Microwave Subsystem

*Final part, by Adrian Knott, G6KSN**

IN PART ONE a description of the system was followed by details of how to convert satellite TV 'Blue Cap' LNBs for use on the 10GHz amateur band. This was followed by the circuit diagram of the subsystem. In part two the PCB is shown (**Fig 6**), plus details of construction and alignment.

CONSTRUCTION

THIS IS QUITE straightforward. None of the components is sensitive to static and no special handling precautions are required. However, it would be a good idea to leave insertion of the semiconductors and inductors until last, as excessive heat can cause problems with both. The inductors have very fine wire attached to the five pins around the base that can be damaged if the pins are forced. Personally, I would begin construction by inserting the Veropins, followed by resistors, capacitors (remembering to check the polarity of electrolytics), filters, inductors, diodes, transistors and finally the ICs, again observing polarity/orientation.

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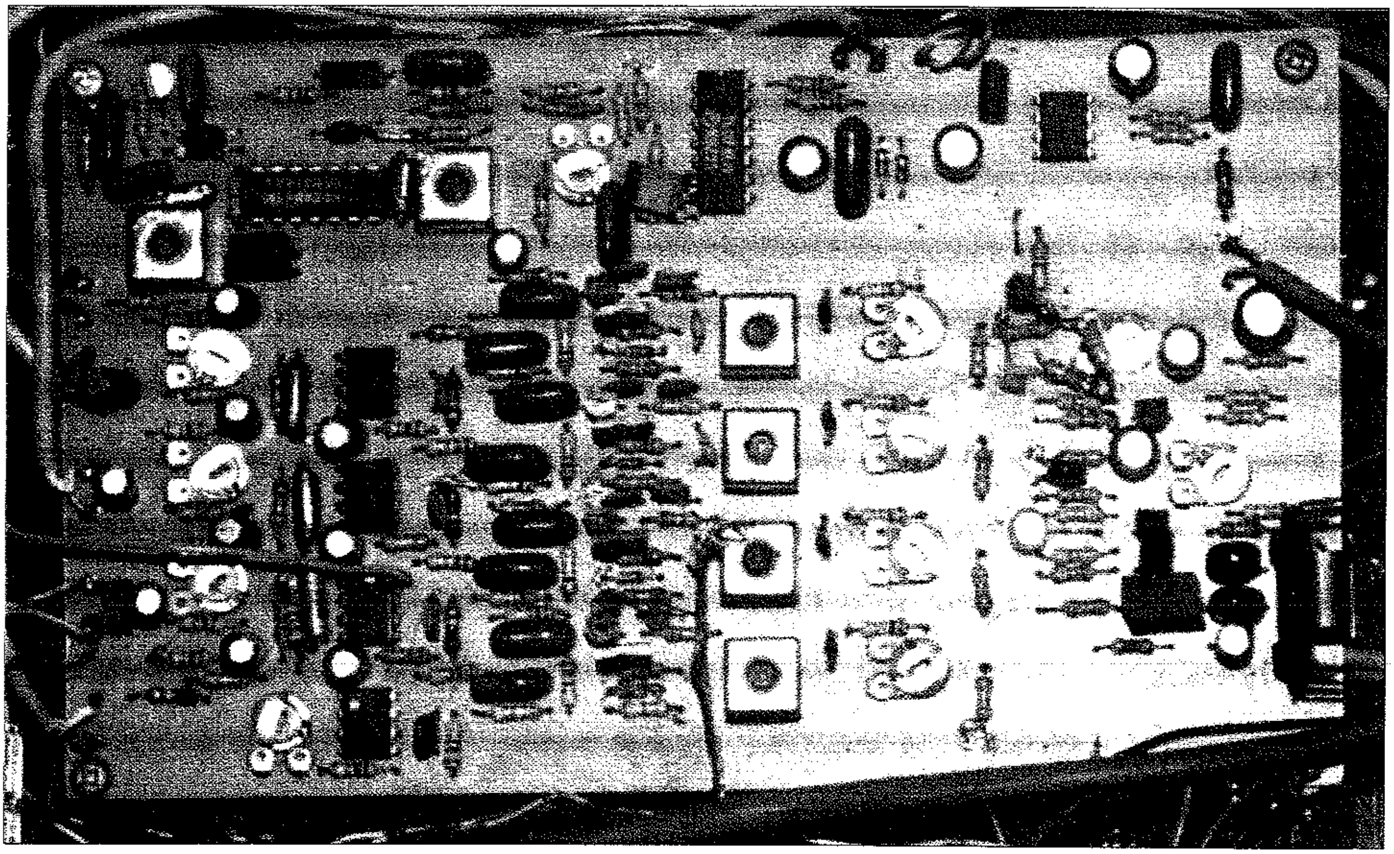
INITIAL CHECKS

