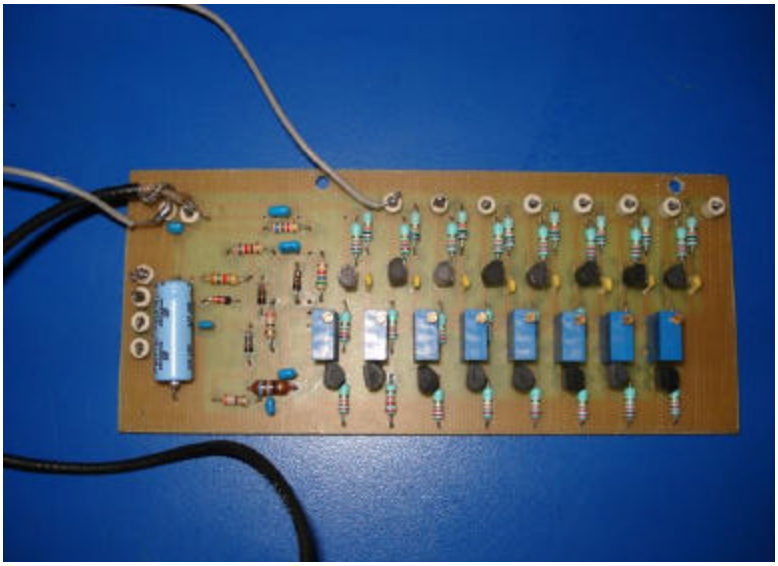
All the indicator lamps are replaced with LED's.

Phase Noise Improvements

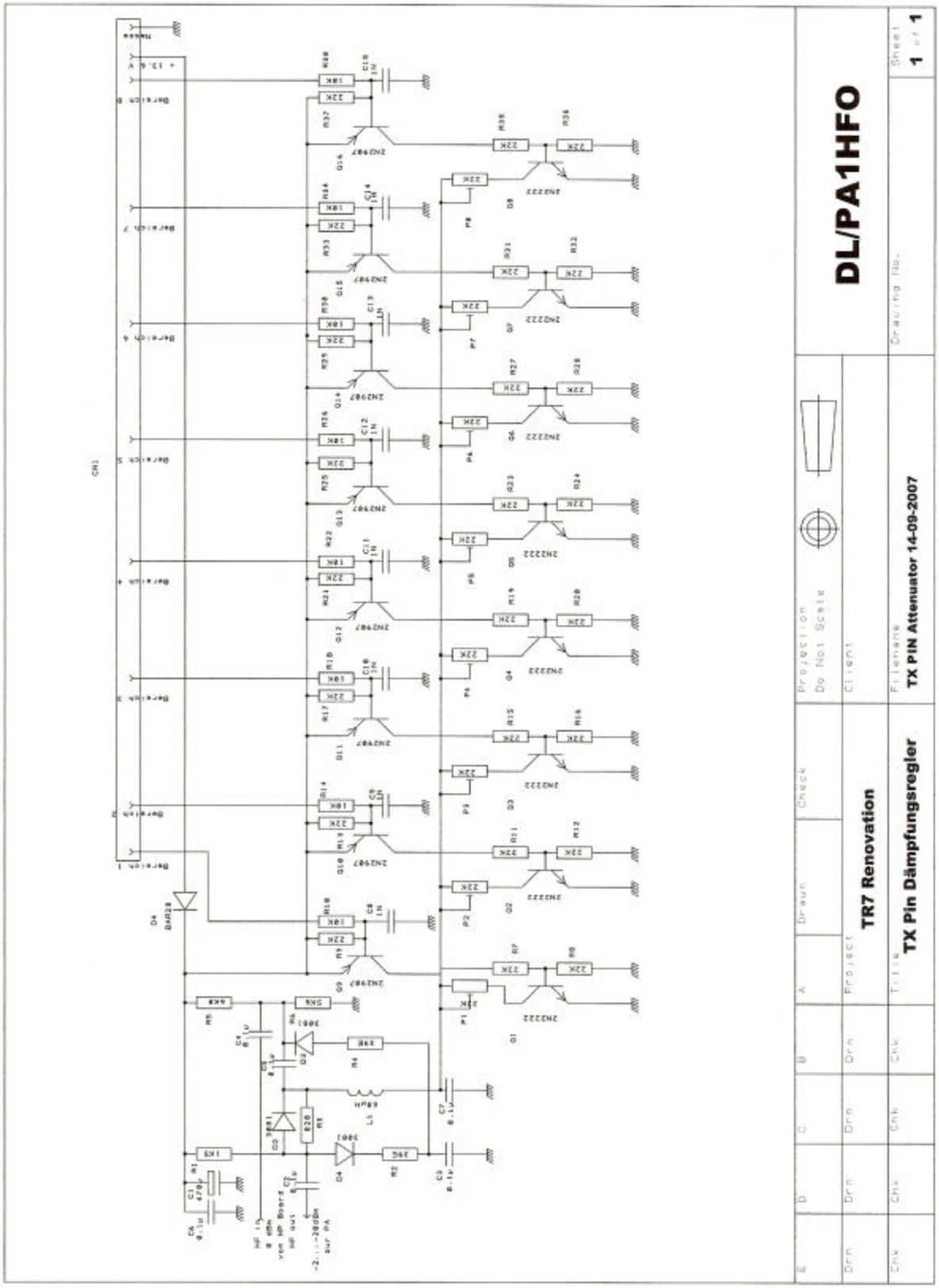
I am busy trying to improve the phase noise by several dB. To measure the phase noise of a receiver or transceiver you need the right instruments. The most important one is a reference signal with a very good phase noise and a good attenuator (140 dB). I have built a crystal oscillator for the range from 1-30 MHz with very good phase noise figure. When I have the attenuator finished, I will then be able to measure the phase noise in a very simple way. I already have an idea on how I can improve the phase noise figure by a few dB with some simple additions. But first I need to finish my test instruments.

