LA9XFA

T7F

70 cm FM FSK Transceiver Handbook

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Holger Eckardt
DF2FQ

English translation :
INFRACOM, 69 boulevard Albert 1er, F-44600 Saint Nazaire / France
Tél : + (33) 2 40 70 97 68 // Fax : + (33) 2 40 70 98 30 // Email : infracom@avo.net

Technical specifications :

Misc.	
Frequency range	430,000 .. 440 MHz
Channel spacing	12 5 or 25 kHz
Tx/Rx switching time	<30ms
Temperature range	-5 .. +50°C
Power supply	7..14V, 60mA RX, max 2,5A TX
Dimensions	145 x 75 x 22 mm
Receiver	
Digital sensitivity	-120dBm (=0 22µV) with a BER < 10^{-4} (tested on a DF9IC modem)
Analog sensitivity	-118dBm for 20dB SINAD (CCITT)
Fréquence range	1Hz .. 7000Hz at -3dB
Intermodulation	-54dB (3 tons measurement)
Selectivity on neighbouring channels	>56dB
Harmonic attenuation	>60dB
Transmitter	
Output power	1.5W at 7V, 6.5W at 12V
Fréquency range	1Hz . 15000 Hz at -3dB
Klirrfaktor	<1.5%
Selectivity	-66dBc (1 OW), <-75dBc
Perturbation on neighbouring channels	< -40dB

Controler :

It is here one of the most important part of the transceiver We use a PIC microcontroler 16F83 from Microchip It has 4 functions : watching the PTT line, programming the Tx and Rx frequencies, with ou without frequency shift, and with a synchronization.

Above this, the user side is also under control : channel switching, entry of new frequencies, etc

Assembly :

The whole module is to be mounted on a 72 x 144 mm board. See the placing of all components on drawing 5 and the part-list at the end of this manual Please put a cross on the value each time you solder a component. This way, you won't forget any

The VMOS transistor T1 T11 (BS170) should be placed only when setup is done.

Place all components as close as possible to the PCB and cut all legs on the solder side. Don't use any IC holder, except for IC1.

On T5, le longuest leg is the *Drain*, and *Collector* on T6. D2 (BB405) has no printing on it but has a black body and a white ring.

Unfortunately, Q2 legs don't have the right spacing : mount it carefully

You'll have to make 4 coils by yourself. They are identified *3W3D* on the drawing : 3 turns on a 3 mm diameter. Use copper wire of 0 4 mm and wind it on a 3 mm drill. Scratch the protective varnish near the soldering points

Attention : the color code of L14 (3,3µH orange orange gold) is very similar to the one of 0,33µH coils (orange orange silver). 0,1 µH coils (brown black silver) are also close to 1 µH (brown black gold).

The PA module is the only component to be mounted on the solders side of the PCB, its heatsinker (the aluminium plate) has the PCB in its back The module has to be fixed on the aluminium plate with a 4 mm spacing between the plate and the PA pins, using two 4 mm nuts.

Once the board assembled, place it in the enclosure by gathering and soldering both aluminium corners. Separating nuts are then put in place. The 5 mm long nuts go through both central holes, two more 4 mm pieces are placed between the PA module pins and the board.

Screw up everything in the box, then solder the PCB edge to the enclosure.

From outside the box, insert the BNC plug and the by-pass capacitor (power supply); solder them.

Tuning :

Your I7F has 9 tuning steps It may look a lot, but it's easier to reach your goal. You'll need the following equipements :

- Digital voltmeter
- Frequencymeter (30 MHz minimum) with an accurate time base
- Oscillograph (5 MHz is enough)
- A 500 Hz generator with a 500mV output : sinus and square signals
- A capacitymeter
- A steady 70 cm signal, modulated if posisble with a level between -60 et -90 dBm (if you don't have this, a 0 5 Watt handy placed 30 m away should do the job !!)

First connect the power supply : 7 to 12 Vpp. If the board has no short-circuit, you'll notice a current flow of about 60 mA. After deux minutes heating up, connect the frequencymeter on IC3 (MC3371), pin 2 : you should then read 20 950 MHz Use R4 to adjust this frequency : please be accurate since this is the reference, multiplicated 20 times to get the final frequency One Hertz difference means 20 Hz drift !

