13 cm Amateur Television By Ian F Bennett G6TVJ

Thirteen CMS is probably one of the more obscure amateur bands in use in the UK and is one of severa1 that span the gap between the familiar 24cm and 3cm (10 GHz) bands. The amateur allocation starts at 2.310 GHz and extends to 2.4GHz, this actually gives us quite a bit of room and allows all modes of transmission including FM TV up to a maximum power of 400w pep, a somewhat unlikely figure even with today's improving microwave components available to amateurs. The band is more extensively used in Europe and there are many TV repeaters using it as an output frequency and 24cm as an input frequency. A couple of years ago I was fortunate enough to copy DBOTS P5 during portable operation while enjoying some quite astonishing lift conditions. DBOTS was estimated to be as much as 600 km away .

Close to the amateur band and actually in it (We are secondary users) some other TV signals can sometimes be found. But wait I hear you cry, isn't there another source of quite considerable microwave energy in this band? The answer is of course yes, microwave ovens work on this frequency and even the best sealed units still radiate a sniff of power. Ovens can be a problem but as long as this spot ISM (Industrial scientific and medical) frequency of 2.45 GHz is avoided things are not too bad, they do actually provide useful rough frequency markers and prove the sensitivity of one's own equipment.

So why use the band at all when we have several other allocations for TV? I have personally found this band quite interesting as it exists adjacent to other professional frequency allocations. I have also acquired an LNB device which simplifies receiving these frequencies so I naturally decided to develop a transmitter to work with it. It is also in the light of changing amateur allocations, advisable to both use other allocations and develop expertise in them in case we were to loose part or all of a band i.e. l 0 GHz.

How to get onto the l3cm Band

First thing we need is a receiver which tunes about 2.3 to 2.5 GHz, this may seem quite a tall order but luckily by a quirk of fate a satellite band actually exists near by. In addition to the familiar "KU" and "C" bands a band called "S" band has been used for satellite TV which covers 2.5 to 2.7 GHz. The band is sometimes known as the "'Arabsat" band, it is used abroad as you might expect in the far east, but LNB's for this band can be obtained in the UK if you look hard enough. We have been fortunate in obtaining several of these units, one belongs to the Severnside group and several other members have them including myself.

S band LNB's operate in a similar way to other types, they employ a considerable amount of low noise amplification to bring up the signal level and then down convert its frequency using a high side local oscillator running at

3.650 GHz. We have come across two types one made by California Amplifier and the other by Chaparral. they both exhibit very low noise figures as good as any preamplifier and due to the high side local oscillator will actually cover an input range from 2.7 GHz down to 2GHz and hence fully cover the 13cm amateur band. Nigel G7JZP has very kindling carried out a number of tests on these LNB's and found them both to perform quite well. The filtering inside the units is very wide so the gain does not drop of quickly outside their rated frequency range. Unlike other LNB's the RF input is via a mail "N" type allowing the connection of coaxial cable. The output connection is a standard "F" type connector and the LNB's are powered up the coax from the receiver in the normal way.

There are other possibilities for receivers and down converters, *CQ-TV* no 162 November 1992 carried an article for a simple down converter using MMICS (monolithic microwave integrated circuits). VHF communications sometimes publishes articles on this band and there is also a German magazine *DUBUS* which also has articles written in English. Mainline electronics advertises a low noise pre-amp and a narrow band transverter for l3cm. A transverter could be used as a TV transmitter.

Antennas

JVL can supply loop yagi's for this band and the designs for which, have been published in various amateur publications. Tonna also supply an antenna centred on 2.330 GHz, it is a slightly odd beast. it is basically a standard type Yagi with many director elements but the feed point employs an unusual waveguide type launcher with a probe inside. This is the antenna I use and is available through Lowe electronics for about £70. 2.3 GHz is a frequency where dish type antennas start to become viable, it ought to be possible to construct a type of small dipole launcher and use it with a largish dish say 1m in diameter. Unfortunately most coaxial cables are starting to become quite lossy at these frequencies so lengths must be kept to a minimum. The LNB's have the advantage they can be used up at mast height and connected literally onto the antenna itself. Transmitters are best kept close to the antenna, I use a remotely keyed transmitter in my loft space close to the antenna.

