Description of a homemade 28-144 MHz Transverter

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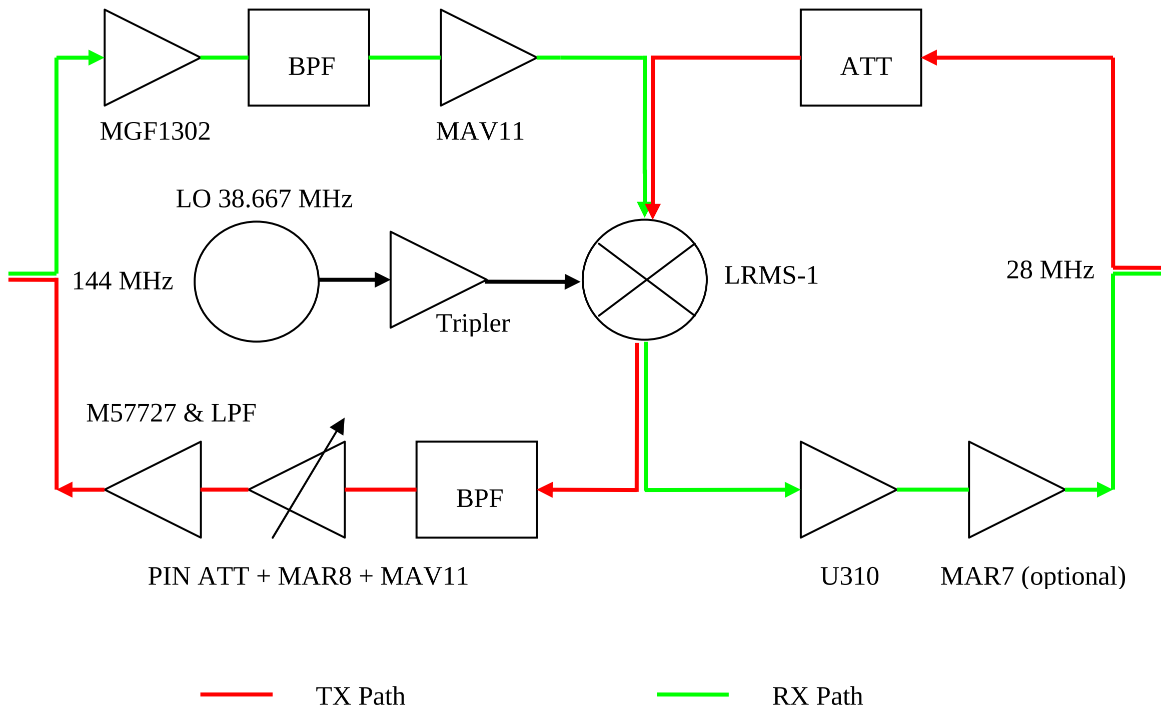
1. Introduction

This document provides the description of a 144 MHz transverter to be used in conjunction with a 28 MHz HF rig acting as Intermediate Frequency (IF). It has been designed and built in 1996 and since I've been requested several times to provide its schematics, I've decided to describe it in the present document. As I don't own anymore the original schematics under soft copy, I provide hereby the scanned hardcopies which have been handwritten updated according to the modifications done in the course of the years following the building of the transverter.

As designed 10 years ago, this transverter is no more state-of-the-art and there could be room for improvement. Neverthless, I use it at the 2m station since then, without a single failure, all the more that the device is remotely operated, away from the shack in a "harsh" environment (ambient temperature ranging roughly from 0° to 40°C).

2. Bloc diagram



3. Principle of operation

3.1 RX path

The signal coming from the antenna enters the transverter through a N connector towards a true coaxial relay. It is amplified in a helical resonator pre-amp using a MGF1302 GaAsFET transistor [possible improvement : an ATF33143 or ATF54143 HEMT transistor, having better IP3 behaviour]. The signal is then filtered in a 3 sections helical Band-Pass Filter (BPF) and further amplified by a MAV11 MMIC [possible improvement : usage of a P8002 transistor]. The signal is then mixed with a local 116 MHz oscillator (see section 3.3) in a standard 7 dBm level LRMS-1 mixer [possible improvement : LRMS-1H 17 dBm high level mixer for better dynamic range]. The 28 MHz mixing component is filtered through a 50 Ω diplexer and then amplified by a U310 transistor. The subsequent MAR7 MMIC stage is optional (and not recommended in most cases), to be used in case of a long coax length between the transverter and its IF transceiver. Indeed, the transverter has been used during contests where the shack was lying at the bottom of a coalheap and the antennas, transverter & PA were located at its top. The IF coax length was about 300 m. In such a situation, if needed (28 MHz is not a frequency where coax attenuation is so high), an other component than a MAR7 would probably be more appropriated to handle strong signals (there is already a high gain in front of that last stage). The RX signal is then finally sent to the IF transceiver.

3.2 TX path

The TX signal is attenuated by a fix value T attenuator followed by an adjustable one, so that the drive level at the input of the mixer is set around -10 dBm. After mixing with the local 116 MHz oscillator, the 144 MHz component is filtered by a helical 3 sections BPF and further attenuated (if needed) by a PIN diode variable attenuator of which control voltage is adjusted by mean of a front panel variable resistor ("Power Control"). The TX signal is afterwards amplified in the driver stage by a MAR8 and a MAV11 MMIC's. This results in around 30 mW (15 dBm) at the input of the M57727 hybrid module which provides, after filtering through a 5 poles Low-Pass Filter (LPF), from 0 to 30W according to the power control variable resistor setting [possible improvment : the usage of a RA60H1317M hybrid module, to get around 60W, that is convenient to drive a medium level triode power amplifier].
There is no ALC nor PTT sequencer in the transverter. This last one is provided by a homemade "Transverter Interface" located close to the IF transceiver.

3.3 Local Oscillator

Quite a basic and common concept, a 38.6667 MHz "low noise" U310 oscillator is amplified (tripled) by a BFR96 and filtered to extract the third harmonic of the oscillator's fundamental frequency [possible improvement : an even more lower noise Butler oscillator]. Even though the usage of a standard quartz and the harsh environment where the transverter is used temperature-wise, the stability is excellent without any temperature control mean. No retune is needed on the IF transceiver even for JT65 operation.

4. Building details

The following sections show the schematics of the different modules. Here are some advises addressed to the potential builder.

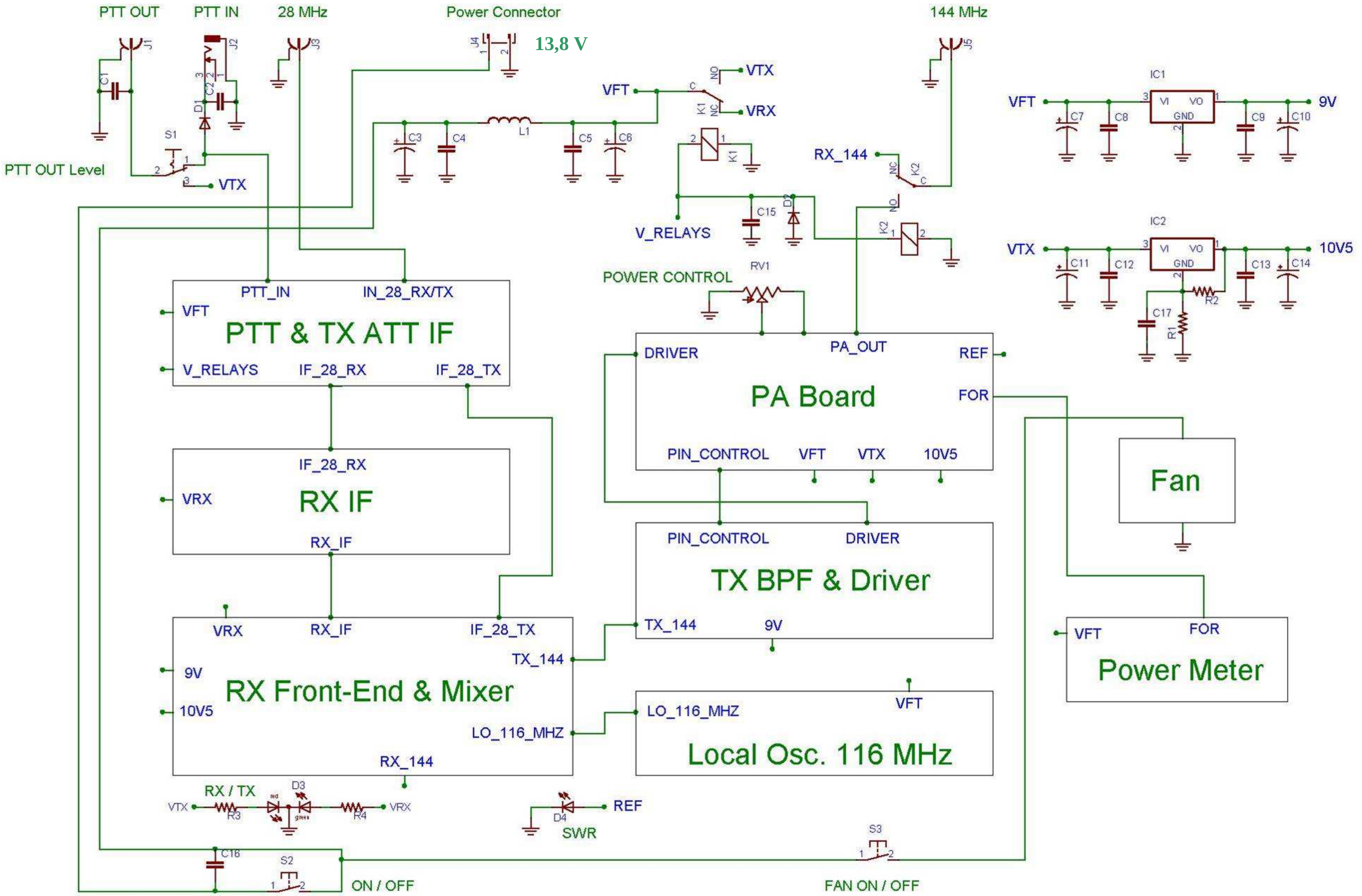
- No PCB layout is provided, all the more there have been some modifications since the original design. Indeed, at the time I built the transverter, my method was not very re-producable i.e. I used to use an adhesive film put on the board; the components were located on the top and the film was removed with a cutter where the copper had to leave. The board was then etched. Nowadays, I use the same technique but instead of placing the components directly on the board/adhesive film assembly, I use any standard drawing editor, for example “Paint” available in the accessories of MS Windows. I’ve drawn several standard component footprints which I copy-paste on my workspace. Afterwards, I print the resulting sheet and place it on top of the board/adhesive film assembly and proceed the same way than before. The difference is that I now have a softcopy of the PCB layout.
  When working at 144 MHz, the PCB layout is not very critical but as in any RF PCB, the tracks must be kept as short as possible and the 50 Ω track’s width must be respected according to the PCB dielectric. Of course, FR4 epoxy (ε_r = 4,8) is more than sufficient. For good ground planes, better use double-sided boards.
- <u>Unless already indicated on the schematics</u>, the component part lists are given in the coming sections. However, if a part data needs more details than just a value on the schematic, they are mentioned in the part list tables.
- Unless otherwise stated, the resistors have ¼ W dissipation.
- Unless otherwise stated, the capacitors of the tuning circuits have a NP0 temperature coefficient. Some capacitors of the local oscillator’s tuning circuits have other temperature coefficients (see the part list in the related section). The temperature coefficient of the decoupling capacitors is not critical (X7R is more than sufficient).
- The RF signal tracks on the PCB will have a 50 Ω impedance. On a standard 1,6 mm thick FR4 Epoxy board, this represents 2,7 mm wide tracks.
- The part lists mention the component data I used (some are oversized power handling-wise) but other types can be used instead (144 MHz is not so critical), as long as values and temperature coefficients remain the same.

