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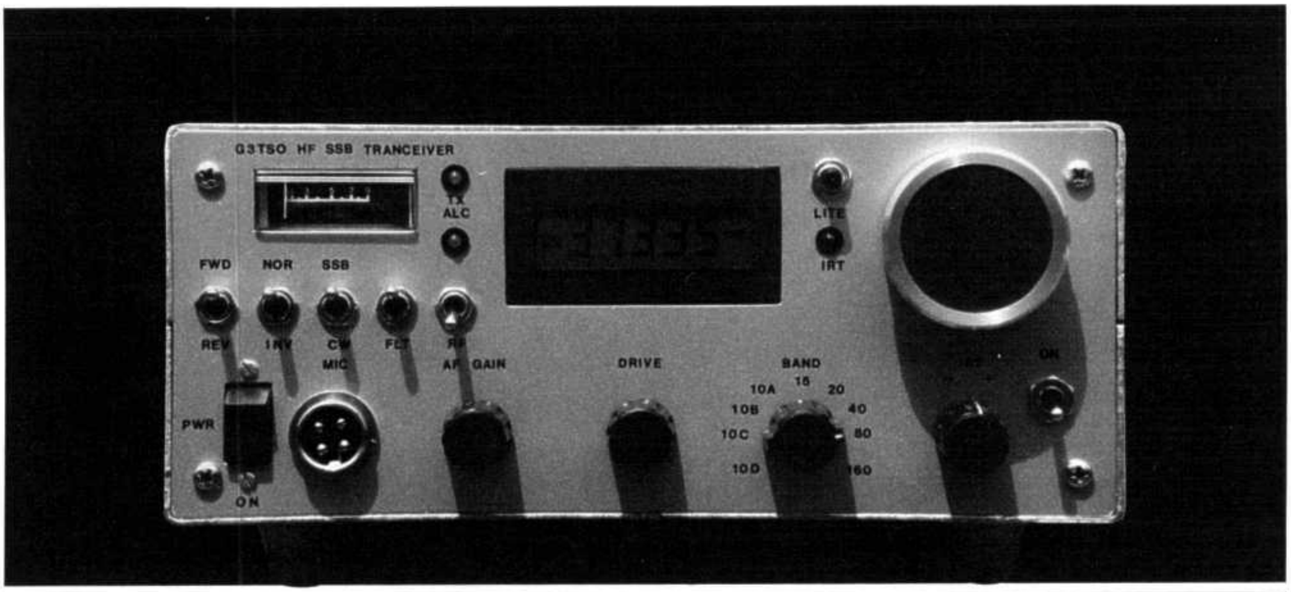
QEX 91

ARRL Experimenters' Exchange

SEPTEMBER 1989



Let's get modular

In this issue, the wrap-up of the G3TSO HF SSB transceiver

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Empirically Speaking. . .

Contributing to the Propagation Art

One way in which radio amateurs can make a contribution to man's body of knowledge is in radio propagation. In fact, hams have done so in pioneering all the frequencies above 1.5 MHz, once thought to be worthless. Within the memories of many amateurs are discoveries by hams of the transequatorial mode (TEM) and, recently, observations of two-way sporadic E as high as 220 MHz.

We don't often get a chance these days to contribute to the understanding of ionospheric HF propagation, owing to the need for vast information-processing capabilities to hold and process the data. While sophisticated ionospheric propagation models exist, there are still voids and inconsistencies in these models. Hams can help by (a) learning what they can about what is already known, (b) identifying what is not known, and (c) developing collection and analysis initiatives to fill in the blanks.

Like many other projects these days, propagation work is best carried out by teams who are in touch with professionals in the field. The world's focal point for propagation science is the International Radio Consultative Committee (CCIR) Study Group 6, which deals with propagation in ionized media. Input is made by each CCIR member organization to CCIR at interim and final meetings of the Study Group in each four-year cycle.

QEX is available to Amateur Radio propagation researchers for the purposes of calls for participation and publication of research findings. The ARRL, working through US CCIR Study Group committees, will bring significant amateur-produced data to the attention of the CCIR. Other Amateur Radio national societies are encouraged to do likewise through their own administrations.

With this as background, Larry Kayzer, W3ZIA, has a puzzle for us. His Telemail

Purposes of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters
2) document advanced technical work in the Amateur Radio field
3) support efforts to advance the state of the Amateur Radio art.

All correspondence concerning *QEX* should be addressed to the American Radio Relay League, 225 Main Street, Newington, CT 06111 USA. Envelopes containing manuscripts and correspondence for publication in *QEX* should be marked: Editor, *QEX*.

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and double spaced. Please use the standard ARRL abbreviations found in recent editions of *The ARRL Handbook*. Photos should be glossy, black-and-white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.


```
                              METHOD  9   IONCAP

                MUF(....)        FOT(XXXX)        HPF(+++)

   00  02  04  06  08  10  12  14  16  18  20  22  00
 MHZ+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+MHZ
40-                             +                     -40
  -                                                   -
38-                                 +                 -38
  -                                             +     -
36-                                                   -36  GMT   MUF   FOT   HPF
  -                                     +   +         -
34-                                                   -34  2.0  20.9  16.7  25.3
  -                         +   .                     -    4.0  21.3  17.0  25.8
32-                                 .                 -32  6.0  19.6  15.5  24.1
  - +                                   .   .       + -    8.0  18.6  14.7  22.8
30-                         .   X               .     -30 10.0  18.9  16.2  20.6
  -                                 X                 -   12.0  30.4  26.1  33.1
28-                                     X             -28 14.0  33.1  29.8  39.8
  -                                         X         -   16.0  31.7  28.5  38.0
26-          +               X                        -26 18.0  30.9  27.8  35.2
  - .   +                                           . -   20.0  30.5  27.5  34.8
24-              +                               X     -24 22.0  29.8  24.4  36.6
  -                  +                                 -   24.0  24.9  20.5  30.7
22-                                                   -22
  -     .   .           +                             -
20- X           .                                   X -20
  -                  .   .                            -
18-                                                   -18
  -     X   X                                         -
16-                     X                             -16
  -             X   X                                 -
14-                                                   -14
 MHZ+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+MHZ
   00  02  04  06  08  10  12  14  16  18  20  22  00
                  UNIVERSAL TIME
```

message states:

> During the solar disturbance in early August and continuing without break since August 6, the PY2AMI beacon on 24,930.6 kHz has been heard by myself around the clock. The signal level has gone as low as what one would expect on a marginal EME link up to almost S1. The pY2 beacon is running 5 watts to a ground plane.
>
> The equipment used here is a TS-440 with a multiband dipole **in a very quite HF location** near Chaffeys Locks, Ontario. The 18,100-kHz beacon from the same station follows a regular pattern of appearance as one would expect of propagation at this stage of the solar cycle. The 24,930.6-kHz signal does not seem to follow any of the expected minute, hourly, or daily changes in propagation. The signal seems to have about a 10-dB change being weakest at night, but is always there.

Just to see whether what Larry was seeing was normal for this point in the sunspot cycle, I ran an IONCAP prediction for the path. A table showing predicted propagation in the 18-, 21- and 24-MHz bands and a graph of MUF, FOT and HPF are shown here. The figure to look at in the table is SNR for each hour shown for 24.9 MHz. It looks like Larry is hearing PY2AMI a lot better than predicted, even without an ionospheric disturbance. Add the disturbance and is even more interesting. Incidentally, we took Larry's word for it being a very quiet location and used a remote location man-made noise level of −164 dBW. Since Larry returned to the wilderness, we couldn't ask him where Chaffeys Locks, Ontario is having failed to find it in any atlas, so we used 47°N, 80°W.

Amateurs with observations should send them to Larry Kayser, 36 Glebe Avenue, Ottawa, Ontario, Canada, K1S 2C1, with a copy to Editor, *QEX*.—*W4RI*

```
                         METHOD 23    IONCAP

          SEP     1989            SSN = 184.
AMERICANA,BRAZIL TO ONTARIO, CANADA        AZIMUTHS           N. MI.      KM
22.45 S   47.20 W - 47.00 N   80.00 W    337.57  148.86     4532.2   8392.9
XMTR    2.0  TO  30.0  VER MONOPOLE H      .00 L     3.00 A      .1  OFF AZ     .0
RCVR    2.0  TO  30.0  HORZ. DIPOLE H      .10 L     -.50 A      .0  OFF AZ     .0
POWER =     .005 KW  3 MHZ NOISE = -164.0 DBW   REQ. REL = .50  REQ. SNR = 26.0

  UT  MUF

 2.0 20.9 16.7 18.0 21.0 24.9 FREQ      14.0 33.1 29.8 18.0 21.0 24.9 FREQ
      3F2  3F2  3F2  3F2  2F2 MODE            3F2  3F2  6F2  5F2  3F2 MODE
     11.8  7.0  7.6 12.9 12.9 ANGLE           7.5  4.9 16.4 13.0  3.7 ANGLE
      .50  .90  .81  .49  .12 F DAYS          .50  .90 1.00 1.00 1.00 F DAYS
       4.  10.  11.  -5. -20. SNR              4.  -3. -65. -38. -14. SNR
      .11  .02  .02  .06  .01 REL             .03  .00  .00  .00  .00 REL

 4.0 21.3 17.0 18.0 21.0 24.9 FREQ      16.0 31.7 28.5 18.0 21.0 24.9 FREQ
      3F2  3F2  3F2  3F2  2F2 MODE            3F2  3F2  6F2  6F2  3F2 MODE
     12.4  6.8  7.2  9.9 12.4 ANGLE           8.9  6.5 20.3 24.6  7.0 ANGLE
      .50  .90  .84  .53  .15 F DAYS          .50  .90 1.00 1.00 1.00 F DAYS
      -3.  14.  14.   8. -15. SNR              1.  -7. -68. -41. -15. SNR
      .08  .05  .09  .12  .02 REL             .02  .00  .00  .00  .00 REL

 6.0 19.6 15.5 18.0 21.0 24.9 FREQ      18.0 30.9 27.8 18.0 21.0 24.9 FREQ
      3F2  3F2  3F2  3F2  3F2 MODE            3F2  3F2  6F2  3F2  3F2 MODE
     11.8  6.8  8.2 12.5 12.5 ANGLE          10.7  7.8 22.5 10.7  7.5 ANGLE
      .50  .90  .69  .35  .07 F DAYS          .50  .90 1.00 1.00  .99 F DAYS
       3.  13.  13. -15. -70. SNR              5.   2. -43. -13.  -2. SNR
      .12  .05  .08  .02  .00 REL             .05  .00  .00  .00  .00 REL

 8.0 18.6 14.7 18.0 21.0 24.9 FREQ      20.0 30.5 27.5 18.0 21.0 24.9 FREQ
      3F2  3F2  3F2  3F2  3F2 MODE            3F2  3F2  3F2  3F2  3F2 MODE
      9.7  5.1  7.5 10.4 10.4 ANGLE           9.9  7.0  6.0  5.7  6.2 ANGLE
      .50  .90  .57  .23  .03 F DAYS          .50  .90 1.00 1.00  .99 F DAYS
      -1.  10.   5. -32. **** SNR             12.  12. -10.   0.   9. SNR
      .09  .02  .07  .00  .00 REL             .13  .02  .00  .00  .00 REL

10.0 18.9 16.2 18.0 21.0 24.9 FREQ      22.0 29.8 24.4 18.0 21.0 24.9 FREQ
      3F2  3F2  3F2  3F2  3F2 MODE            3F2  3F2  3F2  3F2  3F2 MODE
     11.5  6.8  8.1  7.3 11.5 ANGLE           9.6  5.6  4.7  5.0  5.8 ANGLE
      .50  .90  .67  .06  .00 F DAYS          .50  .90 1.00  .98  .88 F DAYS
      -9.   8.   9. -64. **** SNR              9.  14.   3.  10.  14. SNR
      .02  .00  .02  .00  .00 REL             .15  .05  .00  .01  .07 REL

12.0 30.4 26.1 18.0 21.0 24.9 FREQ      24.0 24.9 20.5 18.0 21.0 24.9 FREQ
      3F2  3F2  3F2  3F2  3F2 MODE            3F2  3F2  3F2  3F2  3F2 MODE
      9.9  5.0  3.9  4.1  4.7 ANGLE          11.4  6.3  5.6  6.5 10.7 ANGLE
      .50  .90 1.00 1.00  .95 F DAYS          .50  .90  .98  .87  .51 F DAYS
     -11.   8.  -8.   2.   8. SNR              4.  14.  12.  14.   6. SNR
      .03  .02  .00  .00  .00 REL             .13  .05  .02  .07  .13 REL
```