Now let's program 430 000 MHz (see the Frequency Tuning chapter) Turn L1 until you have 0 8 V on the "cold" side of L3, while receiving

Now, set a frequency in the middle of the band, on 435 MHz for example. This frequency must be the one sent by the generator, your handy, or the local repeater. Connect the digital voltmeter to the RSSI output and set R53 (DCD) on its middle position. With no signal, you should read from 0.4 to 0.8 V. This value increases according to the strenght of the received signal. Turn L6 and L7 in order to read the highest value. When the output is output above - 60 dBm (RSSI of about 3 5 V), don't expect to go further : you'll have to lower the signal before going on with your tuning If you have no generator, a non-modulated carrier should be enough.

Connect a sinus generator to the modulation input (see drawing 7) and set it to 300 mV. Important : do NOT solder T11 beacause this transistor cuts the modulation input when the transceiver receives. You should read about 1 Vpp on the NF-OUT (AF-OUT) pin Use L9 to increase the signal and C70 to get a perfect sinusoidal shape. If you use a double trace oscillograph, you'll have a perfect look at both signals, using both channels

Let's now see to the transmitter. Switch your signal generator to the "square" shape and connect your oscillograph to NF-OUT. The non-modulated carrier should always arrive to the receiver. Turn R41 until the signal has a square shape and about 1 Vpp amplitude Set the maximum level with L9 then with C70 (don't use metallic tools !), and try to have a nice sinusoide Using a double trace oscillograph could help a lot : one channel to the generator output, the second channel to the NF-OUTPUT.

Finally, solder T11

The user interface :

I7F has two headers, one next to the antenna, the second one next to the power supply. One has 10 pins (X2), the other one 14 pins (X1), with the following pineout :

X1

1	D0	2	n c
3	D1	4	n.c
5	D2	6	n.c.
7	D3	8	TXD
9	n.c.	10	RXD
11	PTT	12	12,5 / 25 kHz
13	GND	14	+5V

X2

1	GND	2	+5V
3	DCD	4	PTT
5	GND	6	MOD
7	GND	8	Sortie BF
9	n.c.	10	RSSI

Use a flat cable on an HE10 connector to get all signals. X1 is used to change the freqnency, along with a BCD switch, and to communicate with the computer's terminal. X2 is used to connect to the modem.

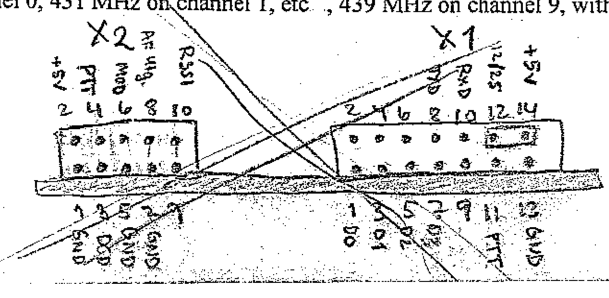
To locate Pin 1 on X1 and X2, place the PCB on your table : it's the lowest left pin on each header

Frequency tuning :

Software version 1.4 can now use a 25 or 12.5 kHz channel spacing. Tx/Rx switching times are more important with the 12.5 kHz mode. Connect pin 12 to + 5 V for 12 kHz, and to 0 V for 12 5 kHz. **NEVER LET THIS PIN WITHOUT CONNECTION !!**

As described in the technical presentation, I7F covers the whole 70 cm band, from 430 to 440 MHz. You can use any shift you want or simply work simplex. 10 channels are available, with separate Tx and Rx frequencies To select a channel, use a BCD code on pins D0 to D3 (X1 connector) D0 is the les significant byte (LSB), D3 the most significant one (MSB). If you don't connect D0 to D3, you'll use channel 0.

All PICs are programmed with 430 MHz on channel 0, 431 MHz on channel 1, etc. , 439 MHz on channel 9, with 25 kHz spacing.



program your working frequencies, connect T7F to your computer :

COM port	T7F
TXD	RXD (pin 8)
RXD	TXD (pin 10)
GND	GND

Set your terminal software to 1200 Baud, 8 bytes, no parity, 1 stop byte and use the following syntax :

Cntttrrr[RETURN]

C is the capital "C" (HEX 43), *n* the channel number (0 to 9), *rrr* the RX channel and *ttt* the TX channel.

Numbers given by *rrr* and *ttt* are calculated as follow :

$$N = (F - 430000) / R$$

R = channel spacing (12.5 or 25)

N = channel number, corresponding to the frequency

F = working frequency, given in MHz

End the programmation with RETURN. It is not possible to edit a line : if you make a mistake, press RETURN and type the line again.