5. Description of the modules

5.1 Assembly of the modules in the enclosure

Part list				
Part ID	Value	Type	Supplier	Remarks
J1	RCA Jack	Connector	Various	
J2	3,5mm Jack	Connector	Various	
J3	PL259	Connector	Various	
J4	Power connector	Connector	Various	Any connector that can handle 10A is suitable
J5	N	Connector	Various	
S1	SPDT	Switch	Various	
S2	SPST	Switch	Various	10A handling
S3	SPST	Switch	Various	
K1		Relay	Various	10A handling
K2	CX-120A	Coax Relay	Tohtsu	
R1	27 Ω	¼ W	Various	
R2	560 Ω	¼ W	Various	

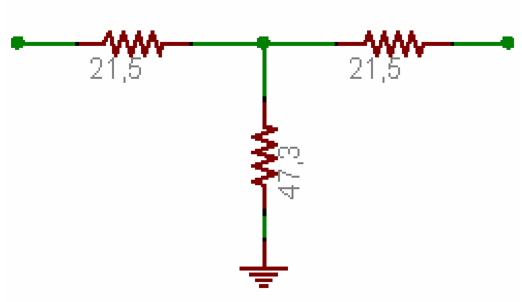
R3	1 kΩ	¼ W	Various	
R4	1 kΩ	¼ W	Various	
RV1	4,7 kΩ	Linear	Various	Variable Resistor
C1	10 n		Various	
C2	10 n		Various	
C3	470 µ	25 V	Various	
C4	10 n		Various	
C5	10 n		Various	
C6	470 µ	25 V	Various	
C7	1 µ	25 V	Various	
C8	10 n		Various	
C9	10 n		Various	
C10	1 µ	16 V	Various	
C11	1 µ	25 V	Various	
C12	1,2 n		Various	
C13	1,2 n		Various	
C14	1 µ	16 V	Various	
C15	10 n		Various	
C16	10 n		Various	
C17	1,2 n		Various	
D1	1N4148		Various	
D2	1N4148		Various	
D3		LED	Various	Red/Green Dual Color LED
D4		LED	Various	Red LED
L1	A few turns of 1,5 mm Ø enameled wire wound on a ferrite rod (not critical)			
IC1	7809	Regulator	Various	
IC2	7810	Regulator	Various	
FAN			Various	Small fan


PTT OUT
PTT IN
28 MHz
Power Connector
13,8 V
144 MHz
PTT OUT Level
VTX
VRX
VFT
V_RELAYS
RX_144
POWER CONTROL
9V
10V5
PTT & TX ATT IF
PTT_IN
IN_28_RX/TX
V_RELAYS
IF_28_RX
IF_28_TX
PA Board
DRIVER
PA_OUT
REF
FOR
PIN_CONTROL
Fan
RX IF
RX_IF
TX BPF & Driver
TX_144
RX Front-End & Mixer
LO_116_MHZ
Power Meter
Local Osc. 116 MHz
RX / TX
REF
SWR
ON / OFF
FAN ON / OFF

5.2 PTT & TX ATT(enuator) IF

The RX/TX activation of the transverter is done either via the "PTT IN" connector (J2) that receives the PTT command from the IF transceiver or by mean of the HF VOX lying on the board. The delay of the VOX can be adjusted to the operator's need by changing the value of the 47µF capacitor connected to the base of the 2N2222 transistor.
The "PTT OUT" connector (J1) on the back panel of the transverter can be connected to the PTT input of a subsequent linear amplifier. The "PTT OUT" level towards the amplifier can be either Ground or Vcc (13,8 V); this is selected by mean of the "PTT OUT Level" switch (S1) on the back panel.

The TX attenuator comprises a fix 8 dB T attenuator followed by an adjustable one. It has been designed to handle 10W at the input.
8 dB T attenuator :



For 10W input, the dissipation in the left 21,5 Ω resistor is 4,3 W, in the right 21,5 Ω, it is 0,68 W and 3,4 W in the 47,3 Ω resistor.

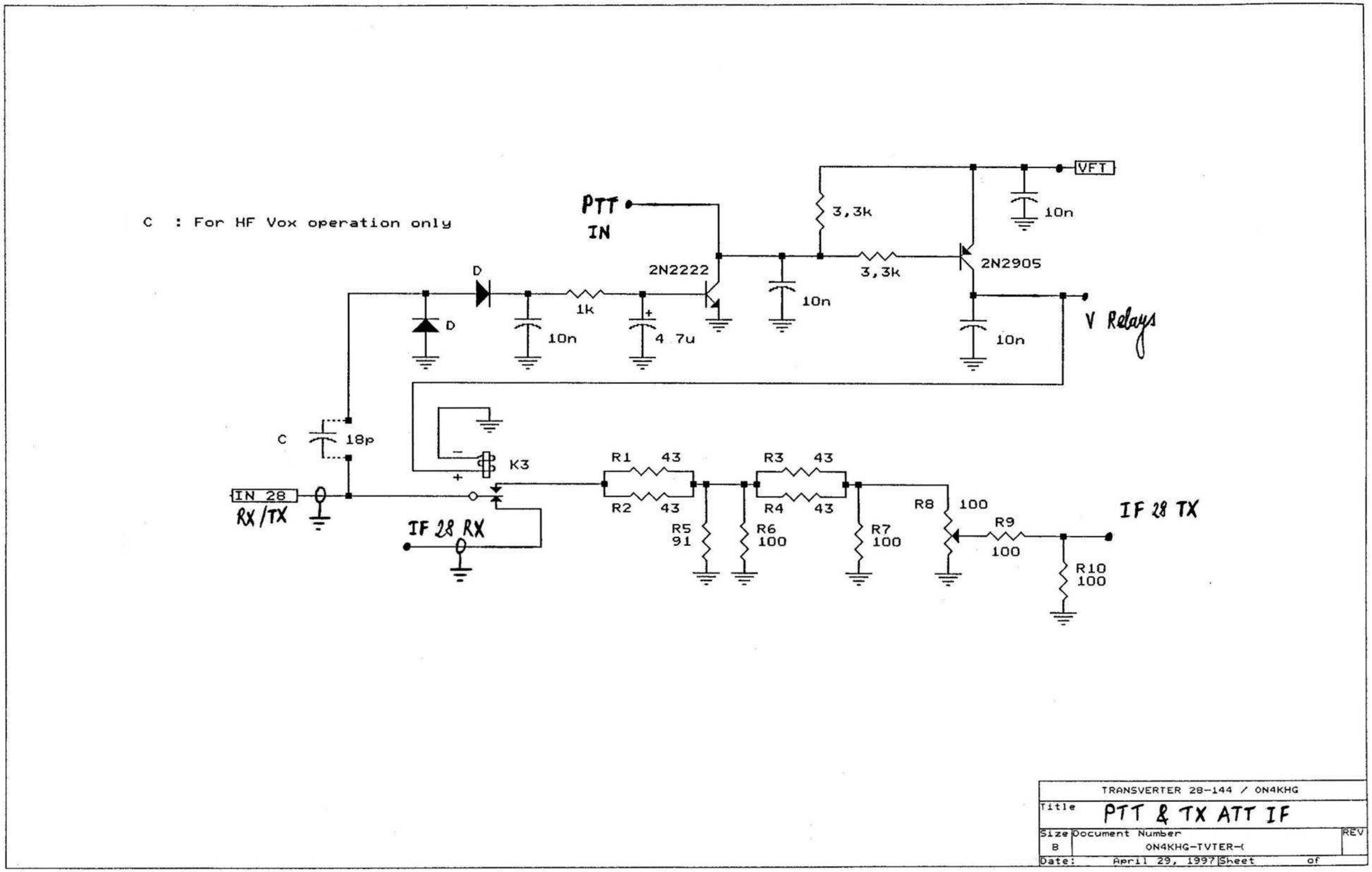
The measured figures on the whole attenuator are (@ 29 MHz) :

S_{11}, $S_{22} \approx$ -23 dB (or a VSWR of 1,15:1). The figure is relatively independent of the R8 variable resistor setting (the attenuator has been designed so).
S_{12}, S_{21} = -22 dB (R8 cursor set to hot point) to -50 dB (R8 cursor set to ground).

Given the mixer would preferably be driven with maximum -10 dBm to avoid too much spurii, the drive level at the input of the transverter (neglecting the loss of K3 and the loss of the switching PIN diode before the mixer) will lie between 12 dBm (15 mW) and 40 dBm (10 W).

The PTT HF VOX operation is not recommended; an external (sequenced) PTT is much better.

Part list (excl. parts data already given on schematic)				
Part ID	**Value**	**Type**	**Supplier**	**Remarks**
R1	43 Ω	2,5 W	Philips	Metal Film PR52
R2	43 Ω	2,5 W	Philips	Metal Film PR52
R3	43 Ω	1,6 W	Philips	Metal Film PR37
R4	43 Ω	1,6 W	Philips	Metal Film PR37
R5	91 Ω	1,6 W	Philips	Metal Film PR37
R6	100 Ω	3 W	Philips	Metal Film PR03
R7	100 Ω	3 W	Philips	Metal Film PR03
R8	100 Ω	½ W	Various	Variable Resistor
R9	100 Ω	¼ W	Various	Mini-Melf
R10	100 Ω	¼ W	Various	Mini-Melf
D	1N60		Various	Any Standard Si or Ge diode


C : For HF Vox operation only
PTT IN
VFT
3,3k
10n
2N2222
2N2905
3,3k
D
D
1k
10n
10n
4.7u
10n
V Relays
C
18p
K3
R1 43
R3 43
R2 43
R4 43
IN 28
RX/TX
IF 28 RX
R5 91
R6 100
R7 100
R8 100
R9 100
IF 28 TX
R10 100
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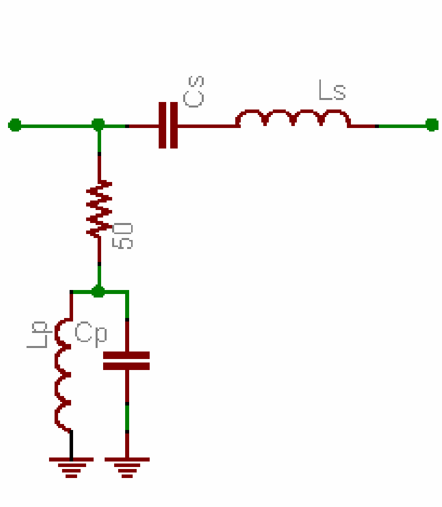
5.3 RX IF

This module amplifies the (RX) 28 MHz IF signal together with providing a broadband termination to the mixer. At the input, one finds a diplexer that acts as making the mixer see 50 Ω over a wide range of frequencies, together with selecting the 28 MHz mixing product to be amplified by the subsequent U310 transistor. Optional additional amplification can be provided by a MAR7 MMIC.