ENSURE ALL components are of the correct value and, if polarity conscious, inserted the correct way round. Check the PCB thoroughly for shorted tracks and dry joints. A little care at this stage can prevent hours of head scratching and fault finding later. Apply the 15V power supply to the unit and check that the regulated supply is in fact 12V. **Table 1** gives typical voltages around the semiconductors for reference and fault finding. If all appears well, set RV1, RV2 and RV3 sliders to their mid positions, RV4, RV5, RV6, RV7 and RV8 sliders to the earthy end. Finally set RV10 to maximum resistance.

ALIGNMENT

CONNECT THE GUNN oscillator unit to the PCB. Low cost 50Ω coaxial cable such as RG58 is ideal for the purpose. A 56Ω resistor in series with a 10µF electrolytic capacitor should be fitted at the Gunn oscillator end of the cable to help prevent instability.

Because the link is full duplex, it will be necessary to set each side of the link to a specific centre frequency fairly accurately. In order to measure the frequency of the transmitter, the LNB's local oscillator frequency must first be calculated. The LNB



Completed printed circuit boad of the subsystem.

will of course still receive satellite transmissions from Astra at the upper end of the satellite receiver's IF passband. ZDF transmits on 10.963GHz for example. If the satellite receiver has to be tuned to 1663MHz to receive it then the local oscillator frequency will be 10963 - 1663 which equates to 9300MHz. It would thus follow that 10.3GHz would equate to 1000MHz and 10.5GHz to 1200MHz. The link that I have set up operates on 10.475 and 10.375GHz, with one transmitter operating horizontal polarisation and the other vertical. This helps to minimise any desensitisation.