Here is an example :

You need Rx 438.100 MHz and TX 430.500 MHz on channel 0, then type :: *C0020324*

You need Rx 434.125 MHz and TX 434.125 MHz on channel 8, then type :: *C8165165*

Each letter typed is sent back by your T7F to control the link

Use "E" (Hex 45) to display the PIC's memory : all channels are displayed, programmed or not, in hexadecimal

Available signals :

AF input and output are compatible with all modern modems. With a 3 kHz deviation, you'll get 1 Vpp on the receiver. On the transmitter, 300 mVpp are needed to obtain a 3 kHz deviation. Most of the modem we tested still activate their AF output when they receive. Therefore, we added a transistor to stop this signal on T7F's input.

T7F has a fast DCD (pin 3), linked to the RSSI voltage. When a signal arrives on the input (trigger to be tuned with R53), this voltage varies from 0 to 5 V. If you turn the trimmer to the link, this function is disabled.

Use txdelay 4, that is to say 40 ms tx/rx switching.

The analog part of many modems needs a certain time to switch from Tx to Rx, due to coupling capacitors. Switching these modems to continuous Tx may be a good solution.

Voice and other applications :

Your T7F can be used for voice operation, providing some modifications : a mic-preamplifier (1 transistor), an AF amplifier (using an LM386 for example) for the loudspeaker. Control the squelch using the DCD signal connected oustide, using X2. R53 is then used to adjust the squelch level.

No modification is need at 1200 Bauds. For higher speeds, you'll have to replace all IF filters with larger versions. Due to the bandwidth, sensitivity and selection of channels could be lowered.

nclusion :

7F can only be used for private use You must ask the author before making any commercial use of the drawing. The author can not be responsible ny damages following the use of T7F

This project meets the European ETS 300-684 norm for hamradio products, and the EMV EN 55022 norm. However, no official agreement has been done until now.

Notes :

F1UNA indicates the following problems !

"I assembled a T7F and checked its performances on a spectral analyzer To improve the transmitter, follow these hints :

