muTek limited
rf technology

BRADWORTHY HOLSWORTHY DEVON EX22 7TU
Telephone: 0409 24-543
Telex: 42513 SHARET G

TVVF 144a
operating data

Firstly, thankyou for purchasing the TVVF 144a. It is a very high performance transverter which will enable you to exploit the facilities of your 28MHz transceiver within the 144MHz band. The design has been carefully optimised in order to ensure maximum performance from the combination of transceiver and transverter, whilst minimising the possibility of receiver or transmitter overload problems.

PLEASE READ THESE INSTRUCTIONS CAREFULLY! We want you to get the best from our products and a few minutes spent in reading and understanding these notes will assist you in doing so.

How the transverter works.

A transverter is a bilateral frequency translation device. In its simplest possible form it could be simply a mixer and local oscillator, however, this would not produce very much power on transmit, whilst most of that generated would not be on the wanted frequency! On receive, the sensitivity would not be adequate and the system would be extremely vunerable to spurious responses. Other system components such as filters, and amplifiers are required in order to make an effective unit. The design of a transverter such as the TVVF 144a requires considerable care in the integration of these components into a complete system.

The receiver signal path.

The receive converter signalpath can be conservatively designed from a knowledge of the expected level of external noise (from sources such as the Galaxy and thermal radiation) and the sensitivity of the following receiver. At 144MHz, the background sky-noise temperature is around 250K (1). This implies that an overall receiver noise figure of around 2.5dB is adequate(2). The vast majority of 28MHz transceivers have noise figures in the 8 - 15dB region: this implies that a translation gain of between about 10 and 20dB is required.Larger gains will simply result in degradation of the large signal performance of the system. The TVVF 144a has its gain variable from around 5 to 22dB, allowing optimisation of the complete transverter - transceiver system.

(1) Reference Data for Radio Engineers, Howard W. Sams & Co., New York. Chap. 29-2, Fig.1. 6th Edition, 2nd printing, 1977. ISBN 0-672-21218-8.

(2) Modern vhf/uhf front-end design. Ian White G3SEK. Radio Communication. Vol. 61. Nos.4 - 7 (March - June 1985).

To achieve the system performance requires careful attention to the circuit design of the individual system components. A balanced mosfet rf amplifier provides superior large-signal performance when compared to conventional single device designs. A pin diode switch steers the signal into the image filter, which is shared with the transmit chain, as is the bilateral diode ring mixer.

It is essential to terminate ring mixers properly, and the HLRM 200g high performance mixer employed in the TVVF 144a is no exception! The if port is terminated with a diplexer, which return all signal components except the wanted 28MHz band output to 50 ohms. This is essential for reproducibly good performance. Poor if port termination can result in more than 20dB degradation of the intermodulation characteristics of the mixer! In order to ensure resistive termination of the image frequency and commutation products appearing at the signal port in the transmit mode, a similar termination system is used before the image filter.

A resistive pad adequately terminates the local oscillator port.

Following the diplexer, a low-noise linear large-signal transistor operating with heavy negative feedback provides a good match to the mixer, whilst maintaining excellent dynamic and noise- figure performance. The 28MHz output from the if amplifier is attenuated by the variable pad used to set the translation gain.

The transmit strip

Unless overdriven, modern hf transceivers are capable of generating high-quality ssb/cw signals, however, the levels of spurious products considered acceptable by licencing administrations at hf, are greater than those at vhf. This provides a challenge for the transverter designer! The objective is to translate the wanted 28MHz signal to 144MHz with a minimum of distortion and to minimise the potential for the generation of spurious outputs.

Most hf transceivers provide outputs in the range 0.1 to 300mW from their transverter port. In the TVVF 144a, this is first attenuated by means of a potentiometer and then by a shunt pin diode voltage controlled attenuator operating under alc control. This reduces the signal level to about -16dBm at the input to the buffer amplifier. The buffer amplifier has about 12dB gain, and also a secondary function as a limiting amplifier cum fuse(!) in order to protect the ring mixer from gross overdrive levels.

After the mixer and first image filter, the signal is amplified to the 10mW level by a mosfet amplifier and is further filtered by a two pole Butterworth bandpass filter. A three stage linear power amplifier follows. This consists of a class-A amplifier employing negative feedback driving a two-stage class-B output stage. The driver transistor actually operates fairly close to class-A, whilst the final amplifier device is very conservatively rated in order to maintain linearity. The 10W output of the linear amplifier passes through a seven element lowpass filter via a lumped component directional coupler to the antenna transfer relay. The levels of harmonically related spurious products are very low indeed.