The diplexer looks like :



Both Ls/Cs and Lp/Cp are tuned on 29 MHz (± BW). The parallel (Lp/Cp) circuit prevents the signal to flow to the ground while the serial one (Ls/Cs) allows it to reach the next stage. Below or above 29 MHz (± BW), the serial circuit is blocking the signal while the parallel one allows any signal to flow to the ground through the 50 Ω resistor, yielding in a broadband matching of the mixer IF port.
The design equations are :

$$Ls = \frac{50}{2\pi B} \qquad Cs = \frac{B}{2\pi 50 f_s^2}$$

$$Lp = \frac{50B}{2\pi f_s^2} \qquad Cp = \frac{1}{2\pi 50 B}$$

For a 5 MHz BW (*B* in the equations) at 29 MHz (f_s in the equations), the calculation gives the following values :

- Ls = 1,59 µH
- Cs = 19 pF
- Lp = 47 nH
- Cp = 636 pF

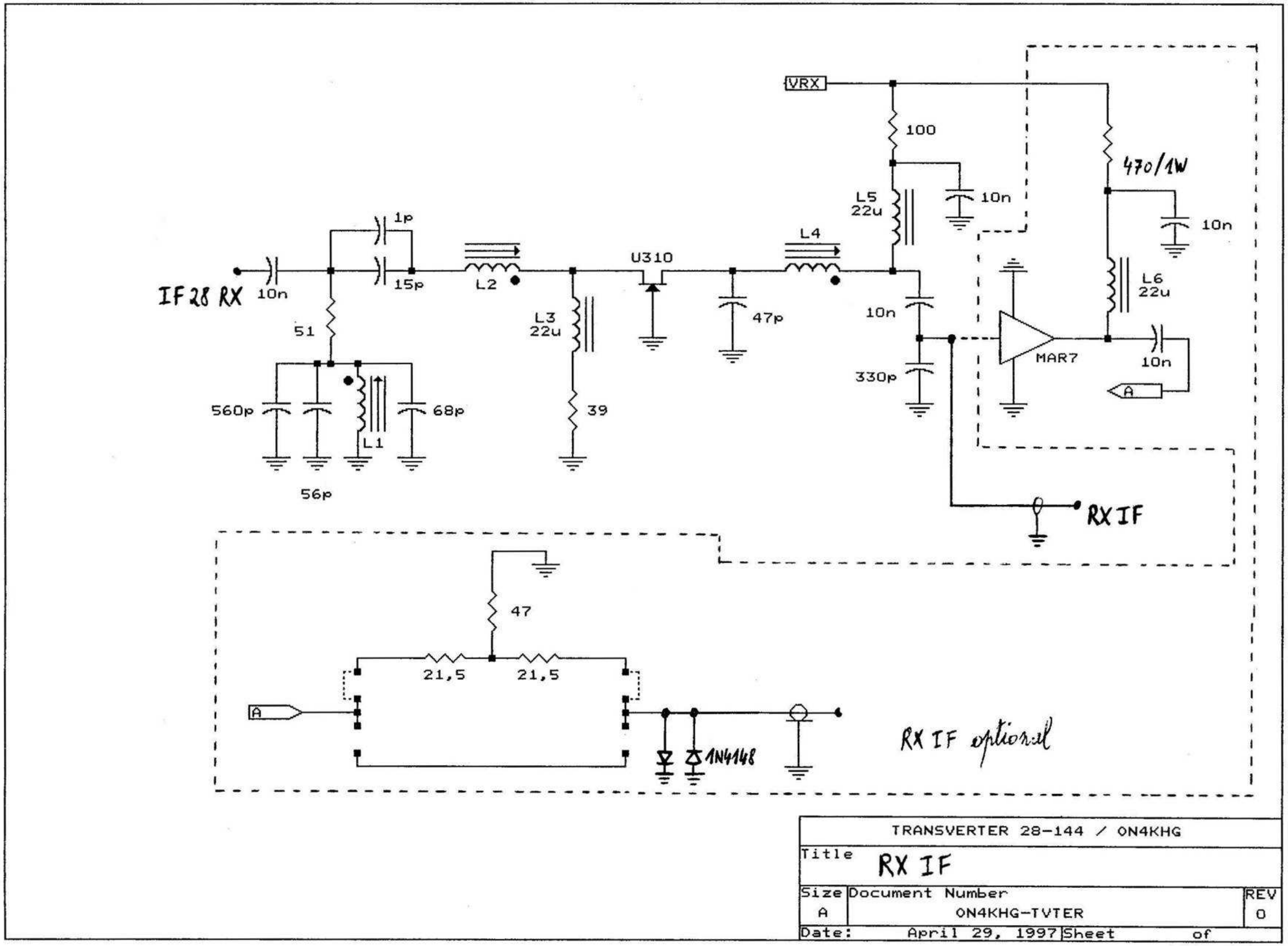
The final optimized values of Cs and Cp are shown on the schematic and the building data of the inductors are given in the table below. As the coil formers have been reused from junkbox, I don't know exactly the grade of the ferrite core but the actual value of these inductors has been measured with a RLC meter after they have been built.

Inductor's part list / building data									
Part ID	**Value**	**Coil former Diam. (mm)**	**Type**	**Wire Diam (mm)**	**Supplier**	**# Turns**	**Winding**	**Core**	**Shielding**
L1	40,9 <-> 54,1 nH	5,2		0,65 Cu enamelled	Home	2	Spaced 1 wire diameter	Ferrite	10mm metal can
L2	1,12 <-> 1,77 µH	5,2		0,4 Cu enamelled	Home	22	Close wound	Ferrite	10mm metal can
L3, 5, 6	22 µH	Moulded choke	TR021		Clo Electronique				
L4	450 <-> 850 nH	5,2		0,4 Cu enamelled	Home	11	Close wound	Ferrite	10mm metal can

The gain of the U310 stage alone amounts to 9 dB and the gain of the complete stage (including the MAR7 MMIC) is 22 dB.

- S_{11} (8 dB output attenuator in the line or not) = -15 dB
- S_{22} (attenuator set to 8 dB) = -21 dB
- S_{22} (attenuator set to 0 dB) = -17 dB

The other useful component data are given on the schematic (most of the capacitors have a NP0 temperature coefficient).
I don't recommend the usage of the MAR7 (see section 3.1).


VRX
100
470/1W
10n
L5
22u
10n
1p
L4
U310
IF 28 RX
10n
15p
L2
L3
22u
47p
10n
L6
22u
MAR7
10n
A
51
330p
560p
68p
L1
39
56p
RX IF
47
21,5
21,5
A
1N4148
RX IF optional
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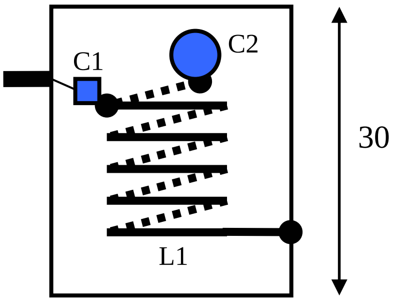
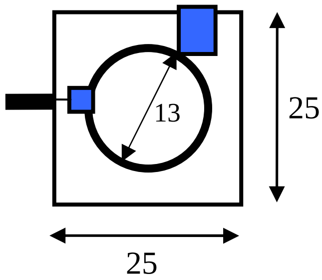
5.4 RX Front-End & Mixer

The first stage uses a low noise MGF1302 GaAsFET transitor, following a high-Q helical resonator of which mechanical construction is given below :



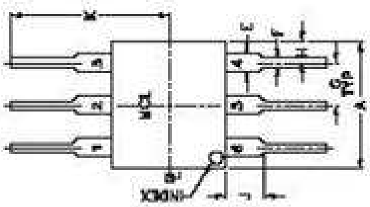


Resonator enclosure is done with 0,3 mm thick Cu sheets.
Coil : 4 ¾ turns of 2 mm diameter Cu-Ag wire, spaced 1 wire diameter. Internal diameter 13 mm.

Wiring of the output transformer (T1 on the schematic), pins 2 & 5 are not used :

To MGF1302 drain

To Ground



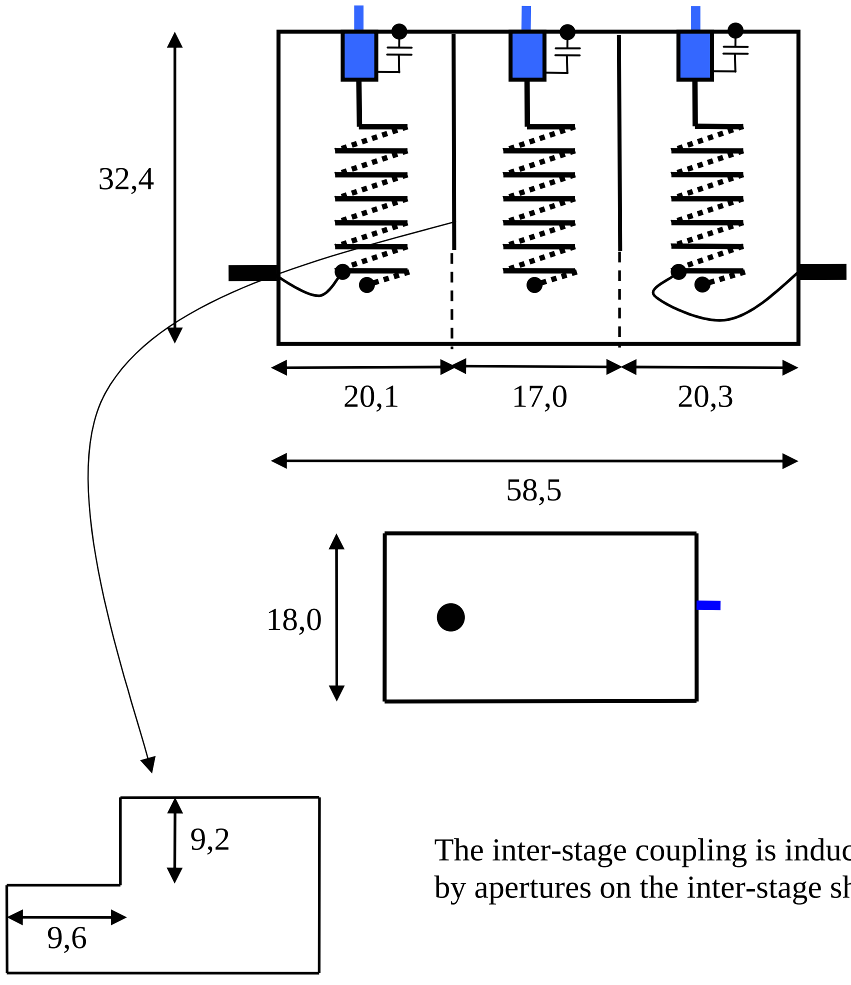
To output attenuator

To Ground

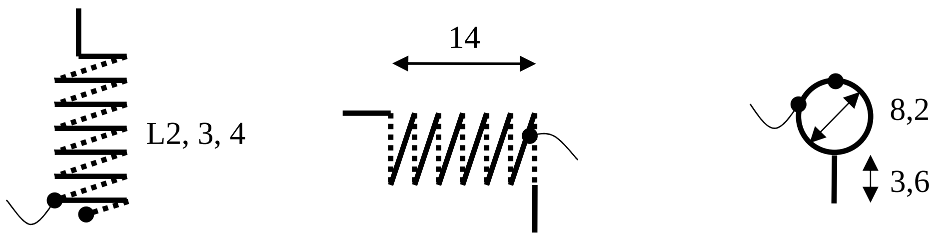
The measured figures of the preamp are (Id = 11 mA @ 144,5 MHz) :

S_{11} = - 20,0 dB
S_{12} = - 15,0 dB
S_{21} = 22,3 dB (= gain)
S_{22} = -2,7 dB

To provide a decent impedance matching to the BPF following the preamp, a 4 dB attenuator has been added at the output of the preamp. The Noise Figure hasn't been measured due to lack of test equipment but it should lie around 0,4-0,8 dB.
The RX BPF has been recuperated on an old transceiver; its description is nevertheless provided hereby.