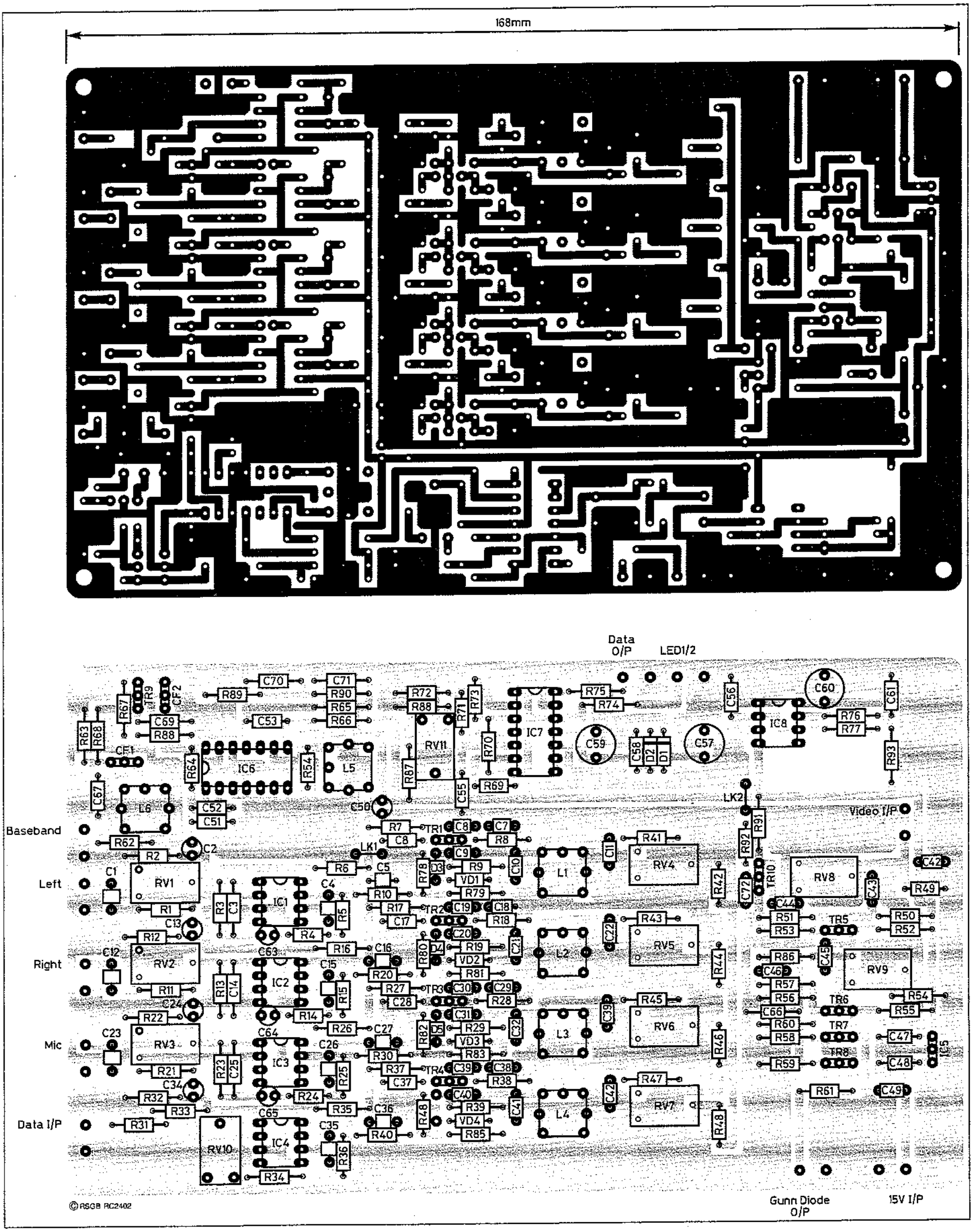
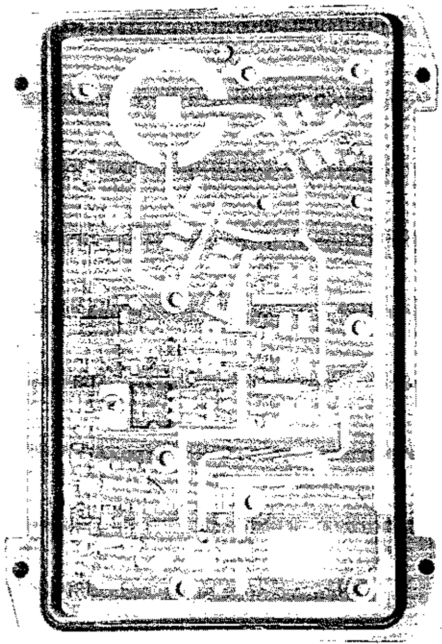


Fig 6: PCB foil pattern and component overlay.



Inside a converted 'Blue Cap' LNB. The glue which is added to 'pull' the local oscillator LF can be clearly seen in the botton right hand corner.

The satellite receiver should be set to the desired receive frequency and connected to a suitable monitor or TV. Apply 15V to the unit and connect a DC voltmeter between the Gunn output and ground. Adjust RV9 until a reading of 6.5V is obtained. Now adjust the tuning and matching screws on the Gunn cavity to give best power and a received signal on the satellite receiver. An indication of power can be estimated by measuring the current flowing through the mixer diode on the Gunn unit (if fitted). Alternatively, a separate cavity fitted with a microwave mixer diode placed a few inches away may be used.

Assuming all is well so far, apply a 1V peak-to-peak video signal to the video input. Rotating RV8 should produce a viewable picture on the monitor. If an oscilloscope is available, connect to the video output of the satellite receiver (suitably terminated with a 75Ω resistor or a video monitor) and adjust RV8 for 1V peak-to-peak as indicated on the oscilloscope. Alternatively, RV8 can be adjusted to give a picture similar in contrast to those received from Astra. If a staircase waveform is available then RV9 may be readjusted slightly for best linearity, readjusting RV8 as necessary to maintain a level of 1V peak-to-peak. Remove the video signal source.