The directional coupler outputs link via dc amplifiers with the pin diode attenuator at the input to the mixer to provide control of forward power level and high vswr shutdown. A further output drives the led bargraph. The use of alc does mean that it is possible to operate the transverter with a wide range of input levels with no adjustment of the input potentiometer, however, linearity is improved slightly by careful adjustment of this control. This is described in the 'Setting-up' section, and is to be recommended if you wish to obtain the very best performance from this transverter.

In common with other muTek 28MHz i.f. transverters, the TVVF 144a also has the ability to interface with the internal alc systems of many transceivers. This can ensure that the transceiver is not driven out of its linear range when operating with the transverter. The transverter contains a negative voltage generator to supply an op-amp differential amplifier and filter circuit which generates the standard zero to -5V alc level required by transceivers.

The local oscillators use low-noise high-transconductance j-fets in a circuit which has been designed to maximise the loaded Q of the crystal, resulting in excellent noise sideband performance. Oscillator selection is by means of a diode switch. A class- A j-fet buffer amplifier follows the oscillator and fulfills the joint tasks of isolating the oscillator from variations in load impedance and raising the output level to that required for satisfactory operation of the mixer.

Transmit-receive control is obtained by means of simple discrete component circuit. Provision is made for both rf sensed control and hand switching. The hand switching will always be overridden by the rf sensing: this is a necessary saftey feature! Presence of 28MHz energy at the transceiver port is sensed and a portion rectified. This switches a bipolar transistor, the collector time constant of which defines the 'hang' time in conjunction with the gate threshold voltage of the of the power fet relay driver. The threshold level for rf switching has quite deliberately been set at around the 10mW level, as otherwise strong

Using the TVVF 144a.

The TVVF 144a connects between the 28MHz transceiver and the 144MHz antenna or linear amplifier. For best performance on 144MHz it is desirable to use a high quality hf transceiver, and of course, the best possible antenna system. A good quality 13.8V power supply capable of at least 4A output with reasonable ripple and stability characteristics is also required.

In order to make the most of the combination of transverter and transceiver, it is essential to CONSULT THE MANUAL OF THE HF TRANSCEIVER regarding its transverter interfacing requirements. If you have any further queries regarding this you should contact the manufacturer, importer, or retailer from which it was purchased. The TVVF 144a is extremely flexible, and should work satisfactorily with any hf transceiver capable of generating between 0.1 and 300mW pep from its transverter port within the 28 - 30MHz band. The interfaces designed into the transverter are detailed below.

The power cable is supplied ready for use, however, the power supply socket also provides access to other functions which may make interfacing with the outside world a simpler task. They are:

Pin 2. Control output. This output is switched to ground when the transverter is in the transmit mode by the power fet which controls the internal changeover relay. A diode and resistor in series protect the fet and define the output impedance of this port at round 30ohms. Note that it is important to provide back-emf protection by means of a shunt diode if relays are switched directly.

This pin may also be rewired to provide a voltage source when the transverter is switched on. This is needed with Icom transceivers. Please see Appendix 1 for details.

Pin 3. ALC output. This line outputs a zero to -5V ALC line with a source impedance of around 100 ohms in order to drive the ALC input of most transceivers.

Pin 4. Hard switching. Taking this line to ground commands the transverter into the transmit mode. The impedance is high (about 100K) and is thus suitable for those transceivers unable to source large currents from their control ports. In the case of transceivers outputting a voltage level on transmit, such as many of those manufactured by Icom, this pin may be rewired to accept this. Instructions are given in Appendix 1. If hard switching is used regularly, it is recommended that the transmit to receive delay is disabled. This may be accomplished by cutting a link. The location of this link is given in Fig 1.

The rf interface may be accomplished either by a single transmit/receive cable or by means of separate transmit and receive lines. The transverter is supplied wired for independent transmit and receive inputs, however, the rewiring of a simple link internally is all that is required to revert to single cable operation. Please see Apendix 1.

Connect the transceiver to the transverter and the transverter to the antenna using good quality 50ohm coaxial cable. For short runs (up to around 1m) small diameter cables such as URM 76, URM 43 or RG 58/U are acceptable. For longer runs (up to perhaps 15m) particularly for antenna feeds, lower loss cables, such as URM67, H100, RG213/U, or real (!) RG8/U are desirable. Where longer runs are unavoidable, consider the use of hardline or heliax type cables such as Andrew LDF4-50. If the losses between the antenna are greater than about 2dB then the use of a masthead mounted preamplifier should be considered for best performance.

