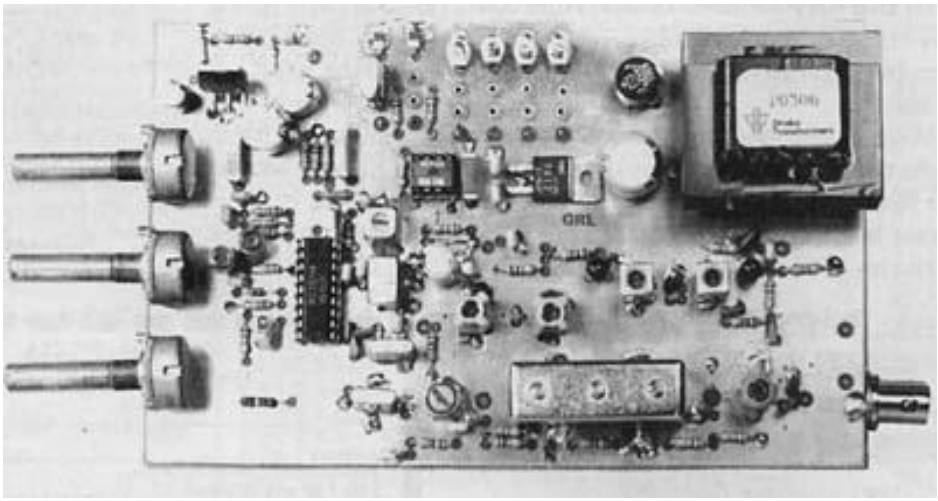
A 2m Amateur FM Receiver for UoSAT

Graham Leighton G8FXB 1982, edited by Matthias DD1US 2020

Background

This receiver was originally designed in 1981 to receive the telemetry from the UoSAT (University of Surrey LEO) Satellites. From the days when synthesisers were not always used, it is a basic 144MHz, crystal-controlled FM receiver with AFC. The design is usable for other VHF bands by changing the filters and multiplier components.



Introduction

This receiver is a six channel crystal controlled design. An AFC facility is available on two channels, since the doppler frequency shift on the 2 meter beacon is about + /-3 kHz which will cause a significant degradation to the signal if a fixed frequency receiver is used. The AFC range is just sufficient to cope with the +/- 15 kHz doppler shift found on the 70cm beacon. A suitable low noise 70cm converter was described in reference (5).

The low noise figure and high gain of the 3SK88 RF and mixer stages are exploited to give the receiver a sensitivity exceeding O.15uV (-l24dBm) for 12dB SINAD. The heart of the receiver is an MC3359/ULN3859 IF IC, which is a tidied-up and slightly improved version of the MC3357. The use of this IC simplifies the design of the IF considerably, and helps achieve the overall excellent price/performance of the unit. A nine times multiplication is used in the local oscillator chain to give the required range from the VXO - which also means that a readily available crystal may be used.

Circuit Description

RF Stages

The RF and mixer stages, Q1 and Q2 are similar to the 2m converter design described in Ref (I), except that the local oscillator is injected to the source of the mixer. This method produces a more stable mixer with improved intermodulation characteristics.