Connect a frequency counter between the Gunn output and ground. Adjust RV4 to its mid position. With the aid of a plastic trimming tool, adjust L1 until a reading of 7.02MHz is obtained. Set the satellite receiver's audio to 7.02 MHz and apply a 1kHz sine wave to the left audio input, set the output to 775mV RMS and adjust RV1 for the loudest signal consistent with low distortion. If a deviation meter is available, adjust RV1 for 30kHz deviation. Reset RV4 to the earthy position. Adjust RV5 to its mid position. With the aid of a plastic trimming tool, adjust L2 until a reading of 7.20MHz is obtained. Set the satellite receiver's audio to 7.20MHz and apply a 1kHz sine wave to the right audio input, set the output to 775mV RMS and adjust RV2 for the loudest signal consistent with low distortion. If a deviation meter is available, adjust RV2 for 30kHz deviation. Reset RV5 to the earthy position.

Adjust RV6 to its mid position. With the aid of a plastic trimming tool, adjust L1 until a reading of 6.50MHz is obtained. Set the satellite receiver's audio to 6.50MHz and apply a 1kHz sine wave to the microphone input, set the output to 1mV RMS and adjust RV3 for loudest signal consistent with low distortion. If a deviation meter is available, adjust RV3 for 50kHz deviation. Reset RV6 to the earthy position.

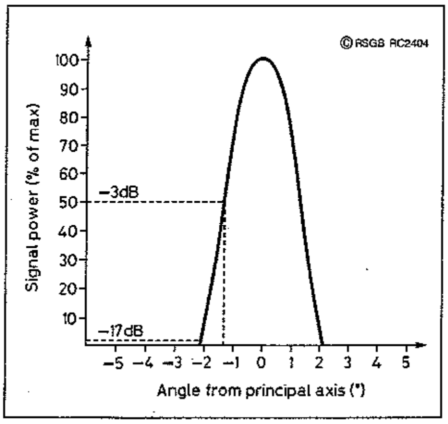
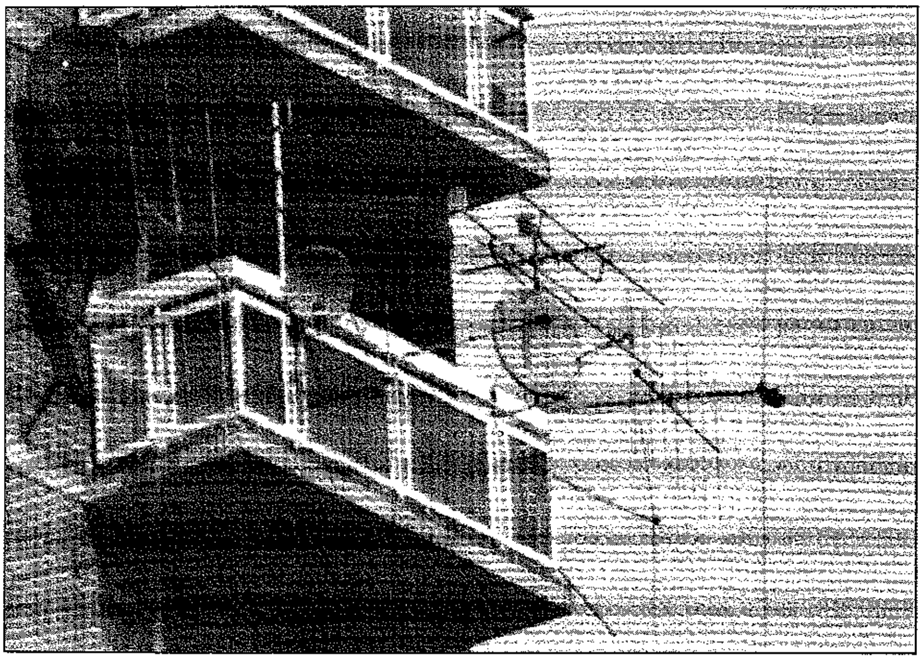


Fig 7: Graph of signal power received by a 60cm dish against deviation from the principal axis.