The load seen by the transverter should be well matched to 50ohms. Although the TVVF144a will continue to supply power into a mismatch, the linearity will suffer. The TVVF 144a will protect itself from severe mismatches by reducing power if the load vswr exceeds around 2.5:1.

Setting-up

The setting-up procedures will vary according to the transceiver with which the TVVF 144a will be used. It will be necessary to carefully remove the U-shaped top cover of the transverter and locate the relevant preset potentiometers. Use a small Pozidrive screwdriver to avoid damaging the special epoxy coated retaining screws. To aid identification of these potentiometers we have colour-coded them: the input level control is coded yellow, whilst the translation gain control is red. Don't attempt to adjust anything else: muTek transverters are very carefully aligned during production, by experienced people using high quality test equipment. ATTEMPTS TO REALIGN THE TVVF 144a WITHOUT THE NECESSARY KNOWLEDGE AND EQUIPMENT ARE VERY LIKELY TO RESULT IN THE GENERATION OF SPURIOUS SIGNALS. No realignment should be necessary unless a component becomes faulty, when the transverter should be returned to muTek limited or your National Distributor for service.

The first step in the setting-up procedure is to make any wiring changes which may be necessary. Use either a small (25W) or temerature controlled soldering iron to do this. Wire and sleeving are supplied in the accessory kit. If hard switching is to be used, take this opportunity to cut the time delay link.

Connect-up the transverter and transceiver, preferably with a suitable 50ohm dummy load terminating the antenna connector and apply dc power to the transverter. Tune the transceiver to 28.00MHz nd in the ssb mode with the mic. gain turned down, transmit. The relays in the transverter will change-over. Return to receive. Set the transceiver's drive control to maximum, and the mic. gain control to its normal position and transmit, fully modulating, preferably with a whistle. Slowly rotate the transverter drive level control anticlockwise until all segments of the bargraph display are lit. If an analogue rf power meter is available, the action of the alc system with a constant input level can be observed: as the level adjust control is rotated anticlockwise the output will cease increasing at one point. This is the threshold of alc action, and is the correct operating point.

This setting-up procedure applies whether or not the transceiver's internal ALC system is employed. Please note that use of the transceiver ALC will result in very slightly less transverter power output, however, this will be compensated for by improved linearity.

Setting of the receive translation gain control is best done on air. Connect an antenna to the transverter and tune in a weak signal. Rotate the control anticlockwise until the (signal + noise)/noise ratio of the signal JUST degrades. This can be slightly confusing if the signal is received on a conventional ssb/cw receiver as the ear is not very good at discriminating between similar (s+n)/n ratios. A better technique is to use the fm position on your transceiver, if fitted, to listen to a weak constant carrier. At threshold, the non-linear characteristics of the fm discriminator mean that very small differences in the carrier to noise ratio of the signal become audible. By adjusting the translation gain control until a just audible degradation of quieting can be heard and then rotating the control a few degrees clockwise, this will ensure that the optimum combination of sensitivity and strong signal performance has been obtained from your system.

Once you have performed the setting-up procedures, the cover should be replaced. If you have damaged the special epoxy coated screws, don't worry, as you will find some spares in the accessory kit.

If you have any queries or problems, please don't hesitate to contact muTek limited, or your national distributor for further advice.

Typical performance data.

Receiver.

Noise figure	2.2dB
Conversion gain	+22dB (gain control max.)
Bandwidth	144 - 146MHz +/- 2dB
Input 3rd order intermodulation intercept point	+3dBm