Bits

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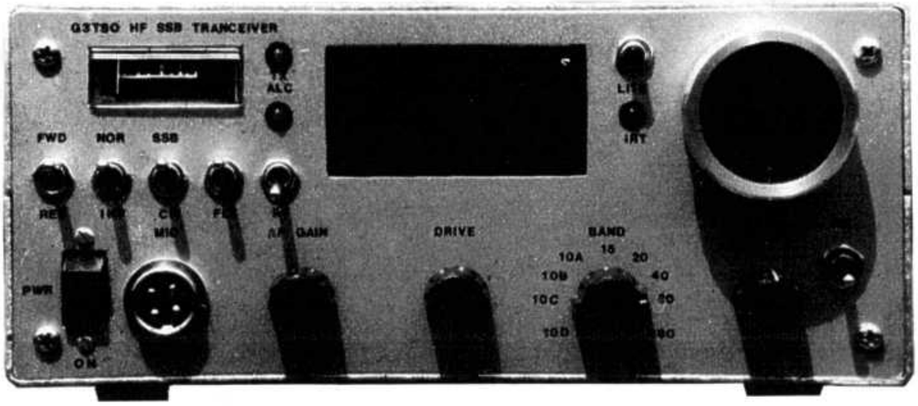
G3TSO's MODULAR HF TRANSCEIVER

Bands 1.8 through 30 MHz and 10 watts output—*Part 2*

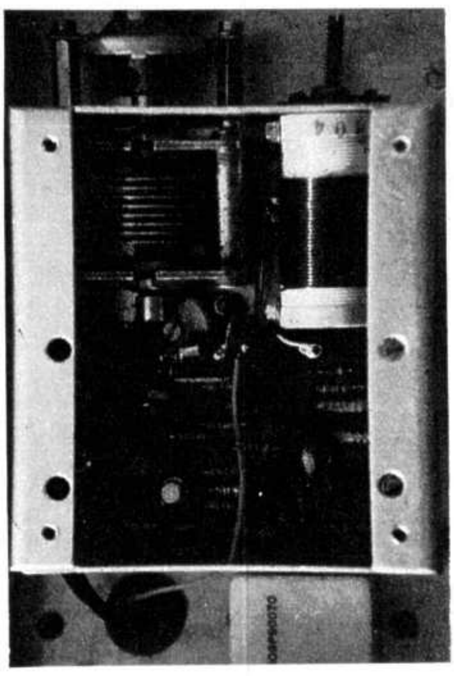
By Mike Grierson G3TSO/KD3CL

G3TSO concludes his explanation of construction of each module, describes their alignment and finally offers the optimum procedure for testing the complete rig

Reprinted from RADIO COMMUNICATION November 1988



Bandpass filter alignment is simple and doesn't require masses of expensive test equipment. As few amateurs will have access to a sweep generator an alternative method will be described. Each filter may be tested independently once it is wired up, but the low impedance input should be terminated with a 50ohm resistor and a 10kΩ resistor connected across the output. Using a signal generator and a suitable measuring device such as an oscilloscope or vvm, inject a signal into the input of the filter while monitoring the level at the output. Peak the filter in the middle of the desired band so as to obtain maximum output. Each filter may then be adjusted to broaden the bandwidth by adjusting one coil at the lf end of the band and the other at the hf end of the band. Tuning of each coil in a filter will be interdependent and several adjustments will be necessary to achieve a flat response across the desired band. By



TRANSCEIVER PERFORMANCE

General Specification

Single superhet transceiver.
Bandwidth: 2·4kHz @ −6dB, 4·3kHz @ −60dB.
Power Output: Variable from 100mW to 20W pep (ssb) 20W (cw) 100% duty cycle.
Receiver sensitivity: 0·25 µV for 10dB S+n/n (28MHz).
AGC: typically 3dB change of output for 80dB change of input.
RF amp gain: 15dB.
IF:9MHz. IF rejection: greater than 60dB.
AF output: 1watt.

MEASURED PERFORMANCE

Local Oscillator Unit

Band	L.O. Freq	2nd Harmonic	Spurious responses
160	11MHz	−45dB	Greater than −55dB
80	5MHz	−30dB	Greater than −55dB
40	16MHz	−32dB	1 @ −35dB (2x Xtal − vfo) others Greater than −60dB
20	5MHz	−30dB	Greater than −55dB
15	12MHz	−35dB	Greater than −50dB
10A	19MHz	−33dB	1 @ −42dB others greater than −50dB
10B	19·5MHz	−33dB	1 @ −47dB others greater than −50dB
10 10D	20MHz	−33dB	Greater than −50dB

Receiver performance

S-meter calibration using Cirkit 200µA S-meter adjusted for fsd at max agc voltage:
Fsd typically 100mV PD.
50µV pd gives S8 indication on 160, 80, 15 and 10m bands.
50µV pd gives S7½ indication on 40 and 20M.
Receiver sensitivity: 14MHz 0·28µV for 10dB S+/n 28MHz 0·25µV for 10dB S+n/n

Receiver Spurious Responses

The following internally generated spurious responses can be heard on the receiver:

80 metres:	a weak response occurs at 3·6MHz when the vfo is operating at 5.4MHz. This also produces a similar out-of-band response on 20m at 14·4MHz.
15 metres:	band edge birdie just out of band at 20·997MHz owing to third harmonic of 7MHz xtal. Fourth harmonic of vfo produces a response at 21·333MHz.
10 metres:	band edge birdie just out of band at 27·997 owing to 2nd harmonic of 14MHz xtal. Similar birdie from 14·460 xtal occurs at 28·92MHz. However, 10C range overlaps this frequency.

Second channel interference

80 metres	minimum detectable signal on 14MHz: 1mV pd.
20 metres	minimum detectable signal on 3·5MHz: 300µV pd.

Each band was subjected to a 3mV signal across the hf spectrum and no spurious responses were found except for:

15 metres	1 response at 23MHz which disappeared at 300µV pd.
10 metres	3 responses at 26·5, 27·7 and 30MHz which dissapeared at 300µV pd.

TRANSMITTER OUTPUT

Band	*2nd Harmonic*	*3rd Harmonic*	*Spurii*
160	−33dB	−42dB	greater than −50db
80	−38dB	−42dB	greater than −60dB
40	−42dB	−60dB	greater than −50dB
20	−50dB	−32dB	greater than −50dB
15	−42dB	−22dB	greater than −50dB

measured at 18 watts output int 50ohms

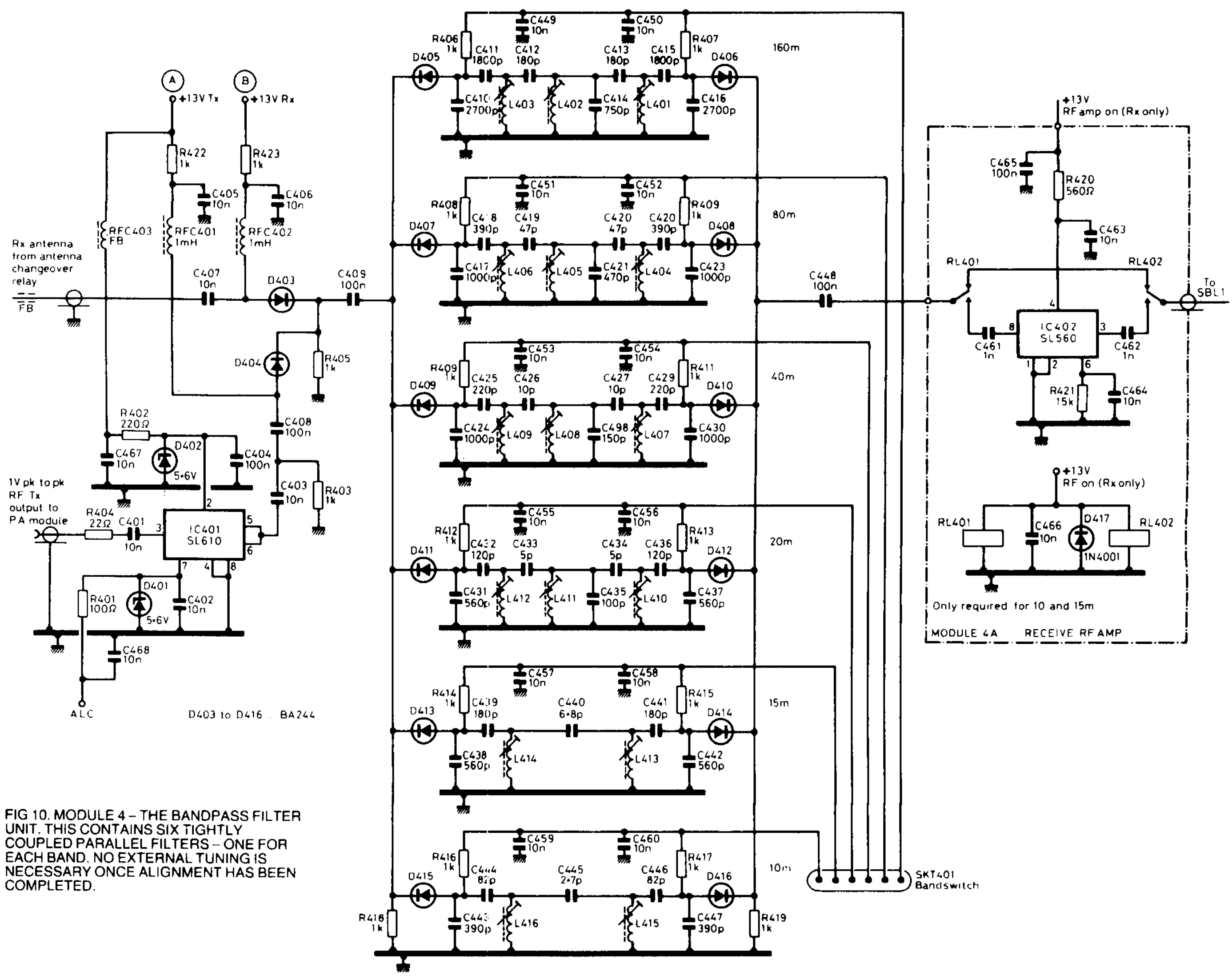


FIG 10. MODULE 4 – THE BANDPASS FILTER UNIT. THIS CONTAINS SIX TIGHTLY COUPLED PARALLEL FILTERS – ONE FOR EACH BAND. NO EXTERNAL TUNING IS NECESSARY ONCE ALIGNMENT HAS BEEN COMPLETED.

sweeping the signal generator across and outside the band the output level should be observed to be as flat as possible up to the band edges and then rapid attenuation of the signal should occur as the generator moves further away from the band edge.