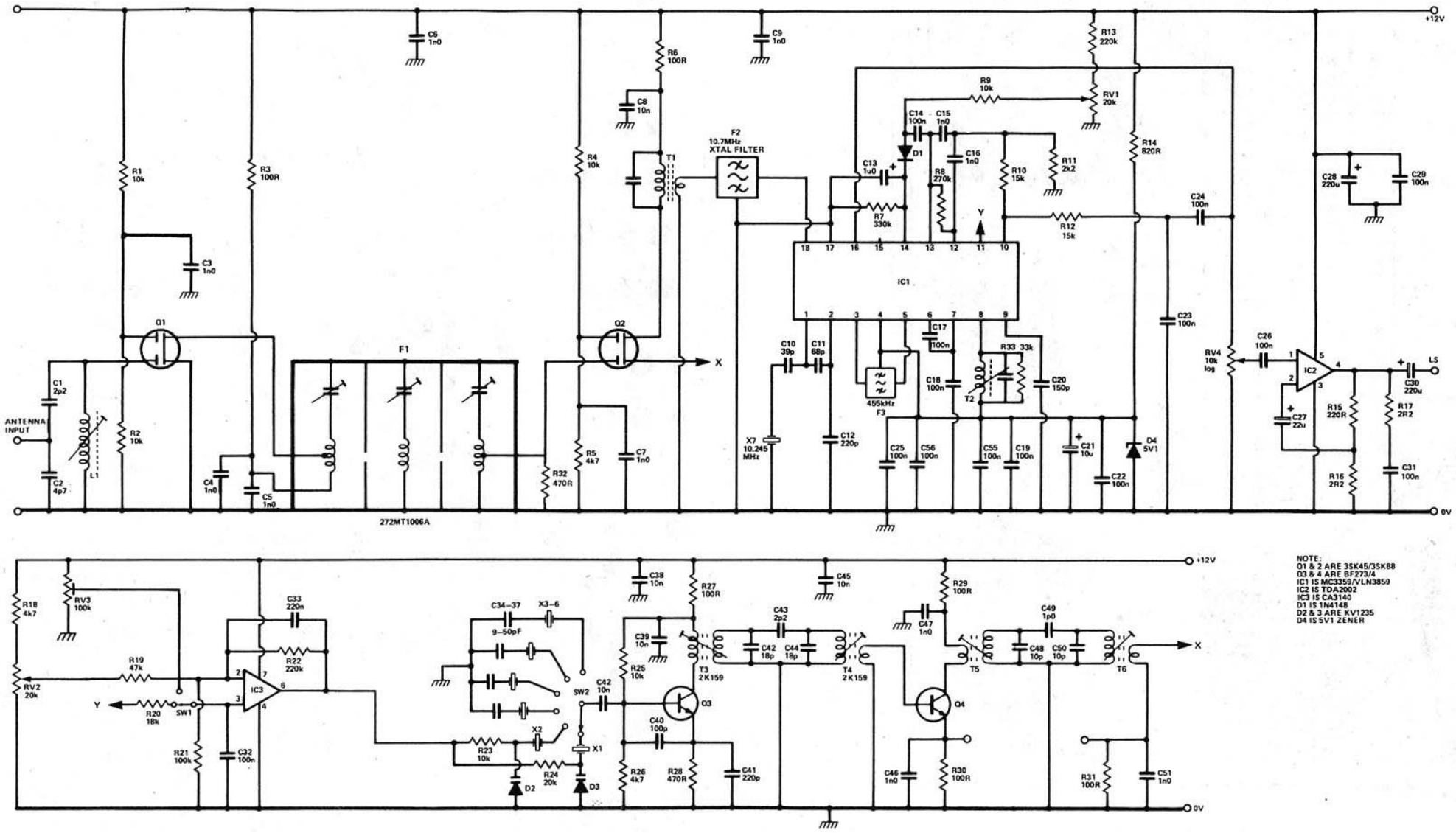
IF Section

The drain of Q2 is tuned to 10.7 MHz by TI, which also matches the mixer to the crystal filter. The output of the filter is the same impedance as that found at the input to ICI (pin 18). The high sensitivity and impedance at this point (about 5uV for 12dB SINAD and 3k respectively) may be demonstrated by the ready reception of shortwave signals if you place your finger near pin 18. The double balanced mixer converts the 10.7 MHz signal to the second IF at 455 kHz. A Colpitts oscillator is provided in Id, which in this case is crystal controlled by X7. The output at pin 3 has a 1k8 impedance which matches directly to a ceramic filter. Most of the gain of the IC is at 455 kHz in the limiting amplifier, and the input to this stage is also matched to the filter impedance. The amplitude - limited FM signal is demodulated using a quadrature detector, and the recovered audio is filtered by R12, C23, C24 and C26 to give the desired response. Unfiltered audio is fed to a bandpass filter formed by an inverting op-amp at pins 12/13 and RI I, R8, CIS. C16. Any noise above the normal audio range, present in the absence of signal, is selected, amplified and then detected by the combination of DI and C14. The squelch sensitivity is adjusted by varying the bias fed via R9 to the squelch detector input. A level of 0V7 at pin 14 will activate the squelch detector causing pin 15 to be open circuit and pin 16 to be grounded via pin 17. Shorting the audio at the top of RV4 mutes the receiver. The ubiquitous TDA2002 is used as the audio power amplifier