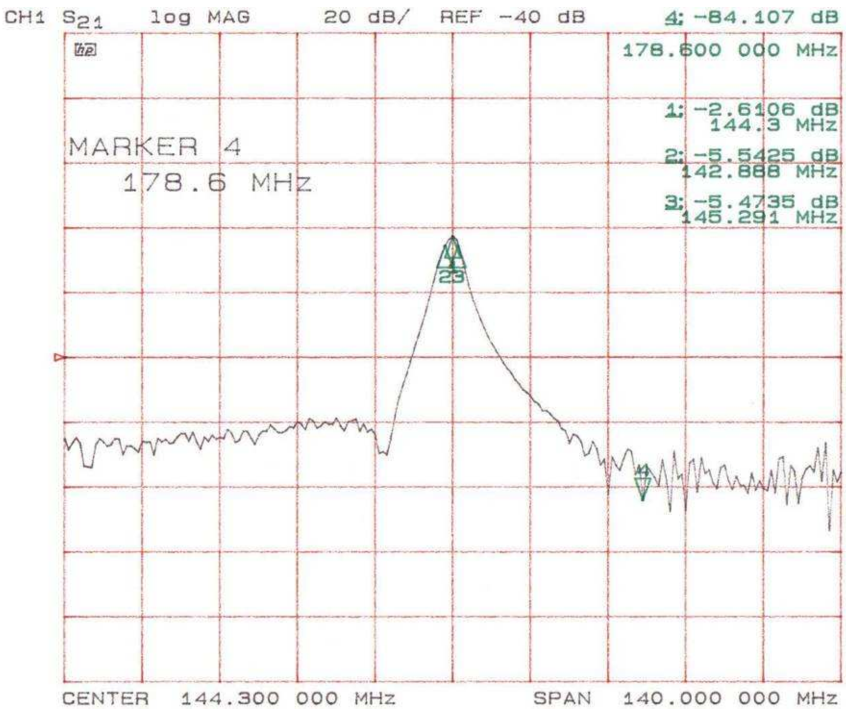


The inter-stage coupling is inductive, achieved by apertures on the inter-stage shielding.



Material of the enclosure : brass.
Coil : 6 ½ turns of 1,2 mm diameter Cu-Ag wire, tapping ¾ turn from cold end.
Tuning capacity : 6 pF tubular in parallel with 2,2 pF NP0 capacitors.

The BPF inter-stages are slightly under-coupled and hence the filter doesn't cover the whole 2 m band with the same insertion loss. However, it then provides very good out-of-band attenuation. Instead of building this BPF, the TX BPF (see section 5.5) can also be build instead, though with less out-of-band attenuation.
Since the transverter has been built, I've designed (for another purpose) a 3 sections BPF filter with the same coil than the one used in the front-end input resonator. This provides an outstanding out-of-band attenuation. Its description will be the object of another article.



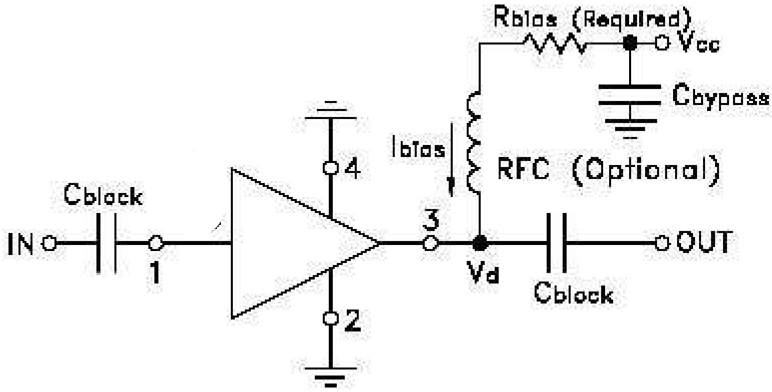
Extra gain (12 dB) prior to the mixer is provided by a MAV11 MMIC.

MINI-CIRCUITS AMPLIFIER GAIN / OUTPUT / NOISE FIGURE SELECTION

Model	Gain Typical dB at Freq GHz 0.1	0.5	1	2	3	4	6	8	Maximum Power Out 1dB Comp @ 1GHz	Noise Figure	IP3 dBm
MAR-1	18.5	17.5	15.5	-	-	-	-	-	+1.5dBm	5.5	+14.0
MAR-2	12.5	12.3	12.0	11.0	-	-	-	-	+4.5dBm	6.5	+17.0
MAR-3	12.5	12.2	12.0	11.5	-	-	-	-	+10.0dBm	6.0	+23.0
MAR-4	8.3	8.2	8.0	-	-	-	-	-	+12.5dBm	6.5	+25.5
MAR-6	20.0	18.5	16.0	11.0	-	-	-	-	+2.0dBm	3.0	+14.5
MAR-7	13.5	13.1	12.5	11.0	-	-	-	-	+5.5dBm	5.0	+19.0
MAR-8	32.5	28.0	22.5	-	-	-	-	-	+12.5dBm	3.3	+27.0
MAV-11	12.7	12.0	10.5	-	-	-	-	-	+17.5dBm	3.6	+30.0
ERA-1	-	-	-	11.6	11.2	-	10.5	9.6	+13dBm (2GHz)	7.0	+26.0
ERA-2	16.0	-	-	14.9	13.9	-	11.8	-	+14dBm (2GHz)	6.0	+27.0
ERA-3	22.2	-	-	20.2	18.2	-	-	-	+11dBm (2GHz)	4.5	+23.0
ERA-4	13.8	-	14.0	13.9	13.9	13.4	-	-	+19.1dBm	5.2	+36.0
ERA-5	20.4	-	20.0	19.0	17.6	15.8	-	-	+19.6dBm	4.0	+36.0
ERA-6	11.1	-	11.1	11.3	11.5	11.3	-	-	+18.5dBm	8.4	+36.5

BIAS CONFIGURATION **SUGGESTED RESISTOR BIAS VALUES**

Model	ImA	Vd	+5Vcc	+9Vcc	+12Vcc	+13.8Vcc	P / Watts Resistor (+12Vcc)
MAR-1	17	5.00	-	220ohm	470ohm	560ohm	0.119W
MAR-2	25	5.00	-	150ohm	270ohm	390ohm	0.175W
MAR-3	35	5.00	-	120ohm	200ohm	270ohm	0.245W
MAR-4	50	5.25	-	75ohm	150ohm	180ohm	0.338W
MAR-6	16	3.50	100ohm	390ohm	560ohm	680ohm	0.136W
MAR-7	22	4.00	47ohm	220ohm	390ohm	470ohm	0.176W
MAR-8	36	7.80	-	33ohm	120ohm	180ohm	0.151W
MAV-11	60	5.50	-	56ohm	120ohm	150ohm	0.390W
ERA-1	40	3.60	35ohm	130ohm	220ohm	255ohm	0.336W
ERA-2	40	3.60	35ohm	130ohm	220ohm	255ohm	0.336W
ERA-3	35	3.50	43ohm	157ohm	243ohm	300ohm	0.298W
ERA-4	65	5.00	-	62ohm	109ohm	130ohm	0.462W
ERA-5	65	4.90	-	62ohm	109hm	130ohm	0.462W
ERA-6	70	5.50	-	50ohm	93ohm	136ohm	0.455W

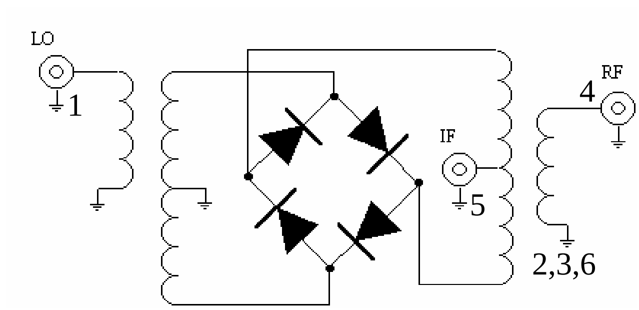


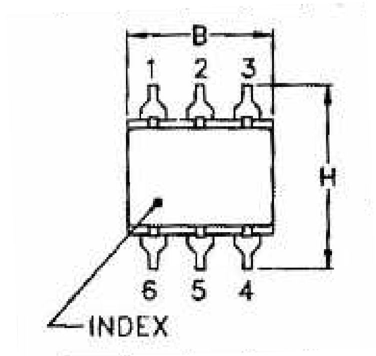
$R_{bias} = (V_{cc}-V_d)/I_{bias}$ and $P_{bias} = (V_{cc}-V_d)*I_{bias}$

Example for the MAV11 : $R_{bias} = (9-5,5)/0,06 = 58\ \Omega$ (the standard 56 Ω value is chosen) and $P_{bias} = (9-5,5)*0,06 = 0,21$ W.

After the MAV11, in order to avoid front-end overload due to strong signals, room for an optional 22 or 6 dB attenuator has been foreseen to reduce gain in case of using an external preamplifier. I admit it is not the right place in the RX chain to set-up this attenuator. It should better take place in front of the MGF1302 stage. But in this case, even in by-pass mode, it would give extra losses before the preamp, yielding in a NF degradation (in case no external preamp is used). As I don’t use an external preamp, the attenuator is just by-passed in my transverter (0 dB attenuation).
Instead of using such a front-end attenuator when using an external preamp, I recommend to by-pass the MGF1302 stage and enter the transverter directly at the RX BPF input.

The mixer is a SMD “LRMS-1” from Mini-Circuits that requires a 7 dBm local oscillator drive level (on its LO port). Maximum level on the RF port is 1 dBm (@ 1 dB compression point). The insertion loss of the mixer amounts to 6 dB.
In TX, the mixer is driven (on its IF port) with around -10 dBm, yielding in -16 dBm on the RF port, prior to the TX driver/PA chain.