Disconnect the power from the board. Disconnect one end of R34 and reapply power to the board. Adjust RV7 to its mid position. With the aid of a plastic trimming tool, adjust L1 until a reading of 6.00MHz is obtained. Remove the power, reconnect R34 and connect a 10pF capacitor between the Gunn out and baseband in. Reapply power and connect an oscilloscope to the collector of TR9 via a x10 probe. Adjust the core of L6 for maximum observed signal at 6.00MHz. Transfer the probe to pin 8 of IC8 and apply a 20kHz square wave to the Data input, set the output to at least 10V peak-to-peak (but not more than 24V peak-to-peak). Adjust L5 for a symmetrical square wave signal, as seen on the oscilloscope. Decrease the resistance of RV10; an increase in amplitude of the displayed waveform should be noted. Continue to decrease resistance until no further increase in amplitude is noted. Re-adjust L5 for best amplitude and symmetry and then *increase* the resistance of RV10 until the waveform is 75% of the maximum amplitude as seen previously. Power down and disconnect one end of R34. Re-apply power and rotate RV11 from one end to the other and back again noting the 2 points at which LEDs 1 and 2 change over. Set RV11 mid way point between these two points. Remove the power, reconnect R34 and transfer the oscilloscope probe to the data out terminal. Re-apply power. A 20kHz square wave of at least 15V peak-to-peak should be observed. Both LEDs should be illuminated at half brightness at this time. Remove the capacitor between Gunn out and Baseband in.

Monitor each subcarrier in turn on the satellite receiver and adjust RV4



G6KSN's antenna-festooned balcony.

(7.02MHz), RV5 (7.20MHz), RV6 (6.00MHz) and RV7 (6.50MHz) for good signal-to-noise ratio on each subcarrier. This will vary, depending on overall system carrier-to-noise ratio as seen by the satellite receiver and should be done by adjusting the position of the LNB so that all 'sparklies' on the monitor are only just banished (ie at the P5 threshold) and only a blank raster remains on the monitor or TV set. Around 60dB should be obtained on the 6 and 6.5MHz carriers, around 50dB on the secondary carriers, although most receivers use a 2 to 1 compander circuit similar to DBX called 'Panda 1'. This system tends to mask the noise on these, and so may actually appear to be better than the main carriers.

TR1, 2, 3, 4 drain	10.8V
TR1, 2, 3, 4 source	4.3V
TR1, 2, 3, 4 gate	0.0V
TR5 collector	9.1V
TR5 base.	3.2V
TR5 emitter	2.5V
TR6 collector	8.9V
TR6 base	1.5V
TR6 emitter	0.9V
TR7 collector	12.0V
TR7 base	8.9V
TR7 emitter	8.2V
TR8 collector	12.0V
TR8 base	8.2V
TR8 emitter	7.6V
TR9 collector	7.0V
TR9 base	2.0V
TR9 emitter	1.4V
TR10 collector	9.4V
TR10 base	0.7V
TR10 emitter	0.0V
IC1, 2, 3, 4 pin 1, 2, 3	6.0V
IC1, 2, 3, 4 pin 4	0.0V
IC1, 2, 3, 4 pin 5, 6, 7	6.0V
IC1, 2, 3, 4 pin 8	12.0V
IC5 input	15-20V
IC5 ground	0.0V
IC5 output	12.0V
IC6 pin 1, 3, 4, 12	0.0V
IC6 pin 2	2.1V
IC6 pin 8	5.3V
IC6 pin 11	8.9V
IC6 pin 13	2.1V
IC6 pin 14	2.1V
IC7 pin 2	6.0V
IC7 pin 4	12.0V
IC7 pin 5	5.9V
IC7 pin 6	5.8V
IC7 pin 11	-9.0V
IC8 pin 1	0.0V
IC8 pin 2, 6, 7	5.8V
IC8 pin 3	5.7V
IC8 pin 4, 8	12.0V

Table 1: Typical circuit voltages.