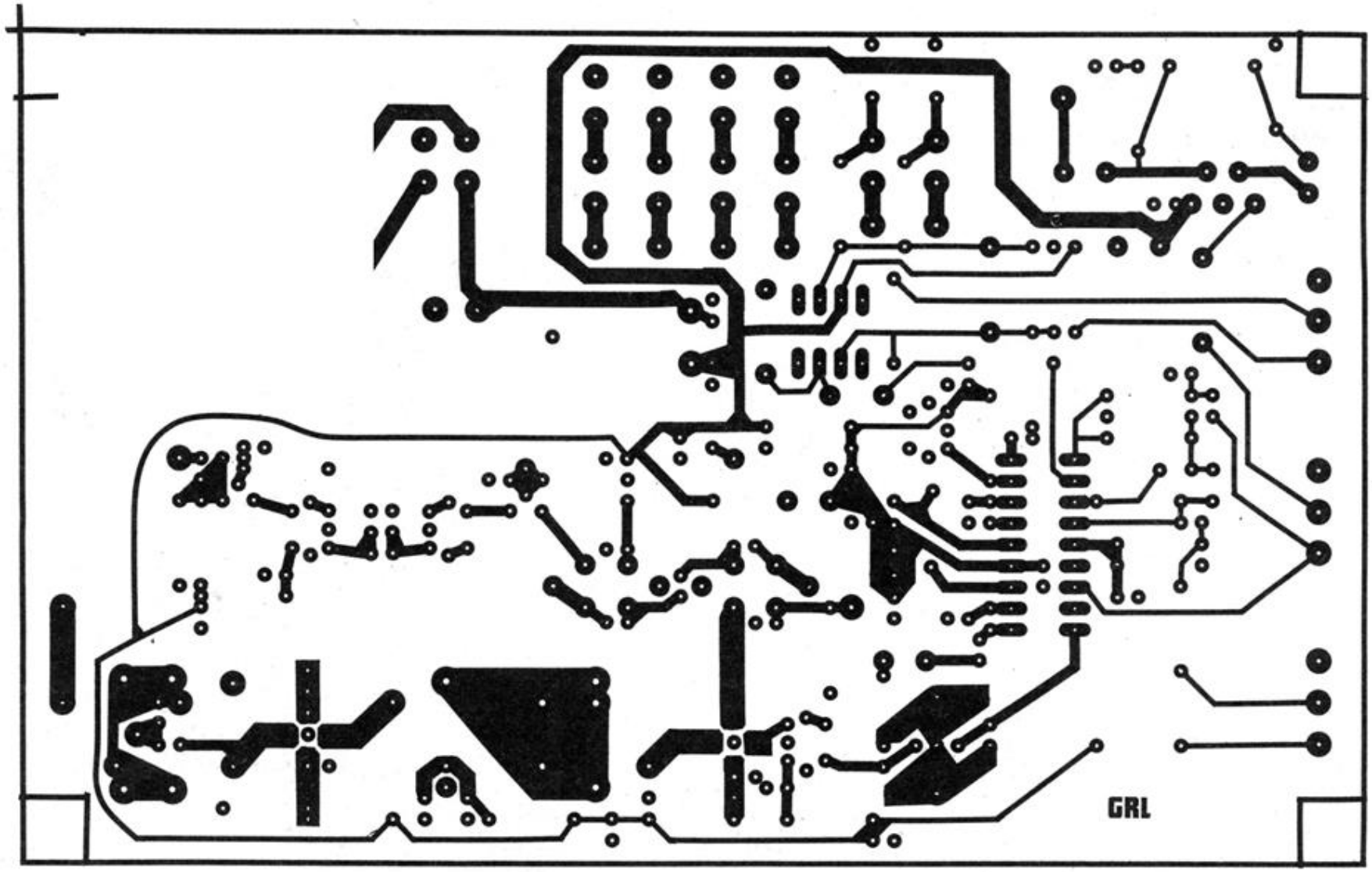
AFC & Local Oscillator

About +2dBm is required at 133.3 to 135.3 MHz as local oscillator. Q3 forms a Colpitts oscillator at about 14 MHz. The frequencies of the crystals are trimmed either manually (by C34-37) or by the AFC voltage via D2 and D3. T3 and 14 select the third harmonic of the crystal frequency. Q4 triples again and its output is tuned by T5 at the LO frequency. T6 forms the rest of the filter and matches the output to Q2. A high multiplication factor is needed to allow sufficient range to be extracted from the VXO. Despite the nine times multiplication, the output at 16 is very clean because of the use of double tuned filters 13/14 and T5/6. The AFC voltage derived from pin II of ICI is scaled by 1C3 and added to an offset which is set by adjusting RV2 97 this allows the receive centre frequency to be adjusted. Manual tuning is available if the input of 1C3 (pin 2) is connected to a fixed bias source, which is set by RV3.

