

# muTek limited

## FT221/225GT front end

Our front-end board has been designed to bring the receiver performance of the FT221 and FT225 series transceivers up to a very high standard. The design has evolved from work done by Ian White, G3SEK, and has been used extensively for advanced experimental work, and routine communication.

The original rf board fitted by Yaesu suffers from several deficiencies. The chief of these are a distinct deafness (noise figures of 8 - 10dB are not unusual in unmodified transceivers!) and a considerable susceptibility to strong-signal overload problems. Fitting a preamplifier can help with the first problem but at the expense of dynamic range. Of course, strong signal problems are not always recognised as such, but with the present level of 144MHz activity there can be few operators who are able to completely disregard signal handling problems. Of course there will always be those people (including some manufacturers!) who will remain convinced that a little extra low noise preamplification can only do good.....

The muTek rf board has been designed to eliminate the need for preamplifiers while vastly improving the dynamic range of the system. To overcome the design problems presented has required careful attention to the linearity of the mixer and amplifiers with particular care being given to proper gain distribution.

The rf stage is a very low noise ion-implanted dual-gate mosfet (3SK88) This device is capable of a genuine (device) noise figure of around 1dB. We have chosen to trade nf with dynamic range resulting in a system nf of perhaps 2dB or a little less. This is more than adequate for normal terrestrial operation, and is probably quite acceptable for eme in most circumstances!

The rf stage feeds a three-pole bandpass filter; this has been dimensioned to provide a 2MHz bandwidth centred on 145MHz (4MHz centred on 146MHz) with excellent stopband performance. The filter - which has relatively high dissipation losses - is terminated with a resistive pad. This not only ensures that the filter is adequately terminated, but also provides a very important broad-

band termination for the input port of the ring mixer.

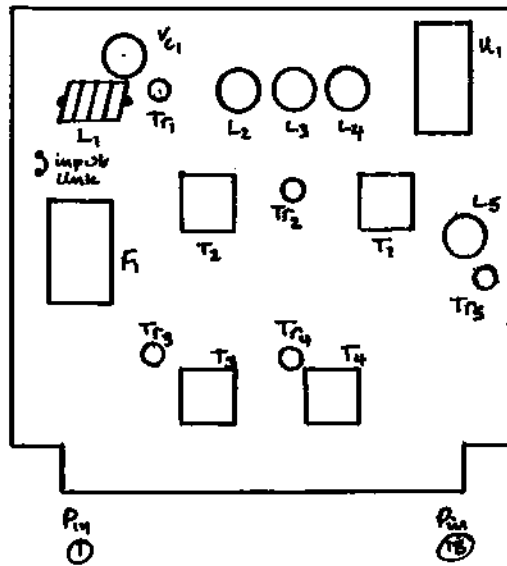
A ring mixer was chosen in preference to the more usual fet for two reasons: the most obvious is that it is much easier to achieve adequate dynamic range with the ring. A second, possibly more subtle reason, is that the inherently balanced structure of the ring results in cancellation of local oscillator am noise. As the phase locked translation loop lo in the 221 and 225 series generates quite large am noise sidebands, a balanced mixer is mandatory.

Proper termination of the mixer is essential for reproducible high performance operation. The lo is terminated with a 5dB pad: this ensures a good broadband match. There is enough power available at the output of the class-A lo buffer to ensure proper mixer performance. The mixer port which requires most careful termination is the if output. The network here has several functions: it must transform the 50Ω output impedance of the diode ring to the optimum source impedance required by the mosfet post amplifier; it must ensure that the mixer has a dc earth return, and most importantly, it must provide a satisfactory termination for the vhf and uhf products generated in the mixing process. The 10.7MHz impedance transformation is accomplished with an L-network, while the rf choke provides the earth return. The series RC network on the mixer output provides a monotonically increasing return-loss with frequency, thus ensuring proper termination of the vhf and uhf mixing products.