- unsolder L16 pin next to C71 and add a 4/20 pF trimmer between both pins (L16 --- trimmer --- PCB)
- add a 33 Ohm resistor between ground and the R49 pin located next to T9
- finally, replace C35 with a 12 pF capacitor

Tune T7F one more time.

artlist :

Part	Value	Package
C1	33p	C25
C2	10n	C25
C3	1uF	ELKO
C4	47n	C5
C5	10n	C25
C6	1p5	C25
C7	1n	C25
C8	1n	C25
C9	10n	C25
C10	10uF	ELKO
C11	4u7	ELKO
C12	100p	C25
C13	10n	C25
C14	1p	C25
C15	33p	C25
C16	33p	C25
C17	100p	C25
C18	1p	C25
C19	100uF	ELKO
C20	33p	C25
C21	0.1uF	C5
C22	10uF	ELKO
C23	10uF	ELKO
C24	10n	C25
C25	47n	C5
C26	47n	C5
C27	47n	C5
C28	~~5n6~~ 5P6	C25
C29	10n	C25
C30	3p3	C25
C31	2p2	C25
C32	33p	C25
C33	47n	C5
C34	100p	C25
C35	100p → 12P (mod)	C25
C36	10uF	ELKO
C37	10n	C25
C38	10uF	ELKO
C39	10n	C25
C40	10n	C25
C41	3p3	C25
C42	100p	C25
C43	5p6	C25
C44	5p6	C25
C45	2p2	C25
C46	100p	C25
C47	2u2	ELKO
C48 (1p 1.10 (modul))	1n	C25
C50	100p	C25
C51	100p	C25
C52	47n	C5
C54	100p	C25
C55	100p	C25
C56	10uF	ELKO
C57	100p	C25
C58	47n	C5
C59	~~4p7~~ 5P6 stimmt	C25
C60	100p	C25
C61	1uF	ELKO
C62	22p	C25
C63	1uF	ELKO
n.b — C64	100p	C25
n.b? — C65	100p	C25
C66	47n	C5
C67	10n	C25
C68	10n	C25
C69	100p	C25
C70	30p	CT5 red trim
C71	5p6	C25
C72	10p	C25
C73	10µ	ELKO
C74	47n	C5
C75	.1uF	C5
C76	8p2	C25
C77	100p	C25
C78	470p	C25
C79	47n	C5
D1	BB204	TO92
D2	BB405	D5
D3	1N4148	D7
D4	BA479	D5
D5	BA479	D5
D8	BA479	D7
D9	ZF5V1	ZD
D10	BB204	TO92
FI1	21U15A	HC45U
FI2	CFUS450D	CFU
IC1	PIC16F83	DIL18
IC2	MB1504	DIL16
IC3	MC3371	DIL16
IC4	78L05	TO92
L1	514630	HELIX
L2	.33uH	SP7
L3	.33uH	SP7
L4	.33uH	SP7
L5	3W3D	SP5
L6	511765	HELIX
L7	511765	HELIX
L8	3.9uH	SP7
L9	455kHz,sw	BANDFI
L10	.33uH	SP10
L11	3W3D	SP5
L12	3W3D	SP5
L13	.33uH	SP10
L14	3.3uH	SP7
L15	.33uH	SP10
L16	.1uH	SP7
L17	3W3D	SP5 → n.b (pa print)
L18	1uH	SP10
PMOD	M67749M	PWR-MOD
Q1	20.95MHz	HC49/U
Q2	CSB1000	QS
R1	100	R10
R2	1M	R10
R3	1M	R10
R4	1M trimmer	R_IR_SI
R5	680	R10
R6	3k3	R10
R7	10k	R10
R8	4k7	R10
R9	4k7	R10
R10	10k	R10
R11	3k3	R10
R12	100k	R10
R13	10k	R10
R14	100	R10
R15	10k	R10
R16	15k	R10
R17	100	R10
R18	180	R10
R19	47k	R10
R20	100	R10
R21	1k	R10
R22	6k8	R10
R23	2k7	R10
R24	10k	R10
R25	10k	R10
R26	33k	R10
R27	10k	R10

