Solid-State 52MHz Converter

Here is a modern solid state design which offers high sensitivity, low noise and full bandwidth, combined with modest cost. Built on a small printed wiring board for easy assembly, it features a protected dual-gate MOSFET in the RF stage, and a balanced FET mixer.

by IAN POGSON

As a follow up to the 130 Tunable IF Receiver described in April and July, 1972, we now present a companion converter for the 52-54MHz band. In arriving at a suitable design, several factors were kept in mind. The converter must be economical and easy to build, but it must also be a good performer. It should also be easy to adjust and give rise to a minimum of spurious responses. We believe that all these points have been met satisfactorily.

In addition to the above features, in common with the 130 Receiver, it must be possible to operate it from a 12 volt DC supply, either stationary or mobile. For mobile use, positive or negative earth connection should also be available.

A look over the circuit will show how this has been done. The RF amplifier is the now familiar cascode. Rather than use a pair of discreet FETs, we have used a Motorola dual gate MOS field effect transistor (MPF121), which also features diode protected gates. In addition to the obvious advantage of using only one device in this stage, the particular arrangement permits a very simple circuit, with a minimum of components. The price may well be less than for two discreet FETs which would otherwise be needed.

Although the MPF121 dual gate FET is diode protected, we have provided for an external pair of protective diodes, such as OA91, on the aerial input to the board. These are optional and the choice is left to the builder.

To help in achieving as wide a bandwidth as possible, we used two pairs of coupled circuits at signal frequency, one each at the input and output of the RF amplifier. These are adjusted and tuned to achieve this end and more will be said about this in the alignment details.

The mixer uses a pair of balanced FETs, type 2N5485. This type of mixer was chosen on the score that it is possibly one of the most economical ways of obtaining good mixer performance with a minimum of cost and complexity. Using active devices obviates the need for an additional amplifier following, and by balancing the mixer, oscillator breakthrough is reduced to a minimum. To ensure balanced operation of the mixer, provision is made to finely adjust the balance with a 2.2K potentiometer in the sources of the FETs.

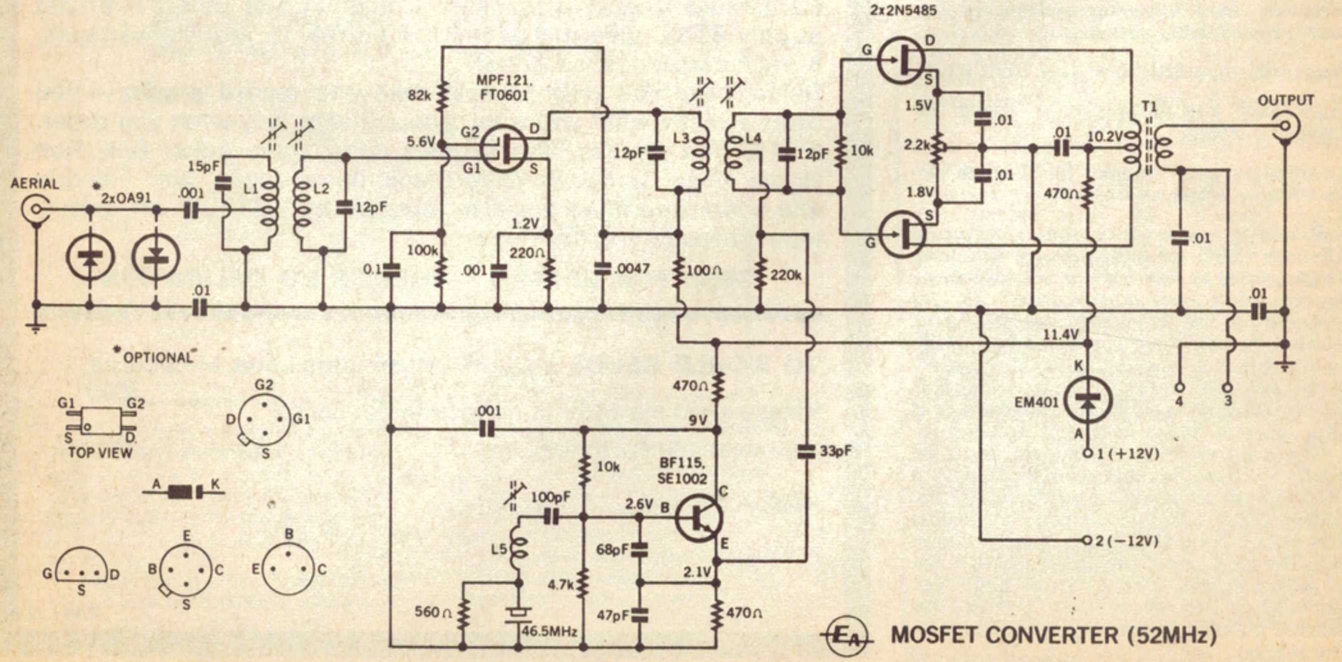
The functions of providing a suitable load for the drains of the two mixer FETs, impedance and balance to unbalance transformation are all incorporated in a small transformer wound on a TV "balun" ferrite core. Again, the approach is one which is simple, economical and effective.