Transmitters on this band can be a bit technically challenging particularly as obtaining any significant level of power on this band seems to get expensive quite quickly. I have seen designs published, and it may be possible to get kits from abroad but I haven't seen anything in this country. *CQ-TV* no 160 again carries a design for a. simple 13cm exciter, I have taken this design and added a synthesiser to it, this will be described in more detail later. As mentioned earlier transverters are available for narrow band operation, if it were possible to generate an FMTV IF on 144 MHz then these devices could be used to

form an up converting transmitter similar to the G6TVJ superhetrodyne 23cms

transmitter published in P5 a couple of years ago.

Results

The results so far on this band have been quite good, certainly the reception of DB0TS from Germany is a personal best and quite a spectacular achievement if not helped by the location of Win Green near Shaftsbury which was about 900ft above sea level. Other terrestrial microwave signals from abroad were also copied up to P5, probably local cable feeds in some mountainous region somewhere. On a somewhat more local basis I have established a link to GlHIA's QTH , both ways using the synthesised exciter and a power amplifier providing a hefty 900mW. Pictures were P5 in both directions with some occasional interference allowing duplex operation with GB3ZZ in the other direction. Some tests were also done from Tog hill about 8 miles away with only the exciter and 10mW, this still yielded a P5 picture when using the Tonna antennas demonstrating the high sensitivity of the "S" band LNB's.

The autumn ATV contest proved to be quite successful on this band G1HIA worked the contest station G7ATV/P both ways on 13 from home and I established a one way contact P5 from Walbury hill some 50 miles away. This was good as the Severnside group was probably the only group to operate a contest station on four TV bands.

The LNB's we have used do have one or two quirks. They seem to suffer breakthrough from broadcast TV stations operating at UHF and also at the output IF frequency range. My 13cm Yagi points towards GlHIA's Q'TH only a few degrees off GB3ZZ, ZZ breaks through P5 almost exactly where the wanted IF exists so some patterning is sometimes experienced . The LNB' appear to `take off' sometimes if not fed from a matched antenna and they also being designed for weak satellite signals can overload easily. One other point to note due to the high side LO in the LNB when tuning up on the sat receiver you are actually tuning down the 2.5 GHz band.

A Synthesised Exciter for 13cms

This is basically a development of the design found in *CQ-T*V no.160 under the title 13cms the easy way, well I don't know about easy but the unit does work reasonably well. I have added a SP5070 Plessey synthesiser to the exciter to maintain the frequency and hopefully make finding signals in this band simpler. I do like synthesised transmitters as they remove one of main variables encountered when attempting to establish ATV links for the first time. Antenna headings, receiver tuning and possible obstacles in the path are quite enough without some doubt about the exact TX frequency as well!

How it works

A voltage controlled oscillator operating at the transmitter output frequency is

formed using a self oscillating mixer device an Avantek MSF8685. The frequency of oscillation is determined by a trimmer soldered directly across the device which forms a tank circuit, the inductance of which is formed by the parasitic inductance of the trimmer itself. The frequency of oscillation is also determined by the power supply voltage to the device, this allows the oscillator to be modulated and tuned.

The output of the VCO is buffered and amplified by a standard MSA048 Mmic device and then by a second Mmic type MSA0585. These devices are starting to struggle a bit at 2.4 GHz but this arrangement produces about l 0mW enough for a line off site contact over a few miles.

Some RF energy is tapped off after the first amplifier and is fed to a SP5070 fixed modulus synthesiser chip. The SP5070 is basically a newer version of the venerable old SP5060 found in many 23cm designs. The 5070 is rated to 2.4 GHz so should be fine for the 13cm band. I did originally build the TX as an experiment to see if the device would work OK which it did. The device is actually a standard DIL package (a surface mount one is available) and I mounted it on standard fibreglass board which is perhaps pushing one's luck a bit at 2.3 GHz as most commercial designs would certainly be using PTFE board and surface mount techniques at these frequencies. The TX frequency is produced at 256 times a crystal reference frequency which the chip uses. I chose 2.330 GHz which is OK for the antennas and is the official TV simplex frequency (I think). this gives a crystal frequency of 9.101562 MHz. The crystal is a standard parallel resonant unit with a 30pf shunt capacity. Crystals can ordered from various outlets without much bother.