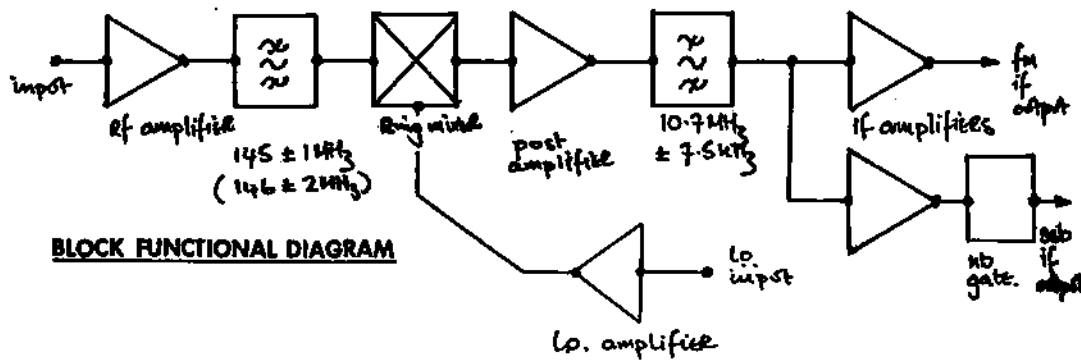
The mixer post-amp is a low noise mosfet which is operated at a high drain current for good intermodulation performance. Although some degradation of the noise figure can be seen, it is still very low and has a minimal effect upon the mixer nf. The device also provides the correct source impedance for the following 6-pole crystal filter.

After the crystal filter the linearity requirements become less severe, but the same circuit techniques are employed. Dual-gate mosfets are used for both the fm and ssb if head amplifiers. The output of the ssb amplifier drives the noiseblinker gate.

The circuit is constructed on a very high quality plated through hole pcb.



**MAJOR COMPONENT LOCATIONS**



**BLOCK FUNCTIONAL DIAGRAM**

|                                  |         |           |
|----------------------------------|---------|-----------|
| C <sub>1</sub>                   | 1n0 pc  | CA-00-130 |
| C <sub>2</sub>                   | 1n0 pc  | CA-00-130 |
| C <sub>3</sub>                   | 8p2 pc  | CA-00-802 |
| C <sub>4</sub>                   | 1n0 pc  | CA-00-130 |
| C <sub>5</sub>                   | 1n0 pc  | CA-00-130 |
| C <sub>6</sub>                   | 12p pc  | CA-00-112 |
| C <sub>7</sub>                   | n10 pc  | CA-00-120 |
| C <sub>8</sub>                   | 12p pc  | CA-00-112 |
| C <sub>9</sub>                   | n10 pc  | CA-00-120 |
| C <sub>10</sub>                  | 68p pc  | CA-00-618 |
| C <sub>11</sub>                  | 1n0 pc  | CA-00-130 |
| C <sub>12</sub>                  | 10n pc  | CA-00-140 |
| C <sub>13</sub>                  | 10n pc  | CA-00-140 |
| C <sub>14</sub>                  | 10p pc  | CA-00-110 |
| C <sub>15</sub>                  | 10n pc  | CA-00-140 |
| C <sub>16</sub>                  | 10n pc  | CA-00-140 |
| C <sub>17</sub>                  | 10n pc  | CA-00-140 |
| C <sub>18</sub>                  | 1u5 tb  | CD-00-165 |
| C <sub>19</sub>                  | 1n0 pc  | CA-00-130 |
| C <sub>20</sub>                  | 1n0 pc  | CA-00-130 |
| C <sub>21</sub>                  | 1n0 pc  | CA-00-130 |
| C <sub>22</sub>                  | 1n0 pc  | CA-00-130 |
| C <sub>23</sub>                  | 47p pc  | CA-00-417 |
| C <sub>24</sub>                  | 10p pc  | CA-00-110 |
| C <sub>25</sub>                  | 1u5 pc  | CD-00-165 |
| C <sub>26</sub>                  | 1n0 pc  | CA-00-130 |
| C <sub>27</sub>                  | 10n pc  | CA-00-140 |
| C <sub>28</sub>                  | 10n pc  | CA-00-140 |
| C <sub>29</sub>                  | 1n0 pc  | CA-00-130 |
| VC <sub>1</sub>                  | 10p pf  |           |
| L <sub>1</sub>                   |         | LA-00-003 |
| L <sub>2</sub> ...L <sub>5</sub> |         | LA-00-002 |
| L <sub>6</sub>                   | 47u rfc | LB-00-417 |
| L <sub>7</sub>                   | 22u rfc | LB-00-212 |
| L <sub>8</sub>                   | m22 rfc | LB-00-222 |
| L <sub>9</sub>                   | 22u rfc | LB-00-212 |

