AN ARGUS SPECIALIST PUBLICATION

OCTOBER '83

HAM RADIO TODAY

morgan

90p

GO FOXHUNTING ON 2M!

Get in tune to this fast growing radio sport

- How to direction find using a simple beam or dipole
- How to organise a DF hunt
- How to build a simple DF receiver

PLUS: –

OMEGA: THE ULTIMATE PERFORMER!

- Synthesised all-band VFO
- Sensational performance
- For use with Project Omega, G3ZVC, G4CLF and other IS systems

HAM RADIO TODAY

CONTENTS

VOLUME ONE NO. 10 OCTOBER 1983

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REGULAR COLUMNS

CONSTRUCTION

FEATURES

REVIEWS

LETTERS

Please address correspondence to:
Ham Radio Today, 145 Charing Cross Rd, London WC2 0EE.

SLAPPED WRIST

Frank, Don't get political and start printing view points which have been slanted to provide a platform for non-radio viewpoints, please. P Thompson sent a letter, condemning the patron of the RSGB, for his views on the nuclear issue, which is to my mind too tenuous a connection to be worthy of printing. Next it'll be a condemnation because he doesn't specify free-range eggs at his breakfast, or wear Gay-Lib badges or suchlike. Keep it relative: if he makes comments — or anyone for that matter — directly involving radio, print them and be blessed by all, but don't let non-radio viewpoints or bias sully your pages, however clever the hidden intent. Our magazine is called 'Ham Radio Today', not 'Letters which must mention the word radio at least once'.

BRIAN EWING G6UBB

SUGGESTIONS

Sir, Thank you for an excellent magazine with just the right amount of technical articles written in a readable manner.

I would like to see a series on the Trio *TS520/520S/520SE* TX/RX which had a seven year production run. I thought your *Upgrading the KW2000* was very good.

Any thoughts on a 29MHz linear transistor (and valve!) for the FM mode? As an add on to the popular CB conversion rigs and perhaps conversion details of suitable rigs like the Icom IC8 1050, D.N.T. and Multimodes.

Finally an article on 28-29MHz band with a detailed list of all beacons, repeaters with frequencies and band plans.

I look forward to future issues, good luck.

E McLEAN GM4EWM

EDITOR: A WALLY?

Sir, I regret I must take you to task over your comments at the start of the Azden *PCS 4000* user view.

I have many interesting QSOs on 2m FM and SSB and listening on the band I do not agree with your comments about the bands being an extension of the CB bands.

I quite often learn things by having QSOs even after many years on the bands. I find 2m very interesting and there are many things that can be learnt about propagation.

There are a lot of ex-CB operators being licensed in this area and I think they make very good radio amateurs.

If the RAE is so easy why do so many fail?

Another thing I found out last Sunday was that I could have a QSO on 2m with my *FT208* handheld with rubber duck aerial at a distance of 50 miles. I was very pleased with this result.

G E R DENMAN G3MEW

WALLIES

Frank, I am one of the many people who operate 27MHz SSB, legal or not. This isn't what compelled me to write. Brian A Carter G8ADD is the reason and many more of the same fraternity. Why should a guy with the brains he is supposed to have resort to "Pathetic Wally" when referring to SSB CB users. Okay, I admit there are quite a lot of 'Wallies' on SSB CB but not all of us are in that category. There are quite a lot of us that are very serious in our 'DXing'. I myself have had QSOs all over the world using 12W, and found it very exhilarating to be able to obtain a QSL card from Indonesia going the long way around.

I was one of 7700 who bothered taking the RAE on May 16 but if this guy and others like him are the sort of people I'm liable to meet then I won't even send for my ticket. At least SSB CBers don't 'blank' out repeaters for hours on end on purpose. And does G8ADD realies that quite a lot of interference on 27MHz is caused by . . . 'Hams' Amateurs?

HARRY M C HALL

VISITING MALTA?

Sir, I would like to draw the attention of your readers that, if anyone intends to visit the Island of Malta, the MARL Amateur Radio League of Malta will extend a big welcome to them.

The club is situated in the central part of Malta, a village called *Attard*, and the meetings are held on Tuesdays and Thursdays from 10.00 to 20.00hrs and on Sunday mornings from 10.00 to 12.00hrs.

Further information will be given to anyone interested from the secretary:— Mr Walter A Gatt, 9H1DU, Box 575 Valletta, Malta.

Your journal is getting more popular amongst our members.

W A GATT 9H1DU

SPEECH PROCESSORS

Sir, In view of your article on 'Speech Processors', may I make an appeal through the columns of your excellent mag.

Twenty years ago, the AM and SSB protagonists argued the case between the two modes — SSB won after a period of 'cleaning up'. Today, we are in a similar situation of cleaning up or (trying to) as the new argument exists between processor users and those who will never use one. History will prove the processors will win, but, please, if you insist on greater talk power, then use it wisely and with responsibility.

The indiscriminate use of the SP is noticed too often when on many occasions it is totally unnecessary. Typical is *5 & 9 Plus* both ways with processors. To educate the use of the SP would be almost impossible. So many rigs have different mic/mod characteristics. Just a brief listen will confirm an equal number of undermod to overmod signals so there are times when an SP becomes a useful mic amplifier but too many times it becomes an overdriving, distorting, band spreading, anti-social, ALC thumping, indiscriminate, obnoxious, TVI generating, ego building, bottle bashing or transistor terminating, switch-off condition, menace.

Listen on 20m and hear the *3 & 9 +20* brigade, that's right *3 & 9 +20*. Don't hesitate to give such a report, but make it very short. Makes 'em think!

GEORGE CLARVISON G3RHM

RAYNET GOES CB?

Editor, I see from *Cycling* that *REACT* and ambulance men using CB radios, and off-duty policemen helped at the Great Bike Ride to Brighton recently. According to RSGB News, *RAYNET* and radio amateurs had this job with several fixed base stations on high ground between London and Brighton.

I wonder which is right or did *REACT*

" . . . We're very keen conservationists, — won't even use the limiter on the Woodpecker . . . "

and *RAYNET* work together as they did in some areas during the Great Snowstorm some years ago?

Possibly Home Office refused to let *RAYNET* do the job? Will we fare better under our new bosses, the Department of Trade and Industry? I doubt it unless we are prepared to take action when annoyed!

L S CHASE G8BHT

UPGRADING THE FT200?

Frank, I read your articles with great interest. In fact all of the magazine. I find the reading very entertaining and educational. I have read the articles of upgrading the *KW2000* with some interest. It is an old but good rig and I am sure many of your readers have welcomed this article. Now, how about a follow up on another equally good rig, the Yaesu *FT200.* it was a toss up as to which one I bought. The *FT200* came up first and I am very pleased with it. I can't operate it yet, but I don't intend it to be long before I am licensed to do so. Dah di Dah.

I am waiting for the results of the May exam, so keep your fingers crossed for me.

GORDON CROWHURST

RF SWEEP GENERATOR

Sir, look forward to each month's issue, this month's *Omega* project being especially interesting. I intend building this for my future Class A licence. Must say I would rather the A licence was G1, and not G ZERO!.

Could a good RF sweep generator design be a future project? I have wanted one for a long while but the few published designs I have seen were either too simple or restricted in range, others required 'special' parts and a couple did not seem repeatable! Please consider this request if you would be so kind, low LF to high VHF should cover most requirements, and I have a feeling that quite a few home-brewers would like to build one. Like the *Technicalities* design this month — keep up the good work.

MIKE SHEPHERD G8YZW

Yes, a sweep generator is a useful gadget. The only thing stopping us publishing a design for one is that we don't have a suitable design to hand. Any offers? Money awaits — Ed.

TERRIFIED

Frank Simpson's letter (July) in defence of the RSGB terrifies me! Effective representation of the interests of radio amateurs can never be based upon the idea of "..obtaining concessions from the Home Office.." and it is high time the supposed champions of amateur radio recognised this fact, acted upon it, and stopped filling their collective trousers with terror that some nasty civil servant will revoke all their licences overnight. Good radio men they may be; as politicians they are totally outclassed.

But I might just be wrong.

For a start, Frank, let's have a £10 licence fee and a total rewrite of existing licensing conditions. As you are so confident of the expertise of the RSGB, I should be content to leave the fine points to them for negotiation but the final draft must apply equally to *all UK* transmitting stations and include effective means of preventing violations. It is also an essential pre-requisite that I see some action immediately — no, I don't mean the start of three years of desultory skirmishing prior to the opening of out-of-date talks — I mean the formation of The Radio Amateurs Rights Association which lobbies Members of Parliament, makes a nuisance of itself in the interest of radio amateurs and tells the Home Office what it wants and is determined to obtain.

Otherwise, let's all do our DXing on HF with no age limits, no exams, no licences and no restrictions; then there's no need for the RSGB at all. This approach has the added advantage of solving your problem of alleged prejudice by *Ham Radio Today.*

JG STORRY G4OID

VINTAGE PHONETICS

Frank, As a comparative newcomer to the gentle art of amateur radio, I felt quite proud of my knowledge of the international phonetic alphabet in current use, and also the fact that I well remembered from my service days with the RAF the 'Able Baker Charlie Dog' pronunciations.

I also excelled from those good old CB days in the humourous versions such as Hay for horses, Beef for dinner and Cee for yourself, etc, therefore feeling a certain invincibility during phonetic exchanges on air!

My illusions are now shattered, having been informed by a G3 veteran that amateurs and service personnel also used a phonetic style which has now practically died out and is remembered by only a few...I refer of course to such designations as "Ack-Ar 88" — for that particular receiver, "Ack-Emma" and "Pip-Emma" for morning and afternoon, and lately, just heard on air, the revived Marconi Radio call sign '2MT which comes across as "Two Emma Tock".

Can any reader or magazine staffer please enlighten me and the Radio Malt Club members as to the remainder of this wonderful and vintage phonetic code?

PETER MURRAY G4UBV

OTT

Frankly Frank you have gone OTT with your first comments on page 63, August *Ham Radio Today.* 2m FM is a million miles apart from 27MHz FM. You obviously don't listen to either band. Subject matter is up to the individual, and what you call banal is other amateur's choice. I agree that some radio procedure is suspect, especially for a month or two after new licences are issued *en masse,* ie. March/September, but this normally settles down in Kent anyway. I take it from your comments that you don't like B licencees even though these are the majority of your readers.

Once again the same old arguments about the multi-choice and home brew. Multi-choice is with us to stay Frank, whether you like it or not. What you are really saying is it's not the elite little club it used to be. Many G6s and new G4s do make their own equipment and experiment but you are too biased to notice.

Many new amateurs and future amateurs did, and are, studying very hard (not wiring plugs). Lorry drivers, dustmen, *ordinary working class people,* not only electronic whizzkids and equipment reviewers.

You are far too out of touch to be the editor of a new magazine.

And to my last comments, I don't think even you or many other amateurs are capable of making transceivers 1% as good as the equipment you constantly slag. The word amateurs means what it says, not professional.

I look forward to seeing if you have the bottle to print this.

PETER STONELL G4TLB

Frank, Brilliant. Scintillating. All is forgiven. When I first picked up a copy of *Ham Radio Today* and thumbed through it I exclaimed to myself. 'Oh. not another!'

Your review of the Asden PCS4000 deserves a gold medal, as do your opening remarks. I've been reading the hobby mags since the early thirties and seldom have I read such an honest and outspoken review that does not kow-tow to the manufacturer and/or importer for fear of losing their advertising revenue. Whilst some of your reviews do lack some technical detail, their general excellence is the main reason why I am hooked on *HRT.* But keep up the standard.

Another gold medal for catering for the newcomer wherein the future of our hobby lies. *Radcom* and the RSGB seem not to have realised that the majority of today's hams are relative newcomers and they fail to cater for the G6/8s. I've been frequently criticised for knocking the RSGB, albeit they, as our representative body will contine to have my loyal support. I'd wager that less than half of the class B licencees understand the type of article that is written up in the official journal. Pat Hawker's TT column is probably the exception.

Although licenced since 1946 and active on 80m through 2m, most modes including *Oscar* and RTTY, I freely admit that the best of my technical years are long since passed and there are many G6/8s who know one hell of a lot more about radio than I have known and ever will know. At the other end of the scale the state of the hobby is appalling. Last Sunday I was doing some antenna tests and was told — "You've gone up one on the meter. One dee bee. It says dee bee under the needle". In all other respects, other than radio, this person was most interesting to talk to. A little later a G8 put me right about something I had not understood about a repeater.

The newcomers greatest asset lies in their enthusiasm for this all absorbing hobby. They should be given every encouragement to improve their technical knowledge before and after the RAE. You are doing just that. Congratulations.

V J COPLEY-MAY G3AAG

RADIO TODAY

News about amateur radio compiled by Richard Lamont G4DYA

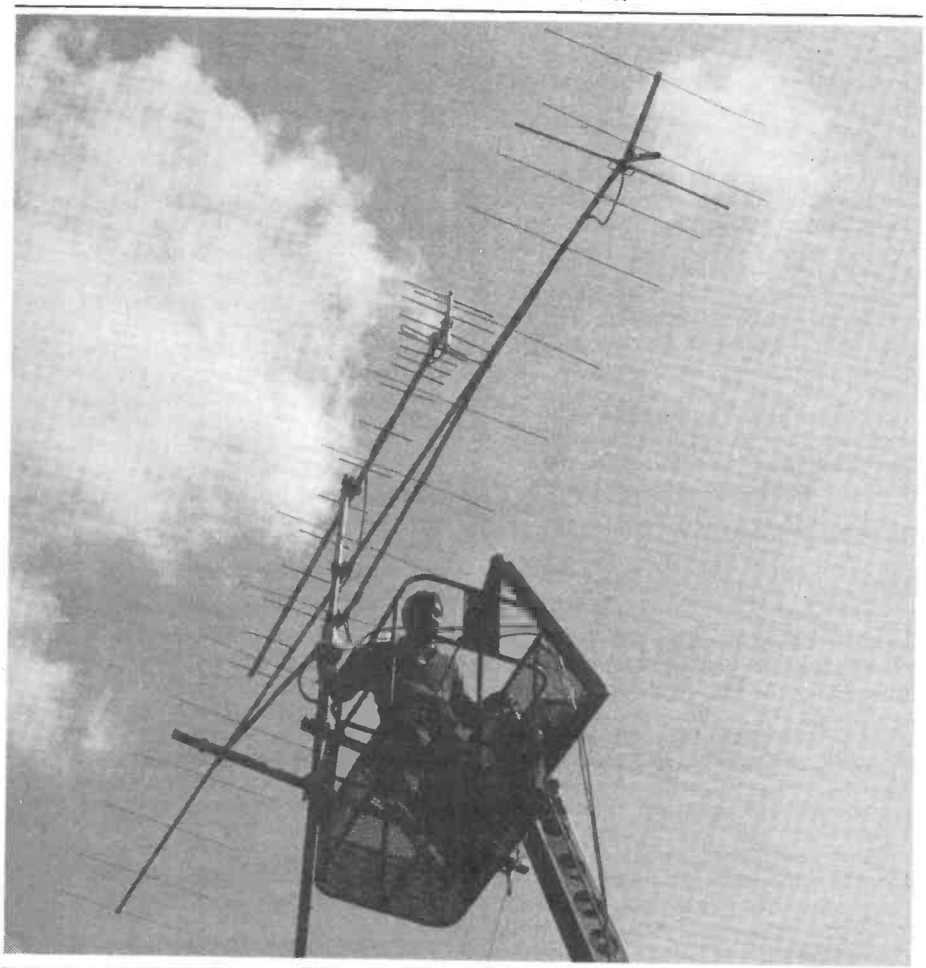
AMATEUR LICENSING MOVE

Amateur radio licences will be issued and renewed by the Post Office as from 19 September 1983.

The transfer of amateur licensing from the Department of Trade and Industry's Radio Regulatory Division to the Post Office was announced by Alex Fletcher MP, minister responsible for corporate and consumer affairs at the DTI, in reply to a Parliamentary question from Geoff Lawler MP (Bradford North). Mr Fletcher said " The Post Office, who will computerise the operation as soon as possible, are prepared to guarantee a turn-round in normal conditions of five working days and at peak times of ten. This will help to ensure that the recent improvement in the speed of issue of these licences is maintained".

Applications for new licences on or after 19 September should be sent to the Radio Amateur Licensing Unit, Chetwynd House, Chesterfield, Derbyshire S49 1PF (Tel: Chesterfield (0246) 207555). Application forms can be obtained from the same address.

Amateurs who hold licences due for renewal during or after October will receive a reminder from the Post Office — these will be sent out from 19 September onwards.



50MHz FOR ALL?

UK radio amateurs will get a 50MHz band when 405-line TV closes down next year, providing that there is room for it in Band I (41–68MHz).

At the moment a team of frequency planners is deciding how the VHF TV bands will be used when the old black-and-white transmissions close down. The majority of the space will be allocated to civil land mobile radio, but the planning engineers have been told to find room for amateurs at 50MHz if at all possible.

The Government has not yet decided whether Class B licencees would be allowed on to any new 50MHz band. Whitehall sources say this would depend on the outcome of talks with both any other users sharing the allocation, and the RSGB.

BELGIUM — UPDATE

More news of the Belgian saga is emerging day by day: this is the latest position at the time of writing.

Apparently pressure from CB groups was behind the idea to introduce a novice licence. With minimal technical qualifications, apparently a very simple questionnaire of a semi-technical nature, this licence would have allowed the use of 15W of FM anywhere in the two metre band. After strong protests from the UBA, this proposal has been cut to 145–145.8MHz. Also, all of the other changes (listed in the September *Radio Today* pages) have been postponed by a few weeks. They were originally going to take effect from 15 July.

The UBA's reaction to the news was to lobby leading politicians and to get maximum media coverage of their views. They pointed out that amateurs had shared primary status on these bands, and that the Belgian Government is a signatory to WARC '79.

The RSGB says that although it is extremely concerned by what has happened in Belgium, it seems that it is an internal Belgian matter rather than the "thin end of a European wedge".

MAY RAE RESULTS

5,307 people passed the Radio Amateurs' Exam in May; this is 70.5% of those who sat it. 2226 failed. A further 444 people applied to take the exam but never turned up.

◀ Here's a novel way of supporting special event station aerials. The Sefton Amateur Radio Club borrowed this 52ft high hydraulic platform for GB4WMS at the Wigan Motor Show.

OSCAR 10 SURVIVES

The latest amateur satellite *Oscar 10* is working almost perfectly despite being damaged during its launch.

Shortly after *Oscar 10's* motor was fired, a damaged fuel valve stuck open, making the 'burn' last for too long. This put the satellite into the wrong orbit. AMSAT says, however, that the satellite will be usable for about 11 hours a day (in the Northern hemisphere) instead of the planned 16 hours a day. It is expected that in about 12 to 18 months the orbit will drift to favour the Southern hemisphere, with Northern stations only in range for about three hours a day.

AMSAT says that radiation from the Van Allen belt will not be as serious a hazard as was feared at first, so *Oscar 10* should stay operational for many years. Luckily the 'bending' of the 144MHz aerial has done little damage to its performance.

'HAM IN SPACE' DELAYED

The Space Shuttle launch which was to have carried Dr. Owen Garriott W5LFL, complete with two-metre rig, has been put back until October, perhaps even later.

At the time of writing the frequencies for the Shuttle link-up have not been decided. At first it was suggested that frequencies above 146MHz should be used for the Earth-to-space uplink, but the International Frequency Registration Board (IFRB) objected, because the Region 1 amateur allocation only goes as far as 146MHz.

Now NASA engineers are running elaborate computer programs to calculate which frequencies in the 144-146 MHz band can be used without causing interference to other Shuttle systems.

A normally reliable source has told *HRT* that a rumour that repeaters would be used as 'gateway' units to the Shuttle is incorrect.

GRANBY HALLS

The annual amateur radio show at the Granby Halls, Leicester, is going ahead this October in spite of the Amateur Radio Retailers' Association moving its venue to Doncaster.

Amateurs and traders who wanted the Leicester exhibition to continue approached Frank Elliott G4PDZ, the Secretary of the Leicester Radio Society to see if anything could be done to save the show. The Society joined forces with the Leicestershire Repeater Group, and they are staging what they describe as the 'Twelfth Radio Amateur Show' at the Granby Halls on Friday and Saturday 28/29 October.

". . . you're my first contact from the new QTH . . ."

COMMENT

I am leaving Ham Radio Today to pursue other publishing interests not connected with our hobby.

My privileged position as founding editor of this magazine has given me an insight into amateur radio which is not usually available to those for whom it is a hobby rather than a profession. In short, the course which amateur radio appears to be taking fills me with pessimism. In the space of a few very short years, I have watched our hobby change from a dynamo of inventiveness and improvisation to a machine of sterility and tediousness.

I could argue that 'all you need to get on the air is a valid credit card' lies at the root of the trouble. Certainly home construction gave amateurs something to talk about, and the 'off the shelf' syndrome is surely killing the hobby. However, this is just a symptom of deeper trouble.

Frankly, it is now too easy to become a radio amateur with the result that the ranks are filled with non technical operators, the same sort of people that salivate over adverts in the camera and hi-fi mags. These aren't radio amateurs. They're knob twiddlers with lots of money... Nothing to do with the ability to send morse, Class A, B or whatever. Their licence says that they are radio amateurs but their committment to the hobby runs quite a bit short of some SWLs, CB'ers and unlicenced pirates. In fact, some of the most interesting conversations that I have had while editing this magazine have been with SWLs, CB'ers and pirates...

For proof of this, one only has to listen to 2m. When I first came on the air with the callsign G8SNW in 1979, the entire band was alive with reasonably interesting chat. There were those that could bore the hind leg off a dead sheep but there always were. Now, the 2m band is un-naturally quiet, full of people maintaining listening watch with incredibly expensive equipment, frightened of calling 'CQ' because they know that they are going to be bored with the result.

For me, the division is quite clear. Amateurs who took and passed the written exam are (generally) of a different, higher calibre to those who subsequently passed the multiple choice RAE. The Radio Amateurs' Exam is now so simple that a backward baboon could pass with a credit in at least one half. It doesn't bode well for the future.

Frank Ogden G4JST

ALL MODE TRANSCEIVER Part 3: Synthesised VFO

Part three of this major series concerns the PLL Synthesised VFO module, the Digital Frequency Display, and a receive only SSB adaptor. With these modules, OMEGA becomes a 10 band SSB/ CW receiver.
For all those who have built any of the G4CLF or G3ZVC designs, this VFO can be easily adapted to work with a 9MHz IF and provides an excellent companion unit. Details are given in the text.
In fact, most of the remaining OMEGA modules can be used with such 9MHz designs, filling the gap of published modules needed to turn them into complete Transceivers.

By Frank Ogden G4JST and Tony Bailey G3WPO.

Critical area

A VFO/LO system should possess a handful of obvious qualities. It should cover any/all bands, offer a stable reference source irrespective of the band in use and provide facilities such as IRT. In addition, it should deliver enough drive for use with modern high level mixing systems and — preferably one supposes — a digital readout of the operating frequency.

The average Japanese box offers all of these qualities. The average magazine design has some of them. Generally, though, the story ends there. The invisible, and therefore neglected, side of the coin is spectral purity. This is not just some idealistic goal for those who would blind others with science, it has real significance in the crowded conditions of the HF bands. There are two kinds of purity which the LO (local oscillator) circuitry should possess: minimal noise sidebands within a few kilohertz of the nominal carrier (or local oscillator) frequency, and insignificant spurious products several MHz out from the operating frequency.

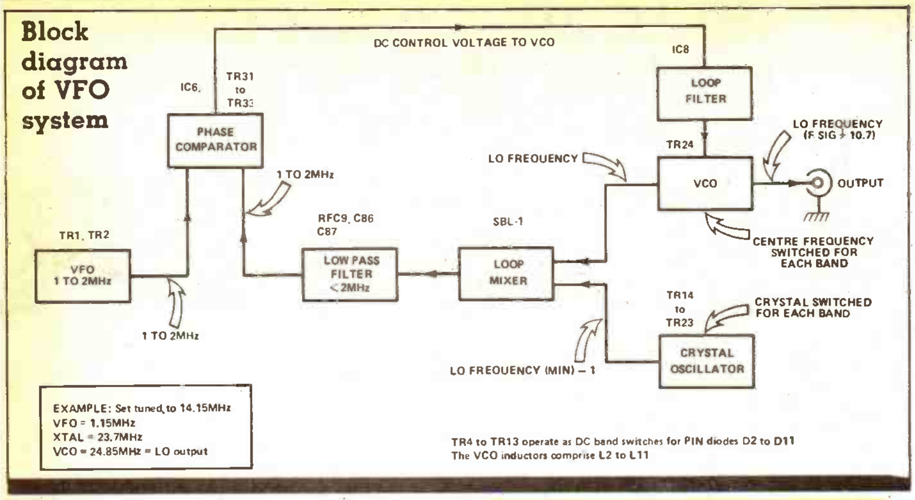
The need for these stringent demands may perhaps not be immediately obvious. One may imagine that SSB/CW receiver selectivity is totally dependent on the crystal filter used in the IF strip. You shell out £24 or whatever and confidently expect that the crystal filter will provide the 90 or 100dB of selectivity specified by the manufacturer. Not so.

Reciprocal mixing

Say, for instance, that you are trying to copy a weak signal around the S1 mark. You want to hear it because it's exotic DX. At the same time, a broadcast station is operating 10kHz away (yes, we are talking abut 40m!) which, on tune, produces a signal of S9+40dB. Assuming that the receiver system incorporates all the latest buzz gimmicks such as a Schottky ring high level mixer and 10 poles of IF crystal filtering, you might reasonably expect to copy the DX. The chances are that you won't because the wanted signal will appear to be swamped with noise, even though the manufacturer may quote 100dB+ of dynamic range for his equipment.

What happens is this. The two signals may differ by 90dB in signal strength although the noise content of the LO signal may only be 60dB down on its on-channel output 10kHz away from its nominal frequency. This noise flank on the main LO signal mixes with the strong broadcast station to produce a random pattern of noise — in-channel — which could be up to 30dB stronger than the wanted DX. In this rather extreme example the

Block diagram of VFO system



operator probably wouldn't be able to copy anything less that an S4 signal even though the receiver had a paper specification suggesting that it would be able to.

Synthesisers

Most commercial gear now uses digital synthesis techniques because of the operating versatility which this type of system allows. It offers fast/slow tuning, complex memory facilities, 'multiple' VFOs and a large number of other 'desirable' things. What it is very bad at providing is a decent RF performance ie, its prime function. This is because the cleanliness of any phase locked loop synthesiser system is largely dependent on the individual channel spacing.

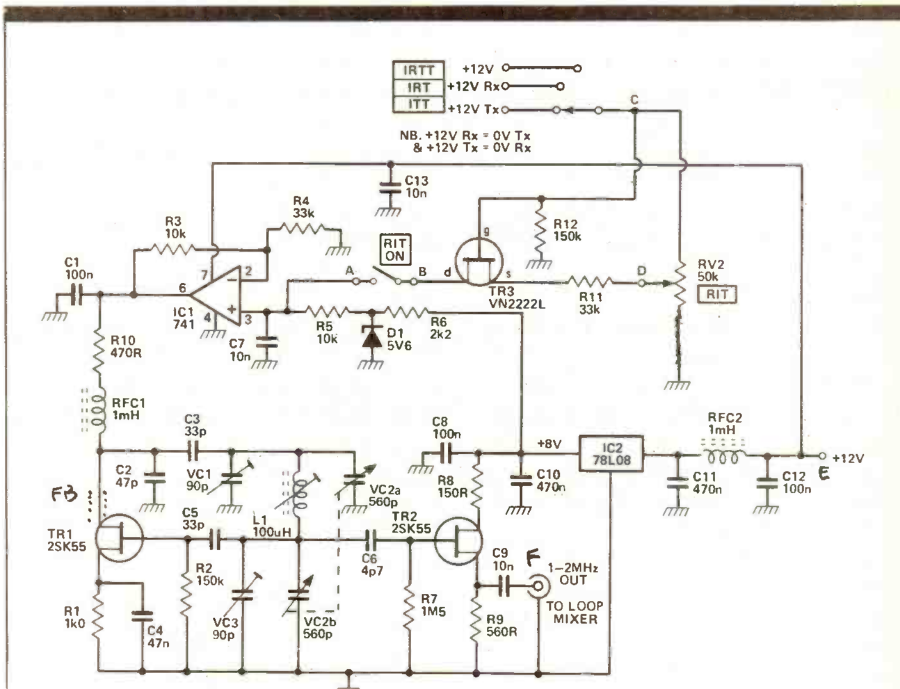
Generally speaking, the PLL can only produce a 'clean' RF spectrum within the bandwidth of the loop but — this is the whole point — the bandwidth of the loop will be typically less than half the channel spacing of the basic synthesiser system. When directly synthesised channel spacings are down to 10Hz, the minimum frequency increment when you turn the front panel tuning knob, the noise performance of the LO signal will be almost totally determined by the characteristics of the VCO's circuitry. These can be improved somewhat on the basic varicap tuned arrangement by narrowing the frequency coverage, but they will always be a horribly noisy type of circuit, certainly not the kind of device for generating LO signals with unless the output is cleaned up dramatically.

The Omega synthesiser

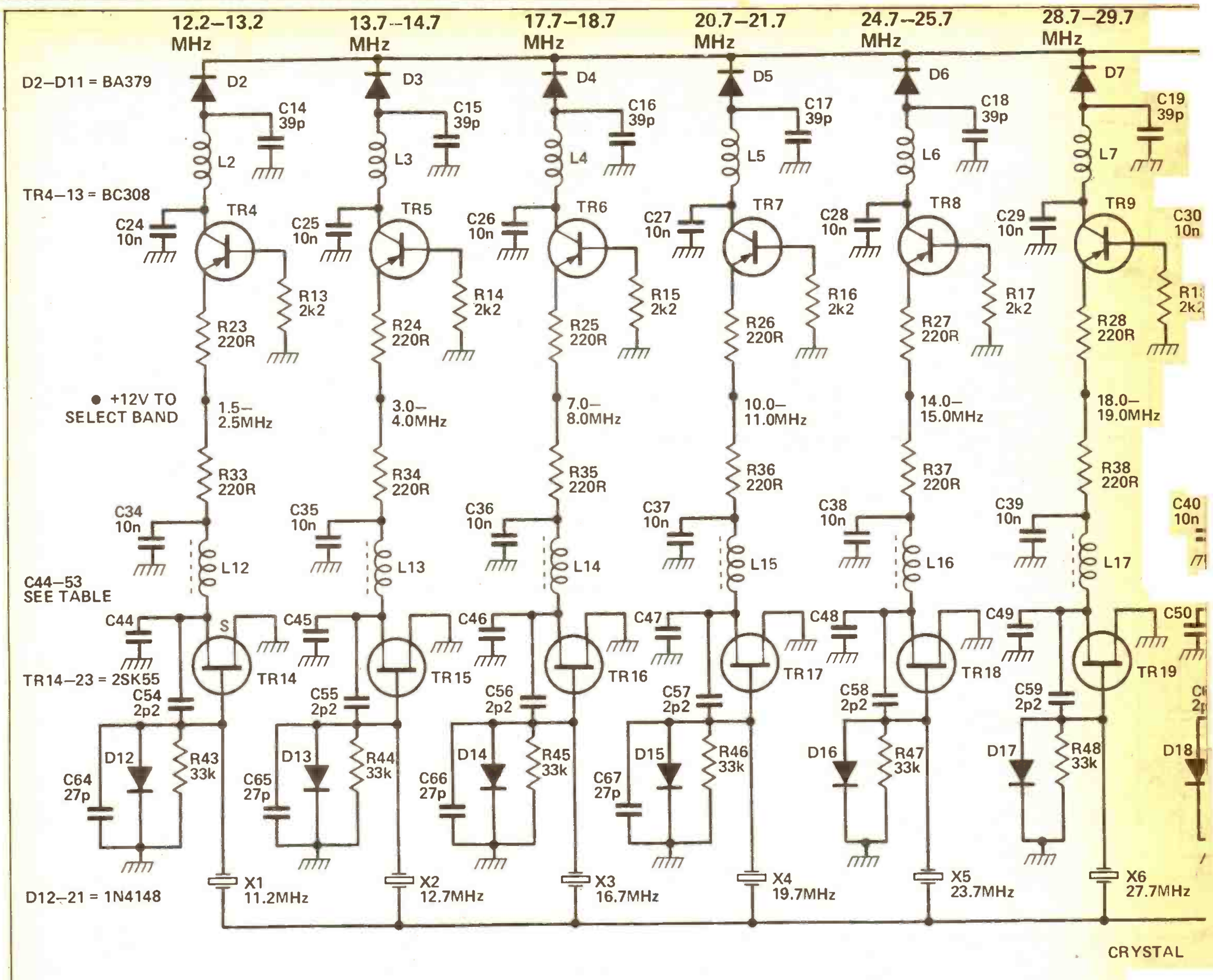
The VFO/LO module produces a spectrally pure LO signal on all ten amateur HF bands (10m is regarded as two) at a user defined IF offset above signal frequency. Coverage is in a one megahertz sweep. Thus the 80m band is covered over the range 3 — 4MHz and the 15m band in a sweep from 21 to 22MHz. The module has a high level output capable of delivering some 100mW. When used with mixing systems such as the SBL-1, MD108, a 10dB attenuator pad should be included. As well as cutting down the drive power to a safe level, the pad provides a resistive return loss path for out-of-band mixing products produced by the Schottky ring mixer. This kind of mixing device must 'see' a resistive termination at one of its ports at least an octave beyond any of its operating frequencies (both higher and lower) if its full intercept performance is to be realised. Since it is easy to produce surplus LO drive power, the resistive pad can be fitted in series with this port without any sacrifice of signal to noise ratio.