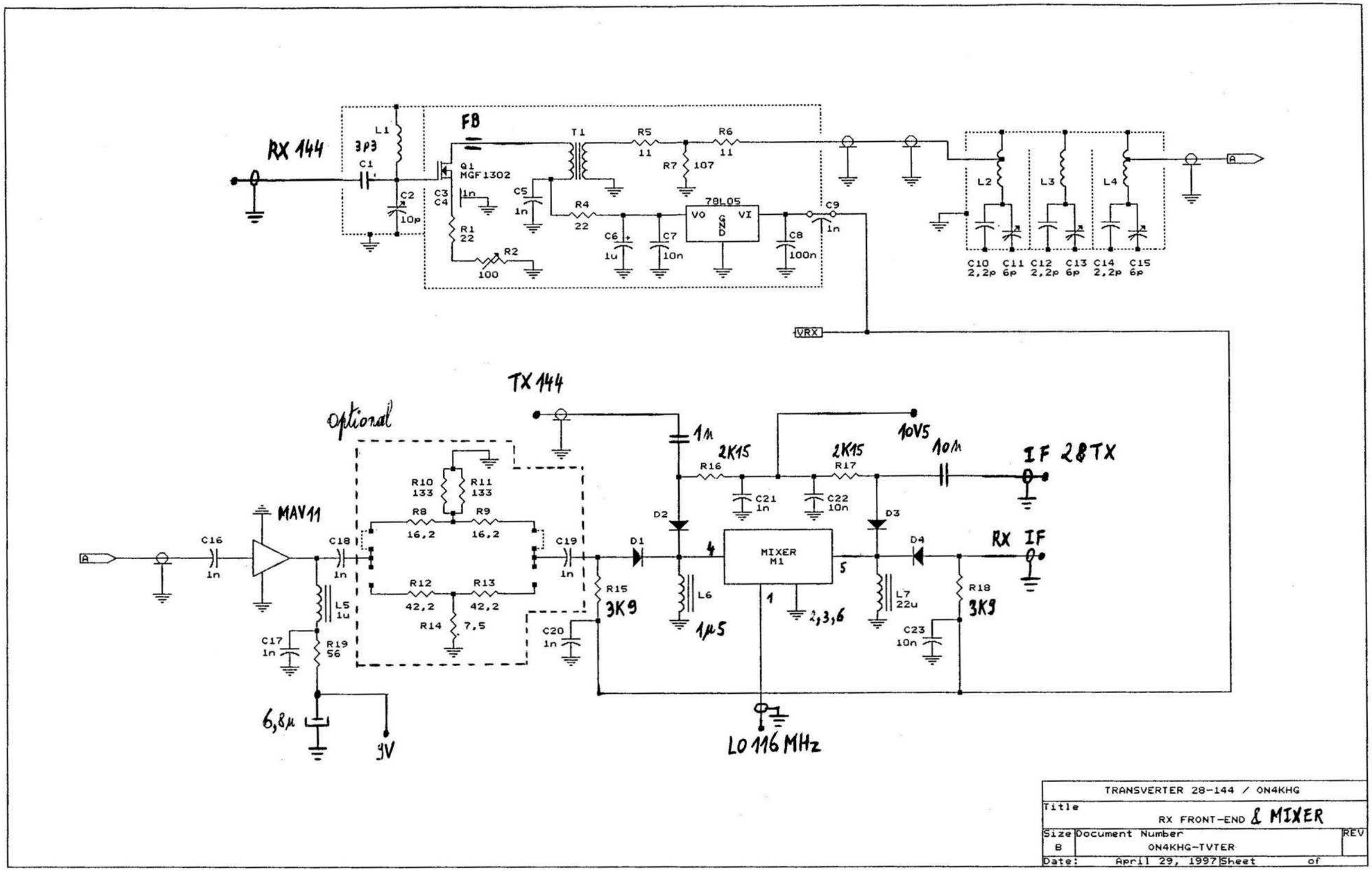




The RX/TX switching around the mixer is done by “BA682” PIN band switch diodes.

Inductor’s part list / building data									
Part ID	Value	Coil former Diam. (mm)	Type	Wire Diam (mm)	Supplier	# Turns	Winding	Core	Shielding
L1		13		2 Cu-Ag	Home	4 ¾	Spaced 1 wire diameter	Air	Resonator enclosure
L2, 3, 4		8,2		1,2 Cu-Ag	Home	6 ½	Length 14 mm, tapping ¾ turn from cold end	Air	BPF enclosure
L5	1 µH	SMD	Simid 02		Siemens				
L6	1,5 µH	SMD	Simid 02		Siemens				
L7	22 µH	Moulded choke	TR021		Clo Electronique				

Part list (excl. Inductors & parts data already given on schematic)				
Part ID	Value	Type	Supplier	Remarks
C1	3,3 p	Hi-Q	Temex	500CHB3R3BV. ATC also OK
C2	10 p	Var. Hi-Q	Johanson	The higher the Q the better
C3	1 n	Disk	Various	Trapez type also OK
C4	1 n	Disk	Various	Trapez type also OK
C10	2,2 p	NP0	Philips	
C11	6 p	Tubular	Various	
C12	2,2 p	NP0	Philips	
C13	6 p	Tubular	Various	
C14	2,2 p	NP0	Philips	
C15	6 p	Tubular	Various	
FB		Ferrite Bead	Various	
T1	T4-1	Transformer	Mini-Circuits	Impedance ratio Sec/Prim = 4
M1	LRMS-1	Mixer	Mini-Circuits	
D1, 2, 3, 4	BA682	PIN band switch	Philips	


RX 144
3p3
C1
L1
C2
10p
FB
Q1
MGF1302
C3
C4
1n
C5
1n
R1
22
R2
100
T1
R4
22
R5
11
R6
11
R7
107
78L05
VO
GND
VI
C6
1u
C7
10n
C8
100n
C9
1n
L2
L3
L4
C10
2,2p
C11
6p
C12
2,2p
C13
6p
C14
2,2p
C15
6p
A
VRX
TX 144
Optional
MAV11
C16
1n
C18
1n
L5
1u
C17
1n
R19
56
6,8μ
9V
R10
133
R11
133
R8
16,2
R9
16,2
R12
42,2
R13
42,2
R14
7,5
C19
1n
C20
1n
R15
3K9
D1
D2
1n
2K15
R16
C21
1n
L6
1μ5
10V5
2K15
R17
C22
10n
10n
IF 28TX
D3
MIXER
M1
4
5
1
2,3,6
L7
22u
D4
RX IF
R18
3K9
C23
10n
LO 116 MHz
TRANSVERTER 28-144 / ON4KHG
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RX FRONT-END & MIXER
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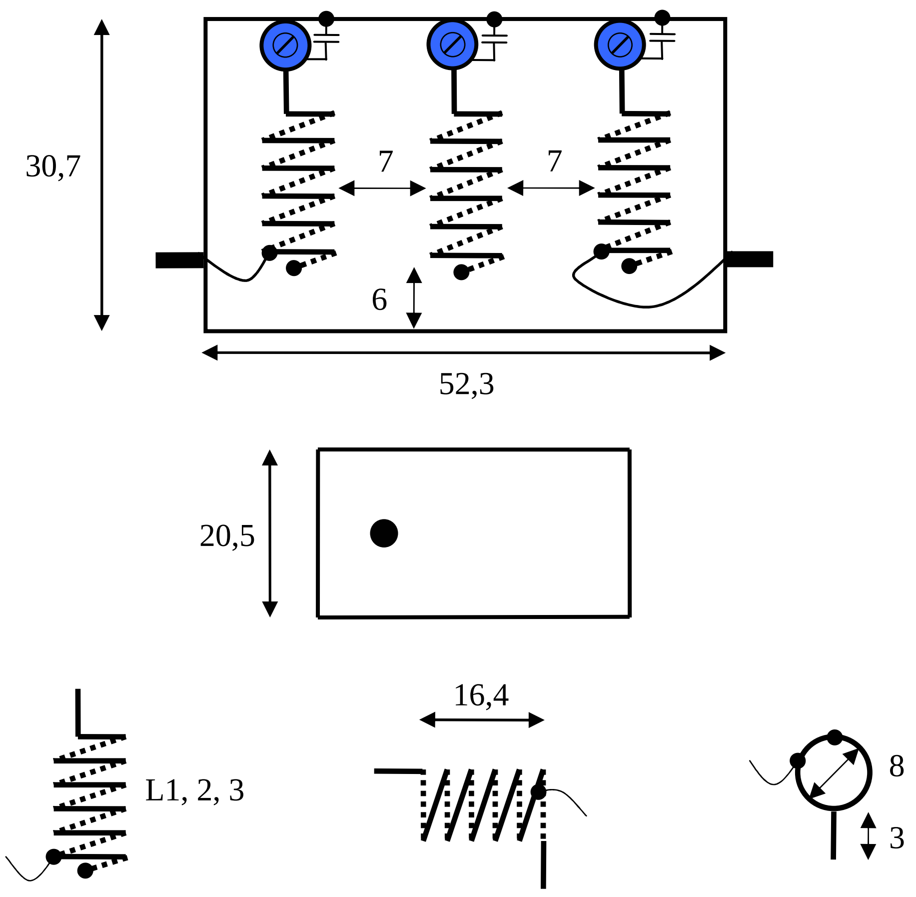
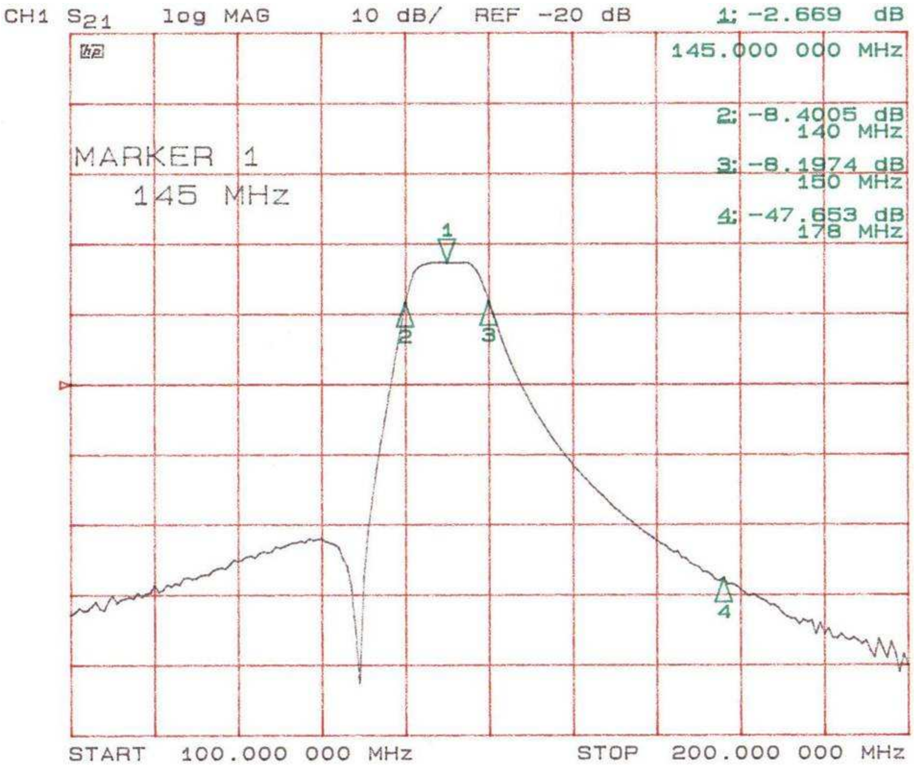
5.5 TX BPF & Driver

The BPF filters the sum mixing product (116+28 MHz) while rejecting the difference product (and most of the spurii). The subsequent PIN diode attenuator introduces some amount of extra attenuation allowing to adjust the transverter output power from zero to full power. The control voltage of the attenuator is set by mean of the front-panel “Power Control” variable resistor. The MAR8 & MAV11 MMIC’s together introduce around 40 dB of gain. The 51 Ω resistor between the two MMIC’s helps to stabilize the MAR8 which is not unconditionally stable. Without that resistor, it is likely that the MAR8 will goes into oscillation, as it has been the case on my first prototype. Obviously, that resistor sacrifices some gain. However, the maximum output power the MAV11 can deliver is 17,5 dBm (at 1 dB compression point) and this is roughly the power needed to drive the PA Board stage at full power. The net gain (thus taking into account the lossy stages) of the whole TX chain from the transverter input to the MAV11 output is sufficient to drive the PA stage at full power.