|                 |                   |           |
|-----------------|-------------------|-----------|
| R <sub>1</sub>  | 82k               | RA-00-842 |
| R <sub>2</sub>  | 100R              | RA-00-120 |
| R <sub>3</sub>  | 39k               | RA-00-349 |
| R <sub>4</sub>  | 100R <sup>§</sup> | RA-00-120 |
| R <sub>5</sub>  | 100R              | RA-00-120 |
| R <sub>6</sub>  | 100R              | RA-00-120 |
| R <sub>7</sub>  | 470R              | RA-00-427 |
| R <sub>8</sub>  | 11R               | RA-00-111 |
| R <sub>9</sub>  | 470R              | RA-00-427 |
| R <sub>10</sub> | 51R               | RA-00-511 |
| R <sub>11</sub> | 39k               | RA-00-349 |
| R <sub>12</sub> | 1M0               | RA-00-160 |
| R <sub>13</sub> | 39k               | RA-00-349 |
| R <sub>14</sub> | 1k5               | RA-00-135 |
| R <sub>15</sub> | 10R               | RA-00-110 |
| R <sub>16</sub> | 3k3               | RA-00-333 |
| R <sub>17</sub> | 39k               | RA-00-349 |
| R <sub>18</sub> | 1M0               | RA-00-160 |
| R <sub>19</sub> | 39k               | RA-00-349 |
| R <sub>20</sub> | 100R              | RA-00-120 |
| R <sub>21</sub> | 3k9               | RA-00-339 |
| R <sub>22</sub> | 5k1               | RA-00-531 |
| R <sub>23</sub> | 4k7               | RA-00-437 |
| R <sub>24</sub> | 33k               | RA-00-343 |
| R <sub>25</sub> | 150R              | RA-00-125 |
| R <sub>26</sub> | 10k               | RA-00-140 |
| R <sub>27</sub> | 100R              | RA-00-120 |
| R <sub>28</sub> | 180R              | RA-00-128 |
| R <sub>29</sub> | 27R               | RA-00-217 |
| R <sub>30</sub> | 180R              | RA-00-128 |
| R <sub>31</sub> | 10k               | RA-00-140 |
| R <sub>32</sub> | 39k               | RA-00-394 |
| R <sub>33</sub> | 82k               | RA-00-842 |
| R <sub>34</sub> | 100R              | RA-00-120 |
| R <sub>35</sub> | 1k5               | RA-00-135 |
| R <sub>36</sub> | 39R               | RA-00-319 |
| R <sub>37</sub> | 100R              | RA-00-120 |
| F <sub>1</sub>  |                   | FA-00-001 |

These component values are given for guidance; § denotes a component which may be adjusted on test.

|                 |       |       |           |                |       |           |
|-----------------|-------|-------|-----------|----------------|-------|-----------|
| Tr <sub>1</sub> | BF924 | 3SK88 | QA-00-088 | D <sub>1</sub> | 1N914 | ED-00-914 |
| Tr <sub>2</sub> |       | 3SK74 | QA-00-074 | D <sub>2</sub> | 1N914 | ED-00-914 |
| Tr <sub>3</sub> |       | 3SK74 | QA-00-074 | D <sub>3</sub> | 1N914 | ED-00-914 |
| Tr <sub>4</sub> |       | 3SK74 | QA-00-074 | D <sub>4</sub> | 1N914 | ED-00-914 |
| Tr <sub>5</sub> |       | BF274 | QA-00-274 | D <sub>5</sub> | BA182 | ED-00-182 |
|                 |       |       |           |                | BA374 |           |

Edge connector pin allocations

|       |         |        |        |        |         |
|-------|---------|--------|--------|--------|---------|
| Pin 1 | gnd     | Pin 7  | mkr/nc | Pin 13 | nc      |
| Pin 2 | agc     | Pin 8  | gnd    | Pin 14 | ssb if  |
| Pin 3 | +13.5V  | Pin 9  | fm if  | Pin 15 | blanker |
| Pin 4 | gnd     | Pin 10 | gnd    | Pin 16 | gnd     |
| Pin 5 | antenna | Pin 11 | nc     | Pin 17 | lo      |
| Pin 6 | mkr/nc  | Pin 12 | gnd    | Pin 18 | gnd     |

Installation

There are two small internal modifications that are required in order to make the muTek rf board compatible with the unmodified FT221/225. They are both reversible.