The source of injection into the mixer from a crystal involves one stage only. Use is made of a crystal oscillating on its third overtone and directly on the wanted frequency of 46.5MHz. Not only does this avoid an additional multiplier stage, with its consequent economy, but it also avoids the need to generate the wanted frequency at a sub-multiple, which can be an extra source of unwanted spurious responses in the overall receiving system. The oscillator uses a conventional bipolar transistor and the circuit is one as recommended by the crystal manufacturers, Hy-Q Electronics Pty Ltd.

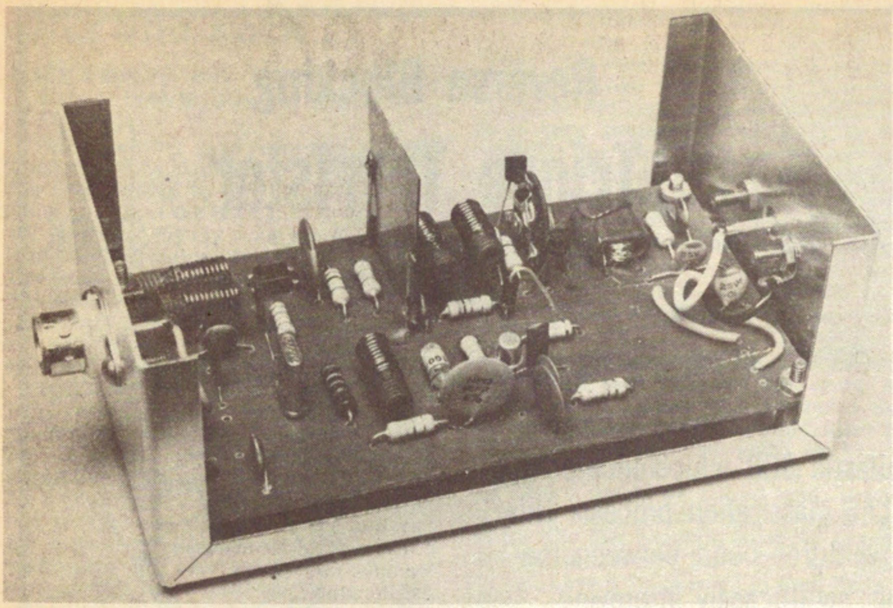
The crystal frequency of 46.5MHz which we have used, is arrived at so that we can use it on the 130 Receiver which tunes from 3.5 to 7.5MHz, with 52 to 54MHz being covered between 5.5 and 7.5MHz. If it is desired to use another tunable IF range, then the crystal frequency will have to be changed accordingly. As an example, supposing we wish to tune from 10 to 12MHz, then a crystal frequency of 42MHz will be required.

On the printed board, provision is made for a diode in the positive supply rail, to guard against possible damage due to inadvertent reversal of the supply polarity. As part of the provision for mobile use, a number of terminations are also provided to allow the greatest flexibility with regard to connection or not of either side of the supply line to frame.