The TX BPF building data is given below.

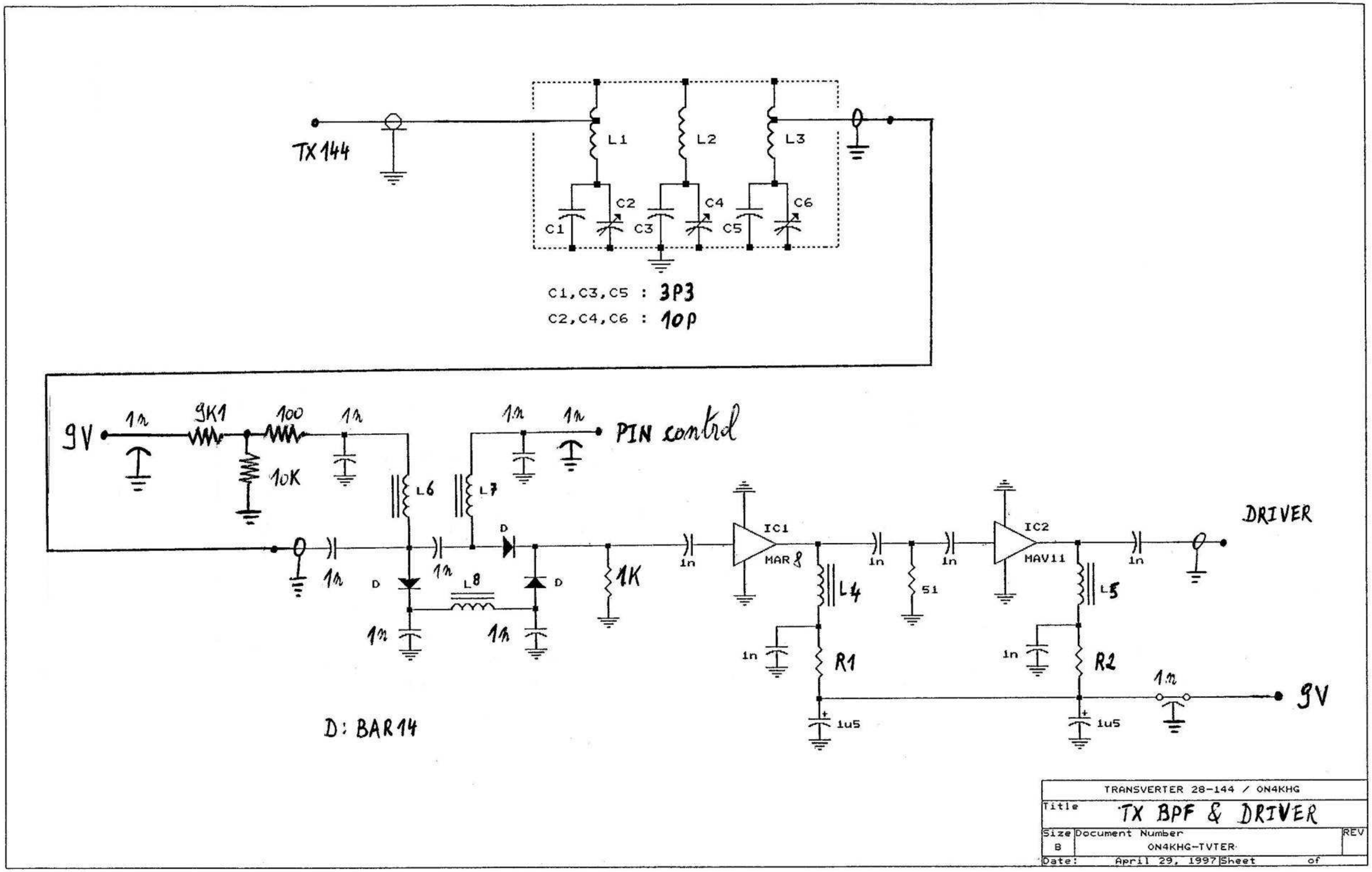


Material of the enclosure : tin-plated iron sheet.
Coil : 5 ½ turns of 1 mm diameter Cu, tapping ¾ turn from cold end.
Tuning capacity : 10 pF Johanson in parallel with 5,6 pF NP0 capacitors.



Inductor's part list / building data									
Part ID	Value	Coil former Diam. (mm)	Type	Wire Diam (mm)	Supplier	# Turns	Winding	Core	Shielding
L1, 2, 3		8		1 Cu	Home	5 ½	Length 16,4 mm, tapping ¾ turn from cold end	Air	BPF enclosure
L4, 5, 6, 7, 8	1 µH	SMD	Simid 02		Siemens				

Part list (excl. Inductors & parts data already given on schematic)				
Part ID	Value	Type	Supplier	Remarks
C1	3,3 p	NP0	Philips	
C2	10 p	Var. Hi-Q	Johanson	
C3	3,3 p	NP0	Philips	
C4	10 p	Var. Hi-Q	Johanson	
C5	3,3 p	NP0	Philips	
C6	10 p	Var. Hi-Q	Johanson	
R1	43 Ω	¼ W	Various	
R2	56 Ω	1,6 W	Philips	Metal Film PR37
D	BAR14-1	Dual PIN diode	Philips	One of the 2 diodes per package is used


TX 144
L1
L2
L3
C1
C2
C3
C4
C5
C6
C1,C3,C5 : 3P3
C2,C4,C6 : 10P
9V
1n
9K1
100
10K
L6
L7
PIN control
D
L8
1K
IC1
MAR 8
L4
51
IC2
MAV11
L5
DRIVER
R1
R2
1u5
D: BAR14
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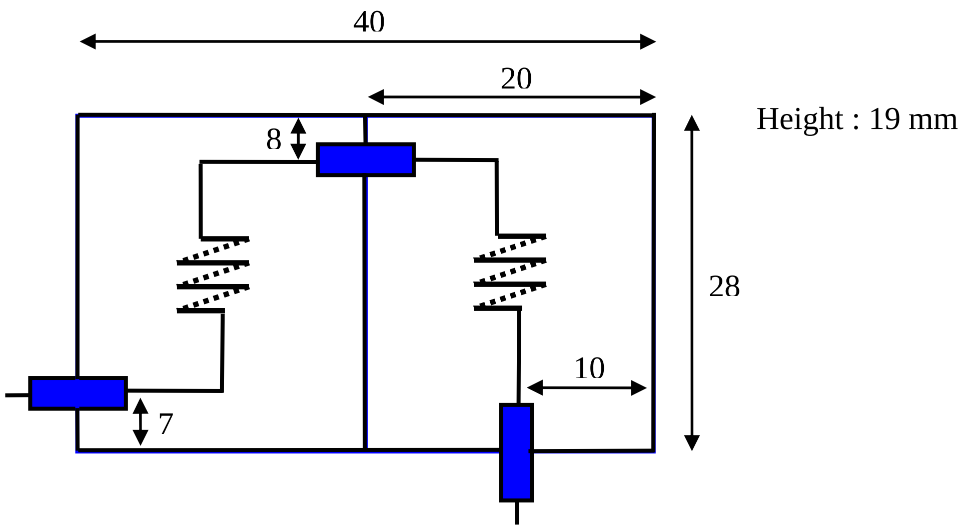
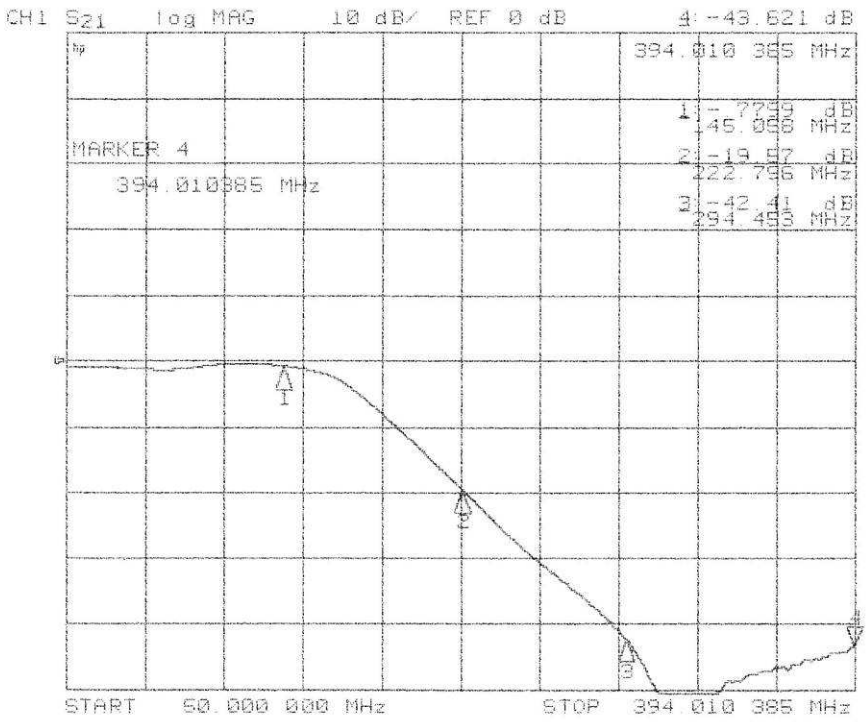
5.6 PA Board

The core of that stage is the M57727 Mitsubishi hybrid power module that provides 27 dB of gain. The maximum linear output power is 20W for 40 mW at the input.
Nowadays, it has become very difficult to buy (or at a high price) that device and it would be better replaced by a new MOSFET device, namely the “RA60H1317M” which has a higher gain and a higher output power (60W). If you use that last module, pay attention that the V_{GG} bias voltage is 5V, instead of 9V for the former one.
No matter which type of module is used, the builder will be careful enough to ensure a proper cooling heatsink to the hybrid module. I must admit I haven’t conducted heat transfer calculation but the heatsink I used is sufficient enough to allow heavy duty operation of the transverter without excessive temperature elevation. In that matter, the bigger the better…

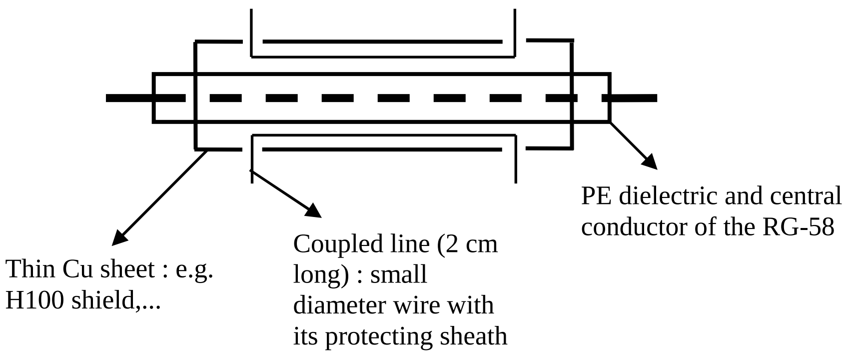
The 5 poles low pass filter (LPF) following the hybrid is described hereafter (blue rectangles are feed-through capacitors); it is fully shielded :



Material of the enclosure : tin-plated iron sheet, 1 mm thickness.
Coil : 3 turns of 1,2 mm diameter Cu wire, spaced 1 wire diameter.
Coil internal diameter : 6 mm.
Feed-through capacitors’value : see schematic.
Capacitors’ and coils’ axis are located at mid-height of the enclosure height.