Improvements in the PA flatness

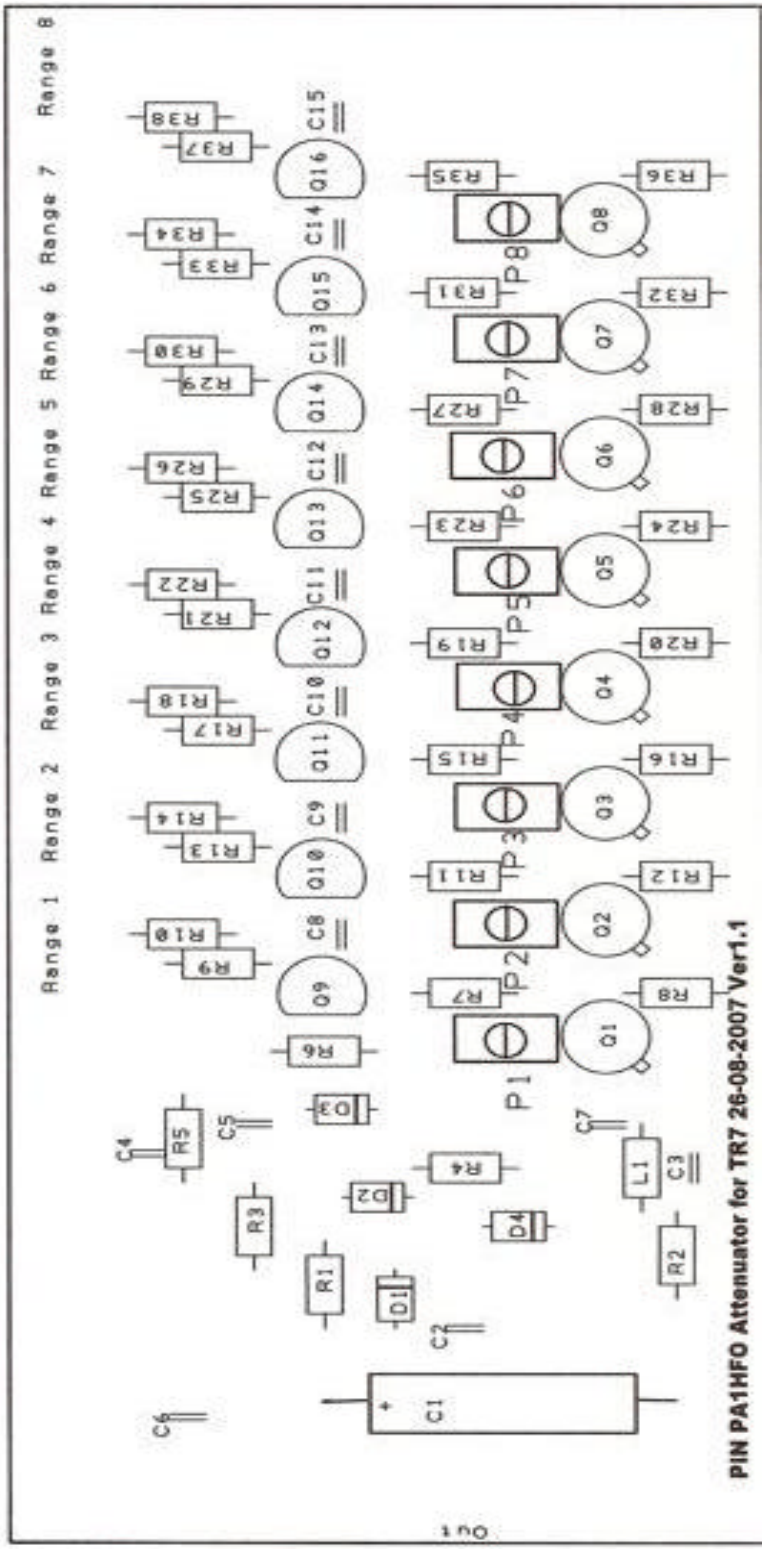
The gain of the PA in the TR7 is not flat over the range 1-30MHz. The result is that the power output fluctuates on the different ham bands. I solved this problem by using an adjustable PIN attenuator. The attenuator is placed between the high pass transmitter output and the driver input of the PA. It has 8 different selectable adjustable ranges controlled via the Digital Control Board. You are now able to use the maximum gain of the PA over whole range from 1-30MHz without oscillation on the lower bands, because you can adjust the right input level of the PA with the attenuator for all of the 8 ranges of the TR7. The design of this attenuator is from DK4SX. For the attenuator I have designed a dedicated PCB board to fit exactly on the left side frame in the TR7 at the under side above of the PA.