Low noise

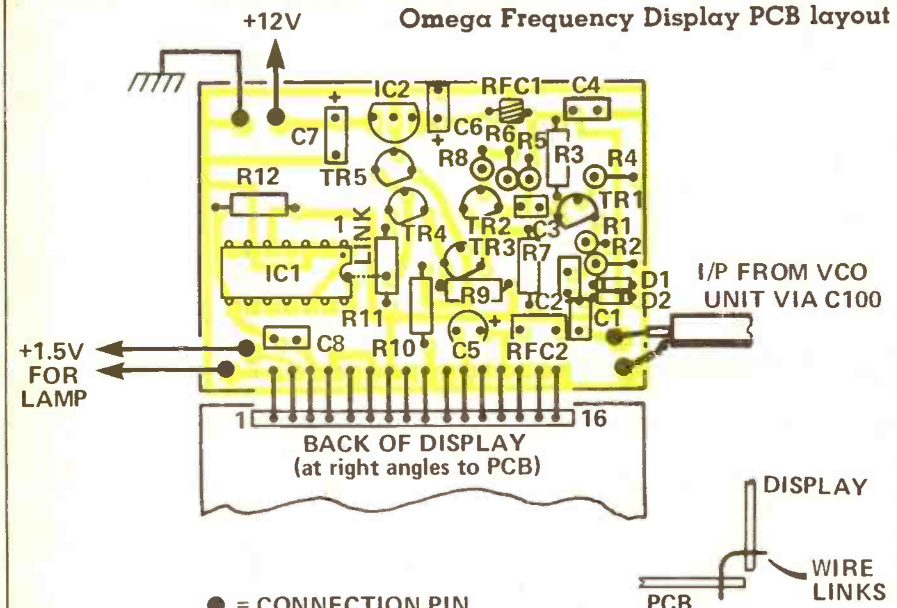
The Omega synthesiser depends on an exceptionally wide control loop bandwidth for its low noise performance. The bandwidth of the loop is such that the servo action of the control voltage applied to the VCO can 'clean' out the inevitable noise sidebands up to 100kHz away from the nominal carrier frequency. When combined with a relatively quiet VCO arrangement and exceptionally clean reference signal



Omega reference VFO 1 to 2 MHz

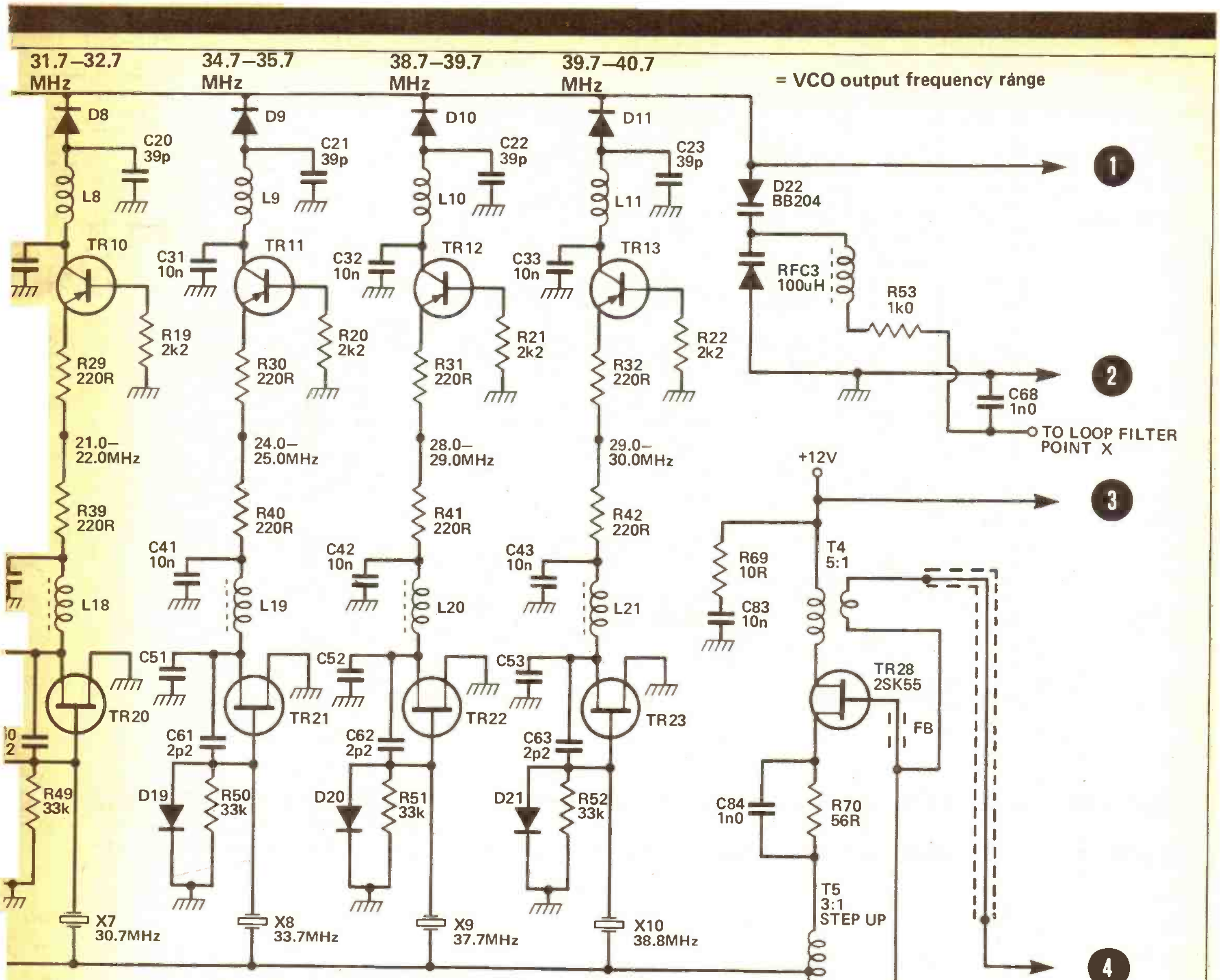


Circuit diagram of crystal oscillator and VCO inductor bank



Component Listing –

R1,53
R2,12
R3,5,77,78,82,90
R4,11,43 — 52
R6,13 — 22
R7
R8
R9
R10,74,89
R23 — 42,62,73
R54,58,61
R55,56,71,72,84,85
R57,63,86,87,88
R59
R60,76,79,80,83
R64,75
R65
R66,67
R68



OSCILLATORS (crystal frequencies shown for 10.7 MHz IF)

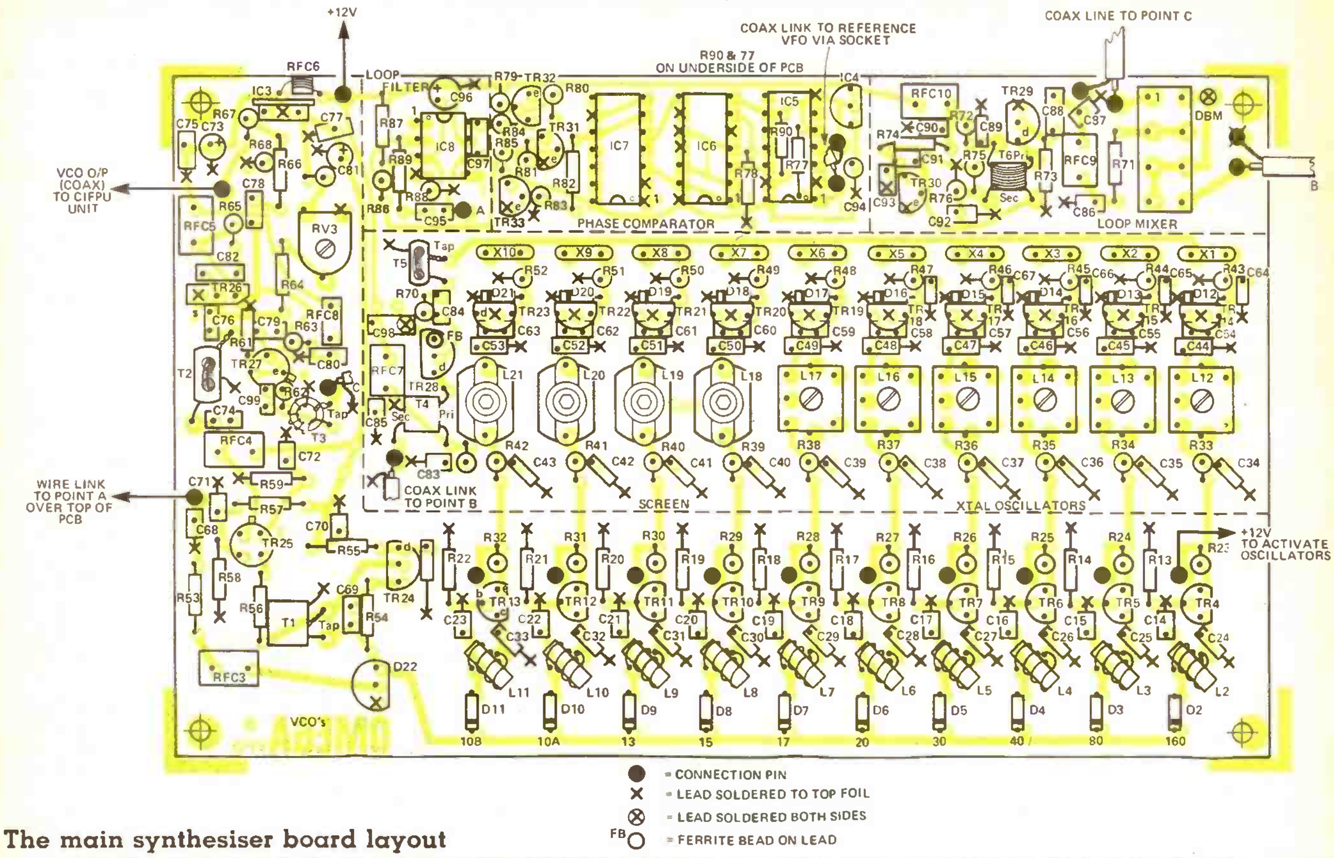
VFO System

1k
150k
10k
33k
2k2
1M5
150R
560R
470R
220R
47k
100R
100k
68R
4k7
22k
330R
27R
47R

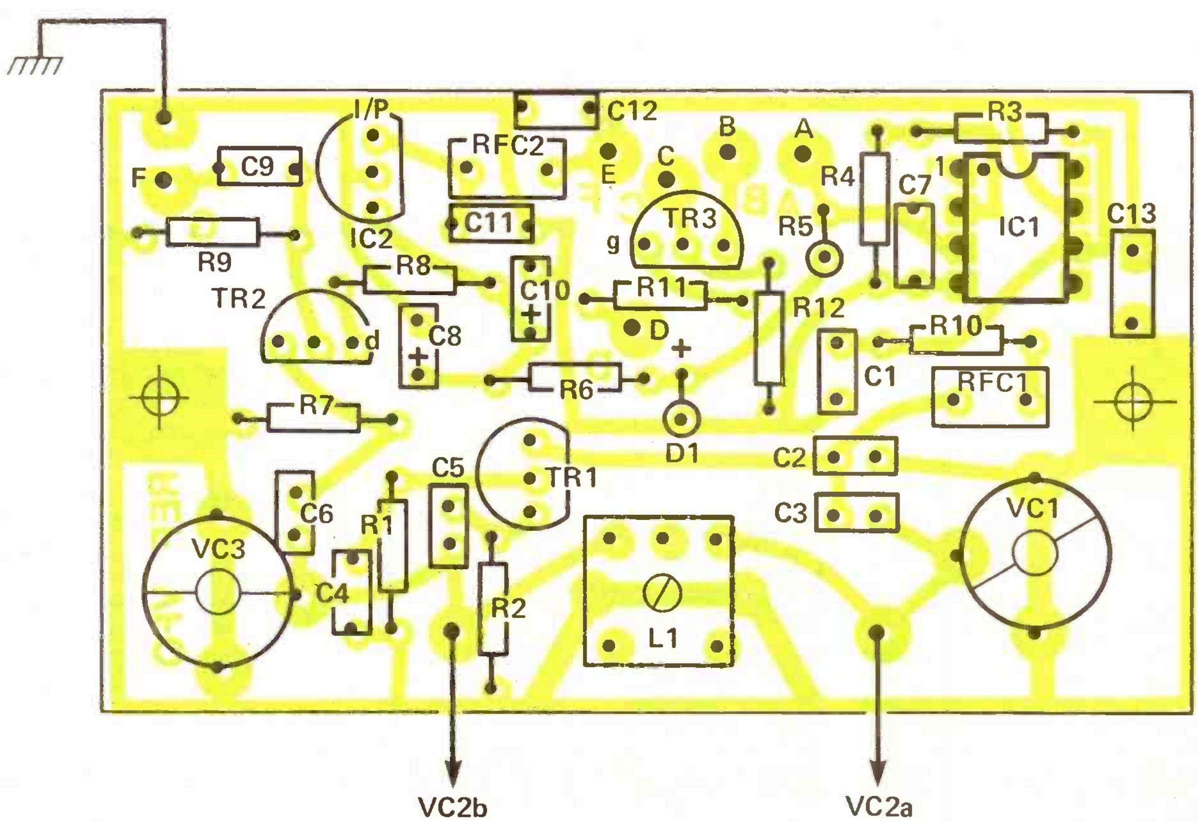
R69	10R
R70	56R
R81	3k9

All resistors 5% carbon film 0.25 watt types.

RV1	not used
RV2	50k lin carbon pot
RV3	4k7 10mm horiz preset
C1, 8, 12, 70, 88, 92	100n monolithic ceramic
C72, 75, 77	100n ceramic disc
C2, 44, 69, 78, 91	47p ceramic plate
C3, 5	33p ceramic plate
C4, 95	47n monolithic ceramic
C6	4p7 ceramic plate
C7, 9, 13, 24 — 43, 71, 80, 82, 83, 85, 93, 98	10n ceramic disc
C10, 11, 94	0.47uF tantalum bead
C14 — 23, 45, 52, 53	39p ceramic plate
C46	not used
C47, 50	68p ceramic plate



The main synthesiser board layout

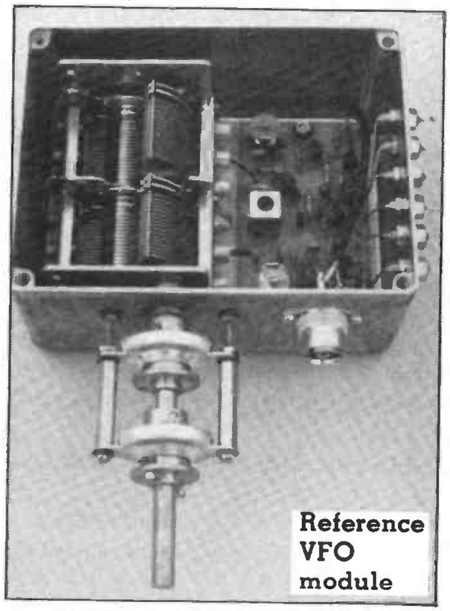


Reference VFO layout

C48,64 — 67	27p ceramic plate
C49	22p ceramic plate
C51	56p ceramic plate
C54 — 63	2p2 ceramic plate
C68,74,76,79,84,86,87,99	1n ceramic plate
C73,81,96	10uF radial electrolytic
C89,90	220n monolithic ceramic
C97	100p ceramic plate
C100	390p ceramic plate
VC1,3	90p film dielectric trimmer
VC2	400 to 560pF max dual gang air spaced, 6:1 drive.
D1	5v6 400mW zener diode
D2 — 11	BA379 PIN diode
D12 — 21	1N4148
D22	BB204B varicap diode
Q1,2,14 — 23,28,29	2SK55
Q3	VN2222L
Q4 — 13,32	BC308,309
Q24	J310
Q25	3SK45
Q26	VN66AF
Q27	2N2369A, BSX20
Q30,31,33	BC238
IC1	741 (8 pin DIL)
IC2	78L08
IC3	7808
IC4	78L05
IC5	74LS14
IC6	74LS74
IC7	74LS00
IC8	NE531 or RS 305-872
DBM	SBL-1
L1	TOKO YRCS18576AQ
2 — 11	Wound on Amidon T37-6 cores
2	23t 0.25mm en Cu wire (30cm)
3	20t 0.25mm en Cu wire (25cm)
4	14t 0.40mm en Cu wire (19cm)
5	13t 0.40mm en Cu wire (18cm)
6	11t 0.40mm en Cu wire (15cm)
7	9t 0.40mm en Cu wire (13cm)
8,9	7t 0.40mm en Cu wire (11cm)
10,11	6t 0.40mm en Cu wire (10cm)
L12,13,14	TOKO KANK3334R
L15,16,17	TOKO KANK3335R
L18,19,20,21	TOKO S18 301SN-0800 Ferrite core
T1	6 turns tapped at 2 turns from earthy end. 0.25mm en Cu wire on Fair-rite balun core type 28-43002402
T2	3 turns bifilar wound 0.25mm en Cu wire on core as T1
T3	6 turns centre tapped 0.25mm en Cu wire on ferrite bead
T4	5 turns primary, 1 turn sec. 0.25mm en Cu wire on ferrite bead
T5	8 turns tapped at 2 turns from earthy end. Core as T1

sources, the result is a synthesised LO signal which approaches that of a free running LC oscillator in spectral purity.

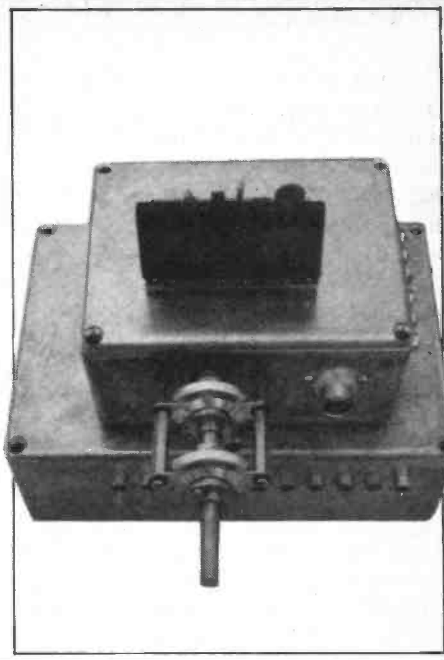
In the Omega design, the digital edge triggered phase comparator — a (circuit arrangement) initially developed by NASA; remember the expression "We have lock..." — operates in the 1 to 2MHz region with an analogue 1 to 2MHz VFO as the primary frequency reference source. The VFO frequency is the effective channel spacing of the system. The result is an error signal with frequency content in the 100s of kHz region rather than the 100s of Hz of most direct digital designs.



Reference VFO module

The low noise DC switched inductor VCO system — which provides the output of the module — also mixes with the output of a low noise DC switched crystal oscillator bank in a double balanced mixer unit. The result is a difference signal between the VCO and the crystal oscillator in use. This is continuously compared with the output of the analogue reference VFO in the phase comparator to produce the error voltage for the VCO. Note how the output from the crystal oscillator transistor in use is filtered through the crystal itself thus effecting a noise improvement on the standard crystal oscillator circuit. The net result is that the VFO frequency adds to the crystal frequency to produce the LO output with a noise spectrum only 4 to 5dB worse than either of these components. Furthermore, the effective system frequency stability is effectively that of the analogue reference VFO on any of its bands.

T6	20 turns primary, 5 turns sec 38 swg en Cu wire on ferrite bead
RFC1,2	1mH TOKO type 7BA/BS
RFC3	100uH TOKO type 7BA/BS
RFC4,5,7,8,9,10	10uH TOKO type 7BA/BS
RFC6	10t 0.25mm en Cu wire on ferrite bead
Also required:	
4	FX1115 Ferrite beads or equivalent
3	miniature ferrite bead
Crystals	see circuit diagram. p10, 11
Miniature coax cable	RG-95/U or similar
Diecast Boxes — small	RS type 509-945
— large	RS TYPE 509-995
2	6:1 slow motion drives Jackson type 4511/DAF
17	screw in 1000pF feedthrough caps
3	Belling Lee sockets or similar



Component Listing — Digital Frequency Display

R1	2k2
R2,3	470R
R4	27R
R5	4k7
R6	680R
R7	1k2
R8	10R
R9	1k5
R10	270R
R11	33R
C1,2,3,8	1n ceramic plate
C4	100n monolithic ceramic
C5	10uF/16v radial electrolytic
C6,7	0.47 uF Tantalum bead
RFC1	10 turns on ferrite bead
RFC2	TOKO type 7BA/BS 1mH
D1,2	1N4148
IC1	74LS90
IC2	78LO5
Q1-5	BF273, BF274
Display	PCIM177 Frequency Counter
Mounting Bezel	Type BEZ-10

Component Listings — Rx only SSB adaptor

R1	39k
R2	27k
R3	560R
R4	1k0
R5	220R

All resistors 5% carbon film 0.25w

C1	100n ceramic disc
C2	270p ceramic plate
C3	150p ceramic plate
C4	1n ceramic plate
VC1	60pf 10mm film dielectric trimmer
X1	10.7MHz crystal
Q1	BC238/239
S1	See text

Also required — 4 1mm pcb connection pins.

KITS

Kits of parts for these modules are available from WPO Communications (see page 7)

VFO — A complete kit of parts for a 10 band VFO, less the crystals, drives and diecast boxes costs (but including air-spaced capacitor) is £64.00 inc.
The crystals are £5.00 each (state band), or £40 inc. for a set of 10. A pair of drives plus spacer etc costs £5.80
Diecast Boxes — Large £5.50 (VCO) Medium (Ref VFO) £4.00 inc.

FREQUENCY DISPLAY — Complete kit of parts including mounting bezel is £31.00 inc.

RX ONLY SSB ADAPTOR — Complete kit of parts £6.20 inc.

PCB's are available separately — VFO (pair) £7.90, DFM £1.60 (interface only), SSB Adaptor £0.90, all inclusive.

Frequency display

There are two ways of monitoring the receiver (or transmit) frequency of the VFO/LO module. The most convenient is to measure directly the LO output frequency, remove the IF offset, and display the result on a digital readout. This is the option offered for Project Omega constructors. The other is to calibrate a slow motion dial on the reference VFO (cheaper, but mechanically more taxing). The display module is described further on in this article.

In use

We haven't had a chance to place the unit on a decent spectrum analyser yet but first indications are that it has to be a *decent* spectrum analyser to make a realistic measurement of the noise sidebands at all!

In practice, the purity of the LO signal makes itself very evident. When used in conjunction with the Omega CIFPU board, some CW transmissions have a sweetness of note which is not evident on the synthesised commercial HF gear. Furthermore, 40m at night is a revelation. Without exaggerating, both G3WPO and G4JST have heard weak DX amateur traffic which we've never heard before. The VFO/LO module may not offer banks of memories and A/B frequencies but it does offer staggeringly good RF performance.

Other than Omega

The VFO/LO system could also be used to augment existing commerical equipment as well as the wide range of single board IF SSB systems of which G4CLF is an example. The precise IF offset is determined by the selection of crystal frequencies. It could be used to great advantage in both the PW Helford transceiver design, and the latest Radcom project by G3OGQ.

Construction

The PLL Synthesised VFO is without doubt the most complex of the OMEGA modules in terms of component count and assembly time, but providing the assembly details and modular testing procedure are followed, there should not be too much difficulty. This is one module where some test equipment will come in very handy — a frequency counter covering up to 40MHz, and an oscilloscope will be very useful. A diode probe is almost essential, and you can easily make one from the diagram given on p.36 of the JULY issue.

If you don't have a counter, the companion Digital Frequency Display could be used in its place, in which case this should be constructed prior to assembling the VFO units. It does however subtract 10.7MHz from the input frequency which will have to be allowed for. If all sections work first time the need for a scope is unlikely, but it is a helpful instrument to have — its about the only way to actually "see" RF energy.

The VFO unit is built in two separate units — the 1-2 MHz reference VFO as a self contained module, and the remainder of the circuit comprising the VCO's, crystal oscillators, Loop mixer, phase detector, and loop filter. The reference VFO is built first.

As with the CIFPU unit, the instructions are detailed for the relative beginner, experienced constructors allow for things that probably seem obvious.

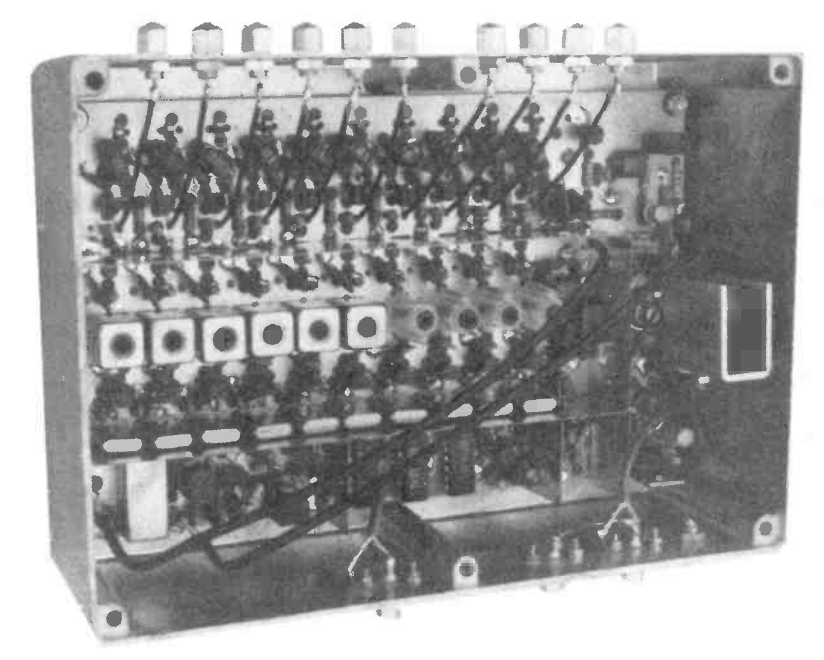
Reference VFO

This module is the basic frequency determining section and care in its electrical and physical construction will pay dividends in terms of final stability. It must be enclosed in a screened enclosure, and a suitable diecast box together with drilling detail is given. Other boxes may be used, but the mechanical strength needs to be good, and the size should be similar if the front panel

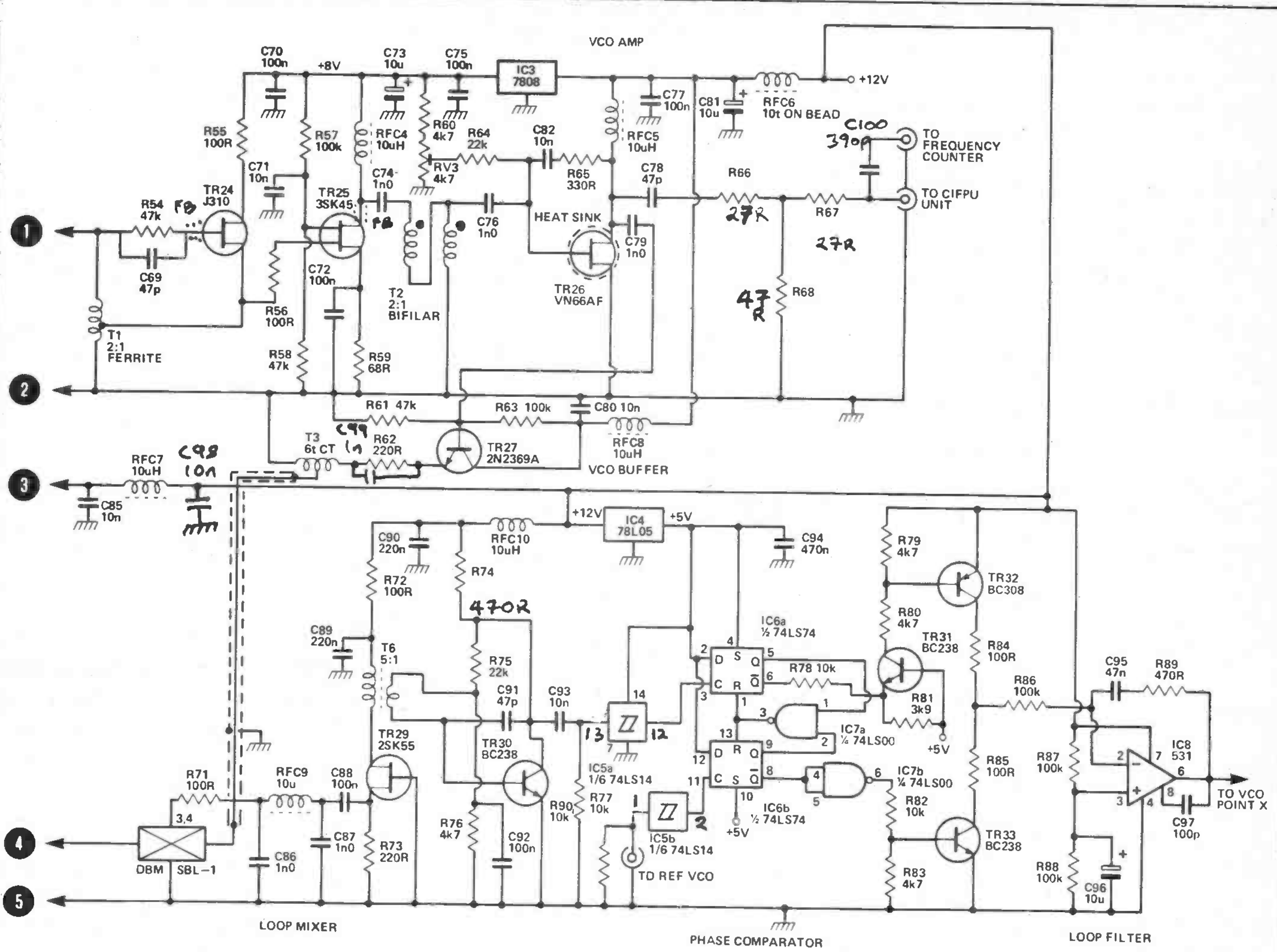
PCB assembly

The VFO circuit is built on a small single sided pcb, which sits by the side of the air spaced dual tuning capacitor. Building this pcb is very straightforward, as follows.

1. Insert the 9 connection pins where shown and solder.
2. Insert and solder all resistors and fixed capacitors, observing polarity of capacitors where needed. Keep all components as close to the board as possible.
3. Insert and solder VC1 and VC3, RFC1/2, and D1, making sure the latter is the correct way round.
4. Insert and solder L1, and the 3 transistors, leaving not more than 3mm of the latter's leads above the



Main synthesiser module



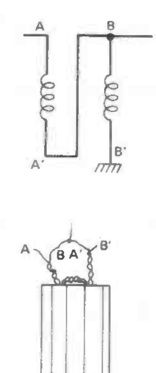
VCO, buffer, output stage and phase comparator

pcb surface.