102
1000 PF = 1nF
103
10000 PF = 10nF

473 = 47nF

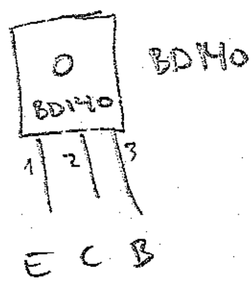
n10 = 0.1 nF
= 100pF

n47 = 0.47nF = 470pF

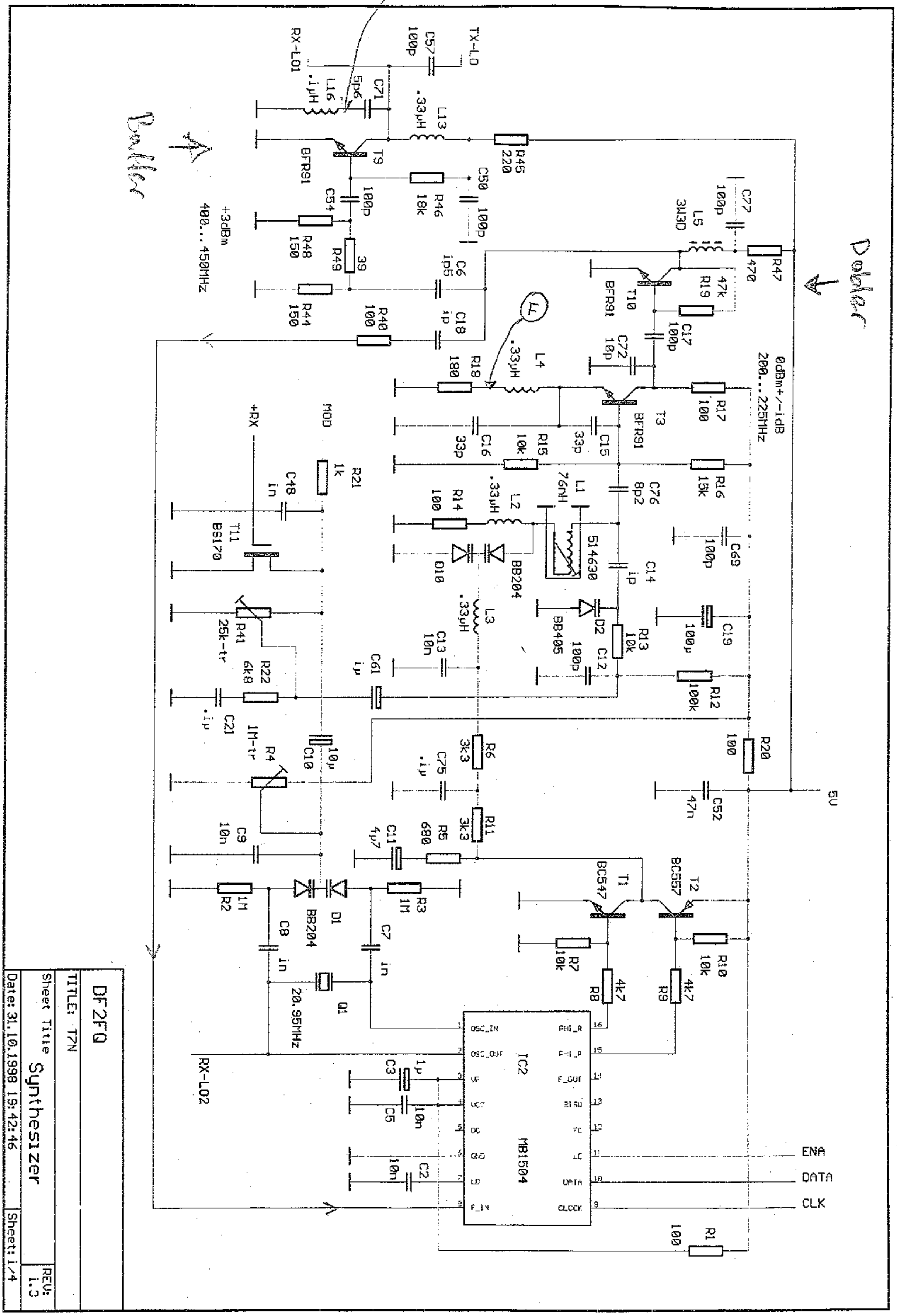
n.b = nicht bestücken

R28	4k7	R10
R29	33 → 10Ω 5W	R75
R30	18k	R10
R31	220	R10
R32	82	R10
R33	18k → 22k	R10
R34	82	R10
R35	10k	R10
R36	470	R10
R37	2k2	R10
R38	2k2	R10
R39	1k	R10
R40	100	R10
R41	25k trimmer	R_IR_ST
R42	100k	R10
R43	100	R10
R44	150	R10
R45	220	R10
R46	18k	R10
R47	470	R10
R48	150	R10
R49	39	R10
R50	470	R10
R51	470	R10
R52	100	R10
R53	100k trimmer	R_IR_ST
R54	10k	R10

R55	10k	R10
R56	270	R10
R57	10k	R10
R58	100	R75
R59	100	R10
R60	330	R10
R61	100	R10
R62	2k2	R10 — R63 100k
R64	1M	R10
T1	BC547	TO92
T2	BC557	TO92
T3	BFR91	SOT103
T4	BC547	TO92
T5	BF966	SOT103
T6	BFR91	SOT103
T7	~~BFR96~~ BFR91	SOT103
T8	BD140	TO139
T9	BFR91	SOT103
T10	BFR91	SOT103
T11	BS170	TO92 ← T12 BC547, T13 ?
T14	BC547	TO92
T15	BF255	TO92
T16	BC557	TO92
T17	BS170	TO92
X1	2X07/90	RM2.54
X2	2X05/90	RM2.54



4 mm avstandstykker : PA-modul
5 " —— " —— : Print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Sheet Title Synthesizer
Date: 31.10.1998 19:42:46
Sheet: 1/4
REV: 1.3