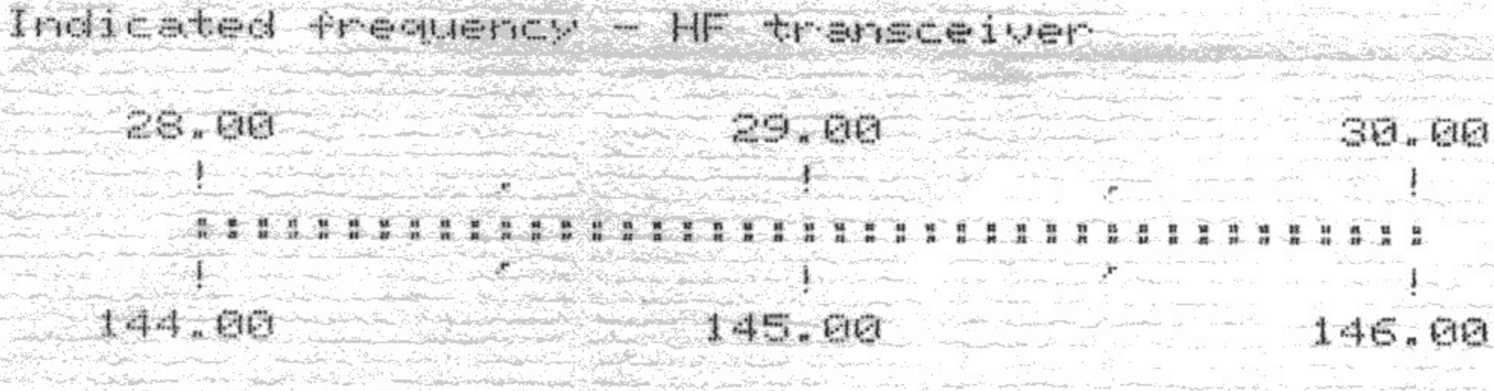
Transmitter.

Power output	10W pep
Output 3rd order intermodulation intercept point	+55dBm
Harmonic spurious	-65dBpep
Non-harmonic spurious	-65dBpep

Local oscillator.

Frequency	116.000MHz
Accuracy	+/- 1kHz at 20C
Noise sideband performance	-135dBc/Hz at 10kHz offset

Frequency translation chart



Appendix 1.

a. Rewiring of Pin 2.

Two voltage levels controlled by the main on/off switch are provided: +8V stabilised and +14V nominal. These are available on two pins located on the circuit board near the power fuse. (See Fig. 1)

Either of these pins may be rewired to pin 2 of the Power/Control connector to enable remote control of the transceiver's transverter port.

b. Modification to enable 'volts on transmit' hardswitching

1. Remove the wire connected to Pin 4 of the power/control socket.

2. Connect the 100K (brown-black-yellow) resistor supplied in the accessory pack between Pin 4 and the pin adjacent to the tantalum bead timing capacitor (See Fig. 1)

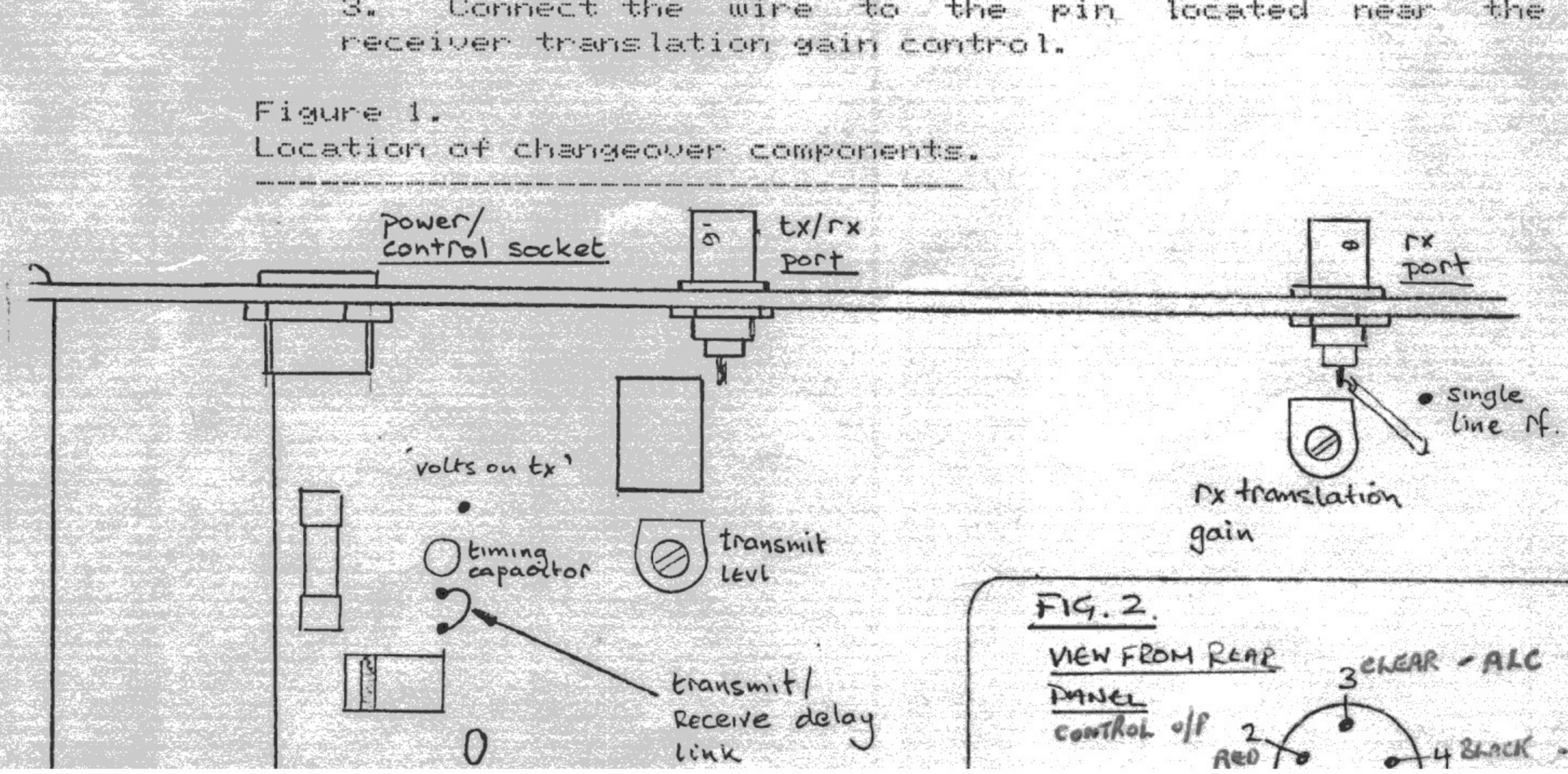
c. Modification for single line rf interface