5. Insert and solder IC1 and 2, observing orientation.

Operation of the VFO can be checked by temporarily connecting up the air spaced capacitor and applying +12v to point E. If a counter is available, attach it to point F and verify that the coverage is under 1.0MHz to over 2.0MHz. The exact limits can be set with VC1 and VC3, which should be adjusted together, and with the core of L1. The inductor sets the lower frequency limit, and the capacitors the upper — the adjustments interact and will need to be repeated a few times. We suggest +/− 50kHz extra coverage each side of nominal.

The RIT circuit adjustments should now be checked by connecting up the potentiometer and switch as shown inthe diagram. With +12v applied to point C, and the switch open, there should be no effect on the frequency as the pot is varied. Closing the switch should bring the circuit into operation, with the pot varying the frequency as it is rotated — near its central position it should agree with the switch open frequency. The actual RIT swing available will vary depending on the frequency to which the VFO is tuned. Near the low end it will be about +/− 5kHz, and at the top end about +/− 9kHz.



Detail of T2 winding

The alternative switch positions are for allowing ITT (Incremental Transmitter Tuning (or TIT (!) if you follow the RIT convention, rather than IRT) ie allowing the control to vary the frequency in the Transmit mode rather than the receive mode, and IRTT, where the control sets the frequency both in Transmit AND receive. These variations can be quite useful when working Dx-peditions, or keeping up with fellow 'Net' operators. The control voltages are derived from the Logic Control Unit, to be detailed next month.

Mechanical Construction

The photographs and drawings should be self explanatory in this respect. They suit the air-spaced variable capacitor which is supplied with the kits, but other capacitors can be use. The important point is that the spindle should be in the position shown if the final case layout to be given is used. The VFO box eventually mounts on its left side in a vertical position.

One of the problems we experienced with this part of the design was with the slow motion drive. It would have been nice to use a good flywheel driven gearbox reduction as used in many of the Black boxes. They are available, but we did not think poeple would want to pay about £40 for this item alone! To get the overall reduction required, which is about 216:1 (or more if you can manage it), we eventually used two Jackson 6:1 epicyclic drives in series, coupled with the 6:1 reduction already present in the capacitor itself.

We do not recommend using the Jackson combination 6-36:1 drive as the torque of the 6:1 section is considerably higher than that of the 2-drive combination and is not pleasant to use.

The drilling dimensions shown for the mounting of the VFO capacitor underside may need slight amendment to get the drives to align exactly with the capacitor. All four of the screw holes on the underside should be used for mechanical stability. The pcb mounts on a couple of 6BA half nuts to space it from the box.

The stability of the finished unit should be excellent — certainly within +/− 100Hz/Hr after a small warm up period. The linearity is also good with this circuit giving a fairly constant tuning increment over the whole range.

The VCO unit

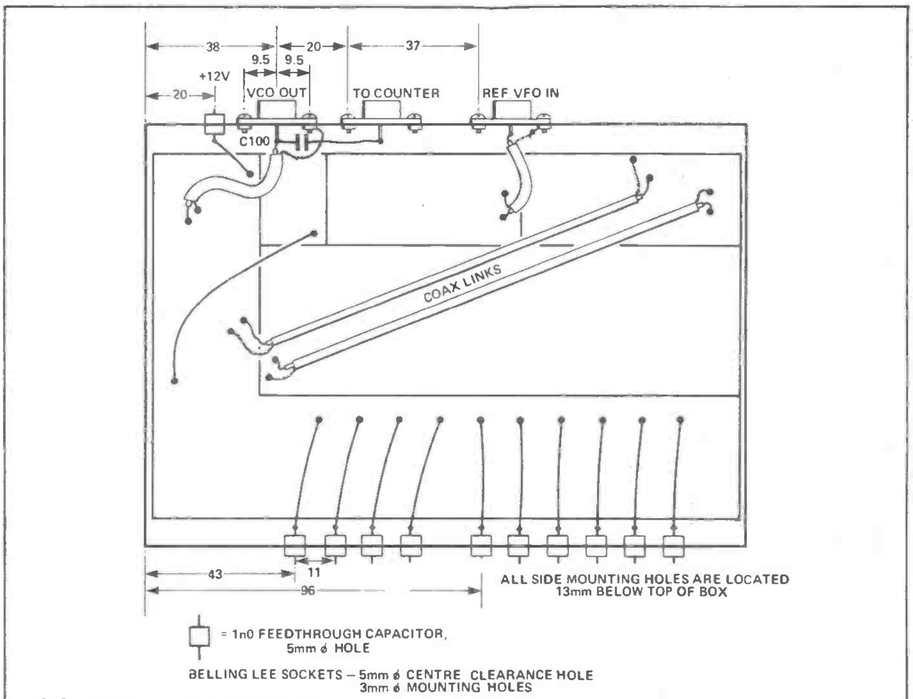
The remainder of the PLL system is constructed on one double sided pcb, with suitable interstage screening made from tinplate. These screens are essential and should not be omitted.

In order to ease problems, the board is built up in stages, with each section being tested as far as possible before starting on the next.

General

1. Insert and solder all (20) connection pins.

2. Make up an L-shaped (or use two separate pieces) tinplate screen 20mm high to fit the section between the crystal oscillators/VCO's and the left hand side of the loop filter. It should be soldered exactly along the broken lines marked on the pcb upper surface.



VCO unit — connections

Crystal oscillators

Three instructions assume that all the bands are going to be used and that all crystals are to be soldered into place at once. If only a few crystals are to be used initially, you will not want to have to remove the pcb from its box to put more in later. The only problem in not having all bands in at once is that each VCO requires a crystal in place to align it so this will have to be done in stages as crystals are available.

There are two alternatives — either use small cage jacks (these are miniature spring loaded sockets) into which wire ended crystals can be plugged (obtainable from Ambit — type CG2), or cut a rectangular hole in the underside of the diecast box along the line of the crystal mountings to allow a soldering iron to be used later (the box mounts against the final chassis so screening won't be affected).

1. Insert and solder Q's 14-23 (2SK55) observing case orientation. Make sure each centre (source) lead is soldered to the top foil.

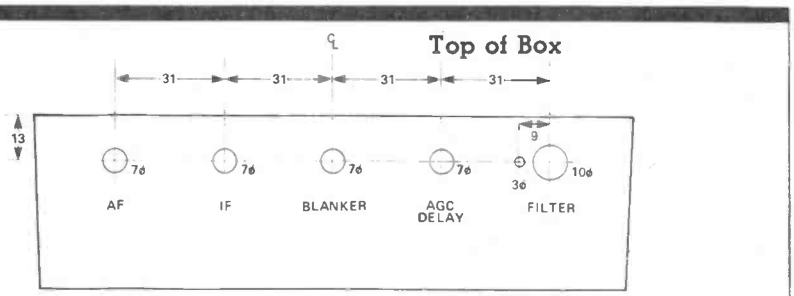
2. Insert and solder all the fixed resistors associated with the oscillators. ie, R's 43-52 (33k), 33-42 (220R), and 69,70. Mount the bodies of vertical resistors in the positions shown.

3. Likewise, mount and solder all fixed capacitors ie, C's 34-43 (10n), 44-53 (see list), 54-63 (2p2), 64-67 (27p), and 83,84,85,98.

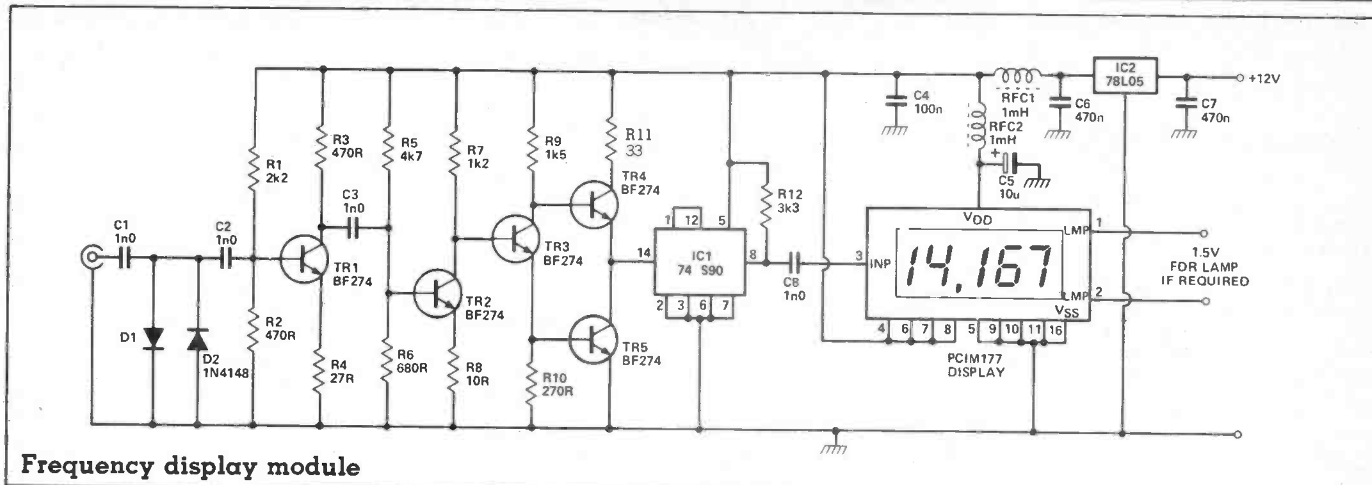
4. Next the diodes (D12-21), observing orientation.

5. Insert and solder RFC7 (10uH — marked 100 followed by a letter).

6. Now wind T4 and T5. T4 is wound as a straight transformer with separate primary and secondary using 0.25mm en Cu wire (primary requires a length 12cm long, secondary 4cm). To help you remember which end is which when soldering in, leave the lead slightly longer on the earthy end when stripping off



CifPU module — drilling details



Frequency display module

the insulation.

T5 is tapped, and wound using 13cm of wire for the 6 turns, and 5 cm for the 2 turns, the join being the tap. Likewise, the primary can have slightly longer leads than the secondary for identification.

Solder both into place.

7. Insert and solder Q28, with a ferrite bead on the gate lead. The gate earth connection is made via C98 which is soldered to the pcb on both sides at one end.

8. Finally, insert and solder the 10 inductors, checking the identification of the screened transformers before insertion (there is no need to solder the cans to the top foil). Then insert and solder the crystals, with the bodies resting against the pcb — do not attempt to solder the cans to the pcb.

Alignment

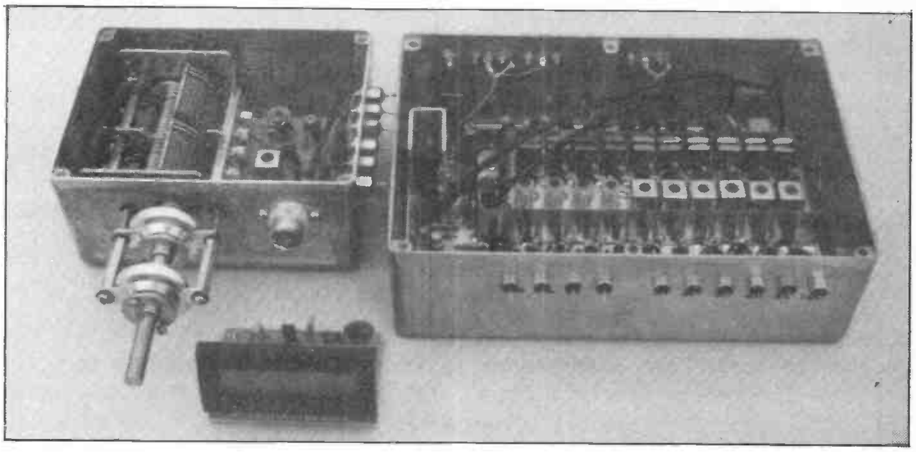
Now check the operation of the oscillators as follows:

1. Apply +12v to the main board terminal and to one of the oscillator pins on the VCO side of the screen (we suggest you start with 160M (11.2MHz) and work down).

2. Using the correct trim tool (kit builders will have the tools required supplied) adjust the core of the inductor for maximum RF output from T4 (at the terminal pin) using your diode probe. Switch the supply on and off to check for reliable oscillation — if the oscillator does not restart adjust the core slightly until it does.

If you check the output frequency, it should be within a kHz or two of nominal — the exact frequency is not important as the Digital Readout will compensate for any offset.

If any circuits refuse to

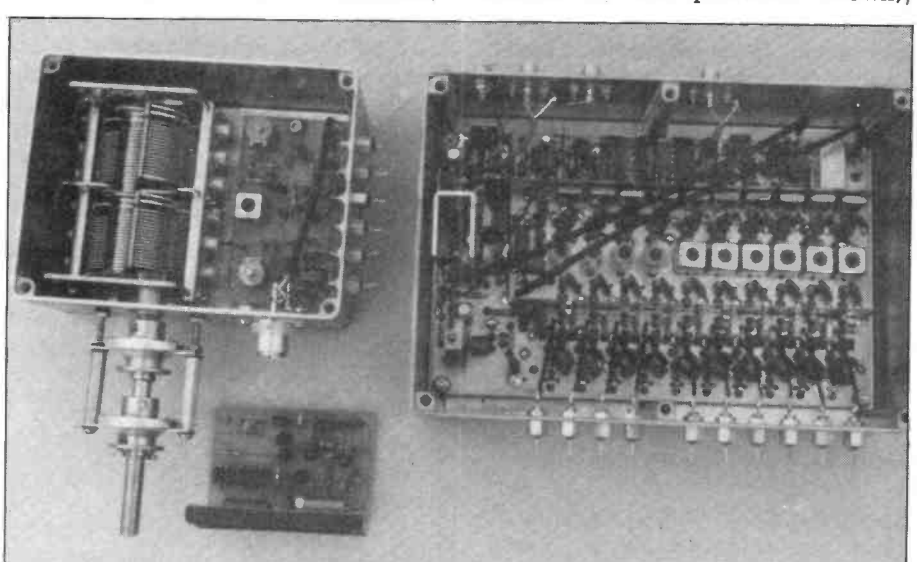


oscillate, look for component errors (if most of them do work), and check dc voltages. If none work, make sure you wound and connected up the transformer's correctly, and then look at the circuit around Q28 for errors.

VCO's

Next the VCO circuits are assembled as far as the bifilar transformer, T2. If you are going to use all bands eventually it is important that ALL the PIN diode circuits are in place as the VCO frequency coverages are affected by their presence, and it is difficult to allow for this after assembly.

1. Insert and solder Rs 13-22 (2k2) — keep the leads short so that the earthy end is just near the screen. Then Rs 23-32 (220R — bodies in the positions shown),



C14-23 (39p), C24-33 (10n).

2. Carry on with Q's 4-13 (BC308), and the PIN diodes, D2-11 (BA379 — keep the end marked with a silver line near the bottom edge of the pcb).

3. Wind each inductor (L2 — 11) as given in the table, leaving the turns spaced round the cores, with the base of the core resting on the pcb. Exact adjustment comes later.

4. Carry on with the rest of the components on the left hand side of the pcb up as far as T2, C74, RFC4, C72. Also insert IC3 (7808 — observe orientation), RFC6, C77,81,73,75. D22 has one lead soldered to the top foil.

T1 is wound with 11cm of wire for the 4 turn part, and 2cm for the rest, the join being the tap. T2 is bifilar wound as per the drawings. To make the bifilar pair, take two lengths of 0.25mm wire, fix one pair of ends in a vice or something similar, and the other ends in a twist drill chuck. Turn the drill to twist the wires together until one end breaks off! The wires are then wound through the core as though they were single. Untwist each end and establish with a multimeter which ends are which, and also that the two separate wires do not have a dc short.

Then connect the end of one wire with the beginning of the other — this end then goes to C76, and the other ends as shown, after reducing the leads to about 15mm in length, and stripping.

Initial alignment

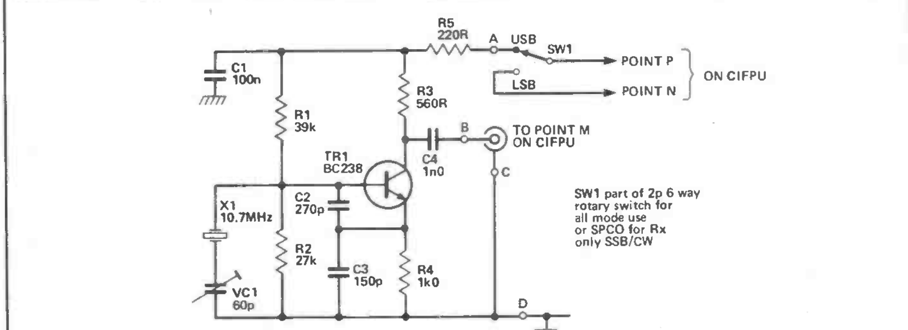
Exact alignment of the VCOs is done later — at this stage general operation is checked.

1. Make up a source of variable voltage to emulate the loop filter output to drive the varicap diode (D22). Use the RIT potentiometer with one end connected to earth, the other to +12v, and the wiper to the pin adjacent to C71.

2. Connect a frequency counter to the output of T2 (the twisted pair end) so that the VCO frequency can be read.

3. Apply +12v as before, and check that +8v is present on the drain of Q24.

4. Set the pot for +10v at the wiper, and activate the 160M VCO.



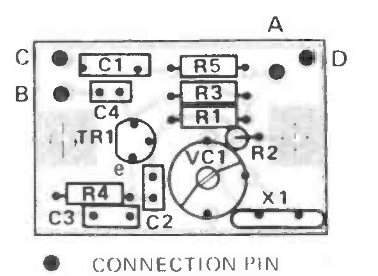
Receive only SSB adaptor

By varying the spacing of the windings on L2, it should be possible to set the VCO output frequency to the upper limit given in the table (13.2MHz for L2).

This adjustment is quite critical but only needs to be approximate at the moment. When you are sure that this adjustment can be made correctly, give the cores and windings a light coat of something like nail varnish (not epoxy resin at this stage!) to temporarily fix the windings in place. A more critical adjustment will be made later and each core fixed in place with epoxy adhesive.

Carry on adjusting each inductor in turn. If necessary, turns can be removed, or added, to the cores but this should be unlikely.

If things don't work check components first. Also check that the PIN diodes are switching on (is there a voltage drop across them?, and across the 220R resistors). Check T1 is the right way round, and that T2 is correctly wound. If you can get a frequency reading on the drain of Q25 but not at the transformer, then T2 is wrong.



SSB adaptor layout

Finishing the VCO sub-circuit

The rest of the VCO circuit can now be built, working up the pcb from T2 with the components. T3 is a simple centre tapped coil wound on a ferrite bead (7cm of wire needed for each half of the winding). Q26 (VN66AF) is static sensitive so DO NOT handle it by its leads — push the leads through a bit of kitchen foil, and remove it after soldering into place. One edge is chamfered and this should agree with the chamfered edge on the drawing, with the source soldered to the top foil. RFC6 uses 13cm of wire.

This transistor MUST have a heat sink attached to it — a drawing is given for a suitable sink. It is important that no insulating washer is used between the transistor and the sink, and that the sink is not attached to anything else — the extra capacity introduced will affect the frequency response of the amplifier.

When all components are in place, turn RV3 fully anticlockwise. Then with a multimeter set to 500mA range in series with the +12v supply, adjust RV3 so that the current taken increases by 100mA (ie the standing current of Q26 is set to 100mA) AT THE SAME TIME shorting the drain of Q24 to earth with a 1n or higher value capacitor (to ensure that the VCO is not oscillating). When you have done this, removing the short should drive the current up by a further 80-100mA or so.

If the current does not increase on removing the short, then drive is not reaching Q26.

Check that the current drain increases as each VCO is selected in turn, with slightly less increase at the HF ends.

Loop Mixer

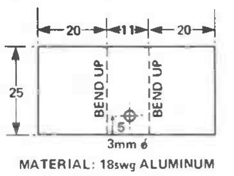
Firstly, the remaining long screen should be soldered into place just next to the cyrstals, 20mm high as before.

1. Insert and solder the components associated with the loop mixer. The SBL-1 mixer has pin 2 (adjacent to pin 1) under the M of "MCL" stamped on the package.

Make sure that the link between the upper and lower surfaces of the pcb is in place just to the right of the mixer. One end of C93 is soldered to a track on the top.

Q29 & Q30 both have one lead soldered to the top foil. Again, wind T6 (primary 31cm wire, secondary 10cm) with the primary leads longer than the secondary for identification. Be careful not to strip the insulation.

Operation of the loop mixer (which produces a difference frequency of 1-2MHz between the VCO and the crystal oscillator) can best be checked with an oscilloscope, after making the coax links to the inputs of the SBL-1 mixer. The output at C93 should be reasonably constant with the difference frequency inputs between 1 and 2MHz, and then drop off rapidly as the difference increases.



Tr26 heatsink detail

Alternatively, a counter connected to the output should read between 1 & 2MHz as the VCO is varied in frequency with the pot. Incidentally, the Frequency Display can't be used for this check.

Loop Filter

Carry on by inserting and soldering all the components associated with the loop filter (IC8). The latter has pin 4 soldered to the top foil including the small screen.

Check operation by transferring the wiper of the variable pot to the unconnected end of R86, and set the pot at the earthy end. Varying the voltage on the pot wiper from around 6v to 0v should result in the comparator output swinging from around 0v to about 11.5v.

When this is working OK, solder in the last of the small screens as close to C97 as possible and remove the pot connection — this is no longer required.

Phase comparator

The remaining components belonging to this section can now be soldered into place. R s 77 & 90 are mounted on the underside of the pcb, with the leads on the top cut off flush with the pcb. Make sure the IC s are the correct way round, and that all the pins marked with crosses are soldered to the top foil, or the tracks on the top where this is possible. One lead of Q31 is soldered to a track on the top, as is one end of R78.

Apply +12v and check that there is 5v +/− 0.2v present on pin 14 of IC6.

Remove +12v, and if you have removed them, reconnect the coax links to the input of the Loop Mixer. Connect a wire link over the top of the pcb between the two points marked A on the drawing.

Apply +12v and activate one of the VCO s. A meter attached to point A should read around 11.5v indicating that the comparator output has gone high. Remove +12v, and also the coax link to the loop filter input from point C. Now connect up the reference VFO to the input next to IC5.

Apply +12v to both modules and check that the comparator output has now gone near 0v. If both these checks work, then the system should be functioning correctly, and you are nearly there!

Problems

If things don't go as planned with the previous section, there are some checks you can carry out, assuming you don't have a scope available. Removing the Reference VFO input should make pin 2 of IC5 change level, and shorting pin 13 with a capacitor should make pin 12 change level (the normal voltage level should be about 2.5v). If this is not the case, the Schmidt triggers are not working correctly. A slight change to the values of R s 77 & 90 to a lower value (try 4k7) should solve this problem.

On IC5, pins 5&6 should be of opposite logic states, as should pins 9&10, when the reference VFO input is removed. Providing the input triggers are working correctly, there is no reason why the circuit shouldn't function and you should then look for components or soldering errors.

Final Setting Up

Now that the individual parts of the circuit are working correctly, remove all power and check that all inputs are correctly connected to the VCO unit, including the reference VFO.

Now apply +12v and select the 160M VCO by applying +12v to the appropriate pin. With a counter connected to the VCO output via C100 (390pF) (or you can use the display which will indicate the eventual receive frequency — a counter will show the actual VCO frequency which is 10.7MHz higher) adjust the reference VFO to its highest frequency.

Connect a multimeter to point A (varicap control voltage) and carefully adjust the VCO turns on the core until the correct highest frequency is shown on the display when the voltage is approx 10.3v +/− 0.2v. Providing everything is in lock (pin 5 of IC6 should be virtually 0v) the voltage will vary wildly as you play with the core initially, showing that the VCO is tracking. Only very slight adjustments are needed to get it right. The control voltage cannot exceed about 11.5v so if this reading is obtained then the VCO frequency is too low and the turns need opening slightly.

All this is far easier to do than describe!

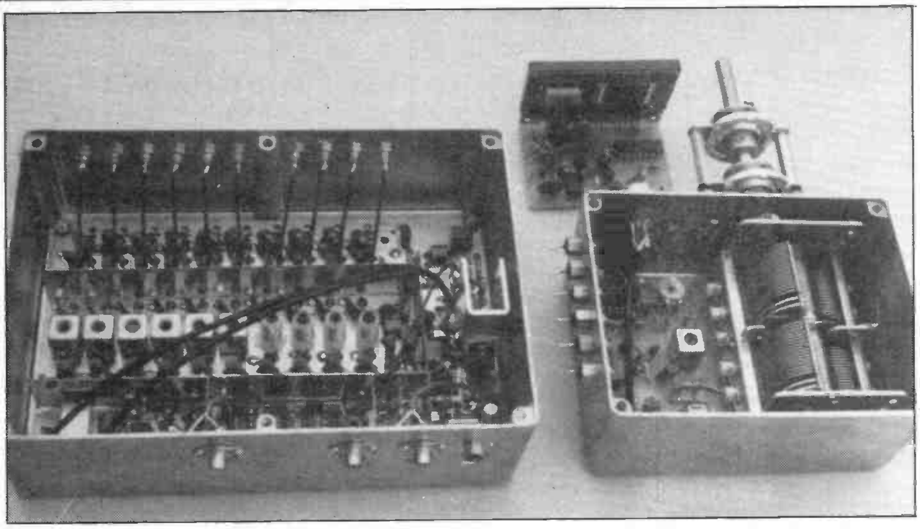
Out with the epoxy...

Winding the VFO to the low end of its range should then cause the control voltage to drop until it reaches about 4-4.5v.

When you are satisifed with the 160M VCO coverage, get some rapid setting Araldite and smear it over the turns and the base of the core so it is locked to the pcb. It is advisable to leave one or two turns free at the top of the core for final adjustments when the module is cased, and to recheck the top frequency for 10.3v control voltage BEFORE the Araldite has set, as applying the adhesive will have almost certainly moved the turns a bit.

The process is then repeated with each VCO in turn.

Finally, terminate the VCO output with a 1N4148 diode (either way round) in series with a 47 or 56 ohm resistor, the latter connected to earth. Apply the diode probe to the junction of the two. With a bit of luck you should have a reading. Carefully note the position of the wiper on RV3, then turn it slowly an-



ticlockwise. The reading should start to decrease (showing that the diode is only just conducting). You should set RV3 so that the reading on the probe just limits — at this point the diode is conducting healthily and the output RF voltage will be about 700mV, which is what we want with the frequency display module connected if used.

If the diode is not conducting in the first place, then the VCO output voltage is too low. The bias on TR26 can be increased a little to compensate from its original position, but a check should be made that the circuitry is correct in the first place.

It shouldn't be a lot lower, or vary wildly — if it is, suspect one of the transformers in the VCO output circuits or capacitor value error.

Casing up

The completed module can now be mounted in the diecast box. Other forms of casing can be used, but whatever is used should be RF tight, and of similar dimensions if our case design is to be used. Feedthrough capacitors are essential — if you have difficulty getting these, AJH Electronics keep the screw in type.

Drill out the various holes as per the drawings, then place the module in the box the correct way round and mark the mounting holes onto the base of the box before drilling them. Not shown in the drawings are a series of 3mm ventilation holes occupying about 2cm square in the lid above Q26, and in the side of the box, just above the bottom next to Q26. The board mounts on 6BA bolts, using a couple of half nuts as spacers between the board and the box.

The various connections can then be made with the coaxial sockets and the feedthroughs. Although they were used for the model shown, and on the CIFPU unit, miniature Belling Lee connectors are not advised — they have a habit of breaking the centre conductor connection after a few insertions and are very fiddly to use. Standard Belling Lee, or even BNC if you like, are a better bet.

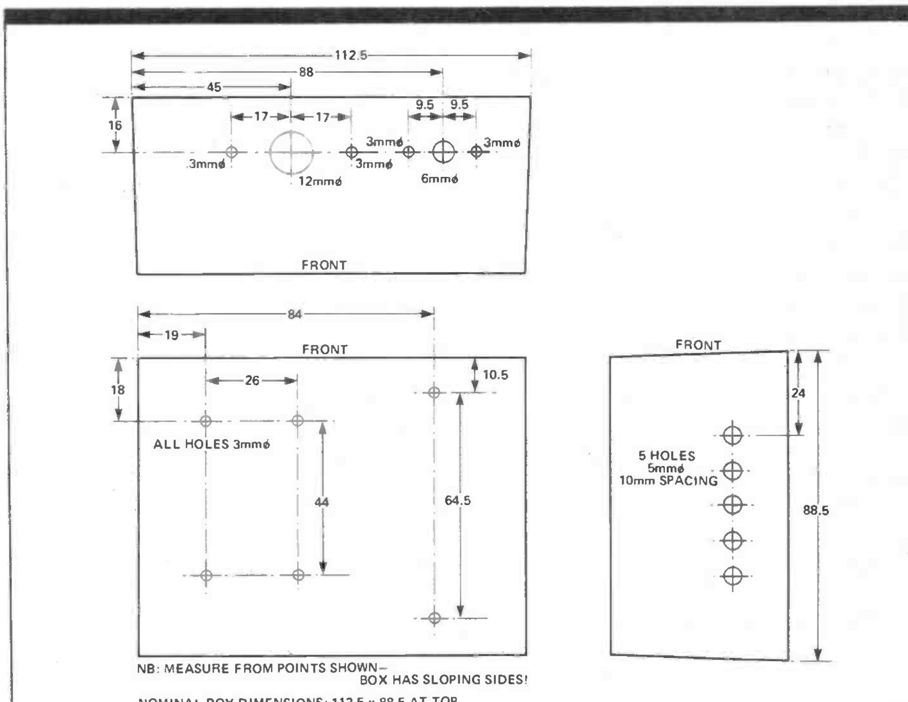
Not shown in the photograph for reasons of clarity is an additional tinplate screen which covers the whole of the crystal oscillator and loop filter/phase comp/loop mixer section. This should be soldered on right at the end when everything is working correclty. Small holes will be needed near points B and A for the coax and wire to emerge — the other cables will go over the top of the screen.

The final act after casing is to once again check the VCO coils for coverage and make any small adjustments necessary — fix the remaining part of the winding into place using nail varnish borrowed from the XYL. The reason for not using epoxy is that you may find, although it should be unlikely, that once the VCO is cased and warms up, drift of the VCO may take the control voltage out of range at the high frequency end (this drift has no effect whatsoever on circuit operation normally). Epoxying the top of the coils would not allow further adjustment if needed.

No 'out-of-lock' indicator has been provided, although one could be made using pin 5 of IC6, as the frequency display clearly shows if this (unlikely) fault occurs (see later). The only condition under which the system may go out of lock and refuse to re-lock is if the VFO input is removed, or power is lost from the VFO and then reconnected. Under normal conditions this will not of course happen.

Connecting to the CIFPU

The moment has arrived to actually try out the VFO. Connect everything up and link up the unit to the CIFPU local oscillator input using a short length of coaxial cable. With the frequency display and preselector in use, you will have a complete receive system.



Reference VFO box drilling detail

Received signals should be pure and clean, and the stability of the system excellent.

Using the VFO with a 9MHz i.f.

To use this module with a 9MHz i.f., such as a ZVC or 4CLF design, the crystal frequencies need changing to 1.7MHz lower, and the VCO coverages also need lowering by 1.7MHz. Other than some possible slight changes to C44-53 for correct crystal oscillator tuning, the rest of the construction and alignment is identical.

Digital Frequency Display

The display selected for OMEGA uses a virtually complete LCD frequency counter subsystem, capable of counting to 4MHz. In order to achieve a full frequency readout to an accuracy of 1kHz, the VCO signal is fed through preamplifier and signal conditioning stages (Q1-Q5) and then divided by 10 in a low power Shottky i.c. divider (IC1).

At this point we have a signal 10.7MHz higher than the signal frequency, which has been divided by 10. To get the correct readout, an internal subtractive circuit programmed into the PCIM177 display is used to subtract 10.7 from the reading and thus end up with the received frequency. This system has the advantage that any errors in the crystal oscillator frequencies are allowed for and the actual display does not take care of is the SSB offset from what is a nominal carrier frequency. However, this is common to many far more expensive transceivers and is not a major problem.