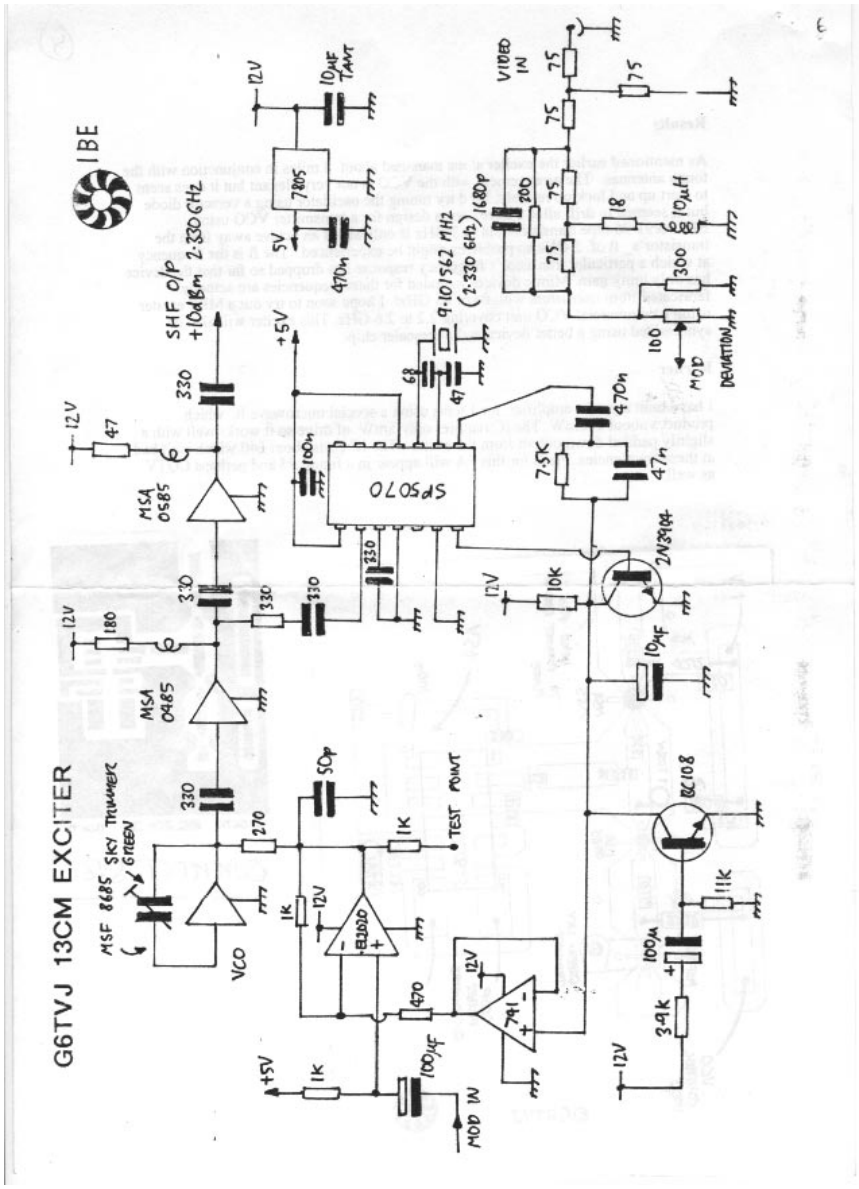
The SP5070 uses a simple loop filter arrangement but care must be taken with the values so that low frequency distortions do not result in the video signal. The values I used work OK but are not ideal, but good solid P5 pictures are possible with these values. Unfortunately the VCO exhibits the wrong frequency voltage characteristic, an increase in volts results in a drop in frequency this is opposite to the output of the SP5070 so an op-amp inverter is used and the system should then lock up. There is however another problem, when the TX is switched on the synthesiser initially sees no RF which causes the VCO volts to rise, as they are inverted the real VC'O volts drop. The VCO volts are in fact its power supply so the device does not oscillate perpetuating the problem, not much good for the receiving station sitting there patiently tuning up and down the band looking for you. The solution is to use a start up circuit, on switch on a capacitor charges up via the base of a transistor which clamps the VCO volts long enough to supply the VCO with power to start up. The capacitor eventually charges up and the VCO volts are allowed to float up and down and hence the synthesiser comes into lock.

Video modulation is applied to the VCO using the non inverting input of the op-amp this results in the correct modulation sense for use with the high side local

oscillators in the receiver LNB's, this I believe is actually negative modulation, if positive mod is required another video inverter can he used. A standard pre-emphasis network is used at the video input to the transmitter. The modulation sensitivity is quite good up to 6 or 7 MHz/V are possible.