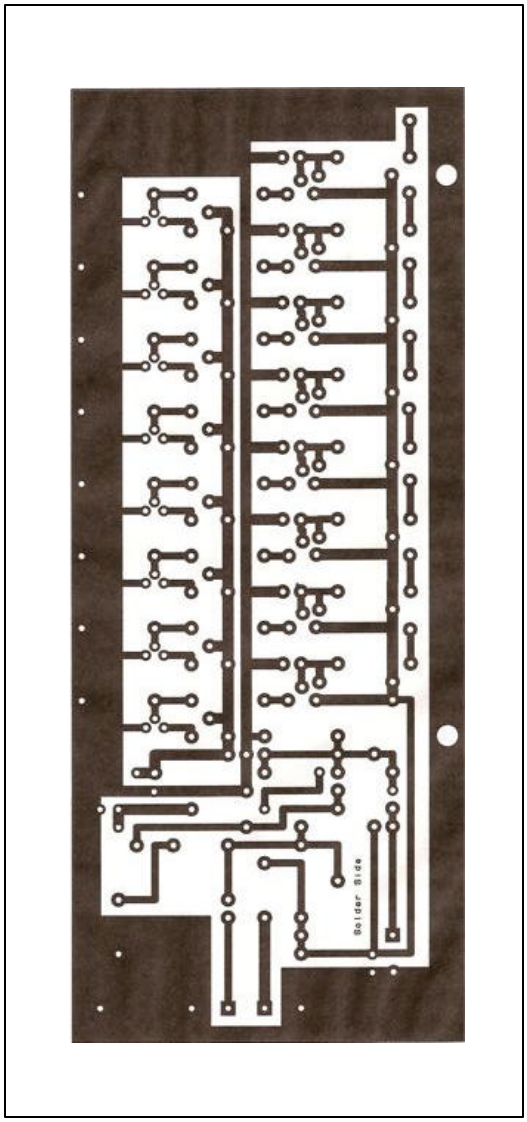
CIRCUIT DIAGRAM PIN ATTENUATOR



Component Layout Component Side



PCB Lay Out Attenuator Scale 1:1



Part List

Ref. Desinator(s)	**Qty**	**Description**
R1	1	1k5 Widerstand,Resistor 1/8 watt,
R2	1	39R Widerstand,Resistor 1/8 watt,
R3	1	820R Widerstand,Resistor 1/8 watt,
R4	1	39R Widerstand,Resistor 1/8 watt
R5	1	6K8 Widerstand,Resistor 1/8 watt
R6	1	5k6 Widerstand,Resistor 1/8 watt
R7	1	22k Widerstand,Resistor 1/8 watt
R8	1	22 K Widerstand,Resistor 1/8 watt
R9	1	22k Widerstand,Resistor 1/8 watt
R10	1	10k Widerstand,Resistor 1/8 watt
R11	1	22 k Widerstand,Resistor 1/8 watt
R12	1	22 k Widerstand,Resistor 1/8 watt
R13	1	22 K Widerstand,Resistor 1/8 watt
R14	1	10 k Widerstand,Resistor 1/8 watt
R15	1	22 K Widerstand,Resistor 1/8 watt
R16	1	22 K Widerstand,Resistor 1/8 watt
R17	1	22 K Widerstand,Resistor 1/8 watt
R18	1	10k Widerstand,Resistor 1/8 watt
R19	1	22 K Widerstand,Resistor 1/8 watt
R20	1	22 K Widerstand,Resistor 1/8 watt
R21	1	22 K Widerstand,Resistor 1/8 watt
R22	1	10k Widerstand,Resistor 1/8 watt
R23	1	22 K Widerstand,Resistor 1/8 watt
R24	1	22 K Widerstand,Resistor 1/8 watt
R25	1	22 K Widerstand,Resistor 1/8 watt
R26	1	10 K Widerstand,Resistor 1/8 watt
R27	1	22 K Widerstand,Resistor 1/8 watt
R28	1	22 K Widerstand,Resistor 1/8 watt
R29	1	22 K Widerstand,Resistor 1/8 watt
R30	1	10 K Widerstand,Resistor 1/8 watt
R31	1	22 K Widerstand,Resistor 1/8 watt
R32	1	22 K Widerstand,Resistor 1/8 watt
R33	1	22 K Widerstand,Resistor 1/8 watt
R34	1	10k Widerstand,Resistor 1/8 watt