The whole unit runs off +5v from an on board voltage regulator fed with +12v.

Construction

All circuits other than the display itself are built on one small single sided pcb, onto which the main display is mounted by means of wire links. The unit mounts against the front panel using a bezel attachment, with an aluminium screen around the rear of the unit (details later).

Construction is simple, and all components should be mounted as per the drawing, observing the orientation of the case outlines of active devices.

The display mounts using small pieces of wire (offcuts from the components already soldered in) as shown in the drawing. The wires should be soldered on the display side of the PCIM177 module (they are through-plated to the other side).

No alignment is required — connecting the display to the VCO output via C100 and coaxial cable should show the correct receive frequency. Note that if the system goes out of lock, the display will read a high frequency in excess of 30MHz which is not stable, or a very low frequency.

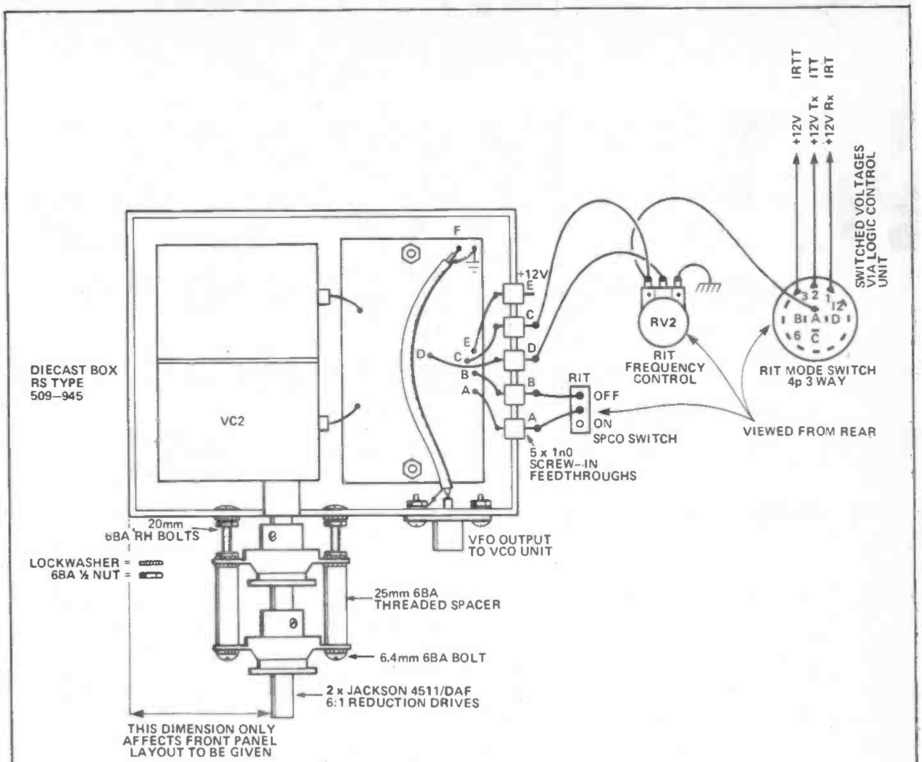
Receive only SSB adaptor

This is an additional module for those who are building the receive only version of OMEGA, and provides access to the missing sideband not covered by the CIFPU unit.

It is simply a repeat of the circuit around Q12 in the CIFPU (July HRT). It is built on a small pcb and mounted on the outside of the CIFPU box.

It is not advisable to try and modify the Tx oscillator in the CIFPU (Q10/11) for this purpose — it may introduce problems with the noise blanker operation.

Once built, the unit is connected as shown, and the trimmer is adjusted for correct reception of the opposite sideband to that of the oscillator in the CIFPU — switch selected by a rotary or toggle switch. Connections between points N & P on the CIFPU will need to be broken, with injection from the new unit at point M. Applying +12v to point N will then select the CIFPU oscillator.



Reference VFO connections

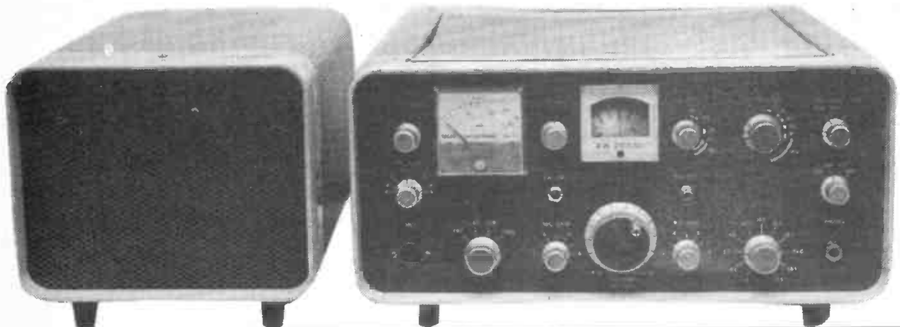
Odd Points:

In answer to a few queries we have had, Omega will run entirely off +12v (actually 13.8v will be ideal), any other voltages required being generated on board.

With the QRO PA in use, the supply current will need to be 15-20A peak.

The case design is now finalised. Its size is 390W x 320 deep x 130 high. Full details will appear in either the December or January issues, but we hope to get a photograph in before then. It will accommodate all planned modules, except psu-extra modules on the drawing board are an in-line SWR/Power meter and 2 metre TX/RX converter. ●

Upgrading the KW2000 series of HF transceivers



Part 6 Adding the new bands

by M.T. Healey, G3TNO and R. Charles

It may seem rather strange, but we start this month with a word of warning! The modifications required to fit the WARC bands require some dexterity and care as they involve a fair amount of 'digging around' in the front end and driver stages as well as the HF oscillator stage of the rig. However, with care it is possible to do the modifications needed in a few hours and this does give the advantage that, not only do the new bands become available, but extra portions of the existing bands can also be added. We have so far only tried the modifications on the *KW2000A*, but they should be equally possible with the other models in the series.

Modification procedure

First remove the PHONES socket from the front panel and link out the wiring from the socket so that the speaker is permanently connected. The socket can conveniently be re-fitted to the lower left hand side of the PSU front panel, making sure that the outer part of the socket is isolated from the panel in order to prevent hum being introduced into the headphone circuit by heater current flowing to earth via the headphone wiring. Next remove the links on the existing bandchange switch wafers, as shown in **Fig. 131**, not forgetting to remove the links on S2i wafer to disable one PA valve on 18 and 24MHz to comply with the current licence conditions! Next fit the coils L_A, L_B, and L_C listed in **Table 101** between the appropriate tags as in **Fig. 131**, remembering to keep the leads to the extra coils as short as possible, and also to position the coils so that access is possible to their ferrite cores during alignment. Now fit the new extra switch S1000 into the hole previously occupied by the headphone socket. Some care is required in this operation in order not to damage components in the HF oscillator compartment. You may well find, as the writers have, that it is easier to remove one or two components during the fitting of S1000, replacing them after the switch has been fitted. The wiring to the crystals is now modified as in **Fig. 132**, the extra sections of the existing bands may be fitted by adding extra wire ended miniature crystals to the contacts of S1000.

The wiring changes to the PA stage should be tackled next. First remove the links from S2E, and then

Table 101

Component	Details	KW2000 TUNING RANGE
L_A	3 off. 2 turns 22swg on 5mm dia with ferrite core. close wound.	
L_B	3 off. 3 turns 22swg on 5mm dia, with ferrite core. close wound.	
L_C	3 off. 11 turns 28swg on 5mm dia. with ferrite core. close wound.	
L_D	6 turns of 22swg Enam. Copper. Wound Directly on to ¼" dia. Iron Dust Core.	
L_E	10 turns of 22swg Enam. Copper. Wound Directly on to ¼" dia. Iron Dust Core.	
L_F	8 turns of 22swg Enam. Copper. Wound Directly on to 5/16" dia. Iron Dust Core.	
C_F	150 pF silvered mica.	
X19	Final o/p freq = 25.80MHz + 3.155MHZ = 27.95MHz ÷ 2 = 13.9775MHZ (XTAL FREQ) wire ended miniature crystal.	24.80-25.0MHz
X20	Final o/p freq = 18.0MHz + 3.155MHz = 21.155 MHz ÷ 2 = 10.5775MHz (XTAL FREQ). WIRE ENDED MIN.	18.0-18.2MHz
X30	Final o/p freq = 10.00MHz + 3.155MHz = 13.155MHz ÷ 2 = 6.5775MHz (XTAL FREQ) WIRE ENDED MIN.	10.0-10.2MHz
S1000	3 pole 6 way miniature switch. No particular make is specified but the writers made theirs up from RS components. *Maka — switch kits.* These just fit, but only just.	

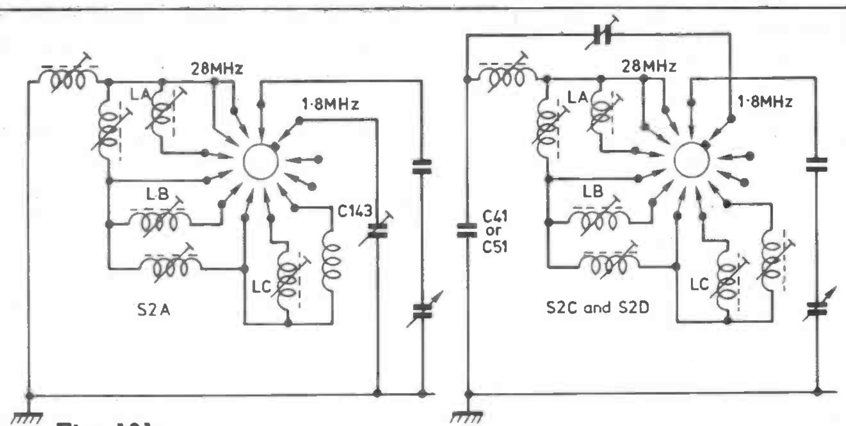


Fig. 131.

route additional leads to the pi-tank coil using PTFE covered copper wire as in **Fig. 133.** It is as well at this point to check the condition of the existing wiring to the PA coil, since we found that in some cases it had deteriorated to such an extent that the insulation actually fell from the wires when touched! At G3TNO it was found easier to carry out the above modification by first removing the sections of shaft coupling the bandswitch wafers to the front panel indexing mechanism and then, with great care, to remove each wafer in turn from the transceiver, so that it could be modified on the bench instead of in situ. Care should be taken when re-installing the wafers to make sure that the wipers of all switch sections are correctly aligned before refitting the shaft.

The wiring changes to the bandswitch will, of course, alter what this switch does in practice, so **Table 100** lists the old and new (ie. modified) band positions.

After carrying out the modifications, or any part of them, a complete re-alignment of the front end is needed as per the instructions in **Part 3** of this series. In addition, the new bands will need to be aligned. Ideally, the equipment used for this should consist of:—

1. Signal generator with *accurate* frequency calibration.
2. RF millivoltmeter with high impedance input.
3. General coverage receiver.
4. RF wattmeter/dummy load.
5. Absorption wavemeter.

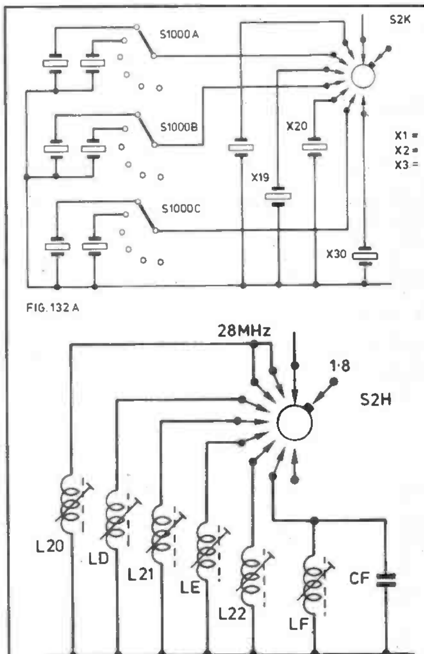
Alignment of the new bands

This should be carried out *after* the complete procedure for alignment given in Part 3 has been performed.

1. HF oscillator: Select the 24MHz band and remove the crystal for that band. Connect the RF millivoltmeter to pin 1 of V9 and the signal generator to pin 1 of V10 (HF osc). Set the signal generator to 27.955MHz and adjust the core of L_D (additional coil mounted on S2H) for maximum reading on the millivoltmeter, making sure that the core is not screwed fully in or fully out. Reduce the signal generator output so that the millivoltmeter reading does not exceed 500 MV. and re-check the setting of L_D, again adjusting for maximum reading.

Next select the 18 MHz band and repeat the above procedure, this time setting the signal generator to 21.155MHz and adjusting L_E for maximum millivoltmeter reading as before. Finally select 10 MHz, set the generator to 13.155MHz and adjust L_F for maximum reading.

If you do not have, and cannot borrow a high impedance RF millivoltmeter it is possible, with great care, to align the HF oscillator using a general coverage receiver tuned to the frequencies listed above. The receiver should be coupled lightly to the HF oscillator as in **Part 2** of this series, using a piece of wire wrapped around the glass envelope of V10, and L_D, L_E and L_F should be adjusted



Note:- Only switches requiring wiring changes shown for clarity.
Fig. 132.

on the appropriate bands for maximum signal. If you do not have access to a decent signal generator (or worse still any at all!), it is possible to align L_D-L_F by using the

Table 100

Band select positions before modification	Band select positions after modification
28.6-28.8MHz	29.4-29.6 (OSCAR DOWNLINK)
28.4-28.6MHz	28-30MHz (Depends on settings of S1000 and XTALS CHOSEN)
28.0-28.2MHz	24MHz band
21.3-21.5MHz	21.0-21.5MHz (Depends on settings of S1000 and XTALS CHOSEN)
21.0-21.2MHz	18MHz band
14.2-14.4MHz	14-16MHz (Depends on settings of S1000) Note XTALLED FOR 14.0-14.6 and 15.6-16. For use with 144MHz transverter
14.0-14.2MHz	10.0-10.2MHz

All other switch positions remain unchanged

Table 103

Band	Position of new taps on PA tank coil
24MHz	Midway between existing 21 and 28MHz taps
18MHz	Midway between existing 14 and 21MHz taps
10MHz	Midway between existing 7.0 and 14MHz taps
	Note: The above taps will work satisfactorily but it is worth trying the position of the taps a turn or so either way, for optimum loading and output. We have modified for *KW2000* so far and the 10MHz tap is one case needed 3 more turns for optimum performance.

appropriate crystals as fitted in the modifications, but do make *sure* that you have tuned the coils to the correct harmonic of the crystals!

2. RF and driver stages: If you have fitted the crystals for the new bands during the previous stage of the modifications, first remove them again!

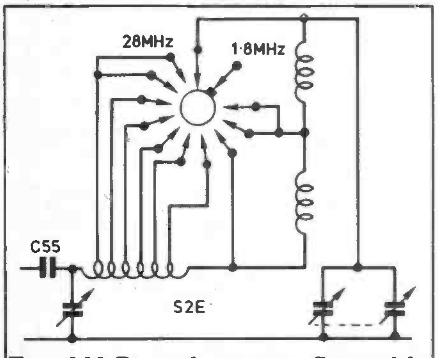


Fig. 133 Pi tank circuit. See table 103 for details of new taps required.

Select 24MHz, inject a signal at Pin 2 of V7, and set *KW2000* to INT MOX. Connect the output of the tranceiver to a dummy load. Adjust the PRE-SELECTOR so that the pointer lies midway between the 28 and 21MHz markings. Set the signal generator to a frequency in the middle of the 24 MHz band, and to an output of approximately one volt. Adjust L_A (S2d) for a rise in PA anode current. Tune and load the PA for a shallow dip into a dummy load/watt-meter, and then re-adjust the alignment of L_A, reducing the output from the signal generator if necessary to keep the PA current below 100mA on the *KW2000,* or 200mA for other versions.

Once the driver anode circuit has been aligned, remove the signal generator from V7 grid and connect it to Pin 2 of V5 (second transmit mixer). Proceeding as above, align L_A (S2c), which is in the anode circuit of V5.

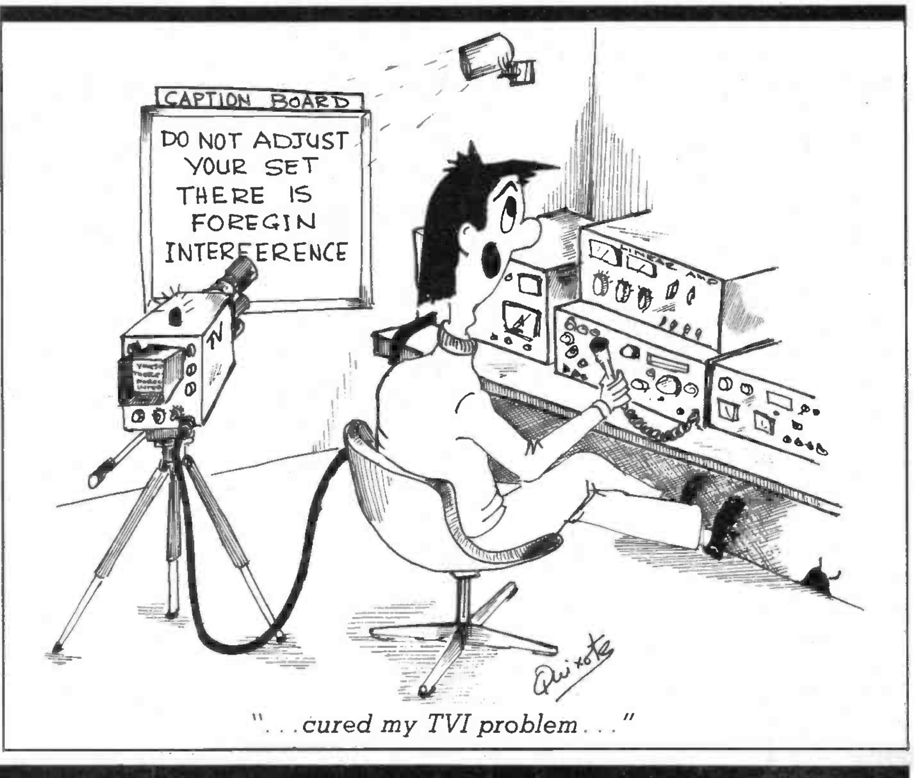
Now change bandswitch to 18MHz, set the pre-selector to midway between the 14 and 21MHz segments, and set the signal generator to the centre of the 18 MHz band. Remove the 18MHz band HF oscillator crystal, and then align L_B (S2d) and L_B (S2c) following the procedure given for the 24MHz band, not forgetting to tune the PA correctly into a dummy load. Finally repeat the procedure for 10MHz, setting the pre-selector midway between the 7 and 14MHz segments and adjusting L_C (S2d) and L_C (S2c).

Now refit all HF oscillator crystals. Set the bandswitch to 24MHz, switch to TUNE and adjust pre-selector and PA as in the instruction manual. *Without altering* the pre-selector setting, switch to receive and connect the signal generator to the aerial socket of the rig. Set the generator to about 24MHz and adjust its tuning until its output is heard on the *KW2000.* Ensure that the signal from the generator is centred in the receiver passband, and then adjust L_A (S2a) for maximum S meter reading, reducing the output level of the generator if necessary to keep the S meter reading below S5. Repeat the procedure on 18 and 10MHz in that order, adjusting L_B (S2a) on 18MHz and L_C (S2a) on 10MHz. The temptation to use off-air signals for this should be resisted, since your aerial may not present the correct 50 ohms impedance to the rig, which will affect the setting of the front end tuned circuit. For the same reason, do not re-adjust the setting of the front end coils after carrying out the adjustment with the signal generator as described above.

Modification for 10MHz only

It is, of course, possible that, like one of the writers, you may only wish to fit the 10MHz band and not the other bands, at any event in the initial case. In this case, of course, a single pole two position switch can be used in the S1000 position, and of course only the extra coils appropriate to the 10MHz band need be fitted!

The next article in this series will cover the improvement of the front end performance on the lower frequency bands, and provision for a separate outboard receiver, and separate receive and transmit aerials.



". . . cured my TVI problem . . ."

Aerials for DX working Part 2

By Sant Kharbanda C.Eng, FIERE, FSCTE, G2PU

Many amateurs have a metal mast or tower to support their 14/21/28MHz rotary beam and do not want to erect more supports. A number of articles have been written on the use of the tower as a vertical radiator by shunt feeding, as shown in **Fig. 5.** However I have found that intermittent contact between the sections of telescopic tower coupled with undesired resonance effects of the many cables attached to the high band aerials and rotator can cause problems and I therefore prefer the use of sloping wire aerials attached to the top of the tower.

Two types are in common use, the half-wave centre fed sloper and the quarter-wave sloper often called the half sloper. The former is illustrated in **Fig. 6.**

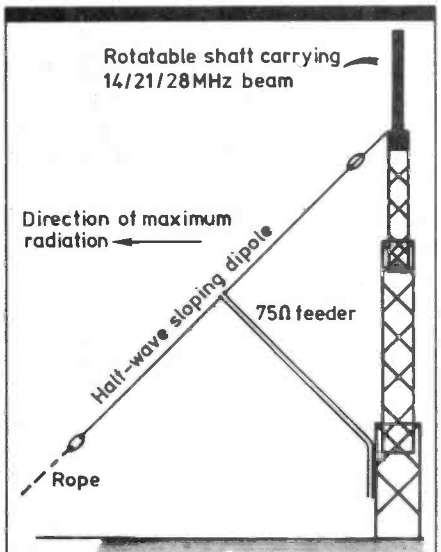


Fig. 6. The full sloper

Best results have been achieved by using a slope angle of about 45° with the bottom end pulled out in the direction to be favoured. The metal tower tends to act as a reflector reinforcing vertically polarised radiation in the plane of the tower and dipole as shown in the diagram. A horizontally polarised component exists which is beneficial should short skip contacts be desired but, of course, gives rise to more interference when working DX than when using an aerial which is solely vertically polarised.

In practice the half-wave sloper is an effective DX aerial and by using four equi-spaced around the tower, each with its own feeder, it is possible by appropriate phasing and switching to select coverage of any part of the world (ref 6).

The half-sloper is illustrated in **Fig. 7.**

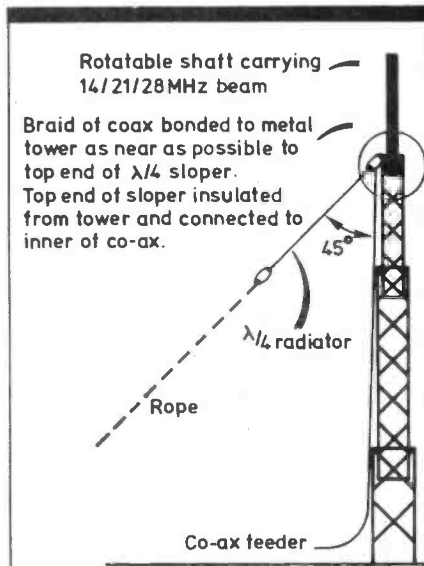


Fig. 7. Half sloper using a tower for support

In this case the tower becomes a virtual vertical ground plane against which the ¼ sloper is energised. On the face of it the half-sloper should be less efficient than the full size ½ sloping dipole. However there are two mitigating factors:

(i) The current loop is higher on the half-sloper and
(ii) The lower end of the aerial is at a greater height than for the sloper and therefore obstructions should have less effect.

The author has found the half-sloper to be less directional than the full size sloper. This is because the current loop (ie the point of maximum current) cannot be spaced from the tower. It may still be useful to use three or four half-slopers around the tower but do not expect spectacular directivity when switching. Full wave loop aerials make excellent radiators for use on the lower frequency bands. For the 7MHz band a total wire length of about 43m is required. A rectangular loop fed at

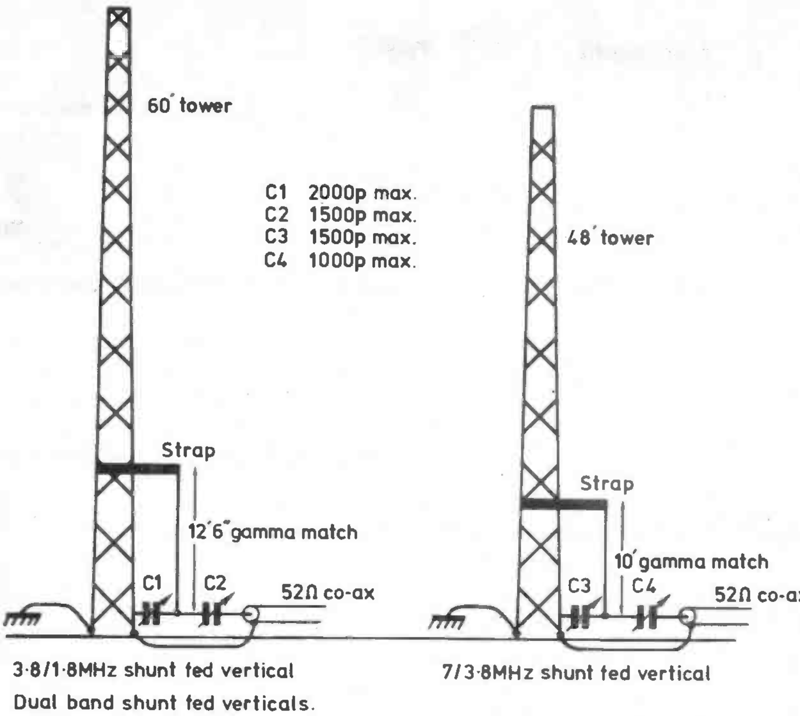


Fig. 5. Dual band shunt fed verticals

the centre of one vertical section works well but requires two supports. The vertical members should preferably be mot less than 8-9m long but the lower horizontal section should be out of reach because of the high RF voltage at the centre. The author invariably uses 75Ω balanced twin lead which should run horizontally from the vertical section for as far as practicable so as to minimise radiation coupling with the vertical wire to which it is connected. This is illustrated in **Fig 8.**

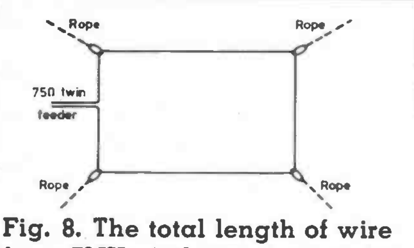


Fig. 8. The total length of wire for a 7MHz fullwave loop is 43m

Full wave vertically polarised Quad loop. Directivity is at right angles to the plane of the wire but is not very pronounced.

A variant of the full wave Quad loop is the Delta loop which again is a full wavelength of wire, this time arranged in triangular format. Many prominent DXers have found this to be an excellent aerial. If only one support is available it is mounted in the normal fashion with the apex at the top as illustrated in **Fig. 9.**

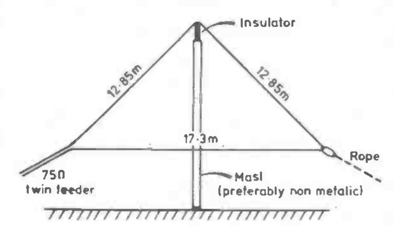


Fig. 9. Delta loop

It is generally desirable to use a non-conducting mast for vertically polarised aerials (except for the slopers discussed earlier). Fortunately a 7MHz Delta loop does not require an excessive pole height.

Many amateurs may possess two fairly widely spaced masts in which case a Delta loop may be strung between them and allowed to hang upsidedown with the 'apex' at the bottom as shown in **Fig. 10.**

The author has tried both varieties and finds only a marginal difference in favour of the inverted version.

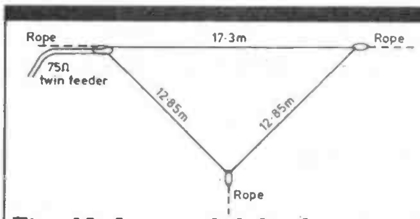


Fig. 10. Inverted delta loop

If a really high mast is available (25m) it may be advantageous to use horizontal polarisation by feeding either at the apex or at the centre of the horizontal base section. The use of a metal mast is perfectly satisfactory in this case because the polarisation is horizontal.

Two Delta loops mounted at right angles from a single mast is another excellent arrangement for worldwide coverage. Again the choice of horizontal v. vertical polarisation is largely dependent on the apex height available. Horizontal polarisation will usually prove superior on the 7MHz band if the apex height is at least 25m.

As shown in **Figs. 9** and **10** the 7MHz Delta loop typically uses some 43m of wire for resonance around 7.08MHz. The length of the horizontal member should be about 17.3m and the two equal sloping sides should each be about 12.85m long. The dimensions are not extremely critical; the main proviso being that the total length of wire employed should achieve full wave resonance at the desired frequency. Varying degrees of coupling with surrounding objects and height above ground will affect the final dimensions and the figures above have been quoted as a guide.

Whilst a Delta loop fed at either one of the two corners (not the apex) will yield mainly vertical polarisation, there is a small horizontally polarised component. This can be avoided by moving the feed point slightly as illustrated in **Fig. 11.**

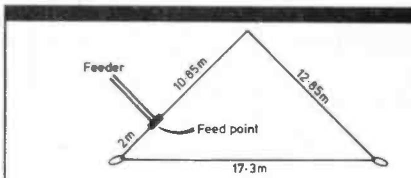


Fig. 11. Altered feed point on delta loop

The writer has found little if any difference in performance and prefers the convenience of corner feeding.

Finally a really effective 7MHz beam can be constructed at very little cost by mounting a 7m horizontal spreader across the top of a mast and supporting a Delta loop from each extremity as illustrated in **Fig. 12.**

Similar remarks regarding horizontal v. vertical polarisation apply to this array also. A steel tower between the two Delta loops will have much less effect if horizontal polarisation is used but vertically

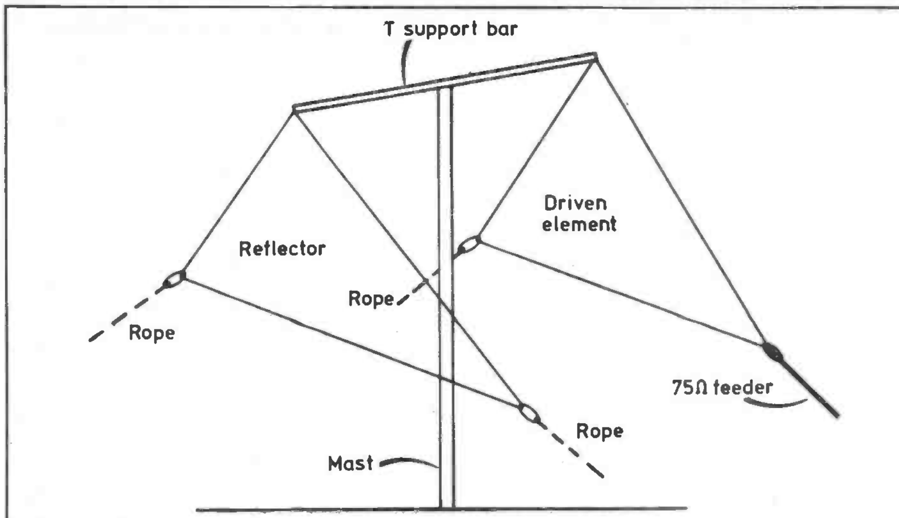


Fig. 12. Pair of delta loops used as beam aerial

polarised loops ideally need a wooden mast. Fortunately in this case much less pole height is needed.

The formulae normally used to determine the overall wire lengths for full wave loop elements are:

Driven element $\frac{306}{f(MHz)}$ in metres

Reflector $\frac{313.6}{f(MHz)}$ in metres

Practical experience at the author's location has shown the need to make the driven element slightly shorter and the reflector slightly longer than the dimensions predicted by the formulae but this may be due to local environmental effects.

Of course both elements may be made of the same size and a separate feeder attached to each. This allows the use of a phase shifting stub to the switched from one to the other feeder for reversing the direction of fire.

3.5/3.8MHz band

Much of what has been written in detail about aerials for the 7MHz band also applies for the 3.5/3.8MHz band except that mechanical difficulties are much more severe. A height of a half wavelength is 43m (for 3.5MHz); so even a horizontal dipole is outside the scope of most amateurs at this height and rotatable beams need not be discussed in this article!

So let us turn our attention to the more simple wire aerials which are possibilities worth consideration by serious 80m DXers.