Further alignment of the filters is possible when both oscillators and the mixer are running. With 13V connected to each filter, switching in turn, and the corresponding xtal selected it should be possible to observe the local oscillator signal level at the output of module 3. As the vfo is tuned across its range the output level should be clean, on the correct frequency and fairly constant across the entire band. Minor adjustment of the bandpass filters can be made to achieve a level response. Output from module 3 should be checked into a 50ohm load and should be 500mV. It is, incidentally, quite common for distortion of the waveform to occur when the output is fed directly to the ring mixer. The output level will vary slightly from band to band, but nevertheless is fairly constant. Some adjustment of output level is possible by varying the gain of TR304 by adjustment of R331.

MODULE 4: BAND PASS FILTER UNIT

Before module 1 can be used as a receiver it is necessary to place a suitable band pass filter between the mixer and the antenna. This filter will provide front end selectivity as well as filtering the transmit signal.

Module 4, Fig 10, comprises six band pass filters – one for each band. The filters are bi-directional and consist of a number of tightly coupled parallel tuned circuits, capacitively tapped to provide a 50ohm input and output impedance. The filters are designed to provide a relatively flat response across each band and provide adequate selectivity for receiver operation. On transmit the transfer characteristics are good enough to ensure that only minimal attenuation of the low power transmit signal occurs. No external preselector tuning is provided or necessary once the filters are correctly aligned.

Each filter is selected into circuit by biasing on two BA244 low capacitance switching diodes at either end of the filter. Input and output coupling is capacitative into a common line between the filters. Toko coils are used throughout and can be selected for their inductance value or rewound from old stock. No complicated taps or coupling windings are employed, each inductor being a straight solenoid.

D403 and 404 provide switching of the transmit and receive signal paths; D403 routes the receive signal from the antenna change-over relay to the filters. On transmit, additional voltage amplification is required after the BPF and D404 routes the transmit signal to IC401, a Plessey SL610 RF amplifier IC whose gain is controlled both manually and by alc action. Output from the SL610 is in the order of 1V rms and is capable of providing adequate drive for the following pa unit. The SL610 operates from a 6V supply provided by D402 from the 13V transmit rail. Alc is applied as a dc bias to pin 7 of the IC which is shunted by D401 a 5V6 zener diode whose purpose is to prevent more than 6V appearing on the ic. When the SL610 is operated into a low impedance load (50ohms) it is important to include a series resistor in the output line to prevent parasitic oscillations occurring. An ideal value is 100ohms, but this may limit the output voltage too much, in which case it may be lowered slightly. The lowest practical value used so far has been 33ohms. The value of R404 is a compromise between achieving stability and adequate drive. I discovered instability in my prototype when driving a 50MHz transceiver – at full gain the SL610 started to oscillate between 40 and 50MHz and the signal passed straight through the transceiver. In normal operation it had been removed by the low pass filter. It is important not to overdrive the SL610 as it can limit severely and produce a wonderful flat-topped output which will produce severe distortion when amplified by the following wideband amplifier.

It is important to use small capacitors for the filter unit and polystyrene types combine high stability with small size and low cost. Each filter is constructed independently on the single-sided glass fibre pcb (Fig 11) and all filters are connected to SKT401 by fly wires. It is important to ensure that both ends of the same filter are connected to the same pin on SKT401 if they are to switch correctly. The fly wires should be added under the pcb. A layout of module 4 is illustrated in Fig 12.

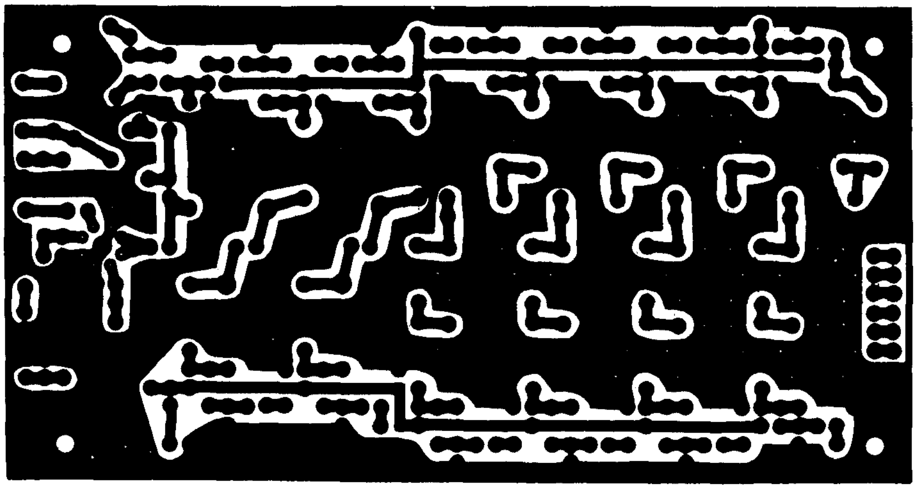


FIG 11. THE BANDPASS FILTER BOARD – ACTUAL SIZE. IT'S MADE FROM SINGLE-SIDED GLASS-FIBRE.

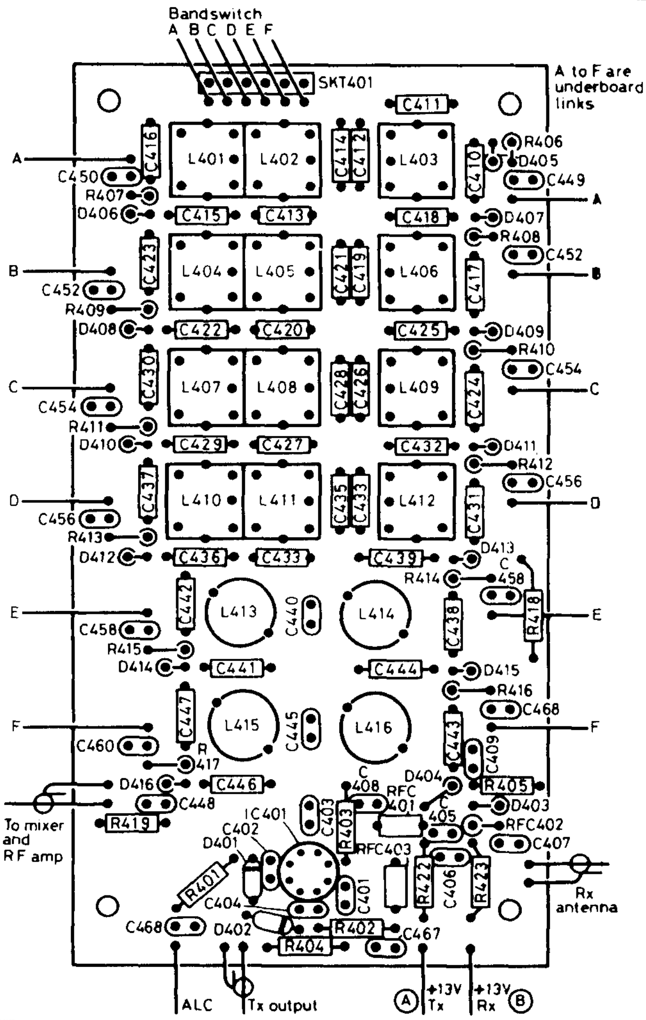


FIG 12. COMPONENT LAYOUT FOR THE BANDPASS FILTER.

MODULE 4

R404	22R (max 100R)
R401	100R
R402,	220R
R403,405,406,407,408,409, 410,411,412,413,414,415, 416,417,418,419,422,423	1k
R420	560R
R421	15k
C401,402,403,405,406,407, 449,450,451,452,453,454, 455,456,457,458,459,460, 463,464,466,467,468	10nF C
C403,404,408,409,448,465	100nF C
C410,416	2700pF poly
C411,495	1800pF poly
C412,413,439,441	180pF poly
C414	750pF poly
C417,423,424,430	1000pF poly
C418,422,443,447	390pF poly
C419,420	47pF poly
C421	270pF poly
C425,429	220pF poly
C426,427	10pF C
C428	150pF poly
C431,437,438,442	560pF poly
C432,436	120pF poly
C433,434	5pF C
C435	100pF poly
C440	6.8pF C
C444,446	82pF poly
C445	2·7pF C
C461,462,	1nF C
D401,402	5.6V zener
D403–D416	BA244
D417	1N4001
IC401	SL610
IC402	SL560
RL401,402	SPCO type OUC
RFC401,402	1mH axial choke
L401,402,403	8μH Toko KANK3334R rewind to 27 turns
L404,405,406	5.8μH Toko KANK3334R (5.5μH)
L407,408 409	2.8μH Toko KXNK4173AO (3μH)
L410,411,412	1.2μH Toko KANK 3335R (1.2μH)
L413m414,415,416	0.45μH Toko S18 0.45μH white

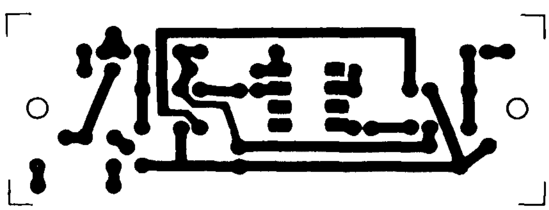


FIG 13. THE PCB LAYOUT FOR MODULE 4A, THE RF AMPLIFIER.

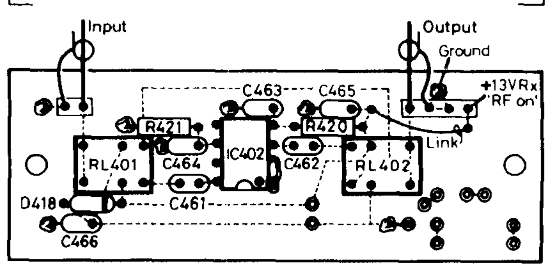


FIG 14. LAYOUT OF THE RF AMP BOARD.