R35	1	22 k Widerstand,Resistor 1/8 watt
R36	1	22 k Widerstand,Resistor 1/8 watt
R37	1	22 k Widerstand,Resistor 1/8 watt
R38	1	10k Widerstand,Resistor 1/8 watt
P1	1	22K Spindel-Trimmpotentiometer
P2	1	22K Spindel-Trimmpotentiometer
P3	1	22K Spindel-Trimmpotentiometer
P4	1	22K Spindel-Trimmpotentiometer
P5	1	22K Spindel-Trimmpotentiometer
P6	1	22K Spindel-Trimmpotentiometer
P7	1	22K Spindel-Trimmpotentiometer

P8	1	22K Spindel-Trimmpotentiometer
L1	1	68 µH, RFC, SMMC
D1	1	BAR 28
D2	1	HP 3081 PIN Diode
D3	1	HP 3081 PIN Diode
D4	1	HP 3081 PIN Diode
C1	1	470 µF Axiaal 16V
C2	1	100 nF Kondensator, Keramisch ,Capacitor, Ceramic
C3	1	100 nF Kondensator, Keramisch ,Capacitor, Ceramic
C4	1	100 nF Kondensator, Keramisch ,Capacitor, Ceramic
C5	1	100 nF Kondensator, Keramisch ,Capacitor, Ceramic
C6	1	100 nF Kondensator, Keramisch ,Capacitor, Ceramic
C7	1	100 nF Kondensator, Keramisch ,Capacitor, Ceramic
C8	1	1n Kondensator, Keramisch, Capacitor, Ceramic
C9	1	1n Kondensator, Keramisch, Capacitor, Ceramic
C10	1	1n Kondensator, Keramisch, Capacitor, Ceramic
C11	1	1n Kondensator, Keramisch, Capacitor, Ceramic
C12	1	1n Kondensator, Keramisch, Capacitor, Ceramic
C13	1	1n Kondensator, Keramisch, Capacitor, Ceramic
C14	1	1n Kondensator, Keramisch, Capacitor, Ceramic
C15	1	1n Kondensator, Keramisch, Capacitor, Ceramic
Q1	1	2N2222
Q2	1	2N2222
Q3	1	2N2222
Q4	1	2N2222
Q5	1	2N2222
Q6	1	2N2222
Q7	1	2N2222
Q8	1	2N2222
Q9	1	2N2907
Q10	1	2N2907
Q11	1	2N2907
Q12	1	2N2907
Q13	1	2N2907
Q14	1	2N2907
Q15	1	2N2907
Q16	1	2N2907
PCB	1	PCB PIN Dämpfungsregler TR7Ver 1.1, 31-08-2007