1. Disconnect the wire attached to the receiver BNC socket.

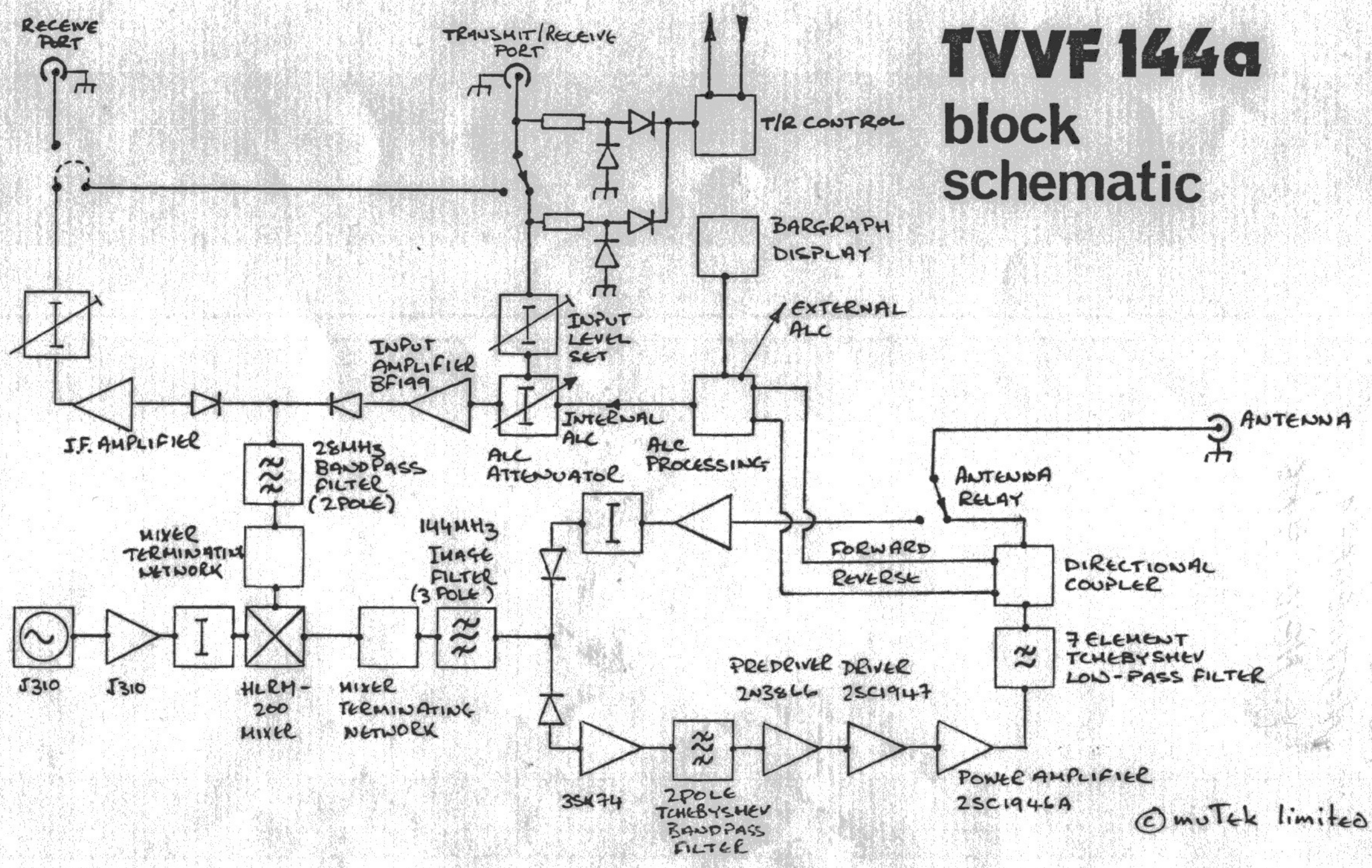
2. Remove the silicone rubber sleeving.