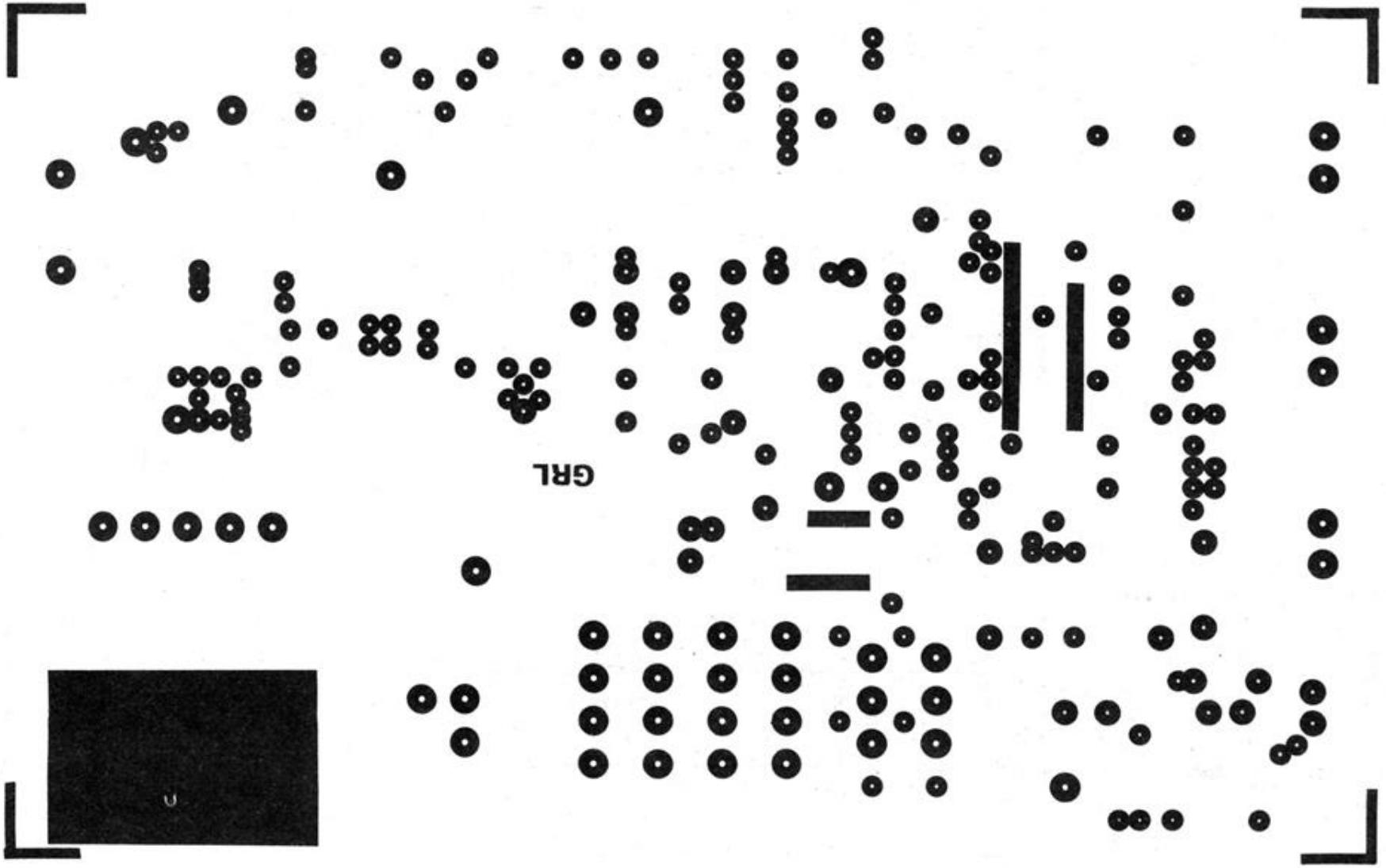
Circuit Diagram



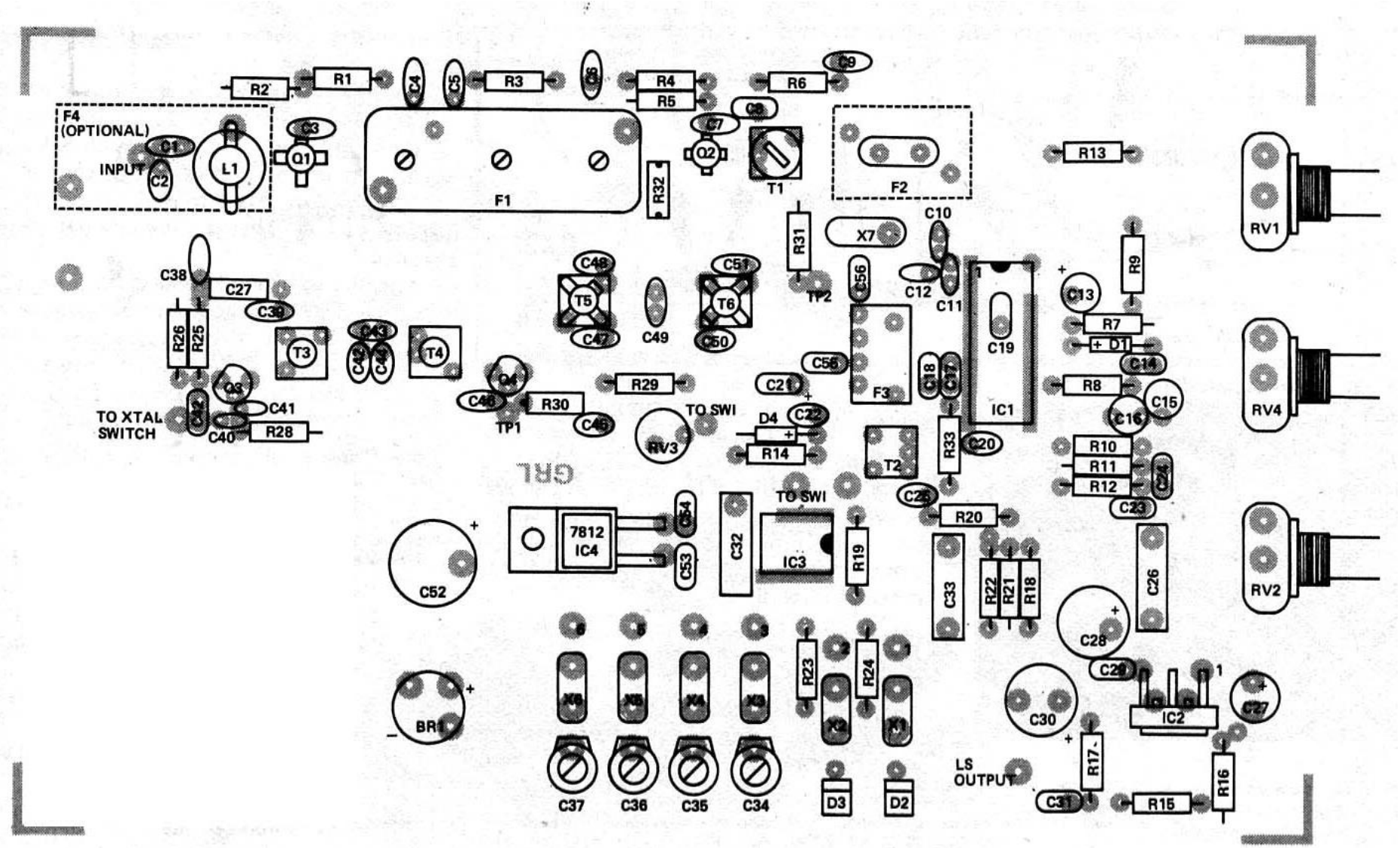
PCB-Layout Track Side



PCB-Layout Component Side



Component Overlay



Components list

COMPONENTS LIST

Resistors

R1,2,4,9,23,24,25	10k
R3,6,27,29,30,31	100R
R5,26,18	4k7
R7	330k
R8	270k
R10,12	15k
R11	2k2
R13,22	220k
R14	820R
R15	220R
R16,17	2R2
R19	47k
R20	18k
R21	100k
R28,32	470R
R33	33k