Bild 1

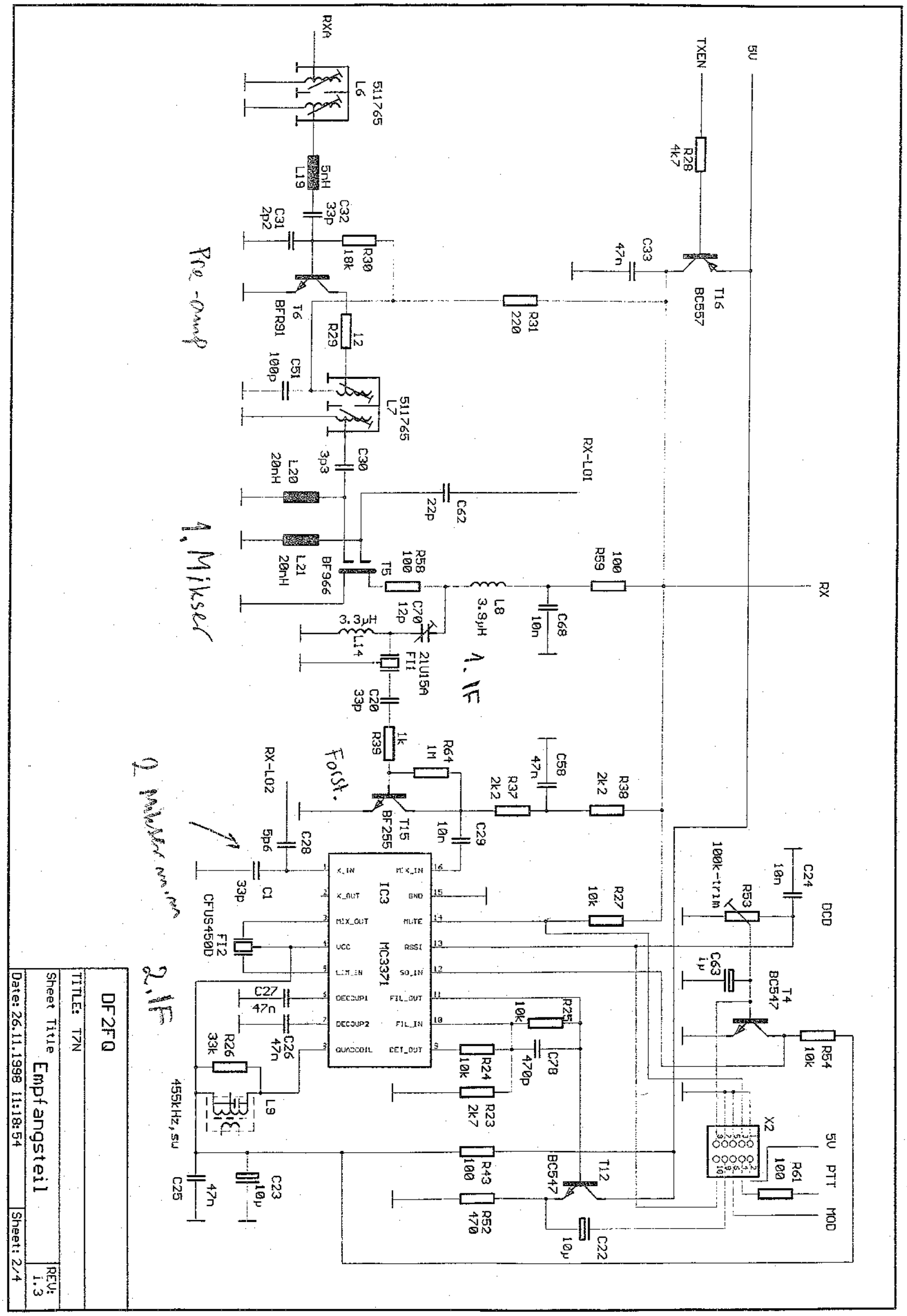

Bild 2

1 GND
2 +5V
3 MUTE P.14 IC3 mm
4 PTT via 100Ω
5 GND
6 MOD
7 GND
8 AF out (via 10µF)
9 DCD 2
10 RSSI

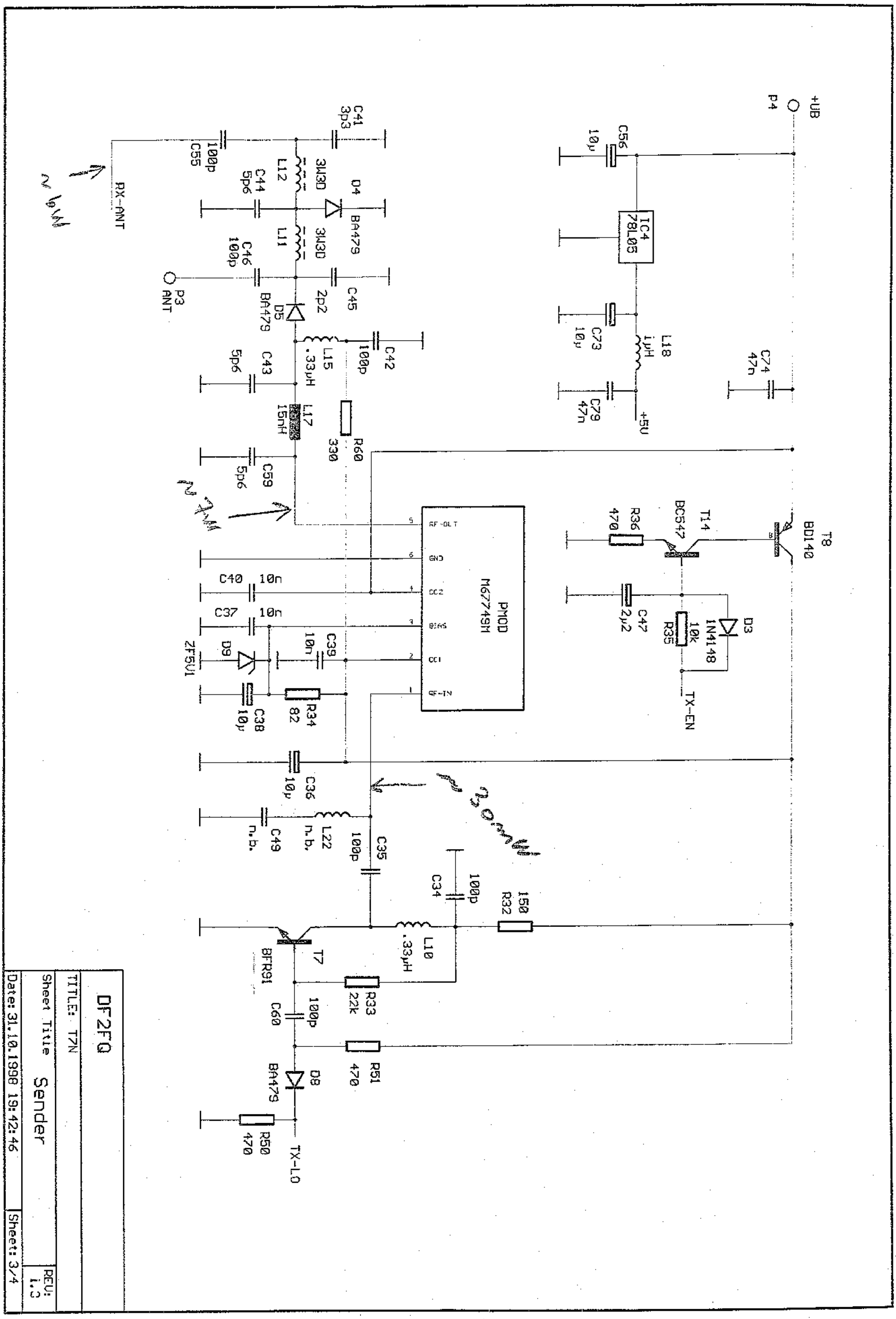
DF2FQ
TITLE: T2N
Sheet Title Sender
Date: 31.10.1998 19:42:46
Sheet: 3/4
REV: 1.3
PMOD
M67749M
RF-OUT
GND
CC2
BIAS
CC1
RF-IN
+UB
P4
P3
ANT
RX-ANT
IC4
78L05
+5V
TX-EN
TX-LO
T7
BFR91
T8
BD140
T14
BC547
D3
1N4148
D4
BA479
D5
BA479
D8
BA479
D9
ZF5V1
L10
.33µH
L11
3W3D
L12
3W3D
L15
.33µH
L17
15nH
L18
1µH
L22
n.b.
C34
100p
C35
100p
C36
10µ
C37
10n
C38
10µ
C39
10n
C40
10n
C41
3p3
C42
100p
C43
5p6
C44
5p6
C45
2p2
C46
100p
C47
2µ2
C49
n.b.
C55
100p
C56
10µ
C59
5p6
C60
100p
C73
10µ
C74
47n
C79
47n
R32
150
R33
22k
R34
82
R35
10k
R36
470
R50
470
R51
470
R60
330