MODULE 4A: RF AMPLIFIER

While not actually part of module 4, the optional receiver rf amplifier is inserted between module 4 and the mixer to provide increased gain on 28 and 21MHz. It is not essential and certainly not required on 14MHz or below.

A Plessey SL560C ic is used as a 50ohm gain block with approximately 15dB gain and is switched into circuit on receive using subminiature relays. The rf amp and relays are switched from the 13V receive rail which ensures that the unit drops out on transmit. This is essential as the amplifier is located in a bi-directional signal path. It is also important to ensure the supply to the ic is removed when not in use as the ic is prone to oscillation if it isn't terminated.

CONSTRUCTION

Module 4 is constructed on a 2·5" × 4·75" pcb which could be expanded to allow the inclusion of the new WARC bands if required. The RF amplifier module 4A is housed on a separate double sided pcb measuring 1·0 × 2·75" and is illustrated in Figs 13 and 14.

BPF ALIGNMENT

Alignment of the band pass filters can be achieved simply using a signal generator and a vvm or oscilloscope in the same manner as the filters in module 3, except that both ends of the filters should be terminated with a 50ohm resistor.

The 1·8 to 14MHz filters comprise three parallel tuned circuits, while the 21MHz and 28MHz filters have only two tuned circuits. The triple-tuned filters have three distinct peaks during alignment and tuning of each circuit is interdependent. The simplest method of alignment is to peak each filter in the centre of the required passband and then increase the bandwidth by adjustment of the input and output tuned circuits towards the hf and lf ends of the band. The centre inductor can then be used to flatten the response across the band. Tuning is fairly critical and small adjustments should be made until a level response is achieved across the desired band. The signal generator should be swept slowly across the band during the alignment process and the output from the filter monitored on either the vvm or oscilloscope. When the generator is swept well away from the required band, the output signal should be rapidly attenuated. Check for the odd response that may appear some way out of band and which may be due to one of the tuned circuits being considerably off resonance. The 21 and 28MHz filters with only two inductors are considerably easier to align.

No adjustment of either the transmit or receive rf amplifiers is necessary or possible, but the gain of the transmit amplifier can be adjusted by means of the manual drive control. During testing, if no dc bias is applied to pin 7 of the SL610, it will rise to the supply voltage and should be grounded for maximum gain.

MODULE 5: LOW PASS FILTER UNIT

The transmitter rf section employs a broadband amplifier taking signals from the milliwatt region up to the final output of several watts. Before this signal can be fed to an antenna it is essential to remove any unwanted harmonics that may have been generated in the amplifier chain.

Module 5 (Fig 15) comprises of six Chebychev low pass filters with cut-off frequencies coincident with the top edge of each band segment on the transceiver. Even harmonics will be cancelled to a large extent by the push-pull pa and driver amplifiers, but any residual second harmonic will be further attenuated by the filter. The third harmonic and above will be attenuated by the filter by at least 50dB.

Diode switching of the filters is not practical owing to the higher currents involved, so a series of miniature relays is used to select the desired filter into circuit. All filters not in use are grounded at both ends to prevent stray signal paths for higher frequency products around the filter. All capacitors used in the filters should be of the silver mica type and ideally of at least 350V wkg. Capacitors with a 125V rating can be used at the 20W level but it should always be born in mind that the rf voltage at the antenna skt will rise with increase in power and swr.

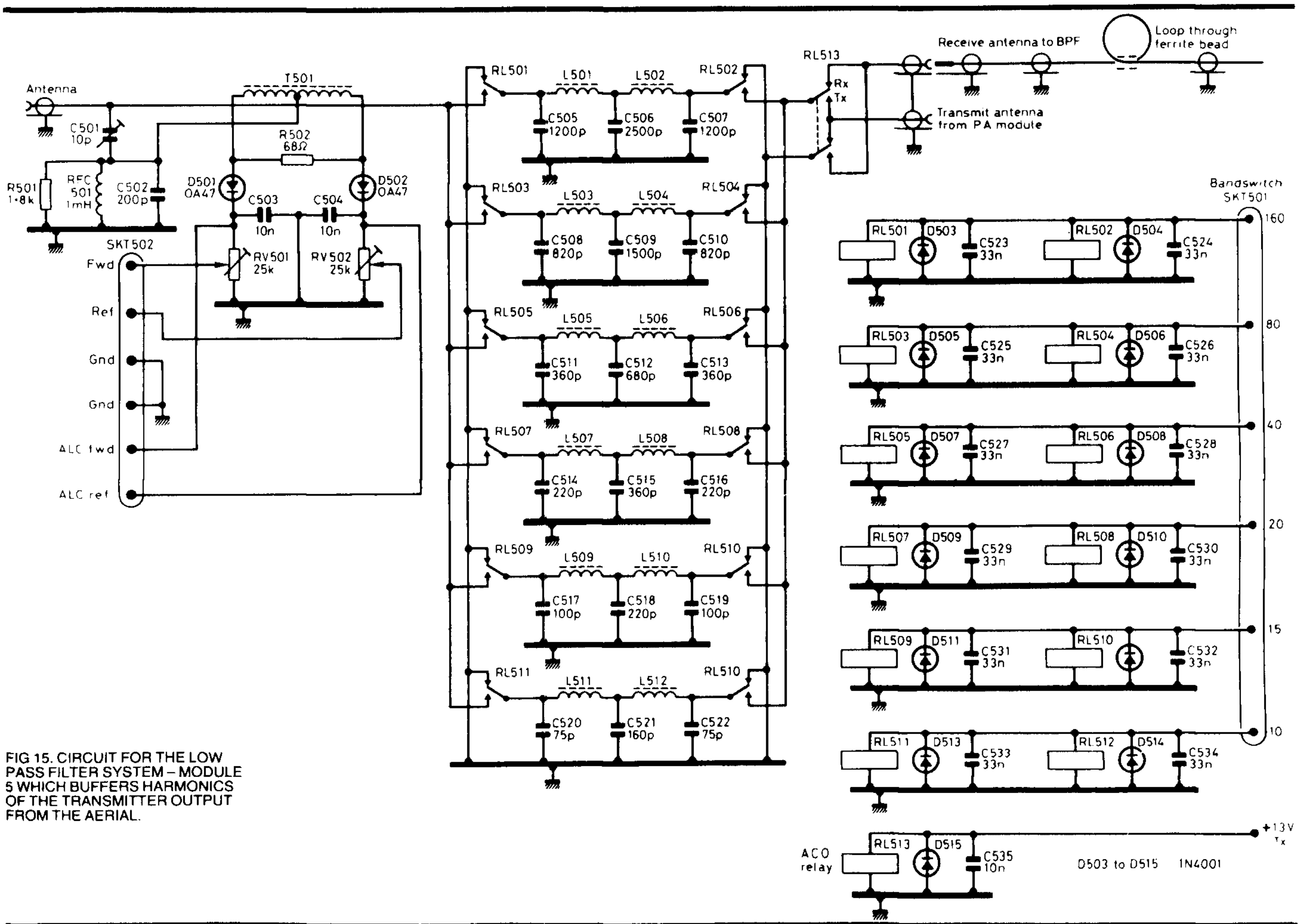


FIG 15. CIRCUIT FOR THE LOW PASS FILTER SYSTEM – MODULE 5 WHICH BUFFERS HARMONICS OF THE TRANSMITTER OUTPUT FROM THE AERIAL.

Capacitor values are critical to correct operation of the filters and must be adhered to. Any values that cannot be obtained should be made up by parallelling two or more capacitors in order to achieve the desired value.

Many commercial designs use elliptic filters which give a greater attenuation of the second and third harmonics. They are, however, slightly more difficult to build if they are to be operated at their optimum performance. With this in mind I chose to use the simpler Chebychev design for home construction. Excellent data on elliptic filters is contained in the latest issue of the *ARRL Handbook* and the extra components could be added to the pcb layout in Fig 16 if desired.

The low pass filters are retained in circuit during receive to provide additional filtering with the result that the antenna change over relay RL513 is located on the transmit side of the filter. This is a dpco type relay and shorts to ground the Rx and Tx lines when not in use. This is particularly important as the Rx ant. line returns to the vicinity of the bpf which is passing low power transmit signals. The use of a heavy duty ferrite bead on this line is also advisable.

An swr detector is included on the lpf unit and serves to provide meter indications of power and reflected power output as well as providing dc voltages for use by the alc system. The bridge is a current sampling type and therefore not particularly frequency conscious. T501 samples the current in the antenna line which develops a voltage across R502. This is summed with the rf voltage developed across the potential divider C501/C502, producing forward and reflected voltages which are rectified by D501 and D502 before being fed as dc voltages to the alc unit. Potentiometers are provided to scale the Fwd and Ref voltages for presentation to a panel meter. An ic Op-amp with a gain of two is used as a buffer amp to prevent the panel meter loading the bridge and also serves as an S-meter amplifier on receive.

The lpf is constructed on a single-sided glass fibre pcb measuring 3″ × 4″ (Fig 16). The component density is high and the silver mica capacitors used should be of the modern smaller design rather than the traditional large variety. There is no reason why the pcb layout should not be expanded a little to make more room if required. If operation is contemplated on the WARC bands, then the 14MHz filter can be used on 28MHz, the 21MHz filter on 18MHz and the 28MHz filter on 24MHz. There is no need to build additional filters.