Potentiometers

RV1,2	20k lin
RV3	100k min preset
RV4	10k log

Capacitors

C1,43	2p2 ceramic
C2	4p7 ceramic
C3-7,9,46,47,51	1n0 ceramic
C8,38,39,45	10n ceramic
C10	39p ceramic
C11	68p ceramic
C12,41	220p ceramic
C13	1u0 16V tantalum
C14,17,18,19,22,23,24,29,31,55,56	100n monolythic
C15	1n0 polystyrene
C20	150p ceramic
C21	10u 16V electrolytic
C26,32	100n polystyrene
C27	22u 16V electrolytic
C28,30	220u 16V electrolytic
C33	220u 16V electrolytic
C34,35,36,37	9-50p ceramic trimmer
C40	100p ceramic
C42,44 48,50	18p ceramic 10p cermamic
C49	1p0 ceramic

Semiconductors

Q1,2	3SK45/3SK88
Q3,4	BF273/BF274
IC1	MC3359/U-LN3859
IC2	TDA2002
IC3	CA3140
D1	IN4148
D2,3	BB109
D4	**5V1 400mW** zener

Coils

L1	S18 green (5.5 turns)
T1	119LC30099N
T2	LPCS 4200
T3,4	113CN2K159
T5	200058 (4.25/.25 turns)
T6	200027 (4.25/2.25 turns)

Miscellaneous

F1	272 MT1006A
F2	10.7 MHz 10M15A or 10M15D
F3	455 kHz **LFH 12S-** SLFD-12
X1-6	as required
X7	10.245 MHz

IC sockets, crystal pin sockets, BNC socket, PCB, Case, etc.

POWER SUPPLY

C53,54	1n0 monolythic
C52	470u 16V electrolytic
BR1	W005 bridge rectifier
IC4	**7812**

Assembly

Assembly of the PCB is straightforward, but it helps if the following few notes are adhered to. All components that require an earth connection should be soldered to the top of the board. The earth leads on IC1 and 1C3's sockets are bent outwards before soldering. If an SLF-D type filter is used, its earth connectors are made likewise. Fl, T1 /3/4 connections and the earth leads of C42/44/48/50 should be soldered top and bottom. Qi source and the earth track under F2 should be connected through the PCB to the earth plane. C19 must be fitted before IC1's socket.

Testing

Remove IC1 & 3 from their sockets. Connect the power and check the supply voltages. Check the audio amplifier operation by applying a signal to pin I of 1C2 (finger or signal generator). Fit a crystal in channel 3, set T3 and T4 cores level with the can top, and monitor the voltage on Q4 emitter, TPI, tuning T3 and T4 for maximum reading. Monitor TP2 and tune T5/T6. Retune T3 and T4 for maximum. Switch the supply off, insert IC and switch on again. Set the mute fully anticlockwise. Using either a signal generator or strong local signal, tune T2, TI, and Cl for best signal - to - noise ratio. If a signal generator is available, inject signal at 10.7 MHz to pin 18 of ICI and set the voltage on pin 11 to about 2.8V by tuning T2. Without a signal generator, the discriminator may be set up by tuning T2 as before, but with no signal input to the receiver. Inserting 1C3 activates the AFC to channels I and 2. RV2 provides coarse tuning for these channels. With SWI set to manual - and RV2 to centre of its travel - adjust RV3 to give about 5V at pin 6 of 1C3. This sets the manual tuning range. Although Fl is supplied fully aligned, it may require some minor adjustment to take account of circuit variations. When the receiver has been tuned as above, it is a good idea to slightly retune Ll, Fl, TI and T6 for best signal - to - noise.

References

1. Timothy Edwards, A state of the art 2m Receiving Converter, R&EW October 1981.

2. Peter Whatley, Motorola mc, FM Receiver Mixes High Gain with Low Power, Electronics June 2nd 1981.

3. MC3359 Data Sheet, Motorola Inc.

4. ULN3859 Data Sheet, Sprague

5. Leighton G.R., 70cm to 2m and TV converter, R&EW January 1982.