Bild 3

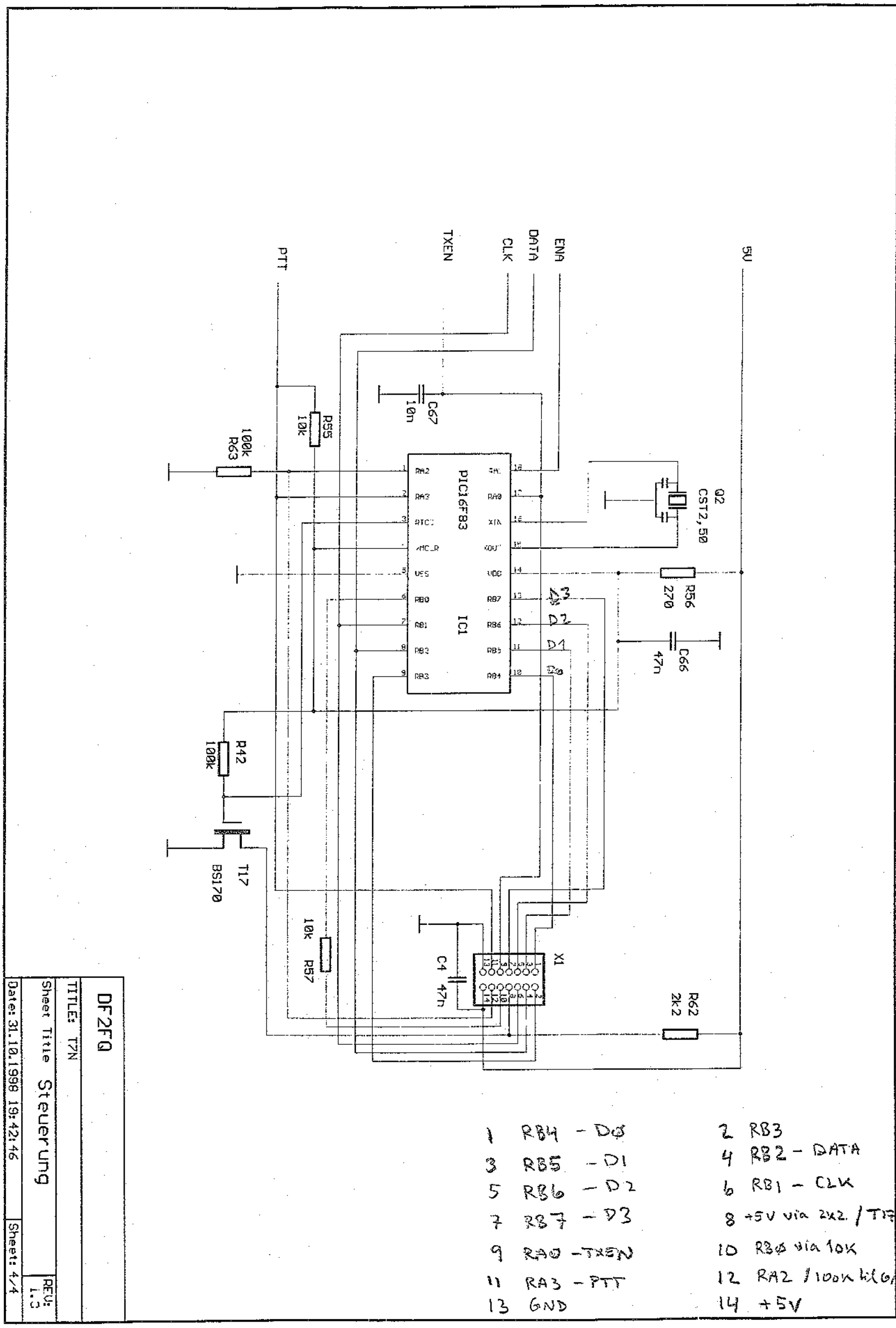
PTT
TXEN
CLK
DATA
ENA
5V
C67
10n
R55
10k
100k
R63
PIC16F83
IC1
Q2
CST2,50
R56
270
C66
47n
D3
D2
D1
D0
R42
100k
T17
BS170
10k
R57
C4
47n
X1
R62
2k2
DF2FQ
TITLE: T7N
Sheet Title Steuerung
Date: 31.10.1998 19:42:46
Sheet: 4/4
REV: 1.3
1 RB4 - D0
2 RB3
3 RB5 - D1
4 RB2 - DATA
5 RB6 - D2
6 RB1 - CLK
7 RB7 - D3
8 +5V via 2k2 / T17 (TXD →
9 RA0 - TXEN
10 RB0 via 10K (RXD ←
11 RA3 - PTT
12 RA2 / 100k to GND
13 GND
14 +5V

Bild 4