All relays on the lpf board should be capable of carrying the pa output current and a good

MODULE 5

R501	1.8k
R502	68R ½ watt
RV501,502	22–25k trim
C501	10pF ceramic trim
C502	200pF SM
C503,504,505	10nF C
C505,507	1200pF SM 350V
C506	2500pF SM 350V
C508,510	820pF SM 350V
C509	1500pF SM 350V
C511,513,515	360pF SM 350V
C512,	680pF SM 350V
C514,516, 518	220pF SM 350V
C517,519	100pF SM 350V
C520,522	75pF SM 350V
C522	160pF SM 350V
C523,524,525,526, 527,528,529,530, 531,532,533,534	332nF C
RL501–RL512	Type 211NA DOO9M20 Surplus at rallies or SMR12 Electrovalue YX94C Maplin
RL513 Type	OUB
L501,502	31t 26swg T50–2
L503,504	22t 20swg T50–2
L505,506	18t 20swg T50–2
L507,508	12t 20swg T50–2
L509,510	10t 20swg T50–2
L511,512	9t 20swg T50–2
T501	9t + 9t 26swg bifilar FT37-43 GW3TMP Electronics
D501,502	Matched OA47
D503–D515	1n4001
RFC501	1mH axial choke

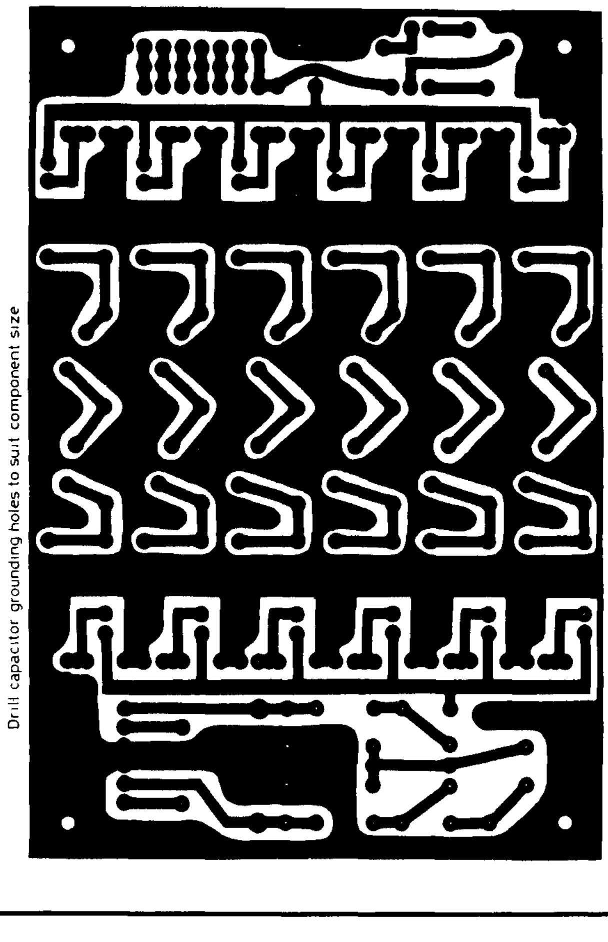


FIG 16. DESIGN OF THE LOW PASS FILTER BOARD (MODULE 5).

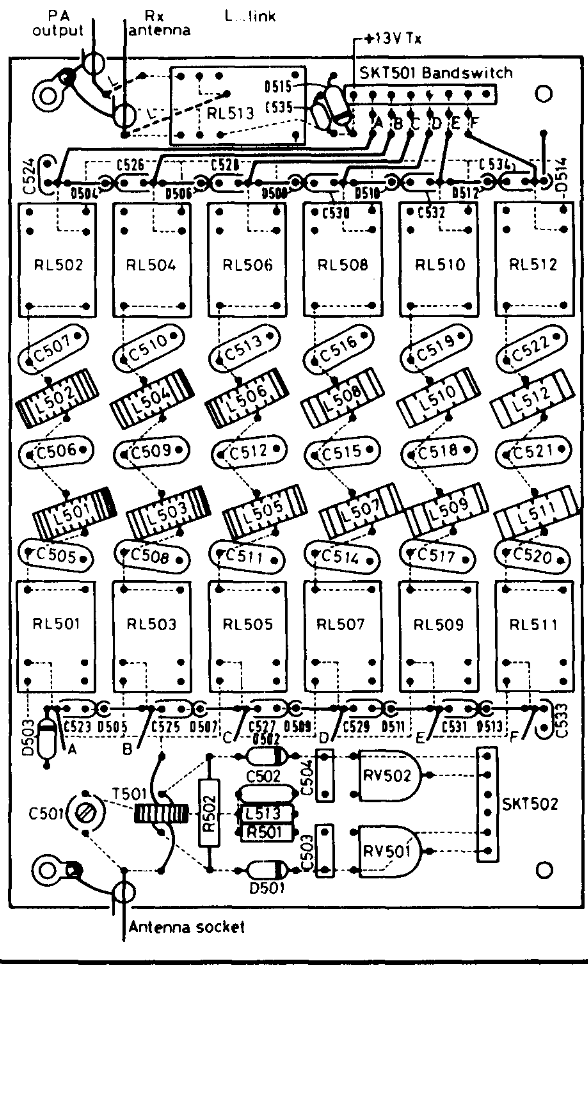


FIG 17. COMPONENT PLACEMENT FOR THE LOW PASS FILTER.

MODULE 6		
R601	5.6k	
R602,616,612,	33k	
R603,606,609,610	1M	
R604	3.3k	
R605	22k	
R607	100k	
R608,614,620	10k	
R611,617,618	47k	
R813	1k	
R615	390R	
R619	220k	
VR601	47k preset	
VR602	10k pot lin	
C601,602,603,605		
606,608,610,611,612		10nF C
C604		0.22µF T
C607		1µF T
C609		10µF T
IC601	MC3401 Watford Electronics or (LM3900)	
TR601	BC109	
D601–606	1n914	
D807	LED	
D608	10V zener	

rating to aim at is two amps. All relays must be shunted by diodes to prevent switching transients and all relay supplies and switching lines must be decoupled to prevent rf pickup.

TESTING AND ALIGNMENT

No alignment of the filters is necessary if they are constructed correctly. A dc path should be checked through each filter when the appropriate relays are activated and the signal path should be checked through the ant. change-over relay. When connected to the bandswitch the lpf relays should operate on changing bands. If power is removed from the board all relays drop out and there is an open circuit across the lpf unit.

The swr unit must be balanced before it can be used, the antenna input should be terminated with a 50ohm dummy load and a transceiver capable of 10W output should be connected to the input of the bridge. C507 is adjusted to null out the voltage appearing at the ref alc terminal. In some cases it may be necessary to reverse the fwd and ref connections – this will become apparent if the voltage cannot be dipped or nulled. Calibration of the swr meter is a matter of personal choice, however. The meter used has a power scale below the S-meter scale and it was convenient to set the fwd scale for 25 watts fsd. The Rev scale can be made more sensitive if required as the alc system will not allow excessive reverse power to appear.

THE PA UNIT

The pa unit is not given a module number as it is purchased as a complete kit from Cirkit Holdings at a price in the region of £28 + VAT. It comes complete with all components, pcb and full assembly instruction.

The output of IC401 is capable of directly driving the pa to an output of at least 20W on all bands, including 1·8MHz where the drive requirement is slightly higher owing to reduced pa efficiency.

Transmit control of the pa is achieved by switching the 13V bias rail to the two bias regulators while leaving the amplifier connected permanently to the 13V rail.

After some months of operation two minor modifications became necessary. The two 100ohm pa feedback resistors R13 and R14 should be increased to 1W rating as they are prone to overheating. It was also discovered that the pa bias was slow to stabilise when switching to transmit, with the result that the first few words were distorted and the pa was found to be almost in class C. This is easily cured by changing R18 in the bias circuit from 10kΩ to 6k8 giving better regulation.

Since building the transceiver a number of Yaesu 100W pa units have appeared on the market as upgrade kits for the FT107, FT707 and FT77 low power models. They are capable of being driven directly from the IC401 and are ideal for the modular transceiver.

MODULE 6: ALC UNIT

Alc is essential on a multiband transceiver to ensure a constant output power on all bands and to prevent excessive overdrive on some bands. It can also provide swr protection by reducing the drive level at a predetermined swr.

PA MODULE
Cirkit 1.6–30MHz HF PA Kit Pt No: 41-00903

MAIN CHASSIS		
R1,2,3,4	10k histab	
R5,6	1k	
R7,8,9,	1M	
R10	8.2k	
RVO1	10k lof AF gain	
RVO2	10k lin IRT	
RVO3	25k preset	
C1	1000µF 25V	
C2–8,11,	10nF C	
C9,10	47nF C	
C12	100pF C	
C13	1nF C	
C14	10µF T	
D1	1N4001	
D2–13	1N914	
LEDs x 3		
FBX	3tFX1115	
FB	3t 26–43006301 Fairite	
S1	SPCO	Fwd/Ref
S2	DPCO	Nor/Inv
S3	SPCO	RF amp on/off
S4	DPCO	IRT on/off
S5	DPCO	Power on/off (to cary 5A)
S6	Yaxley 2 wafers 1 pole 11 way	
IC1	7808 Reg	
IC2	CA3130 meter amp	
Meter	200µA 'S' Meter CIRKIT	
Plugs and sockets as required.		

The alc unit is self-contained and uses a single ic, IC601, which can either be a Motorola MC3401 or the more common LM3900 Quad Norton current comparator. Fwd current from the swr unit is fed via R605 (Fig 18) to IC601b where it is compared with a reference current derived from RV601 through R607. The reference current will determine the alc threshold or maximum gain of the transceiver. If the output level starts to exceed this level the comparator will produce an increasing voltage at the output of IC601b which is fed via a time constant circuit providing a rapid attack and slow decay to IC601c operating as a buffer amp. The output from IC601c is a dc bias which can be used directly to control the gain of IC401 on module 4. An increasing voltage on the alc line reduces the gain of the SL610 and holds the transceiver output power at the level set by RV601. Output from the alc unit is summed with a dc bias obtained from the manual drive control by diodes D604,606 and permits the drive control to overide the alc in turn allowing power reduction from the maximum level set by the alc threshold down to about 100mW.

Reverse alc is provided by IC601a which amplifies the rev current obtained from the swr unit and sums it with the fwd current fed to IC601b. The result is that any reflected power will cause greater alc action than that produced by forward power and the output level will be reduced as long as the high swr condition exists. The threshold level for reverse alc action is controlled by the gain of IC601a which can be altered by changing R601.

The fourth stage of the Norton Amp IC601d is used to feed external alc from a linear amplifier into the alc unit in order to control the total system gain. It is designed to take negative-going alc voltages and is compatible with most

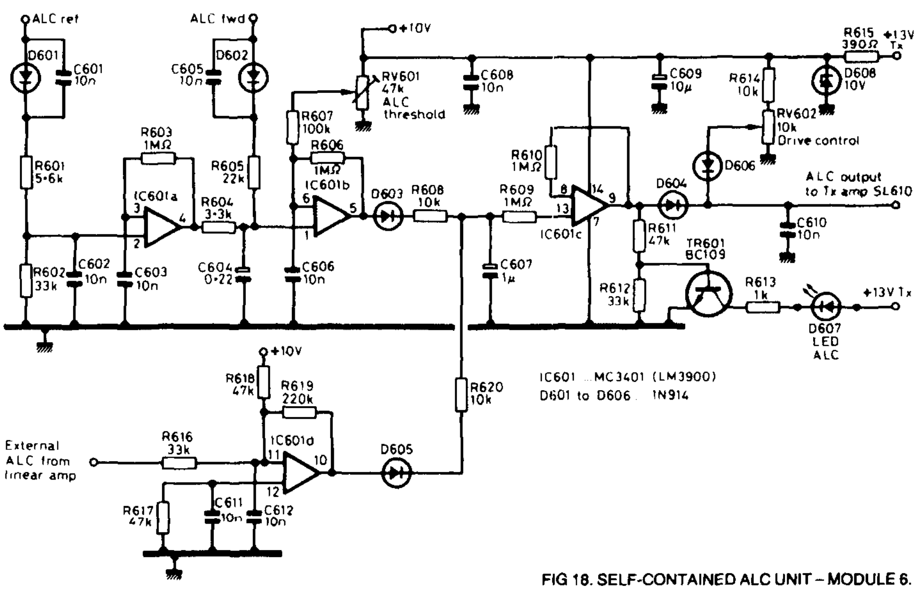


FIG 18. SELF-CONTAINED ALC UNIT – MODULE 6.