The first provides a switched 13.5V line to power the new rf board on receive only. The original board operates from an 8V rail which potentially limits dynamic range.

The second is to switch the 8V supply to the noise blanker if strip. The noise blanker gate doubles as a diode switch for the ssb filter t-r switching. To improve the blanker action we have redimensioned the blanker gate biasing. A result of this is that diode switch needs to be solidly reverse biased in order to avoid losses in the ssb transmit mode.

The modifications described below apply to both the FT221 and FT225. We strongly suggest that the voltage checks detailed are made to confirm the function of the relevant pins. If you have any queries please don't hesitate to contact us.

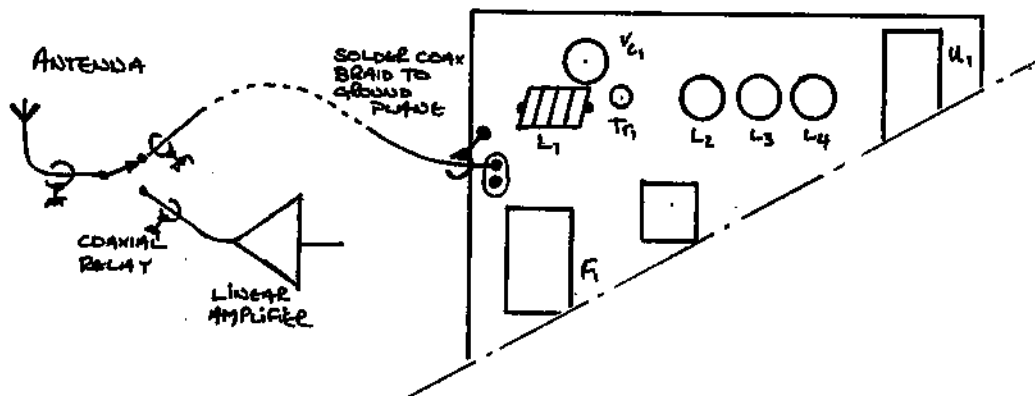
- 1) Remove both the top and bottom covers of the transceiver.
- 2) Remove the original rf board.
- 3) Remove the metal carrier from the original rf board.
- 4) Fix the carrier to the muTek board, taking care to ensure that the orientation is the same as the original.

- 5) Turn the transceiver over to expose the underside.
- 6) Locate Pin 18 on the ssb if unit edge connector - this may also be labelled Pin 9B - it has 13.5V on receive and 0V on transmit.
- 7) Locate Pin 3 on the rf unit edge connector.
- 8) If Pin 3 has a lead connected to it, remove the lead and insulate the free end.
- 9) Run the longer of the two leads supplied between Pin 18 (9B) of the ssb if unit edge connector and Pin 3 of the rf unit edge connector.
- 10) Locate Pin 13 on the fm if unit - this will have 8V on it.
- 11) Remove the leads soldered to this pin (if there is a decoupling capacitor soldered to the pin, don't remove it.) Insulate the bare ends of the leads, which should remain soldered together.
- 12) Locate Pin 9 - this may also be labelled Pin 5A - on the ssb if unit edge connector. This has 8V on receive and 0V on transmit.
- 13) Run the shorter of the two leads supplied between Pin 13 of the fm unit edge connector and Pin 9 (5A) of the ssb unit edge connector.
- 14) Turn the transceiver the right way up.
- 15) Plug-in the muTek rf board. (The track side of the board faces the front)
- 16) Check the receiver performance on an antenna.
- 17) Refit the top and bottom covers.
- 18) Now get in amongst the dx!

Notes

- 1) It may well be necessary to reset the s-meter zero and full-scale adjustments.
- 2) The addition of a relatively narrow-band crystal filter prior to the noise amplifier inevitably causes some deterioration of the noise-blanker performance. We have redimensioned the the blanker-gate circuitry in order to minimise this effect. However some reduction in performance can be expected, particularly with low-level noise pulses.  
We have also observed that when the original board has been used with a presampler, the dynamic range has been so small that the rf board has been acting as an rf noise limiter..!

3) In circumstances where the lowest possible noise figure is required, the transceiver's internal antenna change-over circuit losses may be unacceptable. In order to bypass the antenna relay, we have provided a link (INPUT LINK) in the antenna input microstripline which may be broken to allow a direct connection to be made to the rf stage gate circuit.