Although the idea is by no means original, an unusual feature is incorporated with the terminations mentioned above. We have provided facilities so that the power supply may be fed from the receiver into which the converter is coupled, via the centre conductor of the coaxial cable between the two



MOSFET CONVERTER (52MHz)



The prototype converter. The output to the tunable IF is at the right.

units. The supply return is via the outer braid of the cable. This eliminates the need for extra conductors between the units, and simplifies bandswitching.

There is nothing very special about any of the components but a few words about some of them may be helpful. Most of the capacitors in the prototype are ceramic and it would be wise to stick to those specified in the parts list, unless you have any particular reason for departing from it.

The balun core which we used for the output transformer is readily available and any similar core to those specified should be in order. The slugs for the coils which we have called for are ideal for the purpose. However, any slug between 7 and 8mm in diameter and ½in long should suffice, provided it is suited to the frequencies involved.

With respect to the transistors, we strongly suggest that you use the FETs which appear in the prototype. The crystal oscillator transistor may be any near equivalent to the BF115 or SE1002. The diodes may be substituted with any other similar types. As mentioned earlier, the two OA91 protective diodes are optional and although we have provided space for them on the board, we have not fitted them. The power diode in the positive supply line may also be omitted but it provides very worthwhile protection against accidental reversal of the supply polarity.

The crystal which we used was made by Hy-Q electronics. The type is given in the parts list and these details should be quoted when ordering. There are a number of other manufacturers who make a similar type of crystal and any of these should be satisfactory. Only modern crystals made specially for this service are likely to be satisfactory. The idea of using an old type FT243 can be ruled out as the likelihood of one of these even functioning at all in this circuit is rather remote.

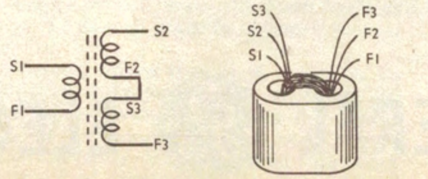
The type of coaxial sockets will naturally be up to the choice of the individual, as they will more than likely have to fit in with existing equipment. Also, the case which we have used is a standard line and may be obtained readily, some builders may have other ideas regarding housing of the unit.

Perhaps the best place to start with the construction would be to wind the five coils and the output transformer. The coils are simply wound directly on the slugs and this results in an efficient coil with a minimum of cost. The wire must be wound firmly around the slug, so that it does not spring open to result in an unduly loose slug. The taps may be made by determining the spot on the wire, cleaning the enamel off for about ¼in. The bare wire is tinned and this length is bent back on itself and straightened out from the two junctions of the solder and enamel. The coil is then wound with the tap facing outwards and with turns added each way so that the tap appears at the right number of turns.

When each coil is wound, the ends are bent radially and cut off with a lead of ½in or so. This lead is stripped of enamel and tinned. Later, on assembly, the lead may be cut precisely to the required length.

The output transformer is "trifilar" wound. This means that we start off with three lengths of wire, sufficient to wind on the required number of turns. The three wires are brought together in parallel and to make threading through the holes of the core easier, a sewing needle may be used. Thread the wires through to the centre first and wind on 10 turns. Then change the needle over to the other end of the wire and wind on another 10½ turns. The extra half turn allows the start and finish of the windings to appear at opposite ends of the transformer assembly. This allows more convenient terminations on to the board.

The three windings are terminated as shown in the diagram and preparatory to this, each of the six ends are cut to a length



The terminations of the output transformer.

of about 1in. The job of tinning the ends may be left until the transformer is actually being mounted on the board, at which time the actual lengths can be determined.

The actual job of assembly is particularly easy as a printed board is used. All of the smaller components, such as the resistors and capacitors may be soldered in place first, followed by the other items and possibly leaving the transistors and crystal last. The crystal oscillator coil may be mounted so that it just clears the board but the other two pairs should be stood off by about 5/16in or so. This is necessary so that the actual spacing and so the coupling between the pairs can be varied on alignment. The usual care should be exercised when soldering, to make good joints without overheating vital components.