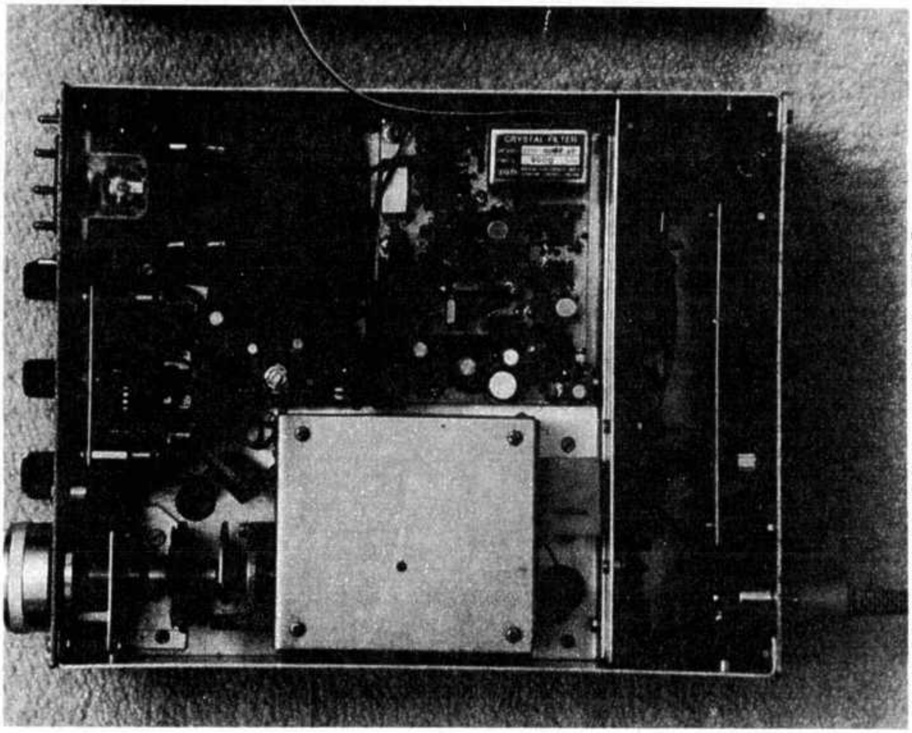
valve linear amplifiers. If not required, this stage can be omitted. The alc range required by the SL610 is from 2V to about 4·5V with maximum gain occurring at 2V or below.

CONSTRUCTION AND TESTING

The alc unit is constructed on a glass fibre single-sided pcb measuring 2·4″ × 3″ (Figs 19, 20). Testing the unit is difficult without the rest of the transceiver and should be completed when everything else is working. With the transmitter producing about 10W into a dummy load and the alc unit in circuit it should be possible to adjust RV601 to a point where the output power starts to reduce. This should also coincide with the illumination of the alc led. If this works, increase the manual gain or drive level for maximum output. The output power should remain at the level preset by RV601 which can now be adjusted to the desired maximum output level – 18 to 20W is ideal for the Cirkit pa unit. When the transmitter is talked up on ssb, the speech peaks will illuminate the alc led but the output should not exceed the preset level. If the alc led illuminates permanently, it is an indication that the transmit gain is a little high and the drive control can be used to reduce the gain to a point where the alc action produces a flickering led.

Reverse alc may be checked by increasing the swr by inserting an atu between the output and the dummy load. As the swr is increased so the alc action will rapidly increase and reduce the power output level.

The manual drive control will simply reduce the power from the maximum set by the alc threshold down almost to zero making QRP operation a simple matter and ideal for tuning up an antenna. The alc led will not function when the power is reduced manually as it only indicates when the alc unit is controlling the output level.



TOP VIEW SHOWING MODULES 1, 2, WITH 5, 6 AND PA AT REAR

MAIN CHASSIS

All modules have been housed in an aluminium chassis which serves as a convenient frame as well as providing an element of screening and heatsinking. Fig 21 illustrates the chassis wiring required to interconnect the modules, plus the associated switching functions.

Bandswitching is achieved with a two wafer Yaxley type switch employing two one pole 11 or 12 way wafers with break before make contacts. The rear wafer should be sited close to module 3 where it directly switches the various xtals into circuit. Lead lengths should be kept as short as possible to minimise stray capacitance. The front wafer is used to switch the 13V rail to the various circuits that require bandswitching using multiway ribbon cable via a small junction pcb. This can be fabricated from a strip of Veroboard or be specially made. All switching lines are decoupled to ground at the junction pcb and the various multiway cables are connected to the respective modules using a simple plug and socket system.

The vfo is housed in a metal enclosure which must be securely fastened to the main chassis and tuned with a suitable slow motion drive with a reduction ratio of at least 60:1 for smooth tuning. Either a mechanical dial or a digital frequency counter can be used to display the operating frequency.

An enormous range of possibilities exist for the layout of the transceiver. It can be large to accommodate additional modules and future modifications or miniature if that takes your fancy. My own transceiver was made 9·5″ wide, 3·5″ high and 12·5″ deep, making it ideal for portable working and still smaller than any multiband commercial transceiver. Location of the individual modules is not likely to be critical provided a sensible approach is adopted. the pa unit ideally should be mounted on the rear panel where heat sinking is relatively easy to arrange. A 2·5″ × 4″ × 0·5″ finned heatsink has proved more than adequate and barely runs warm in ssb operation. The lpf unit should also be located near the rear of the unit and should be screened from the remainder of the transceiver.

CONCLUSION

The modules described were originally built in

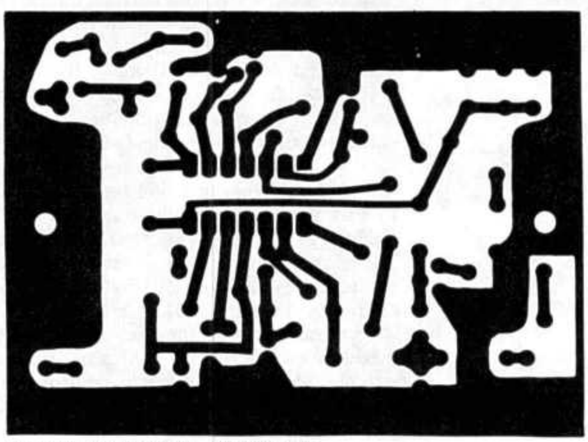


FIG 19. ALC PCB DESIGN – ACTUAL SIZE.

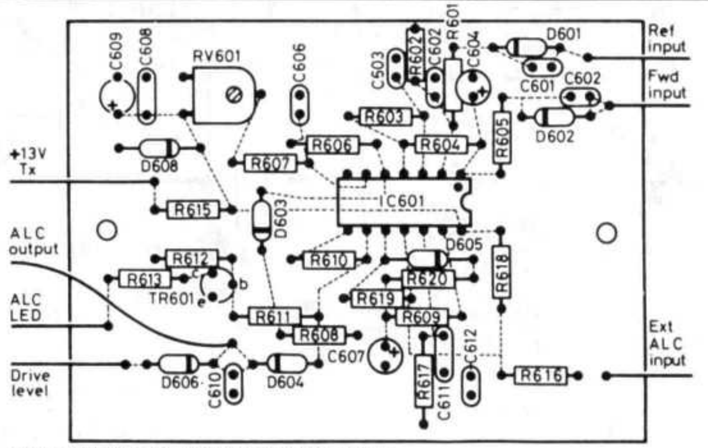


FIG 20. COMPONENT LAYOUTS FOR THE ALC PCB.

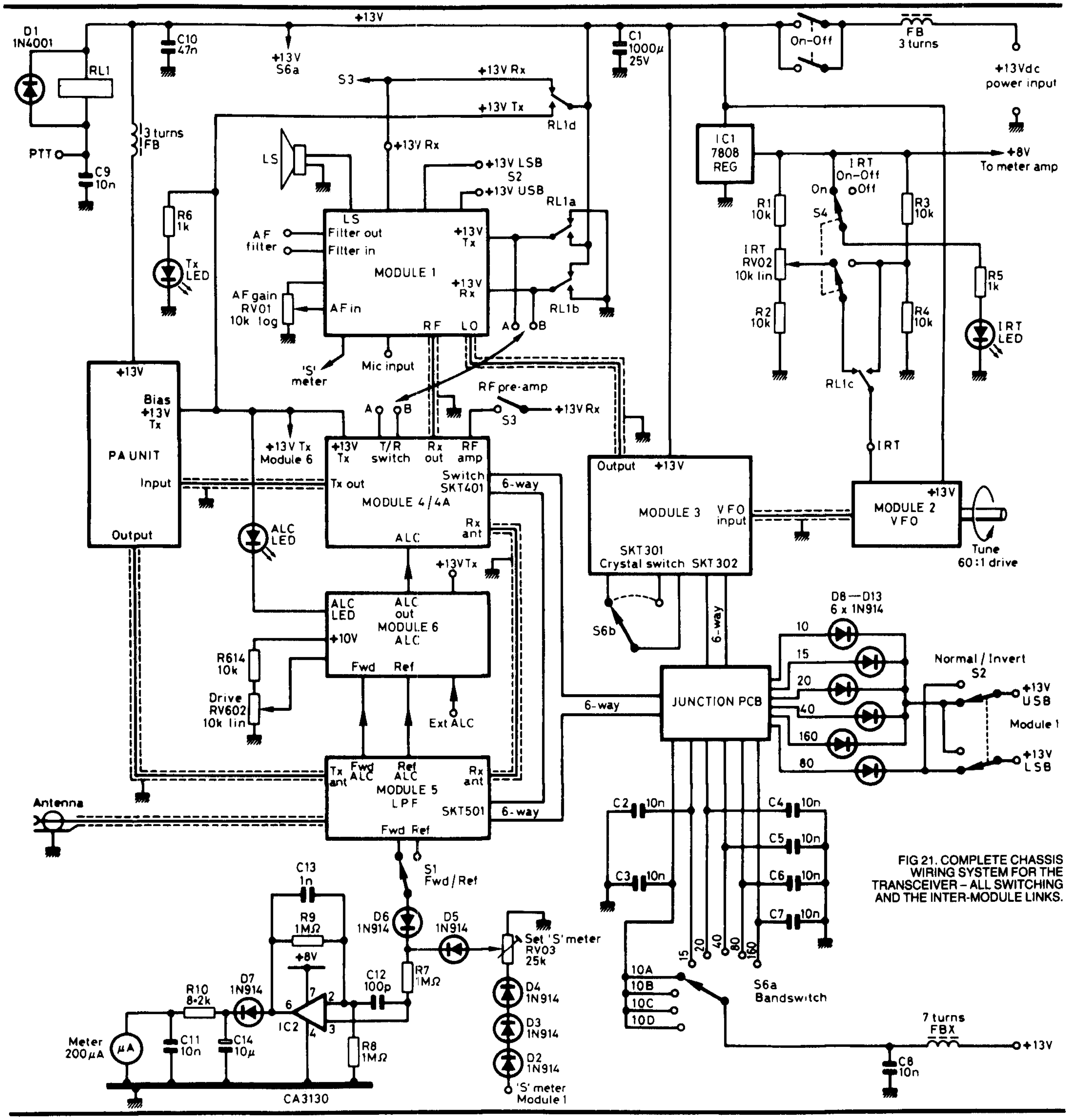


FIG 21. COMPLETE CHASSIS WIRING SYSTEM FOR THE TRANSCEIVER – ALL SWITCHING AND THE INTER-MODULE LINKS.

an attempt to produce a home-constructed multiband amateur transceiver without overcomplication. The results achieved have been far better than originally expected and the home made transceiver is now used in preference to my commercial one. No sophisticated test equipment was used for testing or alignment, but access to a dfm, signal generator and a vvm or oscilloscope is necessary.