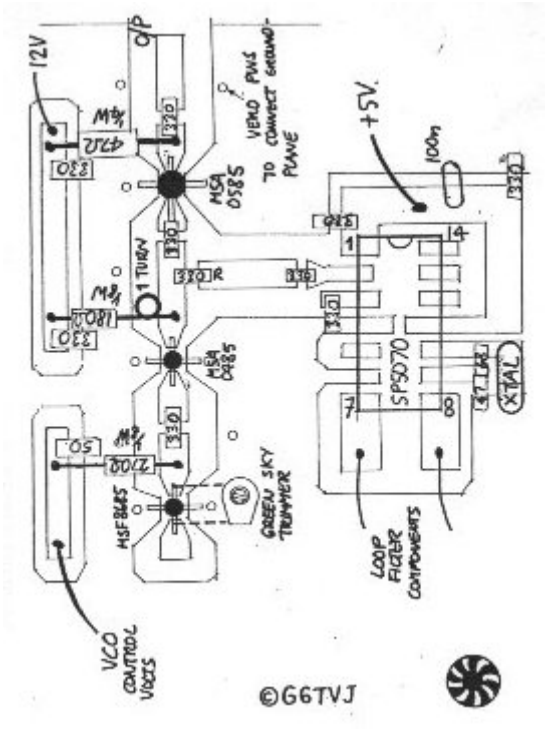
Sound can be added by using a subcarrier of an appropriate frequency. I used a sound modulator down in the shack remote from the rest of the transmitter by simply inserting the subcarrier onto the video near the camera. I have found 200mV of subcarrier sufficient for quietening sound with a reasonable video sig/noise. I have done quite a bit of work on trying to perfect a synthesised sound modulator similar to the in the G6TVJ superhet TX with varying results, actually trying to get the correct audio pre-emphasis and hence a flat frequency response back out of a sat RX is quite tricky.

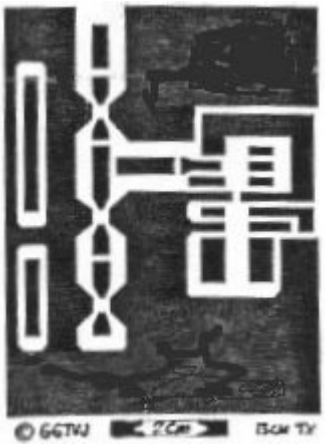
Circuit diagram



Construction

The SHF construction is quite tricky and a PCB layout is shown. Double sided board is used and one side is etched. Holes are drilled for the mmic's in order to sit them down neatly onto the board and keep their lead lengths as short as possible. The pins on the SP5070 are cropped off and the device sat flush onto the board and the remains of the connections soldered down. Only the microwave components are critical the rest of the components including the op-amps can be mounted as convenient. The output connection can be an "N' type or SMA as long as sufficient grounding is employed to both sides of the PCB. The PCB must be housed in a metal box. I used an eddy box with a copper plate at the output connector as the board will not solder directly to the aluminium.





There should be only one major adjustment to make and that is to set up the VCO range. By monitoring the test point the volts should rise up and down as the trimmer is adjusted, care is needed as the trim tool effects the frequency. The VCO should be adjusted for about 10 volts, when correctly operating the volts should be seen to vary as objects e.g. fingers are brought close to the VCO, changing Loads on the TX output will also "pull" the VCO a bit. A receiver can be used to further confirm satisfactory operation. when using an "S" band LNB with an LO of 3.650GHz it should produce an IF of 1.320 GHz.

Final thoughts

As mentioned earlier the exciter alone managed about 8 miles in conjunction with the Tonna antennas. The arrangement with the VCO is not very elegant but it does seem to start up and lock up reliably. I did try tuning the oscillator using a varactor diode but it seemed to drift a lot. I have seen a design for a transmitter VCO using BFR90/91/96 type transistors but 2.3GHz is only about an octave away from the transistors ft of 5GHz so problems might be experienced. The ft is the frequency at which a particular transistor's frequency response has dropped so far that the device has only unity gain. Mmic devices

intended for these frequencies are fabricated from transistors with fts of 25GHz! I hope soon to try out a MK2 exciter using a commercial VCO unit covering 2.2 to 2.6 GHz. This exciter will also be synthesised using a better device and a prescaler chip.

Burner

I have built power amplifier for 13cmss using. a special microwave IC which produces about 900Mw. 'The IC requires only 5Mw of drive so it works well with a slightly padded down output from the exciter. The IC costs about £40 which isn't bad at these frequencies. Plans for this PA will appear in a future P5 and perhaps CQ-TV as well .