To allow measurement of the direct & reflected powers, a home-designed directional coupler has been set at the output of the LPF. This is not a PCB printed coupler but it has been made by mean of a piece of RG-58 coaxial cable, in the following way :

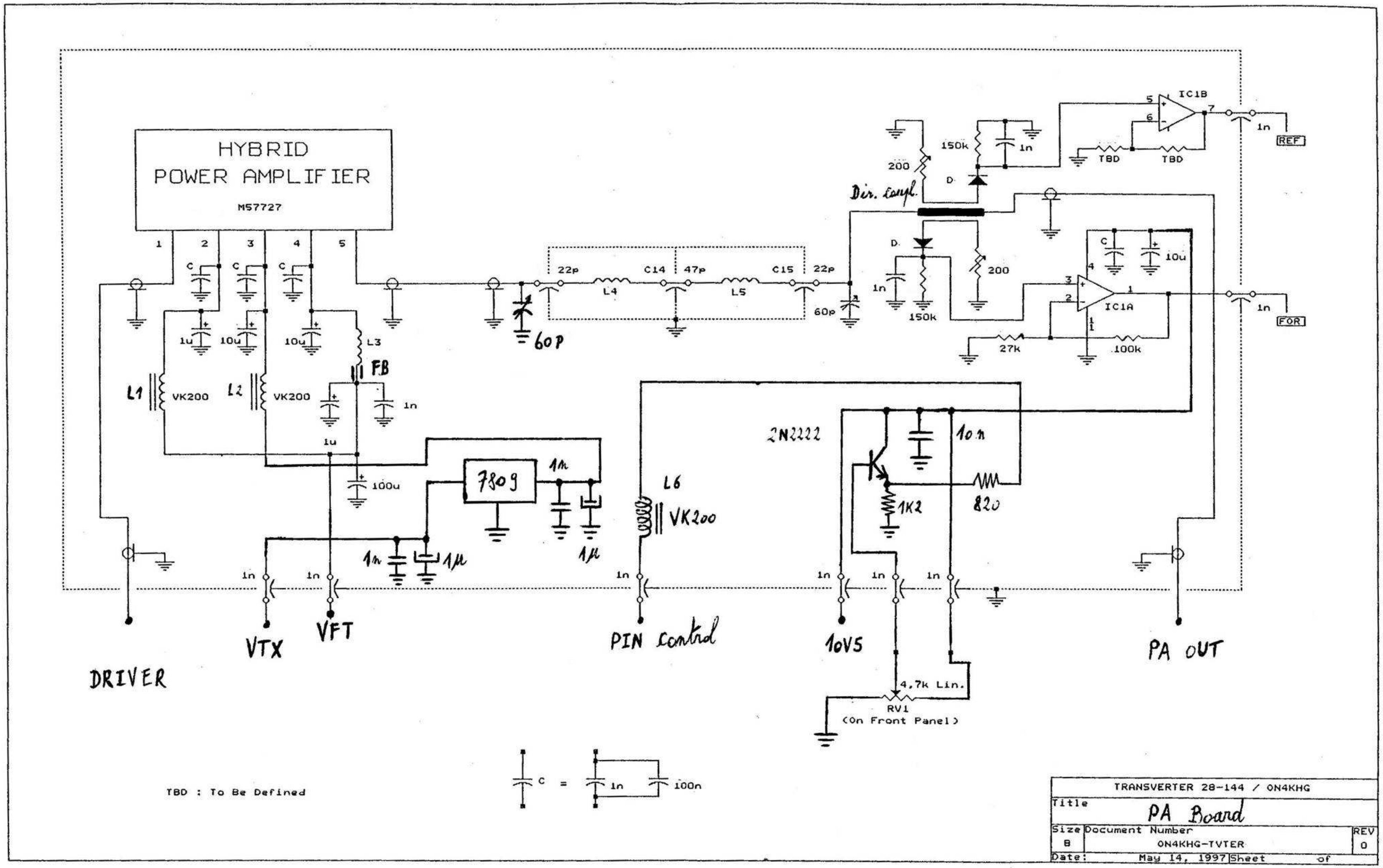


The “TBD” resistors around IC1b (LM324) serve to set the gain of the operational amplifier so that the front panel “SWR” LED on the front panel lights for a 1,5:1 SWR or so. I must admit I’ve never soldered these resistors on my transverter (you know the story, the device is 99 % finished and you want to use it as fast as possible, so that the 1% work remains un-done…). Though the hybrid module can handle a 20:1 SWR for 5 sec, it wouldn’t handle an infinite one and I would better fit these resistors in place one of these days.

The transistor (2N2222) driving the PIN diode attenuator (TX BPF & Driver board) voltage lies also on the PA board.

Inductor's part list / building data									
Part ID	Value	Coil former Diam. (mm)	Type	Wire Diam (mm)	Supplier	# Turns	Winding	Core	Shielding
L1, 2, 6			VK200		Philips				
L3		5		1 Cu enamelled	Home	6	Close wound	Air	None
L4, 5		6		1,2 Cu	Home	3	Spaced 1 wire diameter	Air	LPF enclosure

Part list (excl. Inductors & parts data already given on schematic)				
Part ID	Value	Type	Supplier	Remarks
FB		Ferrite Bead	Various	
D	1N4148		Various	Any Standard Si or Ge diode
IC1	LM324	Op. Amp.	National	


HYBRID
POWER AMPLIFIER
M57727
VK200
L1
L2
L3
FB
7809
60P
22p
C14
47p
C15
L4
L5
60p
Dir. coupl.
150k
1n
200
IC1B
IC1A
TBD
REF
FOR
27k
100k
10u
100u
2N2222
10n
1K2
820
L6
VK200
VTX
VFT
PIN control
10V5
PA OUT
DRIVER
4,7k Lin.
RV1
(On Front Panel)
TBD : To Be Defined
C = 1n 100n
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PA Board
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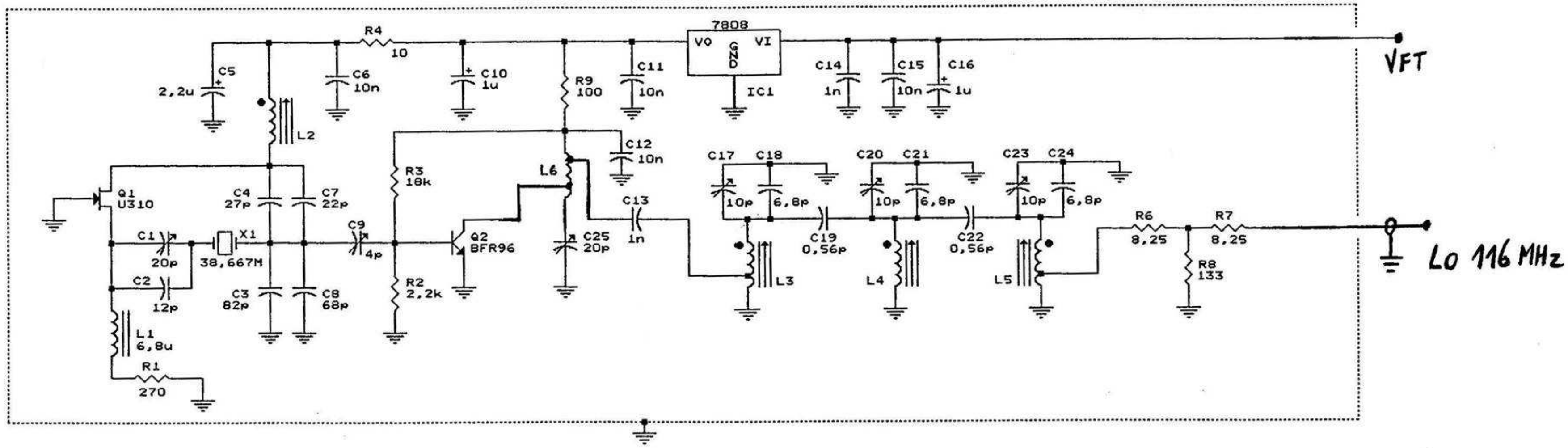
5.7 Local Oscillator 116 MHz

On that board, one finds a classical JFET (U310) oscillator on 38,6667 MHz, followed by a non-linear stage (BFR96S) of which the output content is rich in harmonics. The third one (116 MHz) is selected by L6/C25 and the subsequent BPF. A 3 dB T attenuator is completing the board, helping the Mixer to "see" a decent Return Loss on its LO port.
The output power is 11 dBm on 116 MHz and the leakage of the fundamental, second (77,3 MHz) and fourth harmonics (154,6 MHz) present at the output of the stage are attenuated respectively by 35, 38 and 52 dBc.
Even though running is a harsh environment and using a standard Xtal (without any heater mean), it has never been needed to retune the oscillator so far after 10 years of activity.

Inductor's part list / building data									
Part ID	Value	Coil former Diam. (mm)	Type	Wire Diam (mm)	Supplier	# Turns	Winding	Core	Shielding
L1	6,8 µH	SMD	Simid 02		Siemens				
L2	≈ 350 nH	4		0,3 Cu enamelled	Home	14	Close wound	Ferrite	7mm metal can
L3, 4, 5	≈ 100 nH	5,2		0,8 Cu	Home	4 ½	Spaced 1 wire diameter. For L3 & L5, taping @ ¾ turn from cold end	Ferrite	10mm metal can
L6		4		1 Cu	Home	6	Spaced 1 wire diameter. 2 tapings, each 1 ¾ turn from coil ends	Air	None

Part list (excl. Inductors & parts data already given on schematic)				
Part ID	Value	Type	Supplier	Remarks
C1	2-20 p	Var. Cap.	Philips	Teflon Film Capacitor
C2	12 p	P100	Philips	
C3	82 p	N750	Philips	
C4	27 p	N750	Philips	
C7	22 p	N750	Philips	
C8	68 p	N750	Philips	
C9	1,5-4 p	Var. Cap.	Sprague	Ceramic Capacitor
C17	1-10 p	Var. Cap.	Philips	Teflon Film Capacitor
C18	6,8 p	NP0	Vitramon	
C20	1-10 p	Var. Cap.	Philips	Teflon Film Capacitor
C21	6,8 p	NP0	Vitramon	
C23	1-10 p	Var. Cap.	Philips	Teflon Film Capacitor
C24	6,8 p	NP0	Vitramon	
C25	2,5-20 p	Var. Cap	Sprague	Ceramic Capacitor