The G4CLF module has been built by the author for three separate designs and has performed well in each. The new design of pcb produced an exciter unit that is much easier to duplicate than the original and has now been successfully copied by four other amateurs.

Each module was constructed and tested independently before final assembly. This was initially done in breadboard form to make sure that it all worked. The chassis was also home constructed and scaled up from the earlier 1·8MHz single band unit. G2CKM has faithfully followed my design and produced a very similar transceiver; this has provided much useful feedback including verification of the circuit diagrams and component lists.

Additional features may be added to the basic transceiver to suit personal preference and may include such items as a digital frequency counter, speech processor, audio filter, cw sidetone and keying unit and a variety of other add-ons.

No great originality is claimed for the circuitry which has evolved from studying numerous commercial manuals as well as the *ARRL Handbook*. All I can claim is success in making it all work. Hopefully I can inspire others with a little less confidence to have a go at building something that will become their pride and joy for a long time to come.

Introduction of JAS-1b

By JARL

Three years have passed since Japanese amateur satellite JAS-1 or Fuji-OSCAR 12 was launched, on August 12, 1986, UTC. And we believe that many radio amateurs over the world have enjoyed QSOs via FO-12. Recently, however, degradation of power generation has gradually progressed, so a normal operation of FO-12 will become difficult in the near future.

The remarkable feature of FO-12 is the operational mail-box capability, which can be used by every station having packet radio equipment. More than two hundred and fifty stations in more than twenty countries have exchanged their messages through space BBS, and receive-only stations may amount to more.

JARL is now intending to launch another satellite of the same configuration to succeed the communication system FO-12 has already established.

Here, we will introduce the next bird, named JAS-1b.

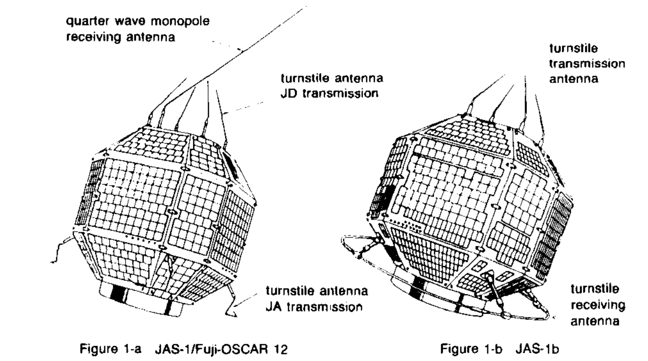


Fig 1—External appearances of two birds.

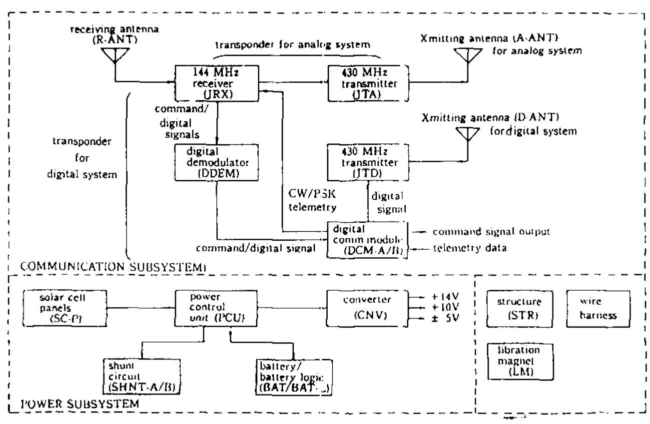


Fig 2—Block diagram of JAS-1b.

System Configuration and Specifications

Dimensions

JAS-1b measures 44 mm across and 470 mm in height and, as with FO-12, has 26 polyhedral faces. These dimensions are the same as FO-12, except that Fuji measures 400 mm across. Both JAS-1b and Fuji weigh about 50 kg respectively. Fig 1-a and 1-b show their external appearances.

Modifications to JAS-1b are proceeding smoothly and according to schedule, and the JARL Lab began preparing equipment for testing the satellite at the Tanegashima Space Center.

Although the external width of JAS-1b is 40 mm greater than that of Fuji/FO-12, overall the two satellites have approximately the same dimensions.

The system configuration can be broadly divided into three parts: the communications/operating system, the power supply system, and ancillary components as shown in Fig 2. The communications/operating system includes the analog transponder, the digital transponder, both in mode J, and the antennas. The power supply consists of solar cell panels, nickel cadmium batteries, and devices for managing charging and discharging of the batteries. The satellite case and wiring harnesses are included together with the ancillary components.

JAS-1b Specifications

Launch and Orbit

1. Launch (scheduled)
   Time: February 1990, day is not fixed
   Launch Vehicle: H-I (2-stage) rocket
   Launch Site: Tanegashima Space Center, National Space Development Agency of Japan (NASDA)
2. Orbit (planned)
   Type: Slightly elliptical polar orbit with 900 km perigee
   Period: 106 minutes
   Orbital Inclination: 99 degrees

Satellite Specifications

1. Dimension
   Size: 26-face polyhedron measuring 440 mm across and 470 mm in height
   Weight: Approximately 50 kg
2. System Configuration
   Analog and digital transponder in mode J (144 MHz uplink, 430 MHz downlink)
3. Attitude Control
   Satellite attitude will be maintained by using the torque generated by interaction of two permanent magnets with the earth's magnetic field.
4. Thermal Control: Passive control using paint and thermal insulation
5. Planned Service Life: 3 years

System Specifications

1. Beacon and Telemetry
   JA Beacon: 435.795 MHz nominal frequency, frequency, approximately 100 mW power, CW or PSK (also capable of A0 [NØN] transmission)
   JD Telemetry: 435.91 MHz nominal frequency, approximately 1 W power, PSKeyed packet
2. Telemetry
   CW Telemetry: 12 analog data items, 33 status items
   PSK Telemetry: 29 analog data items, 33 status items
3. Commands: Equipped with real-time program command function
4. Transponder
   Frequencies and modes are similar to those of FO-12. The analog system (JA) consists of an inverted heterodyne

transponder, a bandwidth of 100 kHz operating mode J, uplink 145 MHz and downlink 435 MHz.

The digital system (JD) functions as a mailbox using the AX.25 link level protocol. Stations currently using FO-12 will be able to use JAS-1b without any modifications to equipment.

(1) Analog System Transponder

Type: Linear translator, with inversely heterodyning
Uplink Passband: 145.9 to 146.0 MHz
Downlink Passband: 435.9 to 435.8 MHz
Transmitter Output: Approximately 1 W PEP
Bandwidth: 100 kHz (3 dB bandwidth)
Uplink EIRP Required: About 100 W

(2) Digital System Transponder

Type: Store-and-forward packet communication, using AX.25 link level protocol
Uplink Frequencies: (1) 145.85 MHz (2) 145.87 MHz (3) 145.89 MHz (4) 145.91 MHz
Bi-phase Manchester code, on FM signal, with a bit rate of 1200 bit/s
Uplink EIRP Required: About 100 W
Downlink: 435.91 MHz/NRZI/PSK, 1200 bit/s
Transmitter Output: About 1 W

(3) Voltage Converter

Bus Voltage: +11 to 18 V (14 V average)
Regulated Voltages: +10 V, +5 V, −5 V
Efficiency: Better than 70%

(4) Power Control Functions

Bus voltage upper limit control (full-shunt type) and UVC function to disconnect load when battery terminal voltage drops.

5. Antennas

144-MHz Receiving Antenna: Ring turnstile antenna mounted at bottom of side panels
435-MHz Transmitting Antenna: Turnstile antenna mounted at the top of satellite (shared by analog and digital modes)

	Polarization	Gain
Receiving Antenna (R-ANT)	Circular polarization	+0.5 dBi max
Transmitting Antenna (T-ANT)	Circular polarization	+4.0 dBi max

6. Power Supply

(1) Solar Cells (planned)

Cell: Gallium arsenide
Size and Quantity: 2 ×2 cm^2 and 1 × 2 cm^2, over 1300 cells
Power Output: More than 10 W, (BOL)

(2) Battery

Cell and Quantity: 11 series-connected NiCd cells (rectangular)
Capacity: 6 Ah

Orbit and Major Modifications

Plans are being made to modify and launch the JAS-1b satellite, which was constructed as a backup for FO-12 and has been maintained on the ground since the launch of FO-12.

The National Space Development Agency of Japan (NASDA) is scheduled to launch the Maritime Observation Satellite MOS-1b on an H-I rocket (2-stage) from the Tanegashima Space Center in February, 1990. JARL has requested that JAS-1b be launched along with MOS-1b.

Here is an introduction to the JAS-1b orbit as well as the major modifications that have been made to the satellite since JARL's decision to launch.

Orbit of JAS-1b

MOS-1b is intended to study oceanographic resources, and

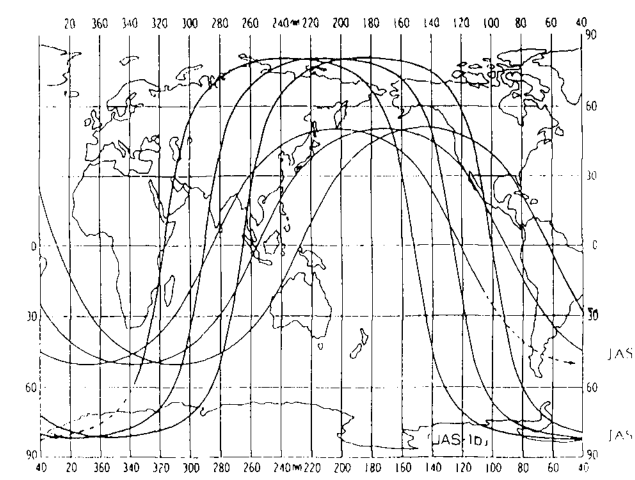


Fig 3—Orbit of JAS-1 and JAS-1b.

to observe agricultural and environmental conditions using three types of sensors: Two infrared radiometers and a microwave radio meter. Accordingly, the satellite will be inserted into a sun-synchronous orbit at an altitude of 900 km and an orbital inclination of 99 degrees. In this orbit, the satellite will pass over a given parallel of latitude at approximately the same times each day. Passing near the north and south poles, the track of the satellite will shift westward by a fixed amount during each orbit, with total shift returning the satellite approximately to its original track on every 17th day. This orbit is very suitable for maritime observations.