It may be noticed from the photograph that there is a vertical shield between the FET cascode RF amplifier and the balanced mixer. We found it necessary to fit this in the interest of stability. The position of the shield is not vital and it may be fitted as shown, or it may be moved between other components towards the RF amplifier. We used a piece of tin plate 1¼in wide x 1½in high. The width is important but the height may be reduced if desired. The shield is held in place by two pieces of 18-20 gauge tinned copper wire. The wire is soldered to the negative copper of the board, brought through two holes suitably positioned, with ¾in or so above the board. The shield is then soldered to the two wires.

Having more or less completed the board, dictated by the application of the converter and the method of feeding power to it, there are some extra connections which will need to be made to suit. If the converter is to be used for mobile work, the question of positive or negative earth may have to be considered. As may be seen from the circuit, provision is made for jumpers to be fitted to the board so that either side may be connected to frame. This is straightforward and is self-explanatory.

If separate supply leads are to be used from an external source, then the +12V and -12V connections will be made to points 1 and 2, respectively. If on the other hand, you elect to feed the supply via the output coax cable, then for negative earth the braid of the cable, point 4, will be connected to point 2, and point 3 which corresponds to the inner conductor will be connected to point 1. Alternatively, for positive earth, 4 would be connected to 1, and 3 to 2.

At this point, for readers who are not familiar with this method of feed, this is how it is done. The connections for the converter end have already been established. At the receiver or tunable IF end, the 12 volt supply has to be fed into the coax cable without interfering with its ability to pass the wanted signal.

At the input to the receiver, a blocking capacitor is introduced in series with the centre conductor of the cable and the normal aerial terminal of the receiver. The +12V is fed into the coax centre conductor via an RF choke of 500uH to 1mH or so. The bottom end of the RF choke may need to be bypassed to earth. This and the blocking capacitor may be a 0.1uF ceramic capacitor. The negative supply is connected via the braid of the coax cable.

An alternative method, which avoids the need for an RF choke, is to series feed via the receiver aerial coil. The centre conductor of the cable is connected directly to the aerial input and the bottom end of the same winding is lifted from earth. This point is bypassed with a 0.1uF capacitor and perhaps a small amount of decoupling with a 47 ohm resistor, through which the +12 volts is introduced.

At this stage, a check should be made to make sure that there have been no errors or omissions in the assembly. Satisfied that all is well, the slugs in all coils are set so that they are about half way into the winding. The preset potentiometer in the mixer sources is set to mid-position.

Power may now be applied and it would be a good idea to check that all voltages are reasonably close to those shown on the circuit. It must be emphasised that there will be discrepancies due to spreads in components but this is normal. Satisfied that all is well, we are now ready for

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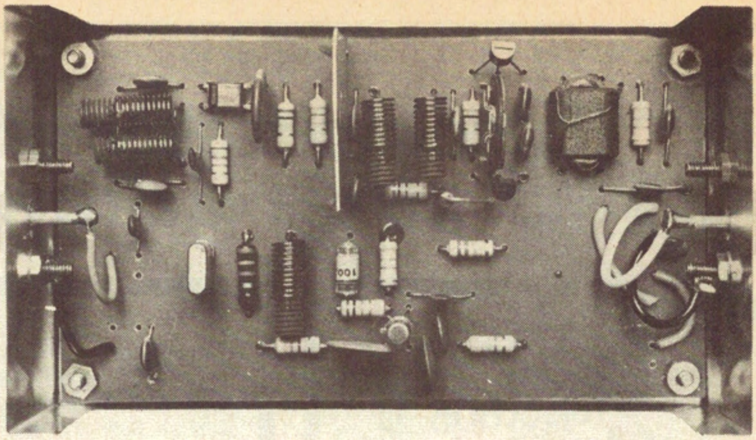
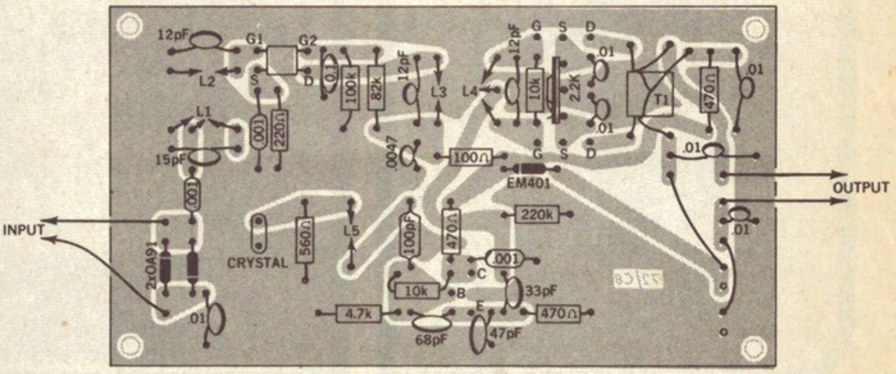