The full size halfwave sloping dipole needs a support height of nearly 30m to keep the bottom end out of reach of people, again assuming a 45° slant which seems near optimum when a metal tower is used. Nevertheless many operators have found this an excellent DX aerial. For all round coverage, an 80m version of the system described in reference 6 may be constructed. The author has also tried shortened half-wave slopers both of the G5RV type and those using traps but performance has fallen short of that obtained with the full size version.

To avoid a repetition of what has been written about verticals, slopers and Delta loops for the 7MHz band it should be noted that all the observations and comments made, equally apply to the larger versions of these aerials for use on the 3.5/3.8MHz band. Additionally the following points are worth bearing in mind:-

1) It is difficult to design an aerial to cover the entire 3.5/3.8MHz band. The easiest way out is to decide if one is essentially a CW or SSB DX enthusiast. Then a bandwidth of only about 25kHz is usually sufficient (even the VK's can now use the 3.8MHz end!)
2) The author has found that ¼ verticals work rather better with resonant ¼ radials (even if they are only about 1m above ground) than buried radials.
3) A pair of phased verticals constitute an excellent DX aerial. A separation of 40-50m is required for in-phase operation when a bi-directional broadside pattern results. A unidirectional pattern can be secured by spacing the verticals a quarter-wave apart and using a quarter-wave delay line in one feed or the other (to change the direction of in-line fire).
4) A single Delta loop is almost invariably better than a ¼ vertical. One reason for this is that all the RF power at the aerial end of the feeder goes into the aerial. Series ground losses reduce the effective power going into any aerial (eg the ¼ vertical) excited against ground. In the writer's opinion Delta loops are among the best practical aerials available to the average amateur for use on the 7 and 3.5/3.8MHz bands.
5) Where adequate mast height is unavailable for a full size half-wave sloper, the ¼ half-sloper may be tried. Considering the small space occupied it can provide fair results but is not in the same class as a Delta loop erected in the clear. Some controversy exists with regard to the functioning of half-slopers (references 7,8 and 9).

The author has used a pair of co-linear inverted Delta loops for DX working on 3.8MHz. This gave very good results to the USA which is in the broadside direction. Whilst individual feeders were used in this case it should be possible to use a single feeder as shown in **Fig 13.**

Perhaps the most effective 3.8MHz aerial the author has tried consists of a pair of Delta loops mounted one behind the other. See **Fig. 14.** Both are driven using 75Ω balanced twin feeder. One Delta loop is strung between two widely spaced 20m masts and is inverted with the 'apex' hanging downwards. The second loop is supported at its apex by a wooden mast which is some 16m behind the inverted Delta loop. This somewhat unusual arrangement was evolved purely because of practical constraints. It was decided to drive both elements rather than use a parasitic reflector (or director) because this arrangement leads to easy beam reversal by operating a single switch in the 'shack'.

An inverted 'V' half-wave dipole with its apex at about 15m has been used as a comparison aerial. All have proved considerably superior to the inverted 'V' for DX operation.

1.8MHz band

It has not been found possible to erect an 'ideal' top band aerial at the author's location without removing the 7MHz and 3.8MHz aerials.

Vertical aerials using inductive loading have been abandoned in favour of capacity hat loading. Both the radiation resistance and

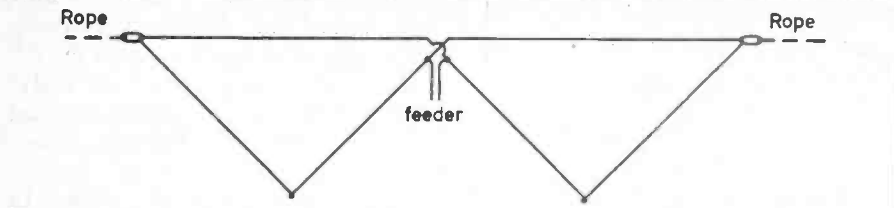
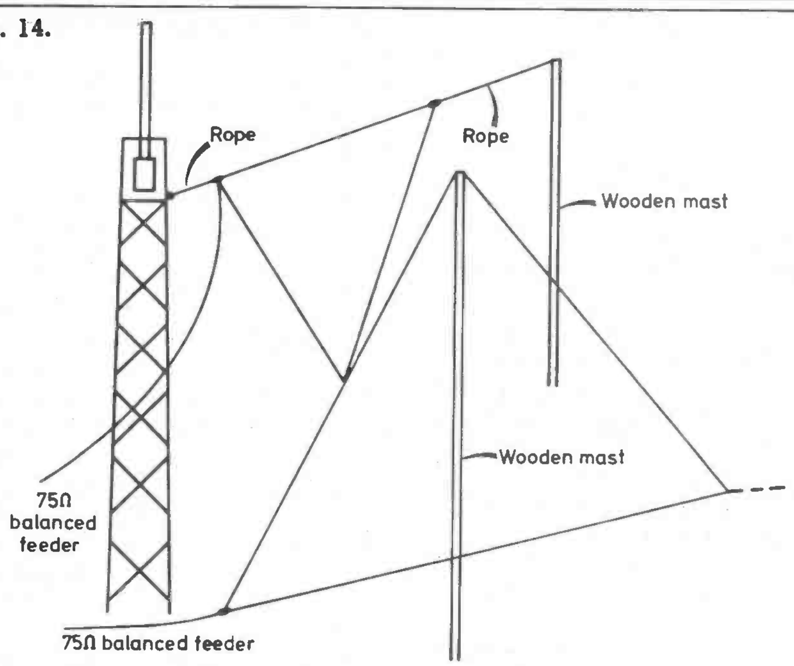
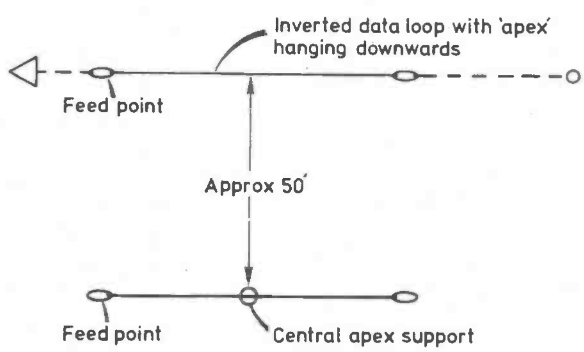


Fig. 13. Conlinear inverted delta loop.

Fig. 14.



Phased 3.8 MHz delta loops at G2PU



Plan view of phased delta loops

efficiency fall alarmingly with a severely shortened element. Therefore good insulation, heavy gauge conductors to minimise ohmic losses as well as a first class earth system are mandatory for DX working with a short vertical.

After considerable experimentation the writer decided to use a quarter-wave radiator excited against ground. As it was not practicable to get the radiator wholly vertical, one eighth of a wavelength is vertical with the remaining one eighth of a wavelength horizontally suspended between two masts. (See **Fig. 15.**) This arrangement can either be regarded as a bent quarter-wave or as a shortened vertical with assymetrically mounted top hat capacity loading. Polarisation is mainly vertical but of course there is also some horizontal polarisation. Eight radials each 1/8 wave long are used at ground level.

The feeder used is a buried 75Ω heavy duty co-axial cable about 100m long. At 1.90MHz the VSWR is approximately 2:1 but no concern is felt about this because the co-ax loss at this low frequency is insignificant.

For those with sufficient mast height the ¼ half-sloper can provide good results (reference 7).

One way of getting the meagre power we are permitted on top band into radiation, and not lost in warming the ground connection, is to use a loop aerial design. For example if an 80m Delta loop is fed by open wire feeder coupled to an ATU it can be current fed in its normal mode but voltage fed on the 1.8MHz band. Earth connection losses no longer play a part in determining the amount of power in the radiating element (but earth characteristics of course affect the polar diagram).

A full wave Delta loop is beyond the resources of most amateurs except for those living on suitable sites in the country. The writer knows of one American amateur who uses one with outstanding results.

The object of this article has been to outline the practical difficulties which confront the average amateur contemplating an efficient aerial for DX working on the lower frequency bands. The author has tried to develop ideas for arriving at acceptable compromise when only modest resources are available. It is intended more as a thought provoking exercise than as a detailed constructional article.

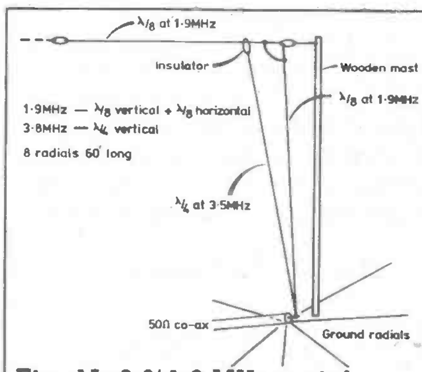


Fig. 15. 3.8/ 1.9 MHz aerial system at G2PU

REFERENCES

6) *40m sloper system.* The ARRL Antenna Book — 13th edition — p200-201.
7) *Putting the quarter-wave sloper to work on 160* — Atchley — QST July 1979 — p19-20.
8) *Additional notes on the half-sloper* — Demaw QST July 1979 — p20-21.
9) *The half sloper — successful deployment is an enigma* — Belrose — QST May 1980 — p31-33.

NEWCOMER'S FORUM

By Tony Bailey G3WPO

Firstly, may I say to the anonymous CBer (who appears to reside in Kilburn) that wants his amateur licence by the same method that he got his CB Licence — ie by paying for it, that no amount of four letter words is likely to change the existing situation, either addressed to me or the Home Office.

Like most people, if you want a licence, then you have to follow the accepted procedures, a route which seems acceptable to the majority. Incidentally, I believe you can get put in the Tower for sticking the stamps on the letter upside down.

CQ DX

As I sit writing this piece, I am occasionally breaking off to have a look at 2 metre SSB on the off-chance that some more Sporadic-E is about. This afternoon saw some nice contacts with Eastern Europe and the Mediterranean, from a less than ideal VHF site nestling at the foot of the South Downs. I often feel like attaching a laser to the beam to cut a hole to the SE, but somehow the RF seems to get over or around the chalk.

I imagine that a lot of the newer licencees are having their first experience of Sporadic-E and the sudden appearances it can make. Unfortunately, this year is likely to be less notable than some previous years, due to the lower activity of the Sun not producing the ionisation levels necessary to induce this propagation mode, although the view that the Sunspot Cycle affects Sporadic-E is not held by everyone.

The occurrence of Sporadic-E is not easy to forecast, but it is generally a summertime phenomenon, and the best times are generally in the early morning around 0900-1000 local, and again in the early evening. It can however occur at any time, but not usually during the hours of darkness.

One of the problems that Sporadic-E propagation gives is that of frequency occupancy. It is not uncommon to find the DX either bang on or very close to 144.300MHz, and this seems to upset a lot of people when they insist on working stations on what is the Calling Frequency. Quite honestly, if there is a lift on, the sheer number of stations makes the calling channel invalid anyway. After all, there are a lot of kHz available to the SSBer and spreading out makes sense. You stand a much better chance on a clearer spot, rather than worrying about someone using 144.3.

One other point, if an SP or I9 or some other exotic DX comes up on 2 metres he won't be all that interested in your name, QTH, height a.s.l. and the colour of your socks! Once you've swopped callsigns, reports and QTH Locators, that is probably that. There will be an awful lot of people wanting a contact and the DX station will no doubt want to make as many QSOs as possible in the short time available. The other side of the coin is that if he does want to chat, it's no good muttering profanities over the air about getting on with it etc, as one G4 who should have known better was doing this morning. Its a bit like the television, you don't have to listen, there are always other channels! So be patient if you have to.

CW anyone?

I apologise to G4NOZ (Letters, July) and his feelings, by casting Nasturtions on the level of CW operation. Active though it may be around Colchester, CW QSOs are still little used by comparison with FM, by I should think a ratio exceeding several thousand to one, if not more. I wish more people would come on the mode when two is at its normal propagation level (which is most of the time) as they would be surprised at the distances which could be covered, even with low power.

Direct conversion DSB

There are a couple of points which have come up from letters on the *DSB80* project we published a while ago, with several people asking if it is possible to convert the design to single sideband transmit rather than the double sideband version detailed by adding a suitable filter.

Unfortunately, it isn't, because to filter off the unwanted sideband, you have to firstly pick a frequency to do the filtering at so that you can construct a suitable filter. Now, with a conventional single sideband transmitter, using the superhet principle, the RF signal that eventually ends up at the antenna socket is initially generated at some fixed frequency, possibly 9 or 10.7MHz, or as low as 455 or 60kHz, depending on the design.

At these fixed frequencies, it is easy to construct, or purchase, a suitable filter, which, after balancing out the carrier, is used to rid us of the unwanted sideband.

However, the *DSB80* is a direct conversion design. In this, the low-level transmit signal is actually generated at the eventual transmit frequency, with the modulation of the carrier taking place at the same frequency, and not at some lower fixed frequency. Balancing out the carrier is no problem, but to get rid of one of the two sidebands resulting is a problem.

You could do it with a filter, but it would have to be rather special, in that it would need to maintain a bandwidth of around 3kHz, while at the same time, have a variable frequency of 3.5 — 3.8MHz, which is clearly difficult.

On the receive side, there is something you can do to remove the additional bandwidth generated by having no form of filtering as you would in a superhet receiver. That is to do some additional filtering at the audio stages, where it is much easier to accomplish.

Even without filtering, the direct conversion receiver is still an extremely popular and efficient way of getting a first receiver going. The lack of selectivity, which as we have said can be improved with an audio filter, isn't such a disadvantage as you might think. The average human ear is an extremely good filter, and the audio image generated by any direct conversion receiver is for all practical purposes filtered out by the ears.

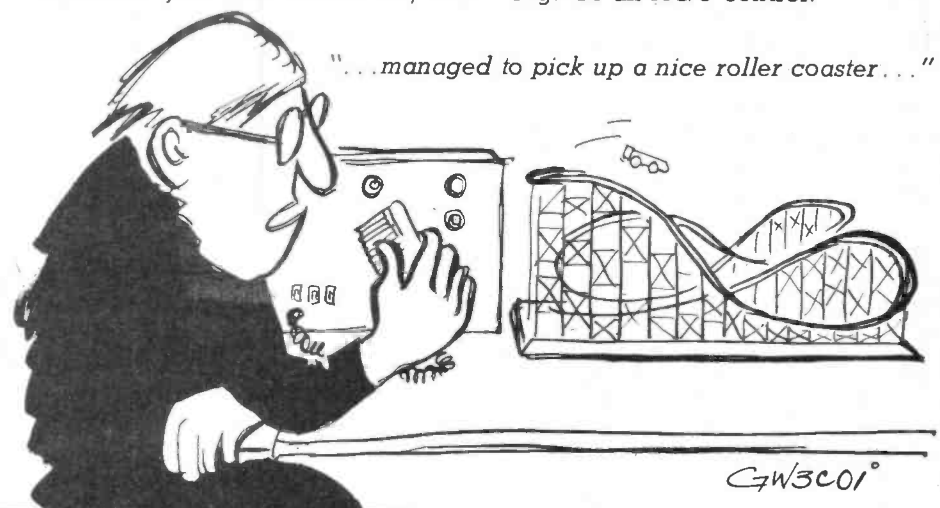
Diodes and FET oscillators

In many of the FET oscillator designs which appear in these pages, there is often a diode connected from the gate of the FET to earth. A couple of people have asked what this is for, and whether it matters which way round it is.

Basically it is there to provide an AGC function. If you think about any oscillator, the circuit is an infinite loop, with the output being fed back to the input by one means or another. There has to be something which stabilises the output level at a constant point — if there wasn't the oscillation level would build up to infinity eventually which is clearly impossible. There are only two things which can stop this happening — either the oscillator limits, or there is some form of AGC present.

With the diode present, as the RF voltage from the oscillation increases just after switch on, the voltage on the gate will similarly increase, and be rectified by the diode, in turn causing a DC voltage to build up across the gate capacitor. This will be a negative voltage from the way the diode is connected, and it is this which provides some bias, driving the FET towards cut-off as it gets more negative. The amplitude of the oscillation thus decreases, until a point is reached at which it stabilises — that is when the gain is only just enough to keep the oscillator running. Or an AGC control.

"...managed to pick up a nice roller coaster..."



RADIO TOMORROW

2 Sep Cambridge & DARC: informal evening/morse class/on air/final plan for Region 1 IARU SSB Contest.
Medway AR & TS (of radio interest).

3-4 Sep 144MHz Trophy & SWL Contest (IARU) (rules in June/July *Radcom).*
SSB Field Day (rules in May *Radcom*).

5 Sep Braintree & DARS: quiz evening.
Leighton Linslade RC: AGM.
Stourbridge & DARS: informal meeting; final arrangements for Stourbridge Carnival.

5-9 Sep Brixton College of Further Education: enrolment for RAE course.

6 Sep Bradford & Ilkley Community College: enrolment for RAE course.
Aylesbury Vale RS: *An Introduction to Microwaves* by G4KNZ.
Chichester & DARC: meeting.
Mid-Warwickshire ARS: junk sale.
Stevenage & DARS: *Aluminium for Antennas, Ideas on How to Use It* by G4MEO.
Wakefield & DRS: on air / natter night.

6-7 Sep Langley College of Further Education: enrolment for RAE course 12.30-8pm.
Melton Mowbray College of Further Education: enrolment for RAE course.

7 Sep Cheshunt & DARC: natter night.
Fareham RC: natter night/on air.
Nene Valley RC: *Satellite Working* by G4HME.
Wirral & DARC: drinking and waffling at the Shrewsbury Arms, Chester High Road.

8 Sep Edgware & DARS: informal meeting.
Stevenage & DARS: beginners' evening (at the Fairlands Community Centre).

9 Sep Cambridge & DARC: talk on aerials.
Spalding & DARS: visit from Mike Bowthorpe (Tandy).

9-11 Sep World Association of Christian Radio Amateurs & Listeners (WACRAL) annual conference at London Bible College. Special event station GB2LBC.

10 Sep Stourbridge & DARS: demonstration station at Stourbridge Carnival.

10-11 Sep International amateur TV Contest (rules in May *Radcom*).

11 Sep Vange rally.
Telford Amateur Radio Rally, Telford New Town Centre Malls, Telford, Shropshire. Opens 11am (10.45 for disabled), talk-in GB4TRG on S22 and SU8/20, food & drink; parking and admission free.
Kidderminster & DARS: Wyre Forest Mini-Marathon station.
Wirral & DARC: DF hunt.

12 Sep Arnold and Carlton College of Further Education: enrolment for RAE course 10am-4pm.
St. Hugh's Comprehensive School, Grantham: enrolment for amateur morse class 6.30pm.

12&14 Sep Sarah Robinson School, Ifield, Crawley: enrolment for RAE course 7-9pm.

13 Sep Bury RS: *Japanese Morse* by Norman Kendrick G3CSG.
Kidderminster & DARS: AGM.

13-14 Sep Arnold & Carlton College of Further Education: enrolment for RAE course 2-8pm.
Hendon College of Further Education: enrolment for RAE course.

14 Sep Cheshunt & DARC: visit to Brookmans Park MF transmitting station.
Fareham RC: *Shack Safety* by G8GNB.
Nene Valley RC: *RTTY by Computer* by G8GIK.
Three Counties ARC: *Raynet.*
Wirral & DARC: *Fire Protection Techniques* by Steve Shakeshaft G8TCC.

18 Sep Peterborough Rally.
Glenrothes & DARC: AGM.
UK FM Group (Western): DF hunt.

19 Sep Braintree & DARS: *From Erk to Test Pilot* by Squadron Leader A.S. Murkowski.
Leighton Linslade RC: meeting; quiz.
Milton Keynes & DARS: visit to Leighton Linslade RC (quiz).
Stourbridge & DARS: *Matching Circuits and SWRs* by Dave Yates G3PGQ.

20 Sep Biggin Hill ARC: RTTY evening.
Mid-Warwickshire ARS: DF hunt (starting 7.30pm 145.350MHz).
Wakefield & DRS: homebrew equipment evening.

21 Sep Deadline for December *Radio Tomorrow.*
Cheshunt & DARC: natter night.
Fareham RC: natter night/on the air.
Hastings E & RC: *Inexpensive Computing for Radio Amateurs* by G4WRT.
Kidderminster & DARS: RSGB lecture by Leo Craven G4EQI.
Nene Valley RC: *QRP* by George Dobbs G3RJV.
Tretherras School, Newquay: enrolment for RAE course 6.30-8.30pm.
Wirral & DARC: drinking and waffling at the Red Cat, Greasby.

22 Sep Edgware & DARS: *The BBC Microcomputer* by John Bluff G3SJE.
Greater Peterborough ARC: video evening.

23 Sep Medway AR & TS: junk sale.

24 Sep Clipperton DX Club: 5th Convention, Le Raincy, Paris.

25 Sep Harlow Rally.

28 Sep Cheshunt & DARC: *RSGB Headquarters* by John Nelson, Assistant General Manager, RSGB.
Fareham RC: *History of the RSGB* by G6NZ.
Nene Valley RC: *Raynet* by G4NUG.
Three Counties ARC: *Hampshire Fire Brigade.*
Wirral & DARC: *QRN — Causes and Cures* by Alan Smith G4EFP.

1 Oct 432MHz — 24GHz IARU Contest (rules in June/July *Radcom*).

1 Oct Braintree & DARS: *Autumn Fayre* (show in Braintree Community Centre).

3 Oct Braintree & DARS: setting up JOTA.
Leighton Linslade RC: meeting.
Stourbridge & DARS: informal meeting; contest season debriefing; arrangements for JOTA.
Swale ARC: *QRP Operating and the G-QRP Club* by G3VTT.

4 Oct Aylesbury Vale RS: *A 160-10m transceiver* by Robin Hewes G3TDR.
Mid-Warwickshire ARS: natter night.
Stevenage & DARS: *Making a Homebrew Lattice Tower* by G8EKU.
Wakefield & DRS: *Computers for Beginners* by Steve Wright G4CPC.

5 Oct Cheshunt & DARC: natter night.
Fareham RC: natter night / on air.
Wirral & DARC: drinking and waffling at the Seven Stars, Thornton Hough.

6-8 Oct 12th ARRA Amateur Radio and Electronics Exhibition, at Exhibition Centre, Doncaster Racecourse, Leger Way, Doncaster.

8 Oct Audiojumble: junk sale of audio and radio equipment at St. James' Hall, Gloucester Terrace, London W2 (nearest tube Lancaster Gate). Admission 90p; proceeds to St. John's Ambulance.

8-14 Oct GB2MOD at *Mod of the Clyde Valley* (Gaelic festival) on HF and 2m CW/SSB: special QSL.

9 Oct 21-28MHz Phone Contest (rules in May *Radcom).*
Wirral & DARC: DF hunt.

10 Oct Milton Keynes & DARS: AGM.

15 Dec *Taurids* meteor shower (max 1 Nov).

11 Oct Bury RS: construction competition.

12 Oct Cheshunt & DARC: *Writing for Amateur Radio* by Tony Smith G4FAI.
Fareham RC: *S-meters and PL259s* yy G4JCC and G6BBS.
Hastings E & RC: visit to TVS, Maidstone.
Three Counties ARC: *HF Contest Work.*
Wirral & DARC: *Computers in Amateur Radio* by Paul Collister G4DLY.

14 Oct Spalding & DARS: *Computers and Amateur Radio* by Terry Roberts.

15 Oct Midlands VHF Convention at British Telecom Training School, Stone, Staffs. Lectures, demonstrations, bookstall, bring and buy, free parking, Talk-in S22. Admission £1 on the door; evening buffet tickets £4 (in advance only).

15-16 Oct EI/GI Convention, Ballmascanlon.
Jamboree-on-the-air.

16 Oct 21MHz CW Contest (rules in May *Radcom*).
1296MHz Cumulative Contest (rules in July *Radcom*).

17 Oct Braintree & DARS: visit by RSGB Regional Representative Tony Howe G3PLF.
Leighton Linslade RS: meeting.
Stourbridge & DARS: main meeting.
Swale ARC: *HF Amplifiers* by G4AXD.

18 Oct Biggin Hill ARC: *Amateur Radio Satellites.*
Mid-Warwickshire ARS: *Safety* by Norman Read G8CXL.
Stevenage & DARS: talk on batteries by Eveready.
Wakefield & DRS: pie & pea supper.

19 Oct Deadline for January *Radio Tomorrow.*
Cheshunt & DARC: natter night.
Fareham RC: natter night/on air.
Hastings E & RC: junk auction.
Wirral & DARC: drinking and waffling at the Victoria Lodge, Tranmere.

20 Oct Greater Peterborough ARC: *Homebrew Transceivers* by G4LOC.

21 Oct Medway AR & TS: social evening 'at home' to Gravesend ARS.

26 Oct Cheshunt & DARC: *Satellite Receiving Installations* by David Woollard (Rediffusion).
Fareham RC: shack layouts — open forum.
Three Counties ARC: knock-out games night.
Wirral & DARC: inter-club quiz night. Return match with Chester ARC.

1 Nov Aylesbury Vale RS: *Semiconductors and Transistors* by G8AYM.
Mid-Warwickshire ARS: natter night.
Stevenage & DARS: *Slow Scan TV* by G4BWU.
Wakefield & DRS: on air/natter night.

2 Nov Cheshunt & DARC: natter night.
Fareham RC: natter night/on air.
Wirral & DARC: drinking and waffling at The Harp, Lower Neston.

CONTACTS

Audiojumble	Ed Lord	01-837 7811
Brixton College RAE course	M.C. Parnell	01-737 2323
Bury RS	Brian Tyldsley	Burnley 24254
Cheshunt & DARC	Roger Frisby	Hoddesdon 464795
Fareham RC	Brian Davey	Fareham 234904
Hastings E & RC	Tony Masters	Hastings 51659
Hendon College RAE course	Chris Holford	01-202 3811 extn. 7
Melton Mowbray College RAE course	K.G. Melton	Melton Mowbray 68810
Mid-Warwickshire ARS	Carol Finnis	Southam 4765
Sarah Robinson School RAE course	Steve Webb	Crawley 25742
Spalding & DARS	Ian Buffham	Spalding 3845
Stevenage & DARS	Cliff Barber	Baldock 893736
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Telford AR Rally Group	M.I. Vincent	Telford 55416
Three Counties ARC	Mrs. C.J. Baker	Bordon 3395
Thetherras School RAE course	Bob Lawrence	Wadebridge 3649
WACRAL	Brian Hancock	Minster 873147
Wirral & DARC	Gerry Scott	051-630 1393

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PBM14/2M	14 ele Parabeam	13.7dBd	£55.77	£3.20
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5XY/2M	Yagi 5 ele crossed	7.8dBd	£28.17	£2.50
8XY/2M	Yagi 8 ele crossed	9.5dBd	£35.65	£2.50
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PMH4/2M	Harness 4-way 144MHz		£28.75	£1.50
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D8/70	Yagi 8 over 8 slot	12.3dBd	£25.87	£2.50
PBM18/70	18 ele Parabeam	13.5dBd	£32.20	£2.50
PBM24/70	24 ele Parabeam	15.1dBd	£42.55	£2.50
LW24/70	Yagi 24 element	14.8dBd	£27.02	£2.50
MBM28/70	28 ele Multibeam	11.5dBd	£21.27	£2.50
MBM48/70	48 ele Multibeam	14.0dBd	£35.65	£2.50
MBM88/70	88 ele Multibeam	16.3dBd	£48.87	£2.50
8XY/70	Yagi 8 ele crossed	10dBd	£42.55	£2.50
12XY/70	Yagi 12 ele crossed	12dBd	£52.90	£2.50
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PMH4/70	Harness 4-way		£22.42	£1.80
CR2/23CM	Corner reflector	13.5dBd	£40.25	£2.50
PMH2/23CM	Harness 2-way		£31.05	£1.50

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FS500H	1.8-80MHz 20/200/2000W Pep	£69.75	FOC
FS500V	50-150MHz 20/200W Pep	£69.75	FOC
FS300H	1.8-80MHz 20/200/1000	£46.40	FOC
FS300V	50-150MHz 20/200	£46.40	FOC
FS200	1.8-150MHz 20/200 Pep	£50.60	FOC
FS001M	1.8-30MHz 20/200W Pep	£51.35	FOC
FS601MH	1.8-30MHz 200/2000W Pep	£51.35	FOC
FS800M	50-150MHz 20/200W Pep	£51.35	FOC
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FS302M	50-150MHz 20/200W	£35.65	FOC
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Review: Metertech MT 301 Digital Capacitance Meter

By Andy Emmerson G8PTH

The most important items of test gear on the bench at G8PTH are the scope and the multimeters, both analogue and digital. After these come the logic probe (two of these as well!) and the capacitance meter. Sure, I managed without a capacitance meter for a long time but two years ago I built a rudimentary one from a kit, and at last I had a means of checking doubtful tantalums (or is it tantala?) and finding the value of unmarked trimmers and subminiature ceramics. This opened up a new world of convenience, even though the device was bulky, had a restricted range and suffered from the effect of stray capacitance.

Now a number of newer, sophisticated hand-held devices have appeared on the market. Specifications and prices vary and I looked through several catalogues before deciding that the Metertech Digital Capacitance Meter (DCM) offered the best combination. A bonus is that its style matches the digital multimeter sold under several names including Metertech and Ross Electronics. I like matching pairs! So I actually bought one (no freebie samples unfortunately!) and I thought my findings might be of interest to others hovering on the brink of choosing a DCM.

Like many hand held digital multimeters the Metertech DCM comes in a grey plastic case with ½" 3½ digit liquid crystal display. (In case you wonder what 3½ digits look like, the half digit can only appear as a 1 or a blank, the other three digits look normal.) A stand will prop up the DCM for use on the bench. The capacitor under test is held by two crocodile clips on short flexible leads, and to avoid stray capacitance problems it is unwise to replace these leads with longer ones. The meter is powered by a PP3 9 volt battery (Supplied) and the controls cover on/off, a knob for zeroing the display and range selection. Testing range is wide, from 0.1pF to 2000µF, with a claimed accuracy of 0.5%. The meter is protected against damage from charged capacitors up to at least 50 volts, though in your own interest you should discharge a capacitor before making tests. A sensible and fairly well translated handbook is supplied, with useful tables of capacitor characteristics at the end.

In use the DCM does all that is claimed of it. Sampling time is stated as 0.5 second, though on the lowest ranges the meter does take a while to settle. Any stray capacitance is nulled out by the zero control before the capacitor is tested and causes no real problem. So far I have no cause for dissatisfaction and I would certainly recommend this device. The distributor claims to have sold quite a number to major industrial concerns and I think the only thing which may put off the average hobbyist is the price, which is £69 + VAT (a case is £6 extra). There are of course some cheaper devices on the market, also add-ons for digital frequency meters, but these involve some degree of compromise and in the end you must decide how highly you value this device. Certainly having once had a DCM I would not like to give it up!

(NOTE: Since I bought my meter I have noted a similar looking device in some shops bearing the ALTAI name. The price is similar as well.)

GENERAL SPECIFICATIONS

Display:	13mm(0.5")LCD (liquid Crystal Display) Max. indication 1999.
Range:	8 Ranges with full scale values from 200pF to 2000uF.
Overload indication:	Indication of "1".
Calibration adjustments:	One internal adjustment for accuracy. One front-panel adjustment for zero.
Zero adjust:	External adjustment for zero value of the display. This is limited to ±20pF.
Out-of-Range indication:	Indication of "1".
Sampling times:	0.5 second
Time base:	Crystal OSC
Operating temperature:	0°C to 40°C(32°F to 104°F)
Operating humidity:	less then 80% RH
Power supply:	006P DC 9V battery
Battery life:	Approximately 200 hours on alkaline or 100 hours on carbon zinc battery with normal usage. (Typical current consumption 3-4mA on 200pF-200µF range)
Dimension:	180x82 x 38mm (7.1"x3.3"x1.5")
Weight:	280g (0.621b)/(including battery)
Standard accessories:	Test alligator clips (red and black) Spare fuse (0.2A) Instruction manual

ELECTRICAL SPECIFICATION

Normal Range	Max. In-range Display	Resolution
200 pF	199.9 pF	0.1 pF
2 nF	1.999 nF	1 pF
20 nF	19.99 nF	10 pF
200 nF	199.9 nF	100 pF
2 uF	1.999 µF	1000 pF
20 uF	19.99 µF	0.01 µF
200 uF	199.9 µF	0.1 uF
2000uF	1999 µF	1 µF

pF = picofarad (10^{-12})
nF = nanofarad (10^{-9})
µF = microfarad (10^{-6})

Accuracy (25°C ± 5°C)	0.5% of full scale ± 1 LSD (least significant digit) on 200pf to 200uf ranges. 1% of full scale ± 1 LSD on 2000uf range.
Excitation voltage	2.8 volts peak, maximum. High input terminal is always more positive than −ve terminal.
Zero adjustment	± 20pF
Protection	The meter is protected against damage from charged capacitors (more then DC 50 volt) by the fuse (0.2A).