SETTING UP THE LINK

THIS CAN PROVE quite difficult, especially if the path is a long one. To receive an adequate signal level the dishes at each end of the link need to be aligned to within about 1° in both the horizontal and vertical plane, as is illustrated in **Fig 7**. It may be useful to try setting the receive dish elevation by receiving a known terrestrial signal. Fortunately there are literally thousands of microwave transmitters operating between 10.5 and 10.7GHz across the UK. These take the form of Radar Doppler modules located on traffic lights. I can receive a number of these transmissions from this QTH and find them very useful indeed. The dish needs to have the elevation reduced by almost 30° compared with Astra, and if a standard offset dish is used it may be necessary to re-drill the bottom bracket so that it can be secured in this new position. The dish will appear to be pointing at the floor and the boom which supports the LNB will be about 10° below horizontal. It will be possible to align the elevation of the transmit dish by momentarily mounting the receive LNB on it and aligning on a traffic light or other known terrestrial source.

With the dishes roughly in alignment in the vertical plane, arrange for the remote station to radiate a carrier. It is easiest if the transmitting station leaves his dish stationary while the receive dish is adjusted. If no signal is detectable then the transmitting dish can be adjusted slightly and the process repeated. Once a signal is acquired, both azimuth and elevation of both dishes can be adjusted for maximum signal. Many satellite receivers have an AGC output for this purpose. A satellite alignment meter may also be used.

Once one side of the link is set up, the whole process can be repeated for the return path. If the link is only a few kilometres it may be possible to dispense with the receive dishes altogether. I can receive at least two radio amateurs from this QTH with just an LNB pointing out of the living room window! Small horn antennas may also be considered as a viable alternative if the path is true 'line of sight' and not more than, say, 15 or 20km.

DATA PORT CONFIGURATION

AS I SAID previously, the data port will work well at least up to 28800 baud (and possibly much higher). If you have a 486 or better machine and 16550 UART chips on the I/O card then try 38400 or 57600 baud. You will soon see when things are getting tricky, as the data rate will decrease or collapse altogether if either the PC or microwave link cannot handle it. On a P75 using Hyperaccess or HyperTerminal the data port will work at 57600 without any problems, but the data deviation and data slicer settings become more critical. 6MHz ceramic filters tend to be quite narrow and I have tried (without success) to find a source of wider ones. With 280 or 330kHz filters, the data port should be capable of 115200 baud. If anyone knows of a source of wide band filters for 6MHz, please let me know. I have been doing some tests with 10.7MHz filters and upconverting the 6MHz data signal by mixing it with a 16.7MHz local oscillator. Currently this seems to be the only way to go, but the 6MHz wideband option has more appeal.

For packet radio data transfer, I use G8BPQ's 408a packet switch software used in conjunction with G6AMU's Easyterm version 1.03g. At 28800 baud the data transfer rate on an old 386SX33 with a very ordinary I/O card exceeds 2000 characters per second. Tests with a 486 and even a Pentium do not yield significant increases in speed, and data rates above 28800 baud just don't seem to work. I put this down to limitations of the software, which was not really designed to work much beyond 9k6.

Table 2 shows an example of how to configure BPQ408a to work with the microwave link.

FINALLY

IN CONCLUSION I would like to say a word of thanks to Martin, G7RTQ. Martin is at the other end of the 3cm link and has been remarkably patient when tests have had to be carried out. Without his support and encouragement this unit would have never reached its current level of refinement. ♦

```
PORT
    ID=19200Bd link to WARLEY
    TYPE=ASYNC
    PROTOCOL=KISS
    IOADDR=3F8H
    INTLEVEL=4
    SPEED=19200
    CHANNEL=A
    QUALITY=10
    MAXFRAME=7
    TXDELAY=1
    SLOTTIME=1
    PERSIST=255
    FULLDUP=1
    FRACK=700
    RESPTIME=2
    RETRIES=25
    PACLEN=255
    MHEARD=N
    KISSOPTIONS=CHECKSUM
ENDPORT
```

Table 2: How to configure BPQ408a to work with the microwave link.