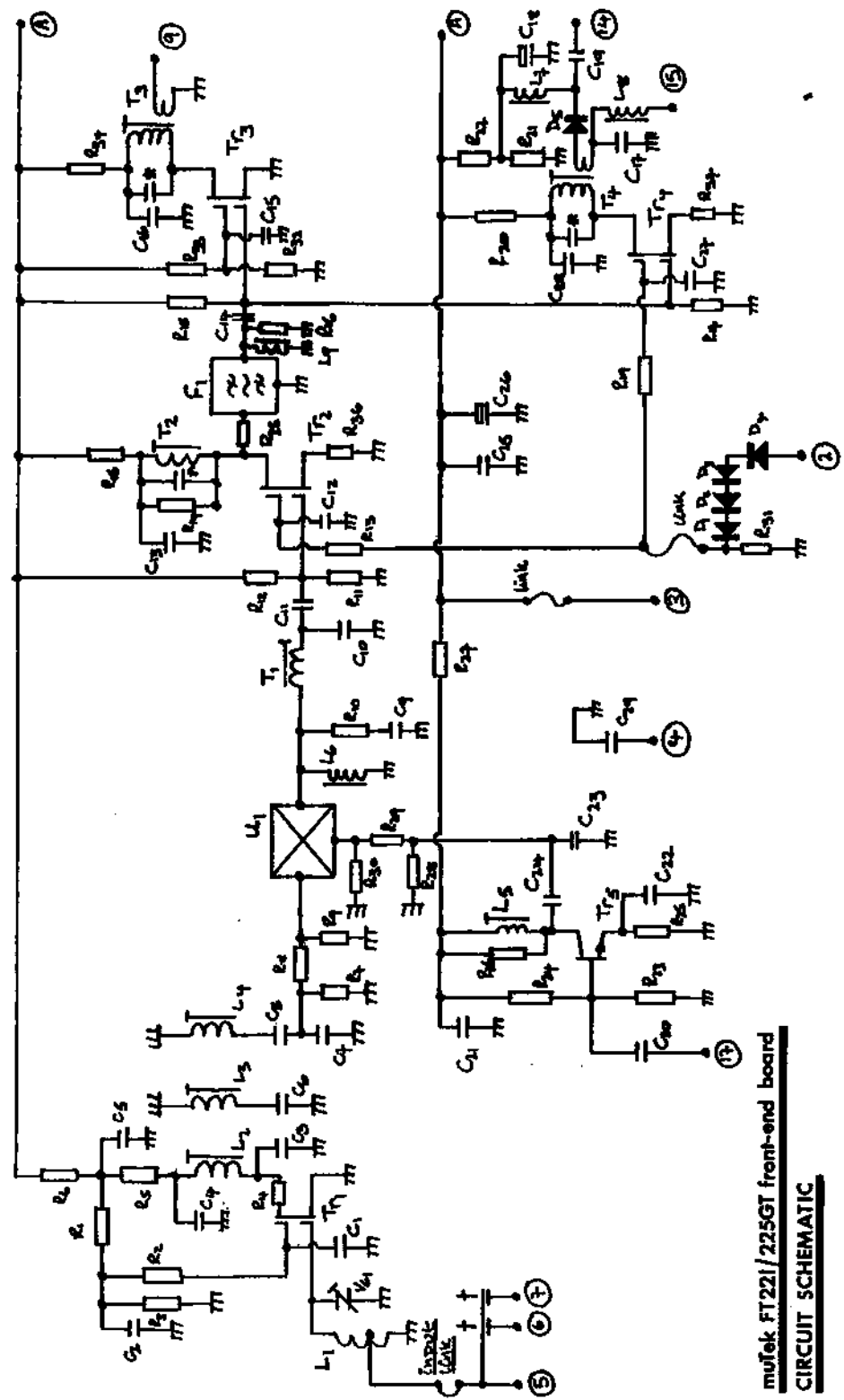


Test data

Serial Number: XXXXXXXXXX

Date: 6 September 1980

Noise figure 2.0 ± 0.5dB



**muTek FT221/225GT front-end board  
CIRCUIT SCHEMATIC**

Yaesu FT221/225 series

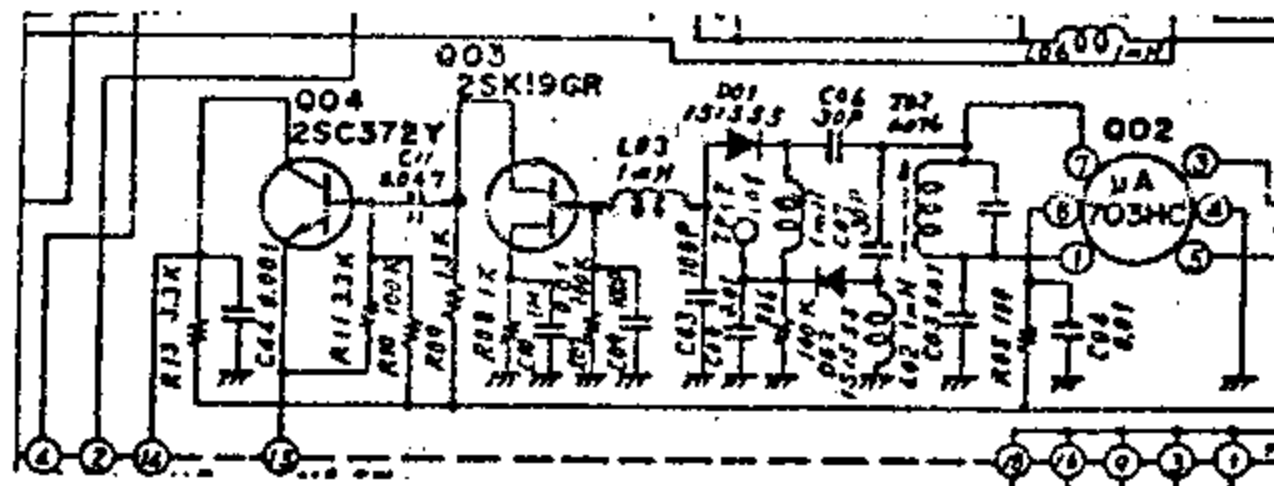
August 1983

Improved noise blanker performance.

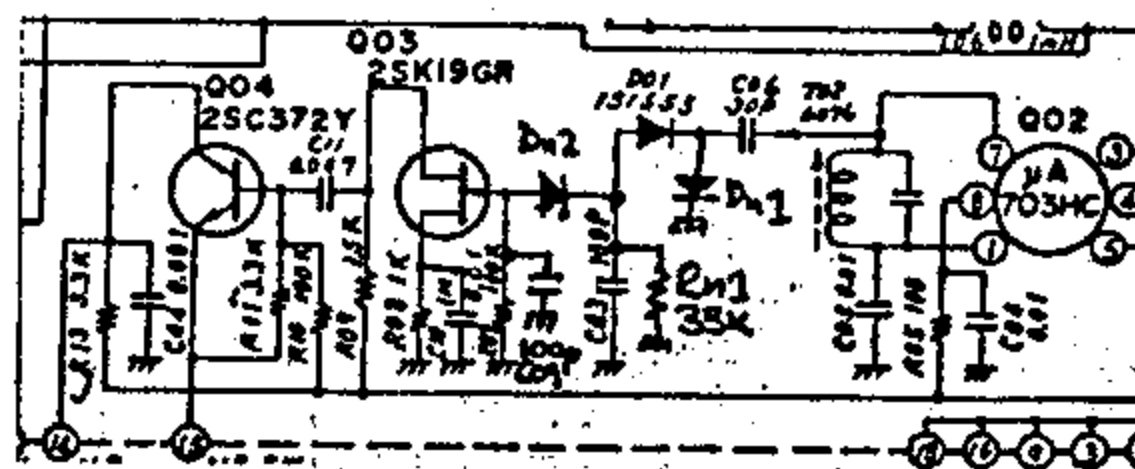
The design of the noise blanker in both transceivers is virtually identical although component designations may vary. In essence the modification involves increasing the size of the blanking pulse applied to the diode gate driver circuit (Q03/Q04).

The two circuit diagrams show the relevant parts of PB1463 before and after modification. The new shunt diode Dn1 can be the 1S1555 removed from the secondary detector position whilst the series diode should be a silicon switching diode such as a 1N4148. The 33k resistor should be a reasonable quality 0.25w carbon film resistor such as a Mullard/Philips CR25 or a Piher PR25 although this is obviously not critical!

Before modification



After modification



This modification comes from a reputable source, and although it has been briefly tested at muTek, we are unable to guarantee its suitability for all transceivers in the series. In other words the modification is made at the owner's risk!