PRICE £69 + VAT. Case £6 + VAT
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*see next page

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Technicalities

By Frank Ogden G4JST

Making coils and matching

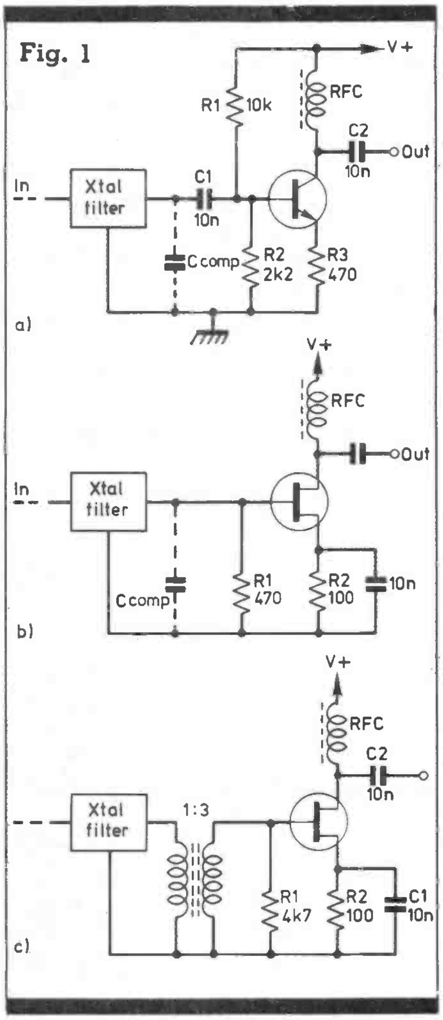
Those of our readers with a slight technical bent will probably have noticed the large number of ferrite transformers, baluns and inductor type devices which feature in many of the designs. There's no apology to be made for the sheer quantity which our projects specify — they are an incredibly useful impedance matching gizmo — but some explanation could be due about how the transformer etc winding and core details are arrived at. But first, a little bit about why the are so useful.

Matching on a blind date

The thing about RF circuit design is that things are not always what they seem. You can't dovetail little parts of circuitry together to make a complete radio system without a compatible interface between the various building blocks. Take your average crystal filter for instance. It presents a resistive termination only at a single frequency. At all others, there will be a greater or lesser degree of reactance ie, it looks to the rest of the circuit as though its got either a capacitor or inductor connected across its terminals. Although the frequency/impedance characteristic is peculiar to say the least, it expects the circuit to which it is coupled to exhibit a constant resistance over a wide frequency range. If the conditions aren't right, then the level of passband ripple will rise to unacceptable proportions.

There are a number of ways of matching a filter to a subsequent piece of circuitry. **Fig. 1** shows three options. For the sake of argument, the crystal filter shown has an impedance of about 500 ohms.

Option a) shows the unit coupled directly into a bipolar transistor amplifier stage. This circuit might present a resistance of 500 ohms to the filter depending to a considerable extent on the exact characteristics of the transisor. Since the manufacturing spread is relatively wide, the input resistance



presented to the filter will be all over the place.

Option b) offers a totally predictable input circuit to the crystal filter. Because the FET input impedance is so high, the actual characterisitcs are those of R1. The capacitor comp is the required input capacity specified by the crystal filter manufacturer minus the gate capacitance of the FET — typically about 5pF. The main drawback of this circuit configuration is that the noise performance is rather poor. At frequencies around 10MHz, the optimum input resistance which the FET itself needs to 'see' will be several kilohms. This contrasts with the 500 ohms of the filter.

The answer of course is Option c) which uses a 1:3 ratio step up transformer to raise the input impedance to 4k5 (9 x 500). Because the transformer is inherrently broadband, this circuit meets both the requirements of both the crystal filter and the FET.

How many turns?

The crystal filter example was just a single instance. In practice, ferrite transformers and associated components are used whenever some broadband matching condition needs to be fulfilled. In addition, they can be used to produce special conditions such as antiphase signals for balanced mixers and unbalanced to balanced transformations. The question arises, whatever the application, about how many turns to use and what size to select the core. This sort of thing can be predicted (it is claimed) by some fairly complex mathematics taking in such things as core area, core volume, magnetic path length, permeability, maximum magnetising force and your inside leg measurement. In practice, when you select half a dozen greyish looking little objects from some equally greyish looking stallholder at a mobile rally, any attempt at scientific design and calculation goes right out the window.

What you must do is this. Decide what impedance transformation you would like to make and translate this figure into a turns ratio. For the record, the turns ratio is the square root of the impedance ratio. Next, you need to find something out about the core material. More specifically, you want to find out the number of turns required on the core of your choice to reduce reactive loading on the external circuit to negligible proportions. For HF frequencies, I recommend this approach. Using a standard HF receiver tune into a medium strength signal (eigher off air or from a signal generator) at the lowest frequency which you want the core to operate at. Break the coaxial connection between the aerial tuner/signal generator and the receiver. Slip the core under test onto the inner of the coax and rejoin the cable. The signal strength of the signal monitored on the receiver will now have dropped. The precise fall off will equate to the reactance introduced by the permeability of the core. See **Fig. 2.** The average permeability general purpose RF ferrite core will produce about ½ to 1 S-point drop over the straight through connection between generator and receiver at 5MHz.

It is possible to deduce from this single measurement that your would need roughly two turns on the core for a 50 ohm winding or six turns for a 450 ohm winding. The rule of thumb is that two turns are required on the core for a 50 ohm winding when using a typical core. Beware though. Some types of core will show either no attenuation on the test jig indicating that they are very low permeability VHF devices — no use for HF designs — or massive attenuation at the 5MHz test frequency indicating that they will probably be very lossy.

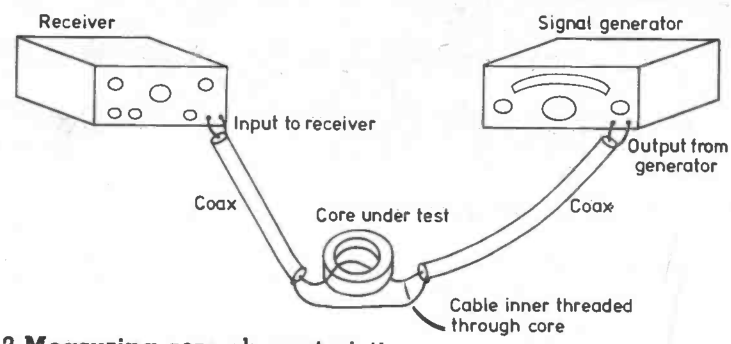


Fig. 2 Measuring core characteristics

How much power?

Although this question doesn't arise very often in receiver design, the power handling characteristics are all important in transmit applications. The perpetual energising and de-energising of the RF cycle in the magnetic material causes some losses due to the hysteresis. These losses amount to fractions of a dB at low frequencies. However, since the losses, which show up as heating of the core, are a function of the number of times that the magnetic state switches in a given time, while the actual hysteresis is a function of the peak flux induced into the core, the two characteristics combine to place a power/frequency limit on the core. There is a further loss. Eddy currents produce losses and associated heating which rise fairly linearly with frequency. All in all, there are definite top limits on what a core can do. If you go beyond that point, the core heats up towards its Curie point at which all losses increase dramatically with an associated collapse of permeability. After the Curie point, it's thermal runaway all the way. Typical Curie temperatures are around 150°C. They could be more. They could be much less. In the practical case a temperature rise of around 50°C is about the limit.

Fig. 3 shows a power test jig. Make a 1:1 transformer out of the core under test and connect in between a transmitter and power meter/dummy load combination. Wind up the power slowly. Transmitters with variable drive are essential for this test, and an additional SWR meter ahead of the input to the transformer is a distinct advantage. An eye on the power meter and a finger on the core will tell all that you need to know about the RF characteristics of a given core type. For guidance, small ones handle in the region of 3W without distress while the big TVI rings, several tens of watts.

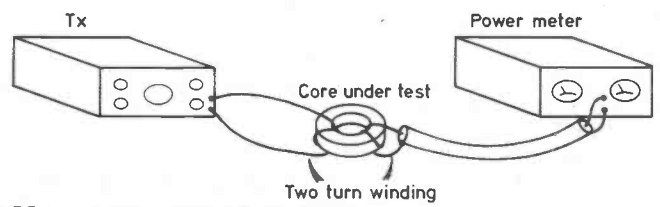


Fig. 3 Measuring power handling

Transmission line transformers

Whenever the discussion comes around to this particular topic, it never fails to amaze me how many otherwise clever people get their undergarments in a twist. They will witter on *ad nauseam* about the differences and even try to kid you that normal transformer laws no longer apply.

The difference is purely this. A conventional two winding ie, primary and secondary, transformer is wound in such a way as to minimise the capacitance both from one winding end to the other, and between the windings. The reduction of the interwinding capacitance thus enhances the high frequency response.

The transmission line transformer regards capacity as a fact of life and seeks to use it to *boost* the frequency response. The windings are introduced onto the core in such a way as to distribute the self capacitance evenly throughout the winding length. This forms a transmission line with the distributed inductance of the winding. Transmission line structures can operate predictably only if the winding capacitance is distributed very evenly, and preferrably concentrated between adjacent turns. Bifilar winding — that is the simultaneous winding of two strands, side by side, on the core — achieves this as does the use of thin coaxial cable. The only other provision is that the transmission line structure 'sees' a termination somewhere near its characteristic impedance. Despite what some of the pundits say, there is no practical difference in operation between transmission line and conventional transforms at low frequencies. Turn for turn, the characterisitcs are decided entirely by the properties of the ferrite core. At high frequencies the story is different. Addition of waves on the transmission line (by connecting one winding end to the beginning of another) structure takes place but never in defiance of normal transformer rules.

The top frequency limit for transmission line transformers is decided by their operating conditions. Where the integral transmission line is perfectly terminated between source and load of characteristic impedance, then there is, in theory, no upper frequency limit on operation. In practice, the wire insultation of twisted pair bifilar windings becomes rather lossy.

Where a mismatch exists, the upper frequency limit will be dependent on the winding length. Generally speaking, the winding length ie, the length of the bifilar pair stretched out flat, should never be greater than 1/16th of a free space wavelength. This also dictates the lower frequency limit incidentaly. Since the amount of transmission line wire is finite, the low frequency inductance is strictly limited depending on the characteristics of the core. With the right combination of core and winding length, it is quite possible to design efficient transformers which operate over the range 1 to 200MHz. Note that the core material for such a device will probably only be specified for operation to around 5MHz although, in conjunction with a transmission line winding structure, the losses in the transformer will be unnoticeable up to and beyond the 2m band.

Wind-up with a drill

The easiest way of producing transformer transmission line wire is to double up a length of 22 to 30 SWG wire with the loop end over a door knob, and attach the free ends into the chuck of a hand drill. With both wires stretched taut, the wire is wound up on the chuck until the required number of twists per inch is achieved. **Table 1** offers guidance about the relationship between twist pitch and characteristic impedance. A third wire may be added for trifilar transmission lines.

General purpose balun

I have a very fine piece of aerial tuning gear, the Yaesu *FC-902*. I use it conjunction with a 400W output home brew transceiver and a number of HF wire aerials, the longest being over 100m long. The only trouble is that the *FC-902's* output is single ended — that means that one of the two terminals on the back is connected to the case of the ATU while the other is connected to the hot end of the matching network — with the implication that it won't work with balanced aerial systems.

One could go to a number of suppliers and purchase a balun (**bal**anced to **un**balanced) with an internal circuit diagram along the lines of **Fig. 4.** These work fine provided that the aerial system with which it is used is perfectly balanced. The thing about nearly all these commerical balun units is that they divide the signal precisely into two (antiphase) parts even though the real world aerial may contain degrees of unbalance. For instance, if one end of a dipole is nearer the ground, or nearer to a house than the other end, this will set up imbalances in the aerial.

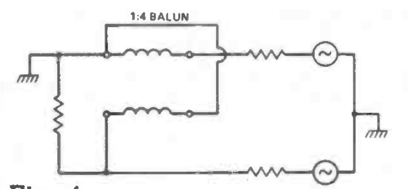


Fig. 4

The best arrangement is to wind a **sortabalun.** This is, in effect, a bifilar wound choke or 1:1 transmission line transformer. Fig. 5 shows the construction. The unit that I made for use in my FC-902 comprised a heavy guage, PTFE twisted pair of wires wound as 20 turns on three stacked TVI rings of the sort available from a number of different manufacturers. The 20 turns on the three cores virtually ensures that no out of balance condition can exist even though the aerial system with which it used may be all over the place. This type of balun provides a straight through path (down the twisted pair) to the aerial while blocking off any common mode currents in the feeder system. Now I think there is no other kind of balun system having used one of these on a large number of different aerials.

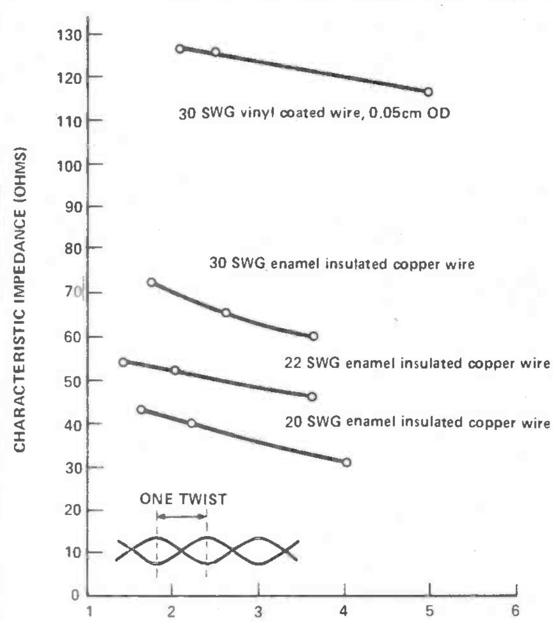


Table 1

Table 1. This series of graphs shows the effect of twist count, measured as twists/cm, on the characteristic impedance of a twisted pair transmission line. Note that tightly twisted wire has a lower characteristic impedance than twists of longer pitch.

Although the graphs shown here were drawn for enamel covered wire, the modern, self fluxing polypropylene covered single copper wire tends to be just as low loss for RF usage while withstanding a higher RF working voltage. However, twisted pair transmission lines can carry no more than about 10W at HF and rather less at VHF where the losses increase rapidly. For higher powers/higher frequencies, it is strongly recommended that PTFE insulated copper wire is used.

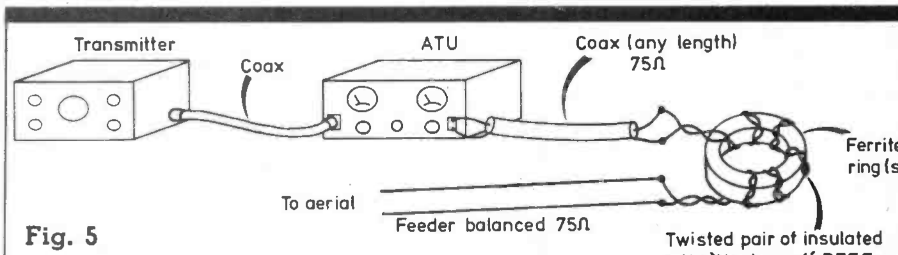
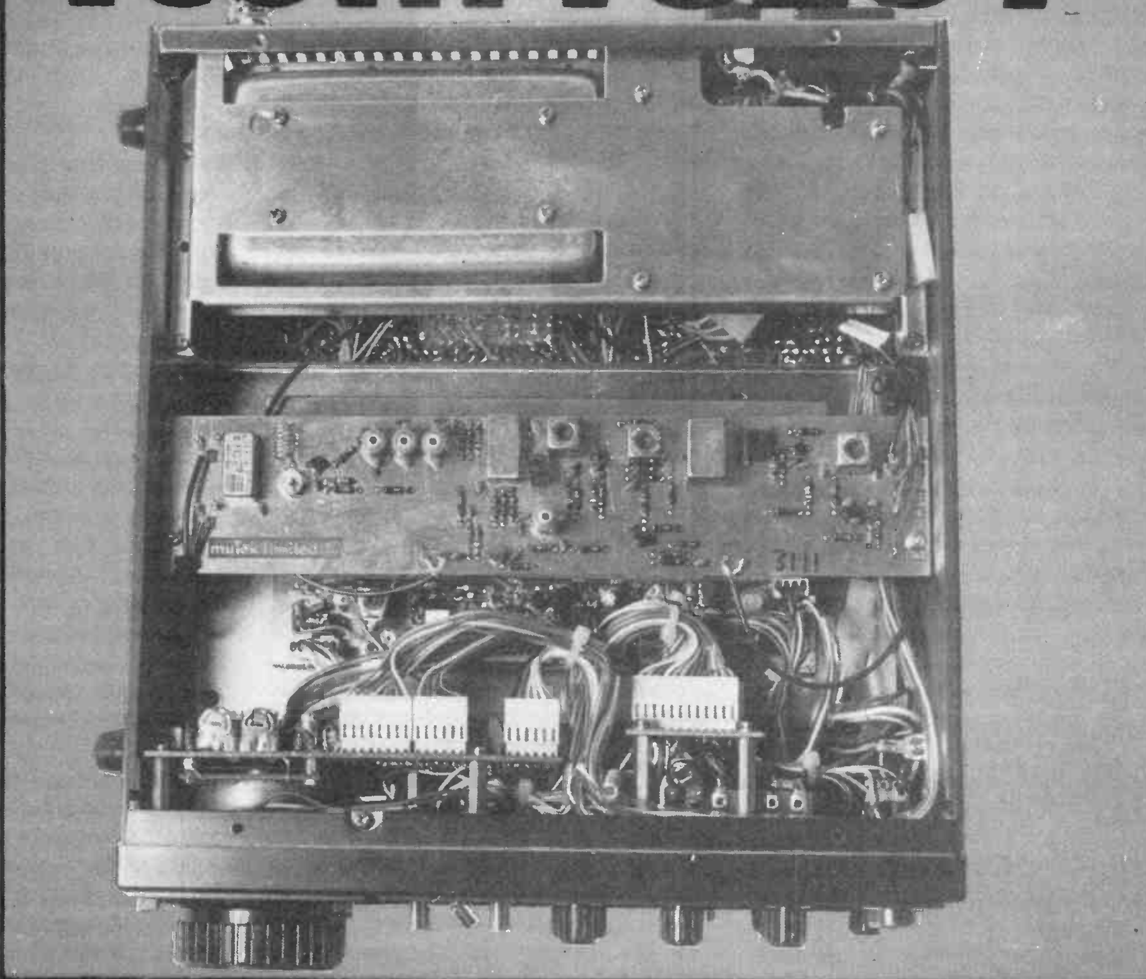


Fig. 5

Since most balanced aerials exhibit a degree of unbalance, the SORTABALUN is often a better performer than the true balun. It is, in fact a 1:1 transmission line transformer.

REVIEW:

Icom IC251 + muTek front end



An investigation into a British front end which transforms this multimode

By Angus McKenzie G3OSS

Rather than being a complete review of this particular rig, the Editor and I decided that we should concentrate on the performance of the receiver section, and in particular on the Mutek front end board which is famed for making rather average receivers ones that can come up to 'state of the art' performance. We decided to use our normal test procedures, but to expand these in order to stretch the equipment to its limit and in doing so found that the rig was almost uniquely excellent in its front end performance. Let's have a look first at the relevance of some of the measured parameters and then see how this rig copes with them.

Front end sensitivity

You can measure front end sensitivity in two basic ways, the first being to attempt to measure the actual noise figure effective on the rig from the antenna socket to the IF or audio output. We were advised by Mutek that this method would be extremely difficult since it would mean opening up the rig and taking an output perhaps from IF, and further, disabling the AGC, so that the gain would not change as introduced noise was being increased on the noise source. We felt that this method would be impractical, but we were informed by Mutek that they had carried out this test on the review sample and had obtained a noise figure of approximately 2dB.

The alternative method is, in a way, more difficult but can be done without fiddling inside the box. This method involves the very careful measurement of sensitivity on SSB, using special leads and attenuators, and relating the sensitivity to the bandwidth measured in the selectivity tests.

This was the method that we adopted and we just could not believe our results, which were inferring that Chris Bartram of Mutek had designed a front end having a *negative* noise figure, which we thought was quite an invention. Maybe this might be possible for a nanosecond in the vicinity of a black hole, but not on *terra firma!* It was not until we measured the sensitivity that we could explain our amazing figures.

The 12dB SINAD on SSB was so incredibly good that we had to make up an Andrews *FSJ4* lead, together with specially screened 20dB and 10dB attenuators, and checking all earth bondings very carefully, in order to keep every bit of leakage out of the system. It seems we did this adequately, for our measurements tie in quite well with Mutek's 2dB noise figure measurement.

Front end circuit

The estimated noise figure of 2dB will, in effect, mean that this rig will be able to pick out extremely weak signals which many other rigs would not pick out at all. But it's no good having sensitivity without an excellent RF intermodulation (IM) performance, a reasonably shaped sensitivity curve, and good reciprocal mixing characteristics. What is all this about?

Let's have a look at Mutek's circuit. They don't use the Icom relay, but substitute a nitrogen filled reed relay, for a kick off, and this loses around 0.05dB, so it's a good relay. The front end device is a BF981 dual gate MOSFET. The input of this device is noise matched to the output of the relay, but its output is intentionally mismatched into a band pass filter which then feeds, with very accurate impedance matching, a Schottky diode ring mixer of +7dBm rating (5mW). This filter is a 3-pole Chebyshev having a 3dB bandwidth normally of 3MHz, but 4MHz for export. The overall front end gain to the mixer is around 12dB. The IF output is at 10.7MHz, and feeds straight into a matched 3SK74 which has very heavy negative feedback. This allows an extremely accurate match onto the mixer output port, as well as giving a very good noise figure. The output from this stage feeds a 15kHz wide crystal filter which is accurately matched into another 3SK74, again with negative feedback. The output from this stage feeds into the normal Icom electronics.

The normal local oscillator output from the Icom rig is fed through a buffer amplifier, and then carefully matched into the LO mixer input port. Mutek state that by very careful matching they can use the +7dBm mixer rather than a more expensive higher level one. They point out that poor matching can deteriorate performance dramatically in this area. An output from the board is available for feeding panoramic adaptors, or spectrum analysers, which is taken from the output of the first IF stage immediately prior to the crystal filter. This feed is, of course, centred on 10.7MHz and should have a bandwidth encompassing the 2m band. The level is extremely low, 9dB above the RF input level, and it is buffered from the feed to the filter in order to avoid degrading the receiver's internal performace.

By employing a front end stage with just 12dB gain, Mutek greatly enhanced RFIM performance at the input of the mixer. Furthermore, by employing the 3MHz band pass filter they are excluding way out of band signals from causing problems at the mixer and beyond. The employment of a Schottky mixer with its inherent superb IM performance at high levels, gives the entire front end an enormous dynamic range. Since the mixer is passive, it loses level, and so it is essential for the following stage, the 3SK74, to be noise matched. Mutek have sacrificed perhaps a ½dB of potential noise figure for a dramatic improvement in dynamic range, but a 2dB noise figure is, frankly, good enough for almost anyone for normal 2m operating. If you want to do better, for moonbounce or meteor scatter work, then you would be using a masthead pre-amplifier, and a luxury cable to achieve the finest possible system noise figure.

The 15kHz filter is placed at its early position in the circuit to knife out fairly close signals from the remainder of the IF stage. It is vitally important for the filter to be matched properly, again to avoid degradation of the system noise figure, and to preserve the filter passband characteristics.

The mixer requires a much higher drive level from the local oscillator, once again to preserve dynamic range, and hence the reason for the local oscillator buffer, which also has to match perfectly into its port on the mixer.

RFIM

From the description of the circuit you will see that out of band signals should not cause any IM problems with signals on 2m. Within the 2m band the IM performance is dictated by the levels reaching the mixer, and since there is the minimum of gain in the RF pre-amp, very high level signals can be present on the band fairly close to an extremely weak one without being evident, providing these signals are themselves clean. You can see that stations with superb receiving equipment are most disturbed by nasty spreading signals derived from grotty rigs, or wickedly overdriven linears. (*Angus, for once I agree with you without reserve. Why is that so much amateur gear is of inferior performance, yet the licenced operators never seem to notice! — Ed.*) After signals have passed through the 15kHz wide crystal filter to the final IF stage on the Mutek board you can see that the RFIM performance within the 15kHz pass band will be determined by the performance of the following stages. A clever touch here is that Mutek take the AGC voltage through to their last IF stage, so that if there is appreciably strong signal off-frequency on SSB, but within the pass band of the crystal filter, then the gain will be reduced at the beginning of the IF strip as well as within the IC251E IFs.

Selectivity and noise

When you measure noise figure, which is extremly difficult, it is a basic property of either the front end itself or, if you want it, it becomes a property of an entire receiving system, irrespective of bandwidth. Noise figure basically concerns a measurement of the degree of excess noise produced by the receiving system over the noise that would be produced from a perfect 50 ohms (or other rated impedance), resistor held normally at room temperature, although the temperature at which the measurement is made is normally stated. Noise figure is expressed in dBs of excess noise, but this parameter can also be expressed as noise temperature, which is the temperature at which the 50 ohm input termination would have to be taken to be equivalent to the noise within the receiver. Noise factor is a power ratio of receiver noise to basic 50 ohm resistor noise and is not in dB (note that many advertisements confuse noise factor with noise figure). A 3dB noise figure is the same as a noise factor of 2.

When you measure the SINAD ratio of an SSB or CW receiver, you are measuring the ratio of the carrier beat, plus noise within the passband of the selected filter, to the value of the noise with the carrier level subtracted. Some product detectors distort the carrier beat signal, and so unfortunately this distortion is measured both with the carrier and with the noise, so a rig having appreciable audible distortion will give inferior readings, since the ratio of signal plus noise and distortion, to noise plus distortion (SINAD ratio), is degraded. The selectivity must be measured accuately to estimate the true worth of the front end. If you measure a 12dB SINAD ratio with a rig having a selectivity of a few hundred Hz, you will get an apparent tremendous improvement in sensitivity as compared with a rig with a selectivity a few kHz wide. The 'noise floor' with a narrow bandwidth is obviously going to be lower than with a wide bandwidth, unless you rate the system noise per Hz of bandwidth. There is another caution here, in that to be strictly correct you should measure the *equivalent* 3dB bandwidth — taking into account the noise power outside this band width — and so the *actual* bandwidth for 3dB drop can be wider or narrower than the equivalent noise band width.

Laboratory measurements

Starting with input sensitivity, we found it to be stunningly good on SSB, and indeed for a while we thought it was defeating the laws of physics. The 12dB SINAD rating was − 134.2dBm. But this represents an input PD of 0.045 V, which is only around 6dB higher than the noise we would expect from a perfect front end having an equivalent noise bandwidth of around 2.3kHz. How could we be seeing 12dB SINAD with a noise figure of 2dB? My colleague, Simon, G8UQX, took great trouble to avoid leakage and we checked and re-checked the accuracies of the Marconi generator on our Racal *9393* power meter, and could not find a problem. It was not until we measured the selectivity characteristics that we found the reason for our not inconsiderable bafflement, made all the more odd because the FM 12dB SINAD figure was virtually perfectly coinciding with what we would have expected from a 2dB noise figure front end, namely 0.1μV. The selectivity curve resembled 'the man with the pointed head', since the 3dB bandwidth was more like that of a CW filter, the 6dB bandwidth not far wrong for a teletype filter, and the 60dB bandwidth about right for a marginally wider than average SSB filter. If we calculate the noise back from the selectivity curve measured with our own measurement of SSB SINAD, we arrive at a figure, which although approximate, is in the 2dB ball park.

The RFIM measurements are extremely good, and indicate an approximate intercept point of 0dBm. The measurements were taken at three different levels, the 12dB SINAD point, and the inputs required to produce −120 and −87dBm third order products. We can see that there is a marginal contribution from the BF981 pre-amp at high levels, whereas the low level products are almost all caused by the mixer and first IF stage combination. What is particularly important is that the RFIM measurements from carriers spaced 25/50, 50/100 and 100/200kHz off frequency gave almost identical measurements, showing that Mutek's philosophy works out extremely well. We have the feeling that our own test equipment was in fact at its limit of performance here, and we are relieved to see the close-in intermod figures only very marginally worse than the further out ones, this meaning that our test equipment and Chris Bartrum's circuit are both good!

The FM selectivity was again stretching our equipment, possibly near its limit, for the 12.5kHz readings cannot be described as

other than stunningly good. Of course, 25 and 50kHz selectivity were even better. Let's put this into perspective by saying that an FM station at 50kHz off carrier would have to be received at a level in excess of 1mV (say, 54dB over S9) to cause a significant deterioration to an extremely weak signal which was just readable on channel. This is, of course, assuming that the off-channel station was using a respectable rig!

Other aspects

The S meter on SSB was the best that I have encountered for some while, averaging at around 5dB per S point between S4 and S9, although below S4 the steps were larger, and indications were a little squashed between S9 and 9 + 40dB, the 40dB indication being 26dB in reality. Note that S9 is, however, around 10uV, which is about 10dB higher than the RF level required for an S9 indication on some other VHF rigs. On FM, matters are dramatically different, the S units representing an average of 1dB per S point, so that not only will it dance about like the clappers on many mobile signals, but most signals will either not read, or be above the S9 mark, the +40dB representing a mere 15dB over S9.

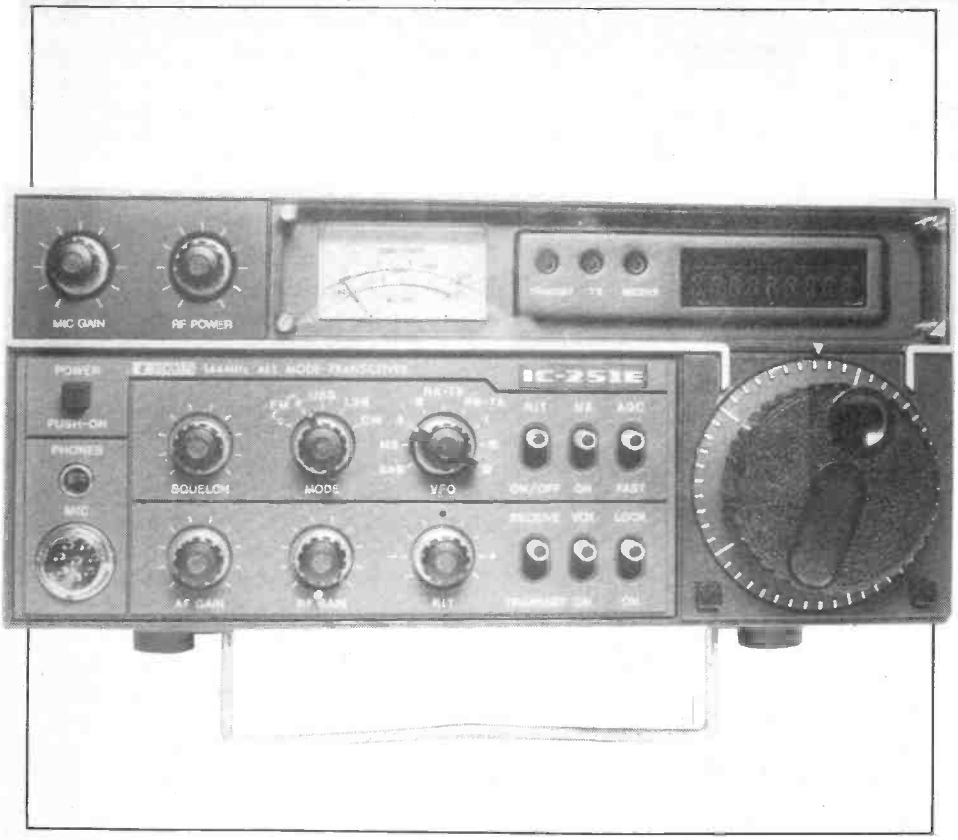
The fast AGC was extremely fast, and I cannot imagine a reasonable circumstance in which you would want to use it. If you note the slow AGC penchart, you will see that the equipment employs an AGC hang circuit, and the pen chart does look rather odd. It indicates that the main gain recovery takes place between 0.5 and 0.8 seconds after the end of a transient. I personally think this is too fast, but I also point out that hang AGC is an acquired taste, and most of my friends and I hate it. I previously found a similar characteristic on a Plessey receiver and found the sudden pumping up of noise very irritating every time someone the other end paused for just a moment.