3. Connect the wire to the pin located near the receiver translation gain control.

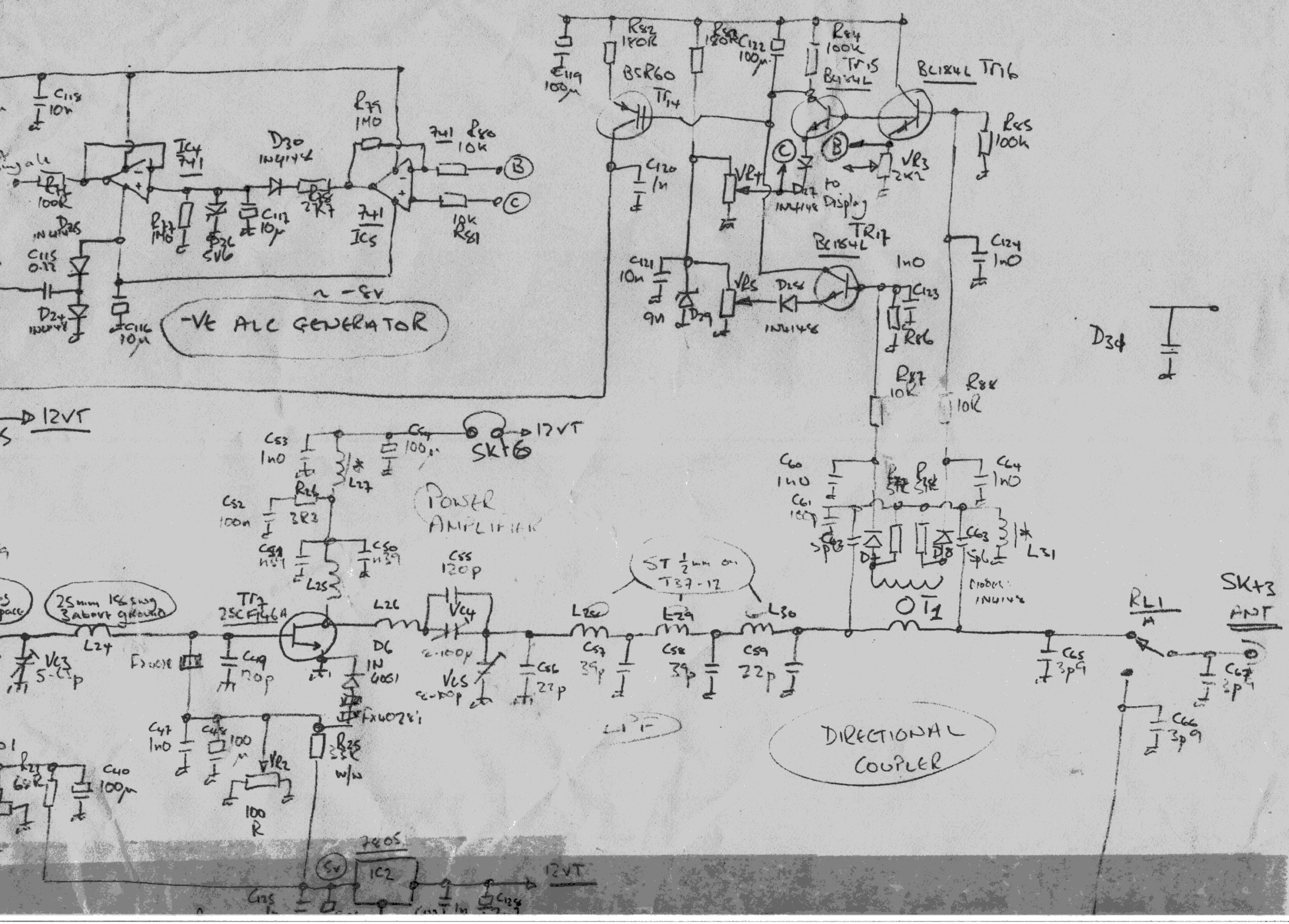
Figure 1.
Location of changeover components.