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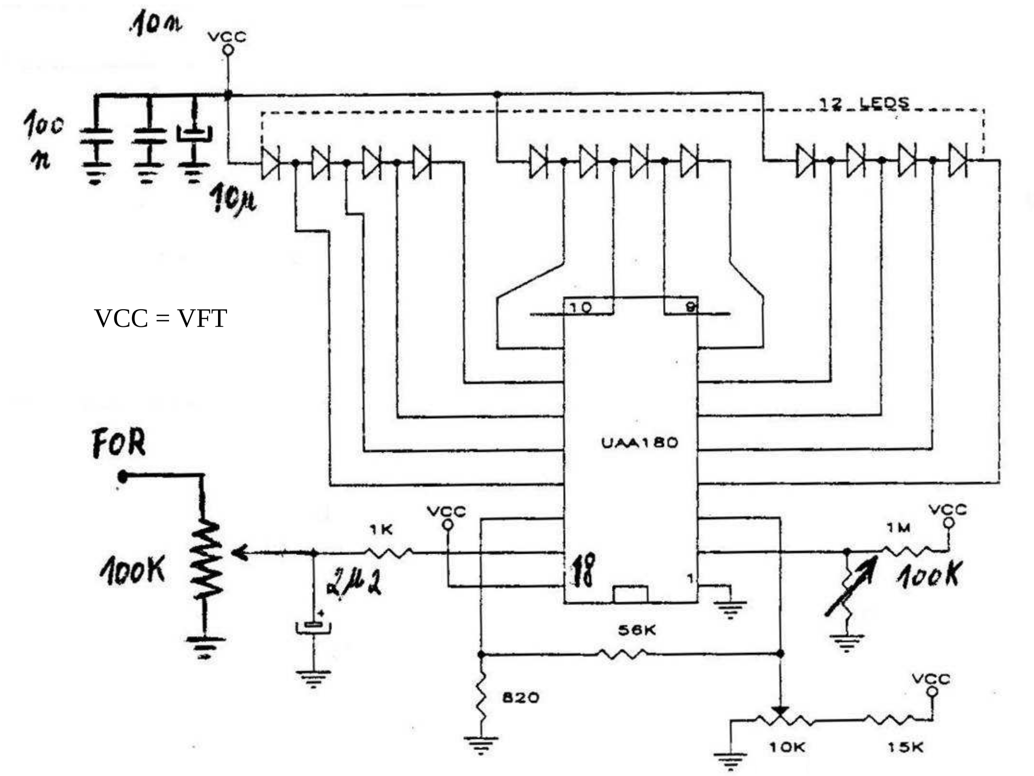
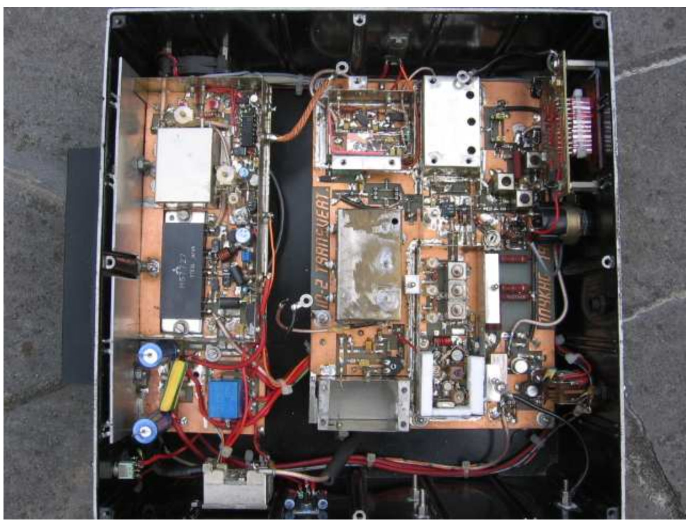
5.8 Power Meter

The front panel power meter schematic has been taken from a “Radio-REF” issue of October 1991 named “VU-mètre universel à rampe de LED” by Charles Baud, F8CV.

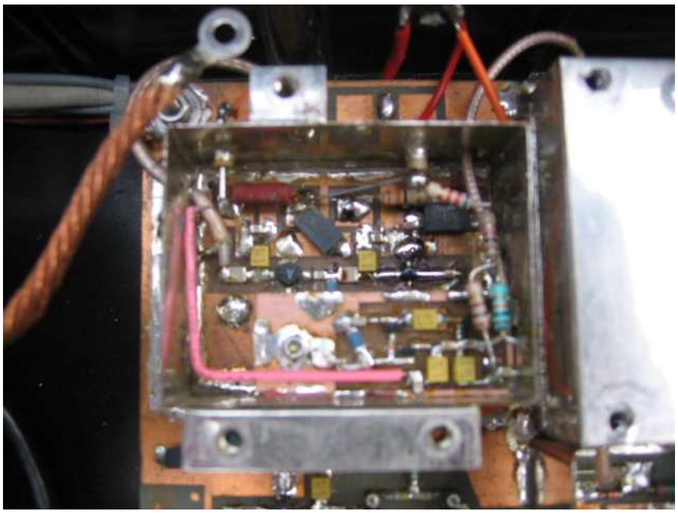


The 100 kΩ variable resistor on the pin 2 of the UAA180 adjusts the brightness of the LED’s. The 10 kΩ variable resistor serves to adjust de amount of LED’s lighting for a given input voltage (on the“FOR” input). The 100 kΩ variable resistor on the “FOR” input adjusts the voltage input level.
Nowadays, the newer LM3914 IC will do the same job in place of the UAA180.

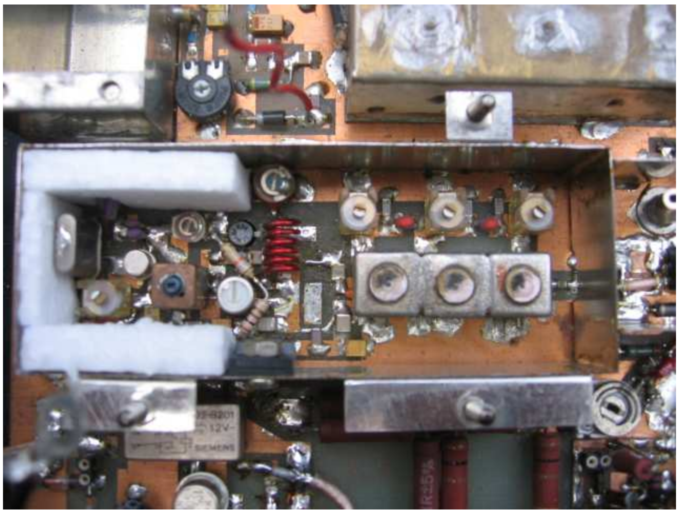
6. Pictures (zoom for close-up views)



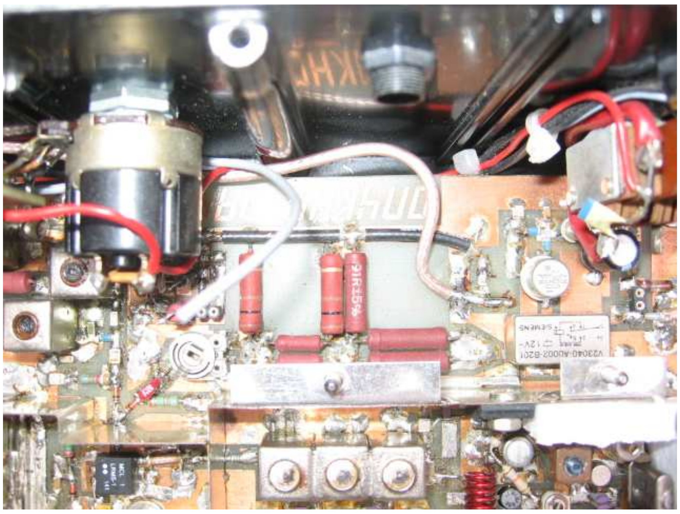
Overall views



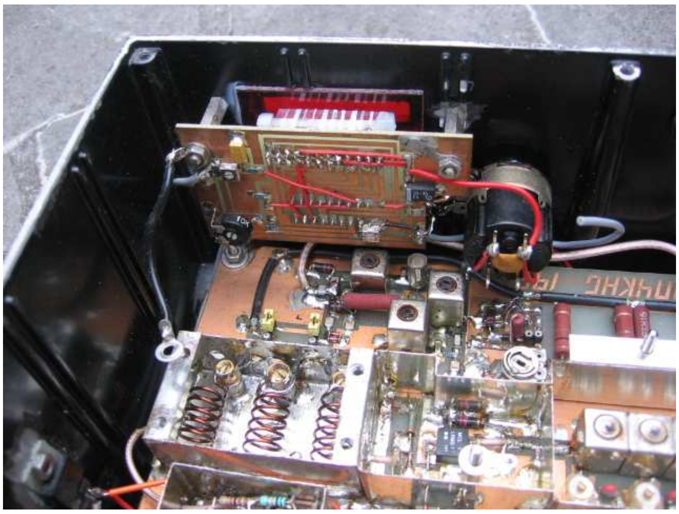
RX IF



Local Oscillator 116 MHz

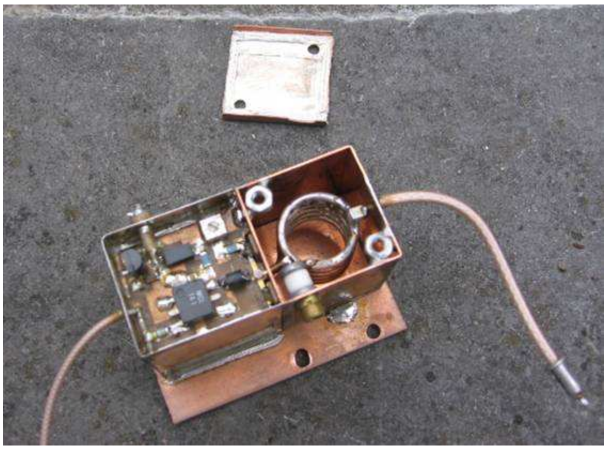


PTT & TX ATT IF



TX BPF & RX IF

PA Board



MGF1302 Preamp.

7. Conclusion

Since at the time this transverter has been designed there were less multiband transceivers than nowadays, operating a good performer HF rig followed by a transverter was a valuable solution as most of the HF rigs had more features than VHF only ones. This is a bit less true today. However, modern multiband rigs perform usually less well than “single” band (HF) ones, mainly in terms of dynamic range. So, beside the advantage that a transverter can be remotely located from the shack (minimizing losses), when using a high dynamic range HF rig as the IF, such a solution remains very valuable.

This transverter has proven to be very stable (even in large ambient temperature swings), thanks to a careful selection of the temperature coefficient of the local oscillator capacitors.
To be compliant with the current “standards”, there is room for improvement in matter of dynamic range (high IP preamplifier and high level mixer), even though I’ve never experienced co-location problems. To take profit of the better dynamic range of most of the HF rigs on 14 MHz than on 28 MHz, I’ve developed a second “plug and play” frequency conversion from 28 to 14 MHz but I have never redrawn the handwritten schematic under an electronic format. However, the “philosophy” is the same as what is already shown in the preceding pages.

I wish the potential builder of this transverter (or parts of it) to enjoy its building and usage as I myself enjoyed it.
I will answer any question sent to the following E-mail address : on4khg@uba.be