Appalling

What is more important, though, is the appalling audio SSB audio quality of this receiver, judging by the review sample. Herein lies the danger of judging something by looking at only one sample, so a friend of mine who has this rig, and a signal generator, checked his, and found the selectivity curve to be only marginally less pointed. On examination, it would seem that Icom are not properly adjusting the loading of their SSB filters, and it would be comparitively simple to put matters right. We felt that audio distortion at an intermediate output level was about average, although higher than I like to see, and maximum output was reached at about 2W. In my opinion this is not really sufficient, unless you are using a fairly nasty but efficent loudspeaker (most efficent small speakers do seem to be rather nasty, and less efficent ones are often much less coloured).

Receiver measurements

Sensitivity, FM for 12dB SINAD 1kHz mod., 4kHz dev. at 144.000 / 145.000 / 145.975 MHz (µV pd)	0.10 / 0.10 / 0.10
Sensitivity, USB for 12dB SINAD 1kHz beat. at 144.000 / 145.000 / 145.999 MHz (µV pd)	0.04 / 0.04 / 0.04
Selectivity, FM. Ratio off channel / on channel to degrade from 15dB SINAD to 12dB SINAD. Above / below channel at following offsets:-	
12.5 kHz (dB)	68 66
25 kHz (dB)	77 / 76
50 kHz (dB)	82 / 81
Selectivity, USB 3dB / 6dB / 60 dB bandwidths (kHz)	0.35 / 1.2 / 4.9
Shape factor (60dB / 3dB bandwidth)	14
RF 3rd order intermodulation distortion, FM. RF level required from each frequency to give: 12 dB SINAD / S3 (equiv. to 1.1 µV signal) / S9 (eqiv. to 2.0 µV signal) products. Causatory carriers at following offsets:	
+25, +50 kHz (mV pd)	1.7 / 2.7 / 3.7
−25, −50 kHz (mV pd)	2.6 / 3.3 / 4.3
+50, +100 kHz (mV pd)	2.0 / 3.1 / 3.5
−50, −100 kHz (mV pd)	2.6 / 3.2 / 4.4
+100, +200 kHz (mV pd)	1.7 / 2.6 / 3.4
−100, −200 kHz (mV pd)	2.3 / 4.5 / 4.9
RF 3rd order intermod. distortion, USB. RF levels of each causatory carrier to give: 12 dB SINAD (equiv. 0.04 µV signal) / S3 (equiv. 0.2 µV signal) / S9 (equiv. 9.8 µV signal) products with the causatory carriers at the following offsets:	
+25, +50 kHz (mV pd)	1.4 / 1.7 / 6.4
−25, −50 kHz (mV pd)	1.4 / 1.9 / 7.9
+50, +100 kHz (mV pd)	1.0 / 1.7 / 6.3
−50, −100 kHz (mV pd)	1.4 / 2.1 / 8.2
+100, +200 kHz (mV pd)	1.4 / 1.8 / 7.8
−100, −200 kHz (mV pd)	1.5 / 2.8 / 9.5
Approximate 3rd order intercept point estimated from above data (mV pd)	200
Reciprocal mixing. Level required off channel to degrade from 15dB to 12 dB SINAD. +20kHz / +100kHz offset (mV pd)	1.3 / 4.2
S meter, FM. RF levels for:	
S1 / S3 / S5 (µV pd)	0.7 / 1.2 / 1.5
S9 / S9+20dB (µV pd)	2.1 / 3.7



Recriprocal mixing

We also had a look at the reciprocal mixing performance. At a 100kHz spacing I am delighted to say that the ratio is better than 100dB, which is excellent. Close in, at 20kHz, the ratio of 90dB is again excellent, but I again have reservations on my test equipment, for the Mutek front end is probably better still, possibly by quite a good margin. I am, therefore, in the throes of organising some special very quiet crystal controlled oscillators at various frequencies, to see if we can get even better measurements in future. These measurements, though, already far surpass those of other black boxes that I have looked at in the last six months. The indicated frequency accuracy was pretty good at +100Hz indicated. We did not note any drift after the equipment had stabilised after a few minutes.

We had a look at the FM alignment, and this seemed to be very well done, since we could get no improvement in overall FM sensitivity if we off-set the generator either way.

We only had a brief look at the transmitter side as this is not affected by the Mutek modifications. The output power was quite even across the band on FM and SSB, the SSB power being just slightly higher than FM or CW. The output power is adjustable down to a very low level on FM only, unfortunately. The FM carrier frequency accuracy was well within 200Hz, whilst on CW there was an off-set from the dialled frequency of +700Hz. My personal preference is for a CW output tone to be at the dialled frequency, and one can then put in a fixed off-set on receive. This allows you, without off-set, to zero beat a signal, and measure a frequency accurately. Icom's philosophy is completely valid and may well be preferred by most readers, for the chances are that when you turn a receiver into a CW carrier at a reasonable audio beat note, the transmit off-set will place your CW carrier in the right territory. This may not be accurate enough though, if you are doing moonbounce experiments, etc.

We had a brief look at the harmonic output, which will be seen to be perfectly reasonable in the table.

Subjective Tests

I've used this rig for a while both barefoot, and driving a Dressler linear. Everyone reported the barefoot transmission to be quite narrow, and the quality acceptable (but not particularly good), on SSB. On FM, transmitted and received quality was excellent, but received SSB was about the worst I have heard for a long time, only as regards audio quality, for the RF and IF performance was fabulous.

We found one or two annoying ergonomic points: Sometimes if you switch from SSB mode, you will get an FM frequency which will be offset no matter what you do with normal tuning. You don't seem to be able to get rid of this unless you go back to SSB, correct it and then return to FM. Pushing the step button twice can sometimes also correct it. Other functions seemed to work quite normally, the squelch working on SSB and CW as well as FM, with variable threshold. Three memories are incorporated, and these are fairly easy to use, but unfortunately you cannot VFO from them. It is not possible to obtain repeater shift directly unless you have previously programmed the 600kHz difference between VFO A and B. Furthermore, you have to switch the backup on two positions on the VFO switch, then allow normal or reverse repeater operation, which is retained when you turn the rig off, if you have remembered to install the backup battery! I much like the tuning ergonomics, SSB being in 100Hz or 1kHz steps (5 or 50kHz per revolution), or 1kHz and 5kHz steps for FM with 50 or 250kHz per rev tuning. There is a snag here, though, for if you are on the 5kHz step mode, and you tune the dial fairly fast, the rig misses many beats since the optical step detector is just not fast enough to follow. (*more likely that PLL goes out of lock — Ed.*) This was extremely annoying for me as I am blind, and it could be aggravating for quite a few people.

An auxillary socket on the back enables many remote control functions to be obtained, many accessories being available for this. Various pins gave some useful functions, including external PTT, an 8-volt on TX rail (limited current, though, of only 5mA), and external ALC input.

Conclusions

I hope the reader will appreciate that space precludes a more detailed explanation of the many functions and controls, in order to devote most of the space to a deep

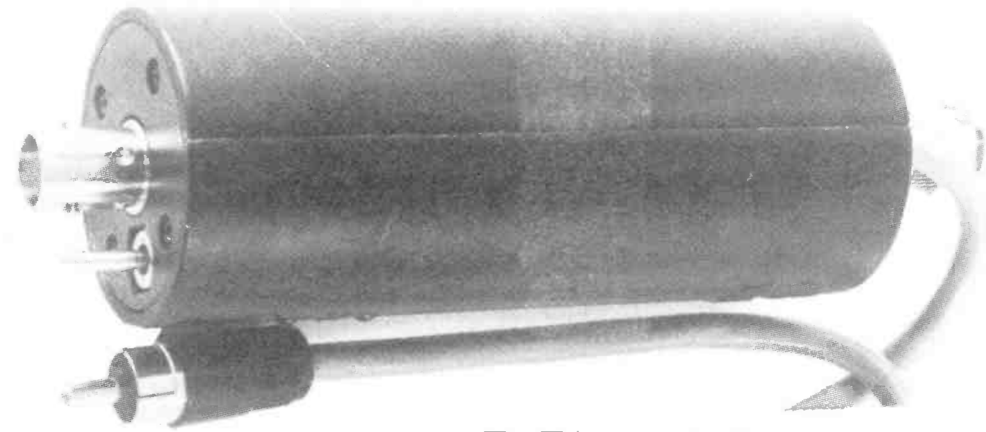
S meter, USB. RF levels for:	
S1 / S3 /S5 (μV pd)	— / 0.2 / 1.2
S9 / S9+20dB (μV pd)	9.8 / 46
Accuracy of dialled frequency, USB (Hz)	+100
Signal generator offset from dialled frequency required for best FM SINAD (Hz)	0 +/− 100 Hz
Audio distortion at 125 mW into 8 ohms audio output. 1kHz fundamental audio output.	
USB / FM (%)	2.2 / 2.3
Audio output into 8 ohms at 10% THD (W)	2.0
Transmitter measurements	
Output power, FM (carrier control max.) at 144.000, 145.000, 145.975 MHz (W)	12.0 / 12.3 / 12.0
Output power, CW at 144.000 / 145.000 / 145.975 MHz (W)	11.2 / 11.3 / 10.7
Output power, USB at 144.000 / 145.000 / 145.975 MHz (W PEP)	15 / 15 / 15
Difference between dialled frequency and transmitted carrier FM / CW (Hz)	+160 / +720 (see text)
Harmonic output, FM (full power):	
Relative levesl of 2nd / 3rd harmonics (dBc)	−56 / −65
4th and greater order harmonics (dBc)	< −70

analysis and explanation of the special Mutek board. My admiration for Mutek has always been high, and so perhaps it's not surprising that this Mutek modification turns a very average rig into one which has the finest RF front end that most of us can wish for. It really is superb, and users of this Mutek version will no doubt agree with me. In particular, using the rig very much brings home the vast differences between good and bad received transmissions. Of course, rigs come and go, and soon the *IC251E* will be phased out, but with the Mutek front end, I have a feeling that the second hand price will remain high, for it is the sort of receiver that is being used by DX chasers. Since its IM performance is so amazingly good, a mast head pre-amplifier with not too much gain will gild the lily without significantly affecting IM. I suggest that this rig with a mast head preamp is better than the average one without, ignoring some of the monstrous boxes that have really shocking RFIM performance. It is worth noting that this is the sort of rig that is likely to be as bomb proof as any for portable contest operating.

Two final points may be of interest. With their help, I estimate that if a circuit as good as Mutek's had been incorporated in the original design, the rig would have cost and absolute maximum of £50 more in the shop, and possibly less. Since this rig was designed by Icom as their top line one, why on earth did'nt they do it for themselves, and why don't other manufacturers make similar improvements just on the top line products? The second point is that I would like to draw the readers attention to an exceptionally important article in January 1983 *QST*, "Modern Receivers and Transceivers — What ails them?", by Doug De Maw, W1FB, and Wes Hayward, W7ZO1. This article details many grumbles about poor design practices in modern amateur radio equipment. I strongly recommend that you read it, if possible, as it covers some very useful ground work.

I would like to thank Thanet Electronics and Mutek for their tremendous co-operation in supplying this sample for review, with Thanet fully acknowledging the excellent improvments of the Mutek front end. ●

Review: Puma 2m PA



and battery pack

By Peter Metcalfe B.Sc, G8DCZ

When the Editor asked me to review this piece of equipment, his description intrigued me: "imagine a four inch length of exhaust pipe — with a BNC at each end — well you stick it on top of your portable rig and it gives about ten or twenty watts out!".

His comment about the weight of the power pack slips my mind at the moment but I seem to recall some mention of a hernia. Anyway, puzzled by what I was letting myself in for, I took delivery of the said items and was immediately struck by the rather amusing model numbers *BIT-02* (that's the PA bit) and *BIT-B* (the power pack. . .). Now I must confess to being a little sceptical as to why anyone would want to operate 20W *portable* but, as you shall see, my general impression of the unit changed as I went along.

BIT-02

Yes it does look like a four inch length of black pipe with a BNC at each end and a short length of power cable sticking out of the bottom. When one opens the die-cast case, there is a quite neatly laid out board containing a small transmit/receive relay with a couple of transistors (presumably for RF sensing and relay drive), a few trimmer capacitors and coils, and a lonely RF power transistor plus biasing components doing all the hard work. A red and a yellow LED indicates ON and TX respectively. All this gives a quoted output of 7W to 20W depending on the drive level (1W to 3W). Apparently, there is a 70cm. version (*BIT-07*) with reduced output power (4W to 15W) available as well. As there was no external indication of the frequency range on the reviewed 2m version, confusion could arise if both versions were purchased.

The use of a relay to switch the RF transmit/receive seems a little odd at first, for, while admittedly this technique introduces lower losses, it will consume rather more current than the alternative PIN-diode switching and this could be an important design consideration for portable usage. However, the rather hefty power pack supplied reduces this problem.

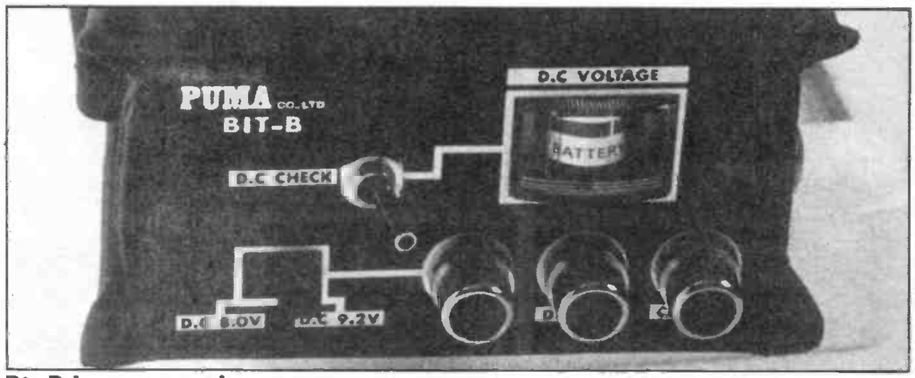
The instruction leaflet (?!) says that the unit "can be used for all types of portable transceiver" and, coupled with a quoted frequency range of 144-146MHz, this could lead to confusion, especially by newcomers to the hobby. With multi-mode portables becoming very popular (eg. *FT290* and *C58*), it must be appreciated that this device is a non-linear amplifier ie. FM *only* and would cause some terse comments if used on SSB.

BIT-B

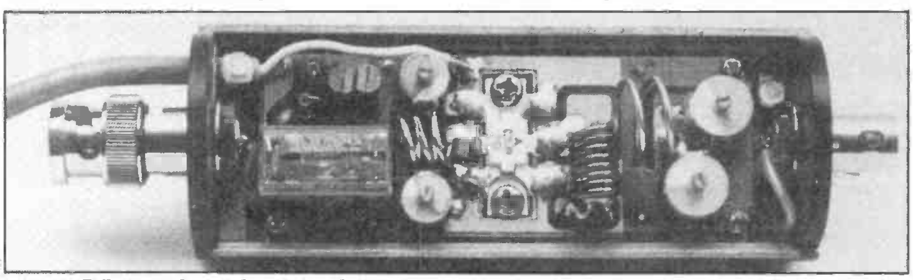
The power pack is practically the same size as a Trio *2400* (ie. rather larger than the *IC2E*). The leaflet says it's a "small and lightweight unit with a high quality leather case". Now I am not disputing the "high quality", for it is quite well made (it has to be, as this is the main container for the battery) but perhaps "leather-type" would be nearer the mark. The case has attached a shoulder strap and a belt loop. Here the terms "small" and "lightweight" take on their relative meanings for, after carrying this pack around at the

Maidstone rally for five hours, it certainly made its presence known!

The vast majority of the power unit is taken up by a "high performance seal battery" (the mind boggles), this being a lead-acid, spillproof, 12V, 1.8Ah device similar to those supplied by RS at around £14. The rest of the unit consists of a small aluminium box-section on which are mounted a battery check meter and switch, three phono sockets and a DC voltage select slide switch. The sockets are for 12V out to the *BIT-02*, a charger input and a switched 8/9·2V output rated at 1A maximum. This output is derived from a small voltage regulator and can be used to power the portable transceiver driving the *BIT-02*. This could be a very useful feature as it would increase the operation time of a typical portable from say 2½ hours on the internal batteries (*TR2400*) to around 10 hours using the *BIT-B* (assuming, of course, that the PA is not used). With extended use on a field day, expeditions or even Raynet exercises you could use this feature but you do have to suffer lugging the pack around with you. A major disadvantage is that all the three sockets are the same type and could lead to expensive mistakes. Another problem is that the 8/9·2V switch is black on a black background and could easily be knocked without noticing. This would cause no problems for the *2400* (9·6V supply) but it may for other rigs.



Bit-B battery pack


Bit-02 PA inside cylindrical case

The meter switch is a little confusing and the leaflet does not make its operation obvious. Taking account of the legend on the panel, one would expect something to happen if switched towards the meter. In fact, the DC 8/9·2V output is switched off in this position and that is all! In the other position, power to the portable is restored and the meter acts as a voltage check on the state of the main battery. As most of the scale on this meter shows 'battery voltage low' and only the tiny top portion shows 'OK', I don't see why a simple voltage metering circuit driving an LED would not have sufficed. The leaflet does warn one to stop operation if the pointer goes into the red zone and this is certainly good advice as the power drops off rapidly once this occurs.

The claimed operation time while using the *BIT-02* at 10W and using the infamous one minute transmit and three minute receive (who does this?) (*Me—Ed.*) is around 120 minutes, but this must be suitably de-rated if the portable is powered from the *BIT-B* as well.;

Precautions and charging the BIT-B

One important precaution mentioned in the leaflet is to take care not to short out any of the phono sockets. This seems a wise piece of advice considering that the maximum discharge current quoted by RS is greater than 40A! That's around ½kW of heat to get rid of somewhere and could be a serious fire risk. A fuse in the battery line would have helped here.

When charging the unit, it is interesting to note the stress that RS places on the need for a constant voltage source. The *BIT-B* notes state "please use a battery charger, regulated power supply (1A or more) or an automobile cigarette lighter" and this is where problems could arise. The quoted charge voltages are between 13·.5V and 15V. At 13·5V to 15V (ie. car battery) indefinite 'float charge' is possible but if greater than 14V is used one has to be careful. I tried it at 14·4V and the current drawn was rather more than 1A, therefore, if the RS recommendation of constant voltage is to be complied with, a supply of much more than 1A is advisable. It is also interesting to note that at 14·4V the quoted charge time is 16 hours but at 15V it drops dramatically to 8 hours. Thus it seems that the charge current rises very rapidly with the charge voltage so take care. I would assume that one has to adhere very carefully to these charge times (from flat) if one is to prolong the life of this rather expensive component.

Performance

A claimed "unique feature" of the *BIT-02* is that "the transceiver and antenna can be combined into one unit". Now while this is a neat idea (with reservations that I'll mention later), I found that it tended to make the portable top heavy, not to mention the strain it must place on the BNC connectors on top of both the *BIT-02* and the portable, especially if a ¼ wave is used on top. Power output figures, using a Trio *2400* to drive the unit and with a freshly charged power pack, are shown in **Table 1.** These figures were measured on a Daiwa *CN630* meter into a 50Ω dummy load. The slight differences in power could, of course, be rectified by careful 'tweaking' of the trimmers in the *BIT-02*. I would also assume that this could be the case when it comes to the very slight

Table 1.

frequency MHz	*2400* output power	*BIT-02* output power
144	1.6W	14.2W
145	1.6W	13.9W
145.995	1.6W	13.5W

attenuation of incoming signal produced when the unit is in place but this is hardly noticeable under most circumstances. More noticeable, however, is the rather drastic reduction in output power when operating with the PA switched off ie. in the so called "straight through mode". This was found to attenuate the normal 1·6W output of the *2400* down to about 1W.

Possibly this is a case of matching problems, for when using a helical aerial no noticeable difference was reported on the air (what helical matches to 50Ω anyway?) but when feeding a 10X/Y the difference was commented upon. When using a helical or ¼-wave aerial, it was noted that both the *BIT-02* and the aerial became rather warm and various suggestions of "some form of new fangled tea warmer" were forthcoming! It did give a difference of three or four S-points (for what that's worth) of apparently very clean RF over local contacts. However, I feel that the unit comes into it's own when driving a rather more efficient aerial eg. 7/8 mobile or fixed base array. Also noted was a rather disturbing amount of metallic deposition, due to arcing, on the BNC connectors after only a few minutes transmitting using a ¼-wave or helical (hardly surprising). Another problem encountered was that when the 8/9·2V output was used to power the main rig and the current drawn was greater than approximately ½A, the voltage regulator became very hot, due to an inadequate heatsink I believe. As this heatsink is placed near to the sealed battery and its wires, excessive heat could cause problems. A further point concerning this output for powering a portable rig is that it is advisable to use screened cable to prevent excessive RF feedback causing very peculiar effects. Indeed, this is also the case when it comes to the power lead from the *BIT-02*. This is *not* a screened lead and with the battery pack in certain positions can cause similar problems of RF breakthrough. This probably explains the incredibly short lead supplied with the *BIT-02* and is my major criticism of the unit, for such a short lead means that:

(i) the power pack must be hand held close to the portable, a very tiring experience, not to mention the proximity of 10W to 20W of RF close to one's head/eyes (a dangerous occupation if you ask me).

(ii) if the power pack is to be carried on one's belt, then the portable must be also, necessitating the use of a speaker mic.

The second point has the two-fold disadvantage of high levels of RF close to one's kidneys (or whatever, depending on how low your belt is.) and that the human body acts as a good RF shield when the aerial is running up one's back. I therefore question the validity of 20W of RF for true portable operation.

Using the Puma PA

Conclusion

Having said this, however, I feel that the power unit is a very useful addition for extended low power portable use. By the way, the quoted 50mA on receive is very wrong for, thinking it was a very high figure, I checked it and found it to be about 3½mA (perhaps they meant 5mA rather than 50mA). The PA seems to be very neat and is certainly one of the smallest 10W to 20W devices I've seen. It is ideally suited for 'in line' use at home or for fixed station use out of doors. It would even be a useful standby for mobile use but it is certainly not for walking along the street. A final comment made by a visitor to the Maidstone rally, where the device was 'soak tested', causing considerable consternation/interest, was "ah, but my *IC2E* with a 5/8 whip on top can out-perform that and with no increase in power consumption". A *2E* plus a 5/8? The mind boggles but at least this device isn't quite so cumbersome!

Postscript

After discussion with a member of the National Physical Laboratory's RF Measurement team, it would appear that some doubt is cast upon the safety of using relatively high power under portable conditions. At 2m obviously one is not dealing with the same problems as at a few gigahertz (the microwave oven effect) but in some quarters it is thought that RF heating could cause physiological damage to bones, arteries etc. When asked to comment upon the use of 20W of 2m a few centimetres away from the human body, one reply was "that sounds like bad news".

GET IN TUNE WITH THIS FAST GROWING RADIO SPORT

Go Foxhunting!

This pastime is becoming an increasingly popular way of burning off the megajoules on a Sunday afternoon.

DF hunting has been around since amateur radio began, but in the early days was confined to 160 and 80m. These bands are still used for this purpose but increasingly activity is moving to VHF.

By Graham Packer
G3UUS

The art of DF hunting is to locate as quickly as possible, or by covering as few a miles as possible, one or several hidden transmitting stations. Rules vary from club to club and ideas are given in **Table 1.** Make up your own but do ensure everyone participating knows the rules in advance.

Suitable equipment

Most 2m hand portable equipment should prove suitable. Naturally an S-meter is desirable but not essential.

A simple yagi, three or five elements, is quite good enough and even a dipole can suffice. A yagi has a radiation pattern like **Fig.1** thus giving sense to the bearing, but is rather broad, while using a simple dipole, **Fig 2**, gives a much sharper 'null' but it could be in either direction.

Once you have selected a suitable antenna, try taking bearings on a known transmitter such as a local repeater. Standing in the clear you'll soon see how easy it is, but getting into a built-up area, reflections make themselves known.

Plotting bearings

Take a suitable Ordnance Survey map and pin it to a large board; some DFers tape the map to the bonnet or roof of their car with masking tape. It's usually better not to bother

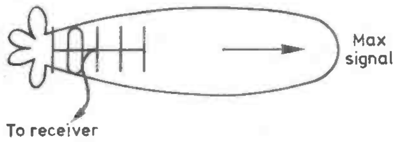


Fig. 1. A beam yagi aerial gives a good first bearing but...

with a compass but to identify landmarks (TV masts, windmills, pylons etc) on the map.

Once the hidden station transmits, swing the beam for maximum signal. If the beam is too

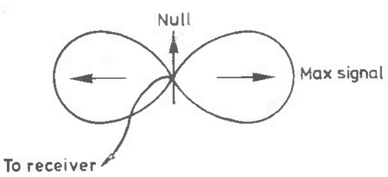


Fig. 2. A simple dipole gives the most accurate fix by listening for the deep null

broad swing for the two points where the signal starts to drop and then guess the mid-point. Relate this point to landmarks (for instance one third the way between the cooling tower and the radio station) and draw a line on the map. Soft pencil can be easily erased, or a plastic overlay with felt pens used.

Now move off at 45° from the bearing as in **Fig. 3.** If we assume

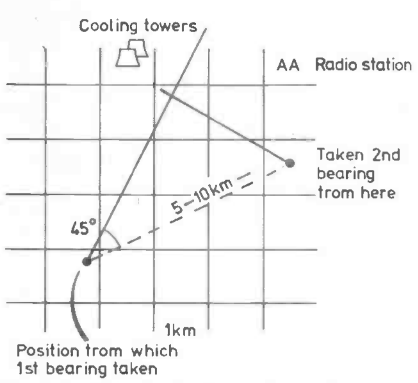


Fig. 3. Plotting the initial fixes

the signal is not devastating then it will be 5-10km from the start (watch it though, many a hidden station has used 100mW 1km from the start to give this effect). Take a 2nd bearing again as in **Fig. 3.** You now have him to within a 1km square! Move in close for the kill.

Now things become difficult. If the rules allow, request transmission on reduced power. Even this may not be sufficient as 100mW at 100m can produce an S9 signal on some handhelds, even with the rubber duck removed. What chance a bearing with a five element beam! A bit of special equipment can help here.

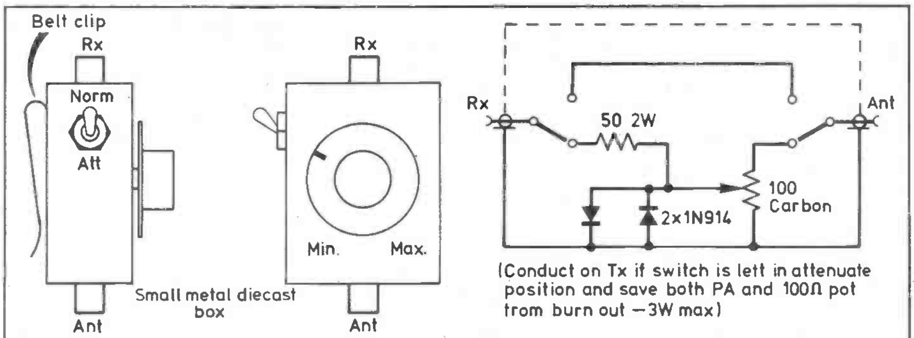


Fig. 4. As you move towards the hidden station, some kind of variable attenuator becomes a must

Table 1

This is a selection of specimen rules and are offered for example only. Make sure that everyone knows the rules chosen for the hunt before it starts.

1. Schedule

a) The hidden station(s) transmits to a pre-arranged schedule such as 30s every five minutes or one minute every 10 mins.
b) The hidden station(s) transmits on demand for 10s, possibly incurring a penalty for the station requesting a transmission (this poses problems for SWL participants).

2. Time/Distance

a) The winning station takes the least time in locating the hidden transmitter(s).
b) The winning station covers the least distance (check his mileometer before starting) in locating the hidden transmitter(s).
c) A combination of the above ie the winner has the lowest minutes × miles.

3. Maps and Area of Search

a) The hidden station is on OS map 156.
b) Between M6, M1, M45 and grid line through centre of Rugby.

4. Start Location

a) Car park of Spotted Dog at 1400.
b) Anywhere within 10km of given grid reference.

5. Secret Weapons

a) Anything goes!
b) Only beams and loops permitted, no Doppler receivers and their displays or equipment capable of being operated on the move allowed.

6. Hidden Station

a) Could be located anywhere requiring battery operated receiver and off road footwear.
b) Within sight of public highway thus allowing more leisurely participation.

7. Polarisation

a) Vertical makes use of dipoles by participants difficult.
b) Horizontal hidden station could use a beam to scatter signals off a local landmark such as a church tower.
c) Random with an ATU the transmitting antenna could be anything, even a barbed wire f e n c e !

8. Power

a) The hidden station(s) will transmit for the duration of the hunt using fixed power.
b) After 1 hour (say) the power will drop by 10dB (15W to 1.5W).
c) Output power will be reduced by 10 or 20dB on request when stations get close.
d) The hidden station will transmit with *random* power levels each time!

9. Multiple Hidden Stations

a) All transmit together from the start on different channels.
b) As (a) but sequentially (Station A 30s every five minutes, Station B 30s one minute later than A).
c) Station B only starts transmitting when Station A first discovered.

Components available from Hamptron, Sanderson Centre, Gosport, Hampshire.

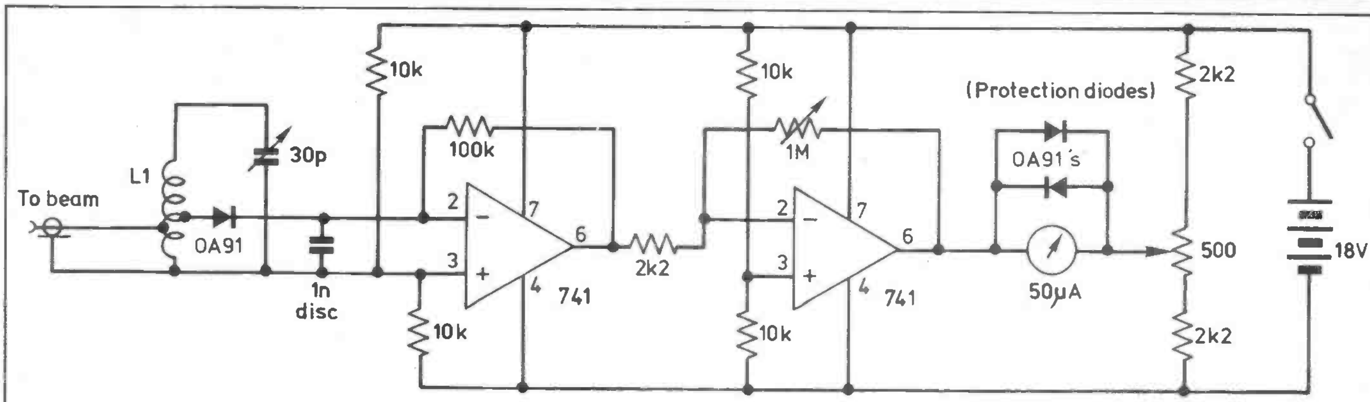


FIG. 5. Simple crystal receiver for DF hunts

In for the kill

You will need to construct the following:

1. A variable attenuator **(Fig. 4)** for use under loud but not rock-crushing conditions and
2. A simple amplified 'crystal set' **(Figs. 5 & 6).**

The variable attenuator is essential in any case if a set without an S meter is used *(ICW2, FT208R* etc) as it allows the signal to be reduced until background noise becomes apparent and hence a meaningful bearing obtained.