However, if JAS-1b is on this orbit, the sun is eclipsed by the earth during about 33 percent of each orbit. Since the orbital period is about 103 minutes, power can only be supplied by the solar cells for about 69 minutes. During the remaining 34 minutes, power must be drawn from the nickel-cadmium storage batteries on board.

For JAS-1b, which is small and has limited electrical generating capacity, this is not a preferable orbit. Accordingly, consideration is being given to obtaining a more favorable period for power generation by raising the apogee of orbit of JAS-1b by several hundred kilometers over that of MOS-1b, and thereby making the orbit slightly elliptical.

JAS-1b has no thruster and thus is not capable of changing its own orbit. However, extra thrust could be obtained by burning the fuel remaining in the second stage of the H-I vehicle after separation from MOS-1b.

For example, raising the apogee by 300 km to 1200 km would, about 150 days after launch, result in a drop in the eclipse rate (ratio of eclipsed time to the orbital period); then, from about day 300 to day 470, the satellite would be in a period of no eclipse. During this period, the power condition of the satellite would be improved, and it would be capable of continuous operation for extended periods of time.

The orbits of Fuji and JAS-1b are shown in Fig 3.

Gallium Arsenide Solar Cell

Fuji has 979 silicon solar cells, each measuring 2 × 2 sq-cm, which produce an average of 6.5 W total power (at the beginning of life). At this level, continuous operation of the digital system is not possible because the system draws power from the storage batteries even when the satellite is in sunlight.

With JAS-1b, greater power generating capacity will be provided by using gallium arsenide solar cells, which have a higher conversion efficiency than that of the silicon cells used on Fuji, and by increasing the size of the satellite to enlarge the effective surface area slightly that accommodates more number of cells than that of FO-12. The satellite will be outfitted with about 900 cells measuring 1 × 2 cm^2, and with about 630 cells measuring 2 × 2 cm^2. The result is an increase in power-generating capacity to about 11 W (at the beginning of life). With this capacity, the CPU memory will be able to operate continuously even with an eclipse rate of 33 percent. Further, the transmitter can be operated at appropriate time intervals.

This will also make it possible to entrust a certain amount of satellite function management to the satellite's on-board computer.

Fuji-OSCAR 12 has 979 pieces of 2 × 2 cm^2 silicon solar cell, which generated the average power of some 6.5 W at the beginning of life, which is not enough for continuous operation of the transponder. Two resting days were necessary in a week at the initial phase for JA operation, and more rest was required for JD operation that was released later.

JAS-1b intends to keep continuous operation of JD, which requires more power than that of FO-12, so the following two items were considered: (1) To enlarge the surface of the bird for more solar cells to be stuck on, and (2) to replace the silicon cell with a gallium arsenide (GaAs) cell to increase conversion efficiency. These may result in output power of more than 10 W on average. GaAs cells have other characteristics, such as (1) more protective against radiation than silicon cell; (2) degradation of efficiency at high temperature is about ⅓ of silicon; (3) heavier than silicon; (4) easy to break, and so on.

One important factor of solar cells for satellite use is their thermal characteristics. Absorption and emission of radiation energy controls thermal condition inside the satellite, and in case the whole surface is covered with solar cells, like JAS-1b, the ratio (a/e) of absorptive (a) and emissive (e) coefficient of the cell becomes decisive of temperature inside the satellite. The temperature of the satellite increases when the ratio of absorption and emission is larger than unity, and vice versa.

JAS-1b carries a pack of NiCd storage batteries whose operating temperature should be between 0 and 40 degrees, which requires effective ratio (a/e) of around 0.9, so it is necessary to adjust the ratio of the cell by selecting cover glass and its coating.

The shape of the bird is a polyhedron with 26 faces, like a sphere. If all cells are mounted on the whole surface of the bird, power generation will be uniform by its direction. But there is a portion called "coupler" which couples with the rocket, where no cells can be placed. Therefore, the relation between the total power generation to solar incident angle is like Fig 4. Attitude of the bird will vary randomly due to the small torque provided by small magnets and geomagnetism.

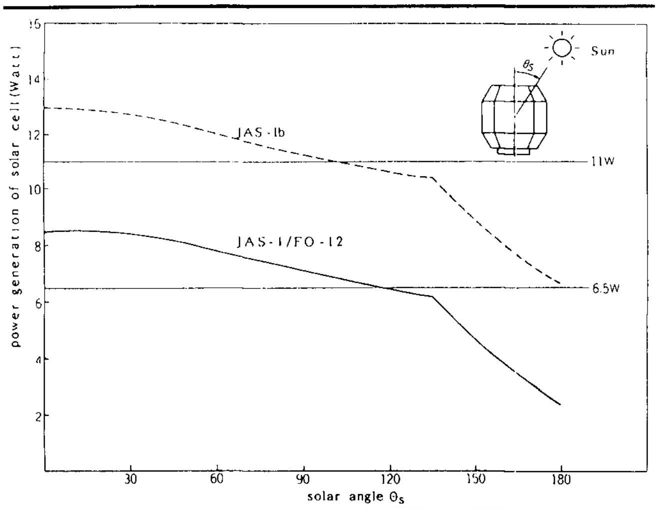


Fig 4—Power generation and solar angle.

FO-12 at present generates less power than it did in the first year. There are several days of very small power generation, due to "coupler" facing toward the sun, because of very slow variation of attitude. And gradual degradation of cells perhaps due to radiation in space will be another cause.

Antenna

One of the major differences between JAS-1b and Fuji/FO-12 lies in the antenna system.

The slanted monopole receiving antenna used on Fuji is fairly directional, meaning that in some attitudes the satellite does not receive the uplink signal well. With JAS-1b, a ring-type turnstile antenna is used for uplink receiving. This makes antenna directivity rather smooth and assures a more stable uplink signal from ground stations. For transmitting, the digital and the analog systems have their respective transmitting antennas, on Fuji; however, on JAS-1b, the analog and digital systems will share the same transmitting antenna. This has resulted in the addition of a hybrid circuit (HYB) and phase shifters, instead of two antenna power dividers and two sets of transmitting antennas.

Antennas of FO-12

FO-12 has a quarter-wavelength monopole antenna affixed to the top of the spacecraft for receiving on the 144-MHz uplink. In contrast, the 430-MHz downlink used two sets of turnstile antennas, one on the top of the spacecraft and one on the bottom, as shown in Fig 1-a.

The satellite has two transponders, one for analog communications (JA) and one for digital communications (JD). The output signals of the transponders are radiated by the analog transmitting antenna and the digital transmitting antenna, respectively. The turnstile antenna on top of the satellite is the one used for digital transmission. The elements of the antenna used for analog transmission are bent due to restrictions related to mating of the satellite to the launch vehicle.

The manner in which the antennas are used during satellite-ground communications is as follows:

The directivity of the receiving antenna is as shown in Fig 5. The pattern shown is highly pronounced, with the gain of about −30 dB from the front to the side. When one of the dips in the pattern is directed toward a user ground station, the uplink signal of that station cannot be detected by the satellite at the power levels ordinarily used. Fortunately, the attitude of the satellite does not remain constant with respect to the user station, so the dip will not be directed toward the user indefinitely. Nevertheless, effective communications through the satellite can be difficult or impossible at times.

Also, since the antenna is linearly polarized, reception is difficult if the user's antenna is linearly polarized and happens to be oriented at right angles to the direction of polarization of the antennas on the satellite.

In short, the strength of the signal received by the satellite is extremely small when a dip is facing the user or two linearly polarized waves are at right angles to each other. While this may not prevent making short contacts in the analog mode, together with increased errors due to ground interference it generally precludes digital communications, such as packet, altogether.

Receiving Antennas on JAS-1b

On JAS-1b, the following plan was developed for obtaining a more omnidirectional receiving pattern.

1. Using turnstile antennas with circular polarization for receiving.
2. Eliminating the transmitting antenna for mode JA and leaving only that for mode JD. In this case, both modes would share the same transmitting antenna.
3. Installing a receiving antenna in place of the eliminated mode JA antenna.

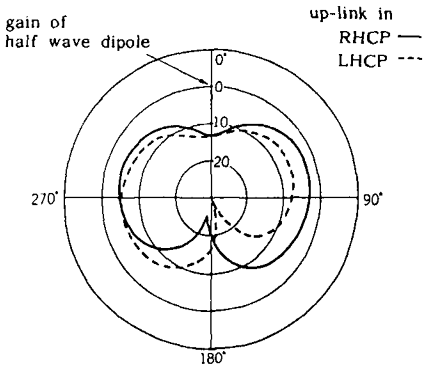


Fig 5—Directivity of receiving antenna of FO-12.

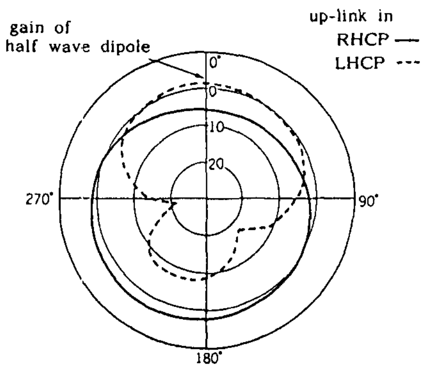


Fig 6—Directivity of receiving antenna of JAS-1b.

For the new antenna system, tests were performed to check the actual characteristics. A full-scale model was constructed, antennas were attached and measurements were made in an electromagnetically shielded anechoic chamber.

Fig 6 shows the pattern of the receiving antenna. If a transmitting antenna of the user station is circularly polarized, a pattern is fairly good unless directly facing the receiving antenna with circular polarization in the opposite direction. The dips are also much less pronounced, allowing good access even when the uplink signal is linearly polarized.

Transmitting Antenna of JAS-1b

A rat-race circuit was applied to allow the JD antenna from the original design to be shared by both JA and JD. Since these circuits fit neatly into the place left upon removing the old JA/JD antenna dividers, it was not necessary to change the internal structure of the satellite. The resulting external appearance of the satellite is shown in Fig 1-b.

The tests also confirmed that the pattern of the transmitting antenna system is more omnidirectional than was the case with the former JD antenna. This is attributed to removal of the monopole receiving antenna. Due to the structure of the hybrid circuit which allows the two systems to share the antenna, JA and JD are oppositely polarized.

User Station Antennas

With the new satellite antennas, the best antenna configuration for user stations is the one which allows selection of either left-hand or right-hand circular polarization on both the uplink and the downlink. In this case it is necessary to know how the bird is polarized for good operations. When JA is received in RHCP, then uplink should be RHCP. And so JD is LHCP.

Ordinarily, transmitting and receiving should also be easily accomplished with linearly polarized antennas, and this is preferable when the bird changes its attitude quickly. However, problems could result in the rare event that the planes of polarization of the satellite and user station signals are oriented at right angles to each other.