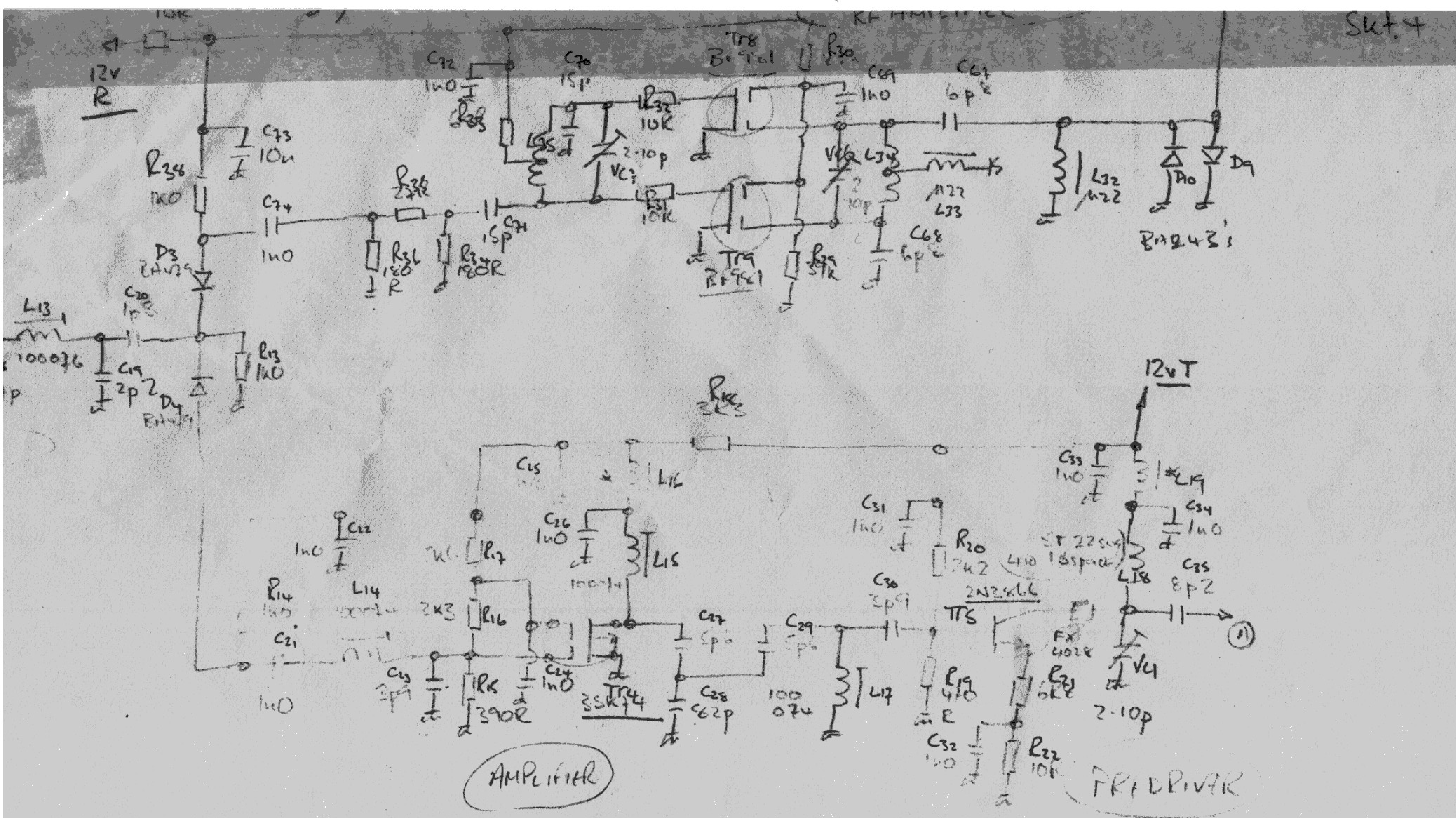


TVVF 144a
block schematic



2

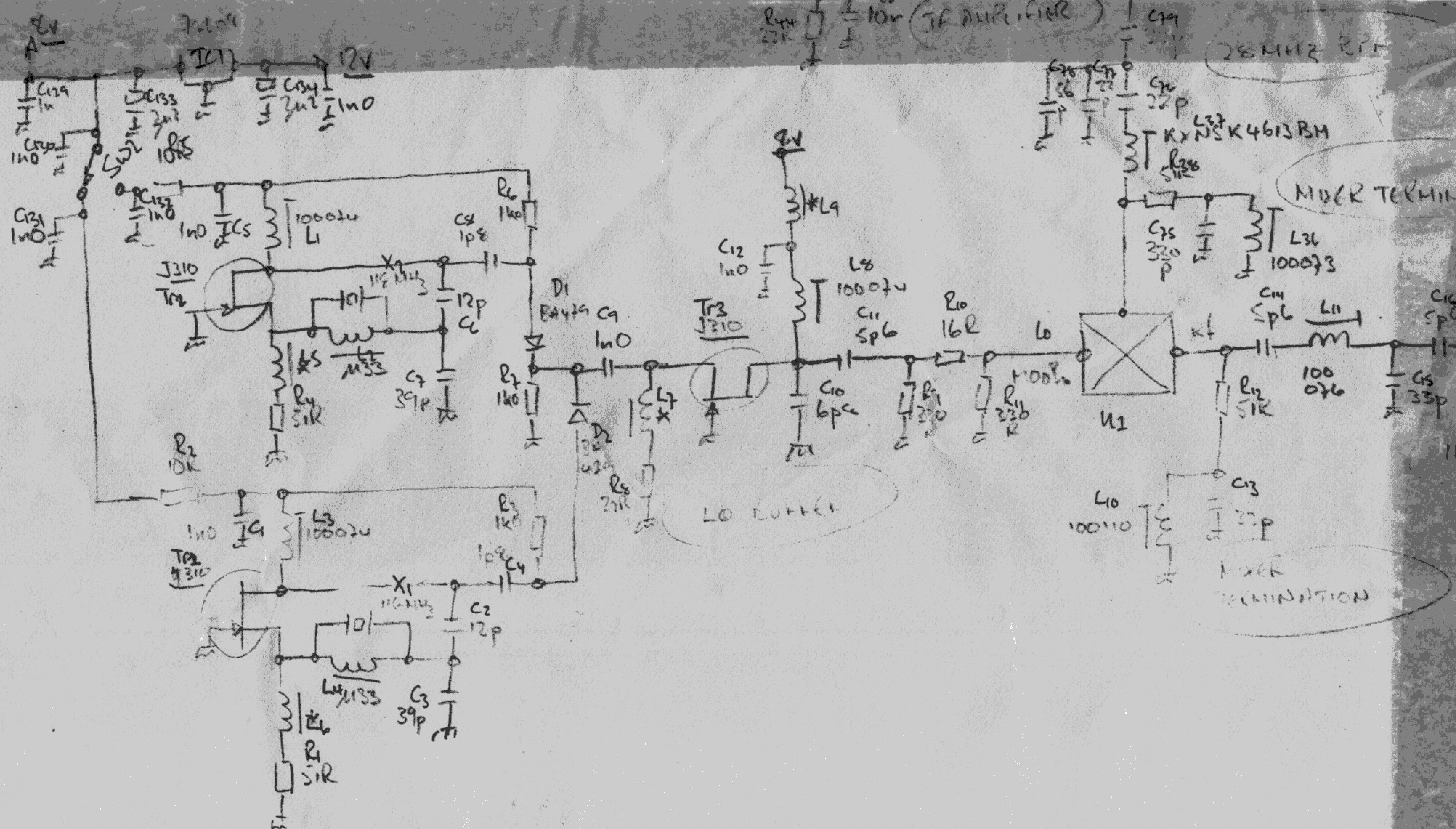

-VE ALC GENERATOR
~ -8V
POWER AMPLIFIER
DIRECTIONAL COUPLER
LPF
12VT
SK+6
SK+3
ANT
RL1
BC184L TR16
BCR60
TR14
TR15
TR17
BC184L
TR7
2SC1946A
IC4
741
IC5
IC2
7805
D34
5T 1/2mm on T37-12
25mm 16swg 3 above ground
to Display



All Relays in n/c position

TVVF 144a

28 May 1985


IF AMPLIFIER
28MHz RF
MIXER TERMIN
LO BUFFER
MIXER TERMINATION
12V
8V
J310
Tr3
U1
D1
KXNSK4613BM