The amplified 'crystal-set' is surprisingly sensitive and rarely will its full potential be required. There is no way that narrow band FM can be easily demodulated in such a simple receiver so you will still need your hand portable around your neck. A word of warning; as you get close in to the target keep the volume down or the hidden station may hear you and keep his voice down.

And finally

As the hidden stations will naturally not be giving their locations, check with your local HO/BT interference people. They may like you to drop the hidden locations (in a sealed envelope) into them just in case there is an interference problem.

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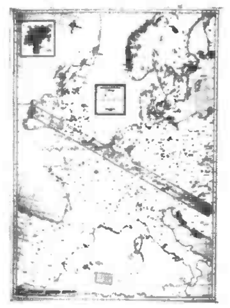

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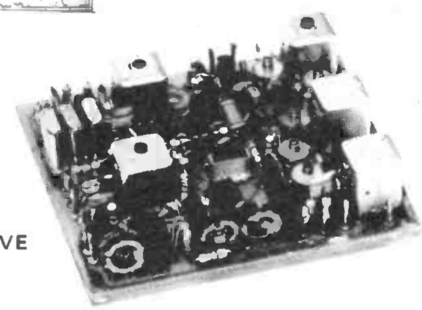

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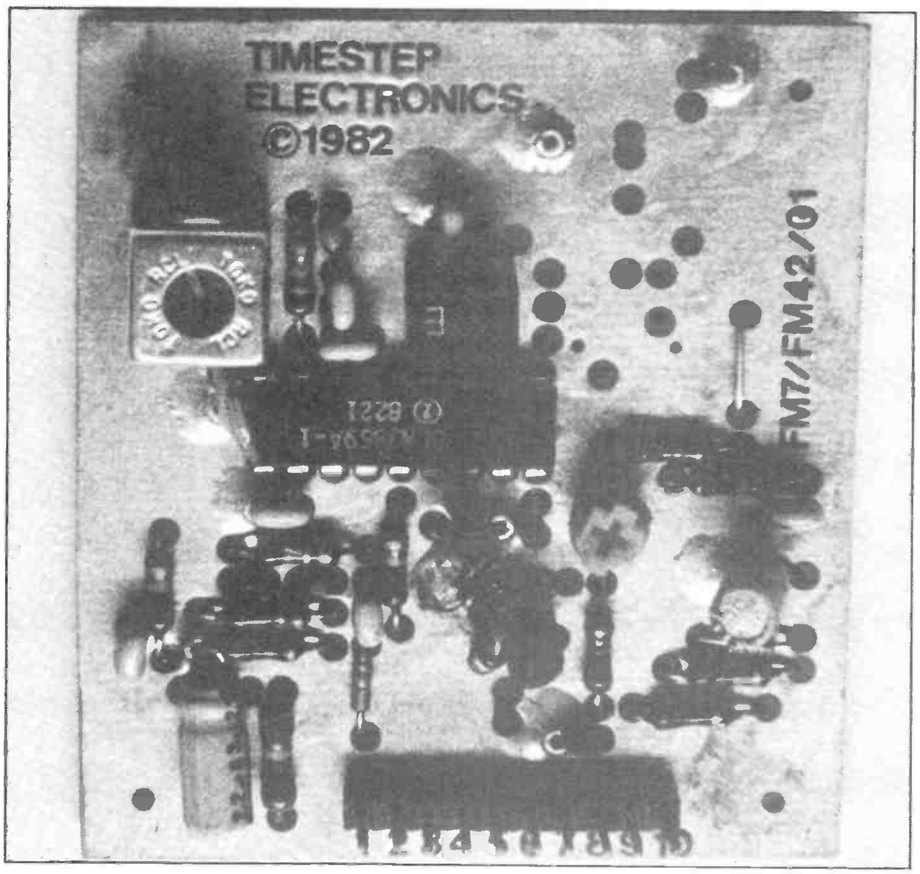
Add-on FM for HF receivers

FM Discriminator FM42 & FM7

By Timothy Edwards

With the advent of legal FM CB many HF receiver owners are disappointed that their receiver will not demodulate FM correctly. More recently there has been a tremendous upsurge in 10 metre FM operation where mobile to mobile contacts of 50 miles are not exceptional and on good days it is possible to work from even a hand held into one of the American repeaters. This too, of course, needs an FM discriminator. It is, of course, possible to slope detect narrow band FM by tuning to one side of the IF filter but the resulting distortion and very bad signal-to-noise ratio gives a totally wrong impression of the high quality signals available via FM. Using this adaptor produces perfect demodulation of narrow band FM signals and will give 12dB SINAD for only 0.1μV input. This is more sensitive than the majority of receivers currently available and many times more sensitive than slope detecting. Of course the ultimate sensitivity will still be dependent on the receiver in use.



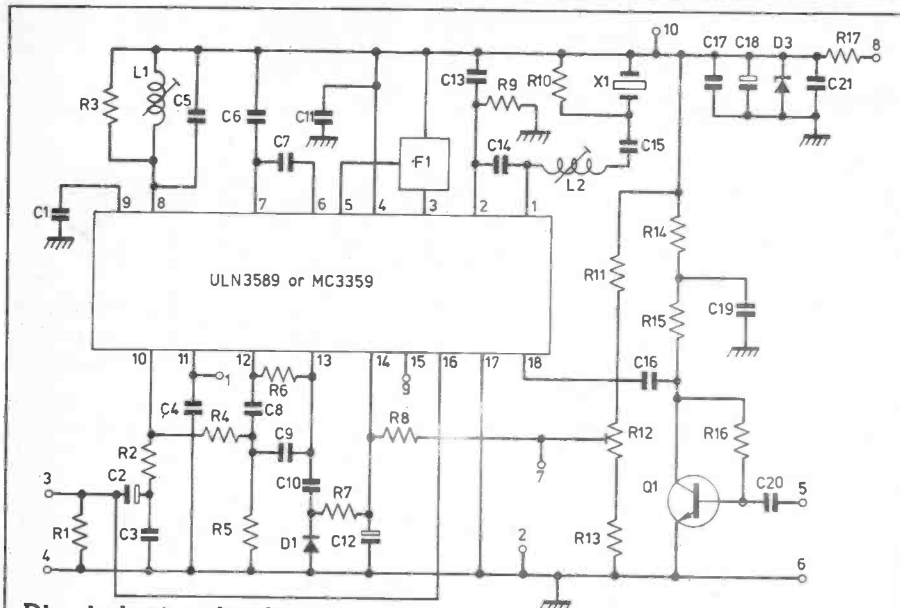
Different modules

There are two separate models, the printed circuit board is identical only the components fitted change. The *FM7* is designed primarily for use with the *FRG7,* although it is also a very useful 455kHz FM demodulator with built in IF filtering and squelch. Its sensitivity of 0.5μV for 12dB SINAD at 455kHz makes it one of the most sensitive discriminators currently available. It may be fitted to a variety of receivers other than the *FRG7*. The *FM42* will operate over frequencies between 455kHz and 50MHz by fitting the appropriate mixer crystal and pulling coil if necessary. Values are given to operate the *FM42* at 10.7MHz as this is a common IF, other frequencies can be used and Timestep Electronics will supply the necessary data if an SAE is sent.

The fitting of a squelch to the modules eliminates the tiring continuous noise when no signal is present. Most other commercial detector modules do not have squelch and tend therefore to be rather useless when used in monitoring applications. The squelch circuitry used is of the 'noise' type which inherently rejects signals other than FM. The attack and decay times have been chosen for rapid two way communication and will give noise free monitoring. The squelch level is adjustable so that barely detectable signals will open it, or so that only very strong signals will open. A pin is available on the module so that the squelch may be defeated so that very weak fluttery signals may be heard without squelch chopping or for tuning across the band without the squelch continuously opening or closing. All the functions necessary for a communications FM IF strip are available on the 10 way edge connector and it is interesting to note that several of these modules have now found their way into professional communications systems.

Circuit description

Q1 is the RF pre-amplifier which is a low noise transistor characterised for IF application and accounts for the very high input sensitivity. In the *FM7* application the onboard mixer is used as a straight forward amplifier and no oscillator components are connected to pins 1 and 2 of the IC. If a very sensitive 455kHz detector is needed then short pins 1 and 2 of the IC with a wire link, this reduces the noise level produced by the oscillator



Discriminator circuit.

transistor and hence improves the noise figure and therefore sensitivity of the mixer, this modification is not necessary for *FRG7* use. The IF signal is filtered by a 4 pole ceramic filter connected between pins 3 and 5 of the IC. Quadrature detection takes place via the coil L1 and its damping resistor R3, C5 is used to pre set the coil from its nominal 470kHz resonance to 455kHz. The 455kHz signal is removed from the audio pre-amplifier via the RF stopping capacitor C1 on pin 9, and the audio output is taken from pin 10 via a 750μS de-emphasis network, consisting of R2 and C3. The squelch or mute is performed by looking at the noise spectrum produced by the discriminator around 9kHz. It can be shown that under weak signal conditions the broad band noise centred on 9kHz will reduce in level far more rapidly with increasing signal strength than any other frequency. Therefore a noise amplifier is built around the op-amp provided on pins 12 and 13. The filter components comprise R4, R5, C8, C9 and R6. The noise centred on 9kHz is then coupled via C10 to the detector diode D1 and smoothed by R7 and C12, this is applied to pin 14 of the IC which is the input to a Schmitt trigger. Also applied to this input is a preset DC level via R8 from the squelch control R12. Under no signal conditions maximum noise is produced by the noise amplifier and produces a positive voltage and in conjunction with the preset level voltage via R8 biases the Schmitt trigger into the 'on' condition. However, this in turn makes pin 16 go down to zero volts and shunts the audio output from pin 3 of the module so that under no signal conditions the receiver is muted.

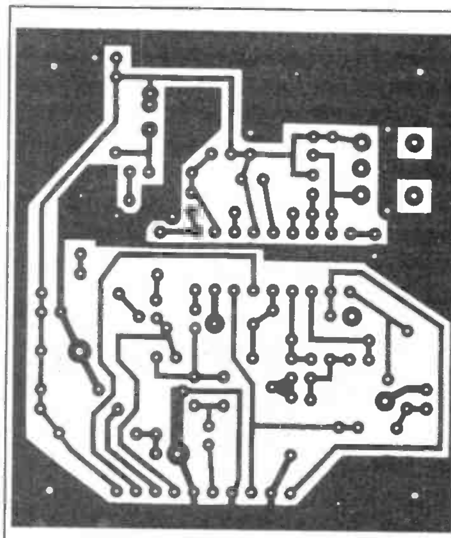
When a valid signal appears the noise amplifier output will significantly reduce and therefore the noise rectified via D1 will decrease and the voltage appearing at pin 14 will drop below 0.7V, therefore the Schmitt trigger will change state and pin 16 will go 'high', allowing the audio to pass out of pin 3 of the module. The mute may be externally defeated by grounding pin 7 of the module so that when tuning across a crowded band the mute will not open and close continuously.

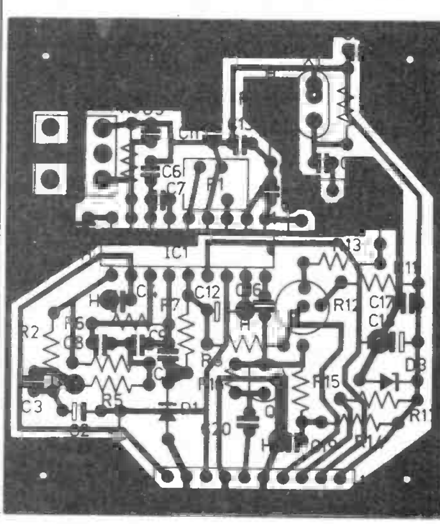
The scan output of the IC which will source approximately 4.0mA is available on pin 9 of the module. An AFC output is available from pin 1 of the module. For applications where AFC is required it is advisable that two 100k resistors be put between it and ground as in the test circuit, it is essential that this pin always be decoupled at RF.

In the *FM42* applications below 18.0MHz a crystal and capacitors C13, C14 and C15 are fitted. The crystals should be fx±455kHz, L2 is linked out and R10 and R9 not fitted. C14 should be 47pF, C13 82pF and C15 in. For frequencies above 18.0MHz R9, R10 and L2 are fitted and the correct values will be dependent on the frequency of operation required, this is a standard Colpitts type oscillator and specific values may, if necessary, be taken from the necessary design tables. It is beyond the scope of this article to detail all combinations of frequencies, although the author's company will advise. For frequencies above 455kHz it is recommended that a coaxial cable is connected directly to the PC board from pins 5 and 6 rather than use the edge connector which is liable to IF breakthrough due to the high sensitivity of the module, it is recommended that the pins of the edge connector are cut off as well.

Assembly

The first items for assembly are the hollow metal rivets supplied. These are inserted through the top of the board and connect top and bottom ground planes together to ensure that the module is perfectly stable. It is necessary to top and bottom solder these before the components are inserted through them. The remaining components can be put in any order, although it is recommended that the IC is fitted first and the electrolytic capacitors fitted last. The link need not be





H = hollow rivet

insulated from the top surface as it is at earth potential anyway. Be careful to get the pot orientation right, the middle leg of the pot goes to the pad with two holes in it, the board is designed to take two sorts of pots, hence the extra mounting holes. If building the *FM7* components C13, C14 and C15, R9, R10, L2 and X1 are not fitted. Before switching on check for solder splashes and dry joints etc. A small modern iron must be used and the component legs cut off close to the PCB. The 1n capacitors supplied are little red ones with a black dot on them. The 100n are either blue or red in a shiny plastic case. The positive end of D1 and D2 is indicated by a stripe or band towards one end.

Installation

The *FM42* should be connected to a suitable point in the receiver, preferably before the main selectivity filter, although this may be difficult if it is a mixer stage where a high level of local oscillator is present which may overload the *FM42* mixer. It may be necessary to provide an LC

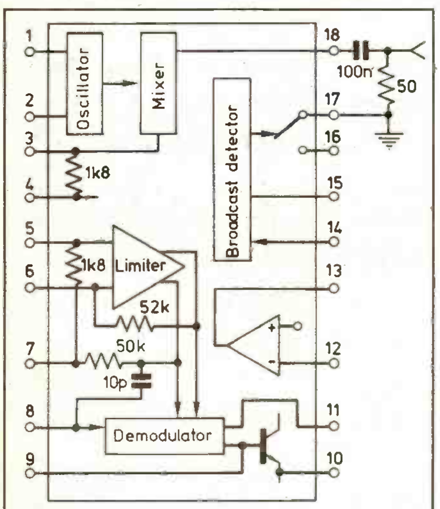
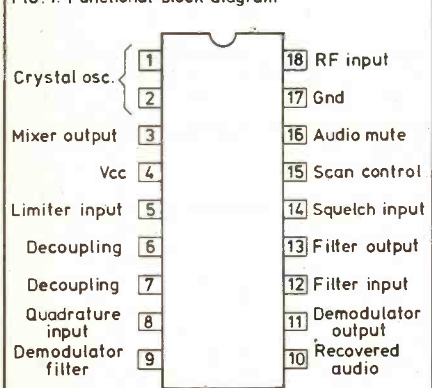


FIG. 1. Functional block diagram



Pi connections

IC1 pin connections.

tuned circuit on the IF frequency in use to reject the oscillator. In other receivers using the *FM7* module, the 455KHz signal should be extracted somewhere in the IF again preferably before the main filter. As this point will vary for each individual receiver no specific technical advice can be given, although if a circuit diagram and stamped addressed envelope are sent to Timestep, then the company will advise.

For the *FRG7* receiver it is possible to completely integrate the detector using these instructions. Uncase the *FRG7* by removing the nine Philips screws and the small black feet. Put the receiver upside down with the controls to the front. Locate the rear wafer of S3 and the mode switch, which is furthest from the front panel. Find the inner conductor of the blue screened cable which is connected to two tags at the bottom of the switch nearest the PCB. Remove this wire and clean both switch contacts. Replace the blue wire on the tag furthest away from the PCB that it was originally connected to. The now spare tag next to the nut on the switch should be connected via a length of wire to pin 3 of the *FM7* module.

Turn the receiver the right way up with the front panel facing you and locate TP405 which is on the PCB immediately below the loudspeaker and near the front right hand edge. Remove the board fixing screw close to it and put a solder tag on this screw and replace it in the PCB. Connect the inner of a length of coax to TP405 and its screen to the fitted solder tag. This coax goes to pins 5 and 6 of the *FM7*, pin 5 of course being the inner of the coax. On the same PCB locate TP408 which is the power supply pin and is on the back edge of the board about half an inch in and fairly close to T401. Connect this pin via a length of wire to pin 8 of the *FM7* module. These simple steps complete the fitting installation.

If a mute inhibit function is required, and it is suggested that this is fitted, then locate the light switch on the *FRG7* and the three spare contacts on one side of it. Connect two wires, one to the middle contact and the other to the contact nearest the PCB and take these to pins 2 and 7 of the *FM7* module. When the light switch is switched off the mute will be disabled although the light switch will still perform as normal. The FM mode is selected by turning the mode

Table 1 Components List

Resistors	
R1	100k
R2	10k
R3,8	68k
R4	22k
R5,13,15	1k
R6	270k
R7	120k
R9	FM42
R10	FM42
R11	470k
R12	47/50k pot
R14	100R
R16	47k
R17	220R
Capacitors	
C1	150p
C2,12,18	2μ
C3,4,6,7,10,11,17	100n
C5	22p
C8,9,16,19,20,21	1n
C13	FM42
C14	FM42
C15	FM42
Semiconductors	
Q1	BF199
IC1	ULN3859 (MC3359)
D1	1N4148
D2	not fitted
D3	7V5 Zener
Miscellaneous	
F1	CFU455
X1	FM42
L2	FM42
PCB	Timestep
SK1	10 way PCB plug
SL1	10 way shell
SP1	10 off pins
HR	9 off hollow rivets
L1	YHCS11100

Table 2 Connection Data

PIN 1	AFC output
2	Ground
3	Audio output
4	Ground
5	RF input
6	Ground
7	Mute defeat
8	+VE input 9-17 volts DC
9	Scan output
10	7.5 Volt output

Note: For maximum sensitivity on FM7 connect pins 1&2 together on the IC. (not needed on FRG7).

switch to AM/ANL. It is suggested that the supplied connectors are used and these should be crimped on to the ends of the connecting leads. It will then be possible to unplug the *FM7* module should service be required.

If it is required to de-modulate fairly wide FM signals on the *FRG7*, such as those used by some 2 metre repeaters, then an alternative connection will be required ahead of the 455kHz filter. This modification is not particularly easy, although with a little time and patience it should be possible to achieve. Locate L405 which is in the drain of the last mixer FET Q402, and replace it with a 455kHz tuned circuit. This should be a *YHCS11100* with a 22pF in parallel, as used in the discriminator. In the group of three pins use the outside two to fit in the holes where L405 was located. This should be done with the smallest possible length of connection wire, certainly no longer than 0.5 inch. Earth the can of the transformer to the nearest earth track on the receiver. Couple the output from the drain of Q402 via a 10pF capacitor to a suitable length of coax into the *FM7* adaptor. No adjustment of this extra coil should be necessary. An additional kit of parts for this modification is available from Timestep.

Operating

Tune the receiver to an FM signal and adjust the tuning for maximum signal strength reading. Switch the receiver to its new FM position and adjust L1 for maximum recovered audio (there are two peaks — be careful to select the one with the maximum output — this will be very close to its normal setting as supplied). Experience has shown that with the superior manufacturing capability of Toko that the coil L1 requires not more than 1/8 of a turn. Tune to a blank frequency and adjust R12 until the noise just disappears, you will find now that the receiver will be quiet until an FM signal is heard. Note that the module will not open up if R12 is turned all the way round.

Kits

A complete kit for this FM detector is available from Timestep Electronics Ltd., Egremont Street, Glemsford, Sudbury, Suffolk. Readers should note than *Ham Radio Today* has negotiated a special price with Timestep. The *FM7* kit is now £9.50 and the *FM7* tested module £13.50. Both these prices include VAT and postage and packing. The *FM42* is by quotation only depending on the IF frequency, although an experienced constructor may prefer to modify an FM7 by himself.

Readers wishing to build this discriminator without buying a kit will find the PCB layouts, circuitry and instructions correct. Please note that Timestep Electronics Ltd. hold the full copyright on the PCB design.

Service

Should your *FM7* or *FM42* module not perform correctly then Timestep Electronics has offered to service it providing it is constructed to a suitable standard. If there are no constructional errors then only return postage will be charged. The nominal service charge is £2.50 but please enclose with your module a cheque crossed "not over £5". Service turnround by Timestep is between 2-4 weeks but may take longer if commercial customers are queuing.

Better than UR67?

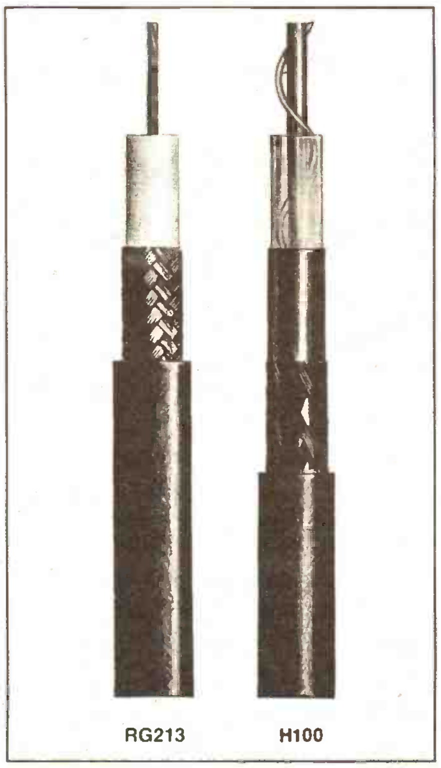
A cable better than UR67 at same price? A special HRT report

Two lengths, each of 25 metres, were acquired for this comparison, and both leads were fitted with N type connectors at either end. Measurements of attenuation were taken from 10MHz up to 1300MHz. The test equipment used included a Marconi *2019* signal generator, a Racal digital RF power meter type *9303*, a Hewlett Packard frequency doubler, various attenuators, and a 1300MHz interdigital filter to clean up the output from the frequency doubler for the 1.3 GHz measurements.

The Racal power meter has an accuracy of around 0.1dB for the applications required for these tests. Extremely accurate 50 ohm loads were used to terminate the Racal measurement heads, measurements being carried out at a level of 1mW up to 1GHz, and approximately 10μW at 1.3GHz. All the attenuation readings include the loss of two N plugs and one N female back to back high quality connector.

You can see from the attenuation figures that not very much is to be gained from a signal attenuation point of view, until you reach a frequency of 145MHz. On 432MHz the difference in attenuation of a 25m run could mean the difference between a contact being just confirmed or lost, but the real gain occurs when *H100* is used on 934MHz, and even more so on 1.3GHz, where a 25m run very nearly multiplies your transmitted power by 2½ times, compared with UR67. Many amateurs cannot justify the expense of the superb cables made by Andrews or Kabelmetal. Such a phenomenal improvement though for long runs on VHF, and even fairly short runs on microwave is very well worth while at the remarkable low price of *H100*, only slightly more expensive, on average, than UR67.

You will notice that the velocity factors of the two cables are rather different, and this may be important to you if you want to make up resonant stubs or matching lines. We also checked what we thought to be a



reasonable minimum bending radius. I personally would not recommend *H100* for other than a very large turning loop around a mast, as it is not at all flexible, and you might be better off to consider Andrews *FSJ4* for this, which is also stiff, but perhaps slightly tougher and safer.

We found the *H100* cable rather more difficult to fix to N plugs than our friendly old UR67, and you may find a heat gun useful for warming up the outer plastic which feels almost slippery to the touch, and yet is very hard, the UR67 plastic being much more supple. I reckon that it will take you about an hour to put two plugs on properly, if you have not previously used *H100*. It is a very robust cable indeed, and is very strongly recommended as being excellent value for money.

Our thanks to W.H. Westlake of Devon, who supplied the cables.

Table 1. Laboratory test results

All tests were made on 25 metre samples of UR67 and *H100*, and the measurements include the effects of the type N connectors.

	UR67	*H100*
Loss at 10MHz (dB)	0.49	0.34
Loss at 30MHz (dB)	0.84	0.54
Loss at 70MHz (dB)	1.37	0.93
Loss at 145MHz (dB)	2.03	1.27
Loss at 432MHz (dB)	3.99	2.36
Loss at 934MHz (dB)	6.40	3.56
Loss at 1300MHz (dB)	8.02	4.22
DC resistance — outer (ohms)	0.08	0.10
DC resistance — inner (ohms)	0.10	0.10
Capacitance (nF)	2.16	2.60
Bending radius (mm)	40	125
Velocity factor	0.67	0.77

". . . the antenna here is of course a loop . . ."

Review: Datong Auto Notch Filter

By Tony Bailey G3WPO

Datong have been building themselves an excellent reputation over the years for quality products, and this latest addition to their range is no exception. In fact, with the change of styling from the usual Vero *G-Line* cases to a solid aluminium extruded cover in this model, the presentation is now very professional, with the contents matching the external appearance.

With three previous audio filters of various types, and now a fourth, there is obviously a good market for this type of aid — I wouldn't be surprised if the various transceiver manufacturers soon latched on to this and started incorporating automatic notch filters to back up the width/shift features which are now standard.

Background

The idea behind this new model has already been exploited by Datong in previous models, notably the *FL3,* but the circuitry and operation of this new version are much more sophisticated.

As they say in their blurb, "as the HF bands become more and more congested, there is a need for counter-measures over and above the facilities built into current transceivers. Model *ANF* is specifically designed to solve the problem of unwanted heterodyne whistles".

And it does solve this problem extremely well, of which more later. The unit is designed to be placed in series with the speaker output of any receiver. For that matter, it could be incorporated into the circuitry of a home built rig as the output stage — it includes an LM380N power amplifier to drive a speaker directly.

Running off 11 to 18V DC at around 400mA peak, it presents a compact appearance and a state of the art circuit using one of the newer integrated circuits — the MF10 dual switched-capacitor filter. With the addition of a PLL circuit for tracking unwanted heterodynes, you have a very sophisticated aid to eliminate 'tuner-uppers', or broadcast whistles on 40 metres.

The front panel has four push-buttons and only one rotary control — most of the time you are unlikely to actually touch the unit if it is being used, as intended, its automatic mode. The unit can be switched off with the input routed direct to the output. Or, by pushing the NOTCH and PEAK buttons together, the internal unity gain amplifier is used, but no filtering (well not much) is introduced. The fourth button is for selection of AUTOMATIC or MANUAL tuning.

In automatic NOTCH mode, there is nothing to do except wait for a heterodyne to appear. While waiting for this, the unit scans the audio range between 270 and 3500Hz continuously, this action showing on a bargraph LED display immediately above the controls. When the heterodyne does appear, it promptly vanishes with the bargraph showing its approximate frequency, and an indication of lock on a further LED at the extreme right of the display. If the interference moves, the filter tracks it almost instantly so there is no need to retune. And it is as simple as that.

Besides this automatic notch, you can tune manually if needed. The only time this is likely to be needed is if there are two interfering signals, and the unit has locked onto the weaker or less obtrusive of them. One simply selects MANUAL and retunes the filter. This would have been quite difficult due to the incredibly narrow notch width, had not Datong still left in some small amount of tracking (+/— 100Hz) in the manual mode. This means you only have to get close to the signal for it to lock.

Although primarily a notch filter, there is also a PEAK filter mode which can be used for CW reception. This is really a manually tuned application as the unit will not lock onto a CW signal, which is a good design feature — it means you can still have the unit in circuit in this mode. The peak width is stated as 60Hz at —60dB with an 800Hz centre frequency — however you can tune it to peak anywhere between 270 and 3500Hz. It is very effective, although it tends to ring a little when the signal is near the noise.

The MF10 IC

It is worth mentioning this package, as it is likely to appear in more and more designs over the coming months. With the addition of a few resistors and capacitors, the IC will allow the building of two complete second order state-variable active filters. As all the outputs from each section are brought out to the pins, all five filtering functions are accessible — lowpass, highpass, bandpass, allpass and notch. Any of the usual filter responses can be synthesised such as Chebyshev, Butterworth, Bessel etc, and with cascading of the units possible for fourth order responses, the possibilities are endless with minimum component counts.

The resonant frequency of each filter is controlled by an external clock, easily made using CMOS ICs. The clock can run up to 1MHz, and the filter with centre frequencies up to 20kHz. As the stability of the filter is dependent on the clock, some applications might require crystal references.

The notch output is synthesised by summing together the highpass and lowpass outputs in an external op-amp (an LF353 in this application) — the notch frequency can be set independently of the filter frequency by means of two resistors.

As you can see from this short summary, a very versatile IC.

The ANF in use

For this review, the filter was used with a *KW2000A* transceiver. This model only has an SSB mechanical filter, so it is an excellent testbed for gadgets like this. There is no reason to suppose that the filter would work differently with any other rig. The input to the unit was fed from the headphone connector, and the output from the *ANF* connected to an external 4 ohms speaker. The filter rear panel carries two phono sockets for this purpose, plus a coaxial DC socket for its power input (centre tip positive). There is a set of plugs supplied with the unit.

I seem to remember showing some enthusiasm over the *FL3* filter in these pages a few months ago. Well, this one is even better (as a notch filter — the *FL3* also does other things). The only gripe on the *FL3* was that you could hear the internal oscillator sweeping about, but this is not a problem here, mainly becuase the clock frequency will be outside the audio range.

Datong claim a notch depth of 40dB+. I suspect that the review sample is much better than this. According to my AF oscillator it is nearer 50dB. This figure, if correct, is expected — and using the *ANF* seems to confirm this figure. Deliberately tuning into 7MHz broadcast station carriers found me unable to locate one that I couldn't completely suppress! This leaves IF notch filters in rigs standing.

It is very pleasant to listen on 20 or 40 metres during peak weekend times with the filter in circuit, and be free of the majority of whistles which plague the ether. I say the majority — if you had two of these beasts in series (or more if you're rich) you could probably be completely free!

The action of the automatic scanning is fast and accurate. When no interference is present you don't know it is in circuit. When heterodynes appear, you hear a short burst of them, then they are gone — the speed depends on which end of the AF range the scanner is, relative to the interfering frequency, when the whistle first appears. It takes at the most about 750mS to kill it.

The notch is incredibly narrow — I found it very difficult to detect any difference in audio quality when tuning it manually through a voice signal. This is a very distinct improvement over any other notch filter I have heard. Coupled with the deep notch, this also means it can be used for signal-to-noise ratio measurements.

One extra not mentioned earlier is the absence of any form of gain control on the unit. I say extra, because the unit incorporates a compander system to keep the gain at constant levels. What happens is that the filter is placed in between two AGC circuits. The one at the input keeps the filter level constant, which prevents varying receiver output levels from affecting the filter performance, while the output AGC readjusts the output level so that any gain or loss in the input circuit is exactly compensated for. The overall effect is that the system remains at unity gain, with the output level matching the receiver volume control setting.

This is very effective in practice and saves having to fiddle with two volume controls (as you had to on the FL1).

In the PEAK filter mode, no problems were found other than slight running at very low signal levels. Tuning is a bit fiddly due to the narrow width of the filter — I found it easier to tune for a notch first on the received signal, then switch to PEAK. In the manual mode the display still indicates the approximate frequency.

I was a bit worried when the unit appeared to be locking onto nothing at times — however a session with the signal generator revealed it was still locking onto signals below the noise level. Another read through the data sheet revealed that this fact stated, so don't worry if this happens. It is just another indication of the performance of the circuit used.

Conclusions

Unequivocally recommended for taking out heterodynes. Given the chance I would have liked to try two in series for the hell of it. Thinking about it maybe Datong could think about getting a second one in the same box — there a lot of occasions when you do get two interfering carriers.

At a price of £67.85 inc. VAT, it sounds a bit expensive but it will be money well spent. You also have the advantage of being able to use it with any other rig you buy.

One other point — it is British, unlike much equipment. ●

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