Using this photograph and wiring diagram, constructors should have no difficulty following the author's layout.



Parts required

1 Case and lid, 5¼in long x 3in wide x 2⅛in deep
1 Printed board, 5in long x 2¾in wide, 72/C8
1 Crystal, overtone type, 46,500kHz ±0.003%, ambient temp, QC18 (HC18/U), Hy-Q type PES or similar
5 Neosid 7.6mm x ½in long, grade 900 slugs with hex bore
1 Neosid type 1050/1/F14, or Ducon type F684, Q2 balun core
1 Transistor, MPF 121 (Motorola)
2 Transistors, 2N5485 (Motorola)
1 Transistor, BF115, SE1002
1 Diode, EM401
2 Diodes, OA91 (optional)
2 Coaxial sockets
4 Spacers, ⅜in long x ¼in OD, ⅛in clearance hole
Screws, nuts, solder lugs, hookup wire, solder, etc.

CAPACITORS
3 12pF NPO ceramic
1 15pF NPO ceramic
1 33pF NPO ceramic
1 47pF NPO ceramic
1 68pF NPO ceramic
1 100pF polystyrene
3 .001uF 100V polyester
1 .0047uF 25V ceramic
6 .01uF 25V ceramic
1 0.1uF 25V ceramic

RESISTORS (½ watt)
1 100 ohms
1 220 ohms
3 470 ohms
1 560 ohms
1 2.2k trimpot
1 4.7k
2 10k
1 82k
1 100k
1 220k

Note: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used providing they are physically compatible. Components with lower ratings may also be used in some cases, providing the ratings are not exceeded.

Converter . . . from P. 29

alignment.

The crystal oscillator should be adjusted first. Adjust the slug in the coil for maximum output as indicated on a dipper set up as a wavemeter at the frequency of the crystal. The slug is adjusted for maximum reading on the meter. The slug should be sealed in place with adhesive.

Alignment of the four signal tuned circuits is best done with a sweep generator and CRO. The prototype was aligned this way and we obtained a bandwidth just under 2MHz, with a spacing between the input coils of about 1/32in. The spacing between the pair of coils between the RF stage and the mixer was best at about ⅛in. This resulted in a dip in the middle of the response of about 3dB.

If sweep alignment facilities are not available, then the next best thing is to align against a signal generator, or from actual signals off the air. To do this, the converter is fed into a receiver covering from 5.5 to 7.5MHz, corresponding to 52 to 54MHz. Although this is a somewhat tedious process by comparison, with patience it is possible to align the converter quite satisfactorily. With alignment complete, each of the four slugs should be sealed in the same way as for the oscillator coil.

With the converter aligned, it now only has to be fitted into its case to complete the project. Ours is held in the case with screws and ⅜in brass spacers. So that the negative copper of the board may be insulated from the case, we used an insulating washer between each spacer and the board. The input and output coax sockets are wired in and the outer connection is directly to the case and a lead is taken from a lug under a mounting screw, to point 4 on the output and the equivalent point for the input.

Coil details

- L1 11 turns 22 B&S enamel, tapped at 3 turns from bottom
- L2 11 turns 22 B&S enamel
- L3 10 turns 22 B&S enamel
- L4 10 turns 22 B&S enamel, centre tapped
- L5 11 turns 22 B&S enamel
  All above coils wound directly on the grooves of Neosid 7.6mm slugs
- T1 10 turns plus 10½ turns 32 B&S enamel trifilar wound on Neosid type 1050/1/F14, or Ducon type F684, Q2, balun core. Terminate as shown in diagram.