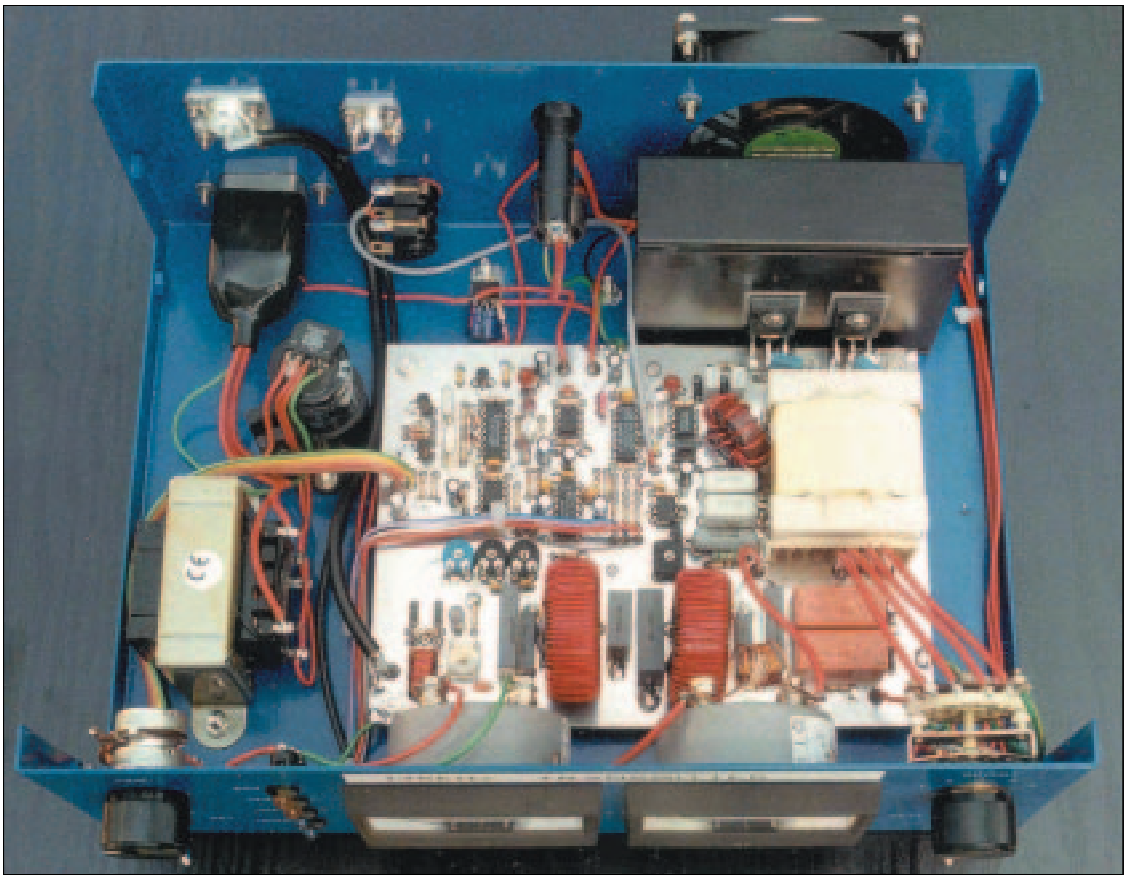
A Class-D Transmitter for 136kHz

The concluding part of the 300W design by David Bowman, G0MRF *



The inside of the transmitter, showing the disposition of the circuit board and the off-board components.

TESTING SHOULD FOLLOW a logical procedure. Apply DC to the 12V and tuning voltage inputs. Check that the two crystals in the VXO are oscillating by looking for the 8MHz signals at pin 8 and 9 of IC1. With the oscillators running and tuning correctly, you should be able to see 274kHz at pin 6 of IC2 and 136kHz at the (Q) and (not Q) outputs of the 4013.

The range of the VXO at 136kHz will be typically 1.5kHz. While this is not sufficient to cover the entire 2.1kHz allocation, it is possible to adjust the values of C2 and C4 and select which portion of the band you wish to cover. On my prototype, I decided to cover the slow CW (QRSS) portion at the top of the band, down through the CW section to 136.3kHz.

Start by setting all the presets to mid-position and VC1 to 80% mesh. Connect the output to a 50Ω dummy load. At LF, almost any load will suffice, even wire-wound resistors are a good match at 136kHz! Fit a 5A fuse temporarily to the main FET supply and switch on. Select the lowest power tap at six turns. Ground the transmit / receive pin and key the transmitter. If luck is on your side you should see between 50 and 100W output. Don't be tempted to switch to high power at this point. Instead, spend some time checking the other functions at this power level. Measure the efficiency of the amplifier and you should see a value above 70%. Values up to 86% are not uncommon. The power meter should read correctly but, if it reads backwards, this can be corrected by reversing the connections on the directional coupler. With a 50Ω load, the trimmer, VC1, can be adjusted to show zero reflected power. When you are satisfied that the transmitter is operating correctly, replace the fuse with a 15A component, and test at the higher power levels. The total number of turns on the secondary of T2 has been specified as 21. In practice, you may only need to use this number of turns if you are using a supply of around 36V. If you have a higher voltage (around 45V), you will be able to achieve maximum power output using the 18-turn tap.

The final part of the setting-up procedure is to adjust the reflected power and over-current trip points. I suggest that you turn up RV3 to maximum sensitivity and see how it responds. The current trip should be set for 10-11A with a supply of 36V, but if you're using a higher voltage supply, then the trip should be arranged to cut in at 400W DC input. At 45V supply, this equals 8.9A. Preset RV6 provides a fine adjustment of the over-

*38 Wyndham Crescent, Hounslow, Middx TW4 5HZ.
E-mail: g0mrf@aol.com

current trip point. Coarse adjustments can be can be made by adding 1Ω 0.5W resistors in parallel with R25.

PRACTICAL ANTENNAS FOR LF

WITH A completed transmitter you're half way there. The only remaining problem is to choose an antenna and find some way of matching it to the transmitter. It's a popular misconception that you need huge antennas to be successful. However, you don't have to have access to a field and a 130ft tower to get good results. Practical antennas at 136kHz require a little ingenuity and care, but can be constructed with ease.

Three popular antennas are the Marconi T, an inverted-L or a simple vertical. As any choice will be electrically short ,you will need to arrange to resonate the antenna with a loading coil. **Fig 3** shows three possible arrangements: (a) is a loading coil in series with the antenna. Its function relies on the collective losses of the matching components and the earth system being approximately 50Ω; this arrangement has been found to work satisfactorily with simple earth systems and a wire antenna between 30 and 100m long; the arrangement has the advantage of having a high impedance when off resonance, offering extra protection to the transmitter; (b) and (c) show refined versions where a transformer or a tap on the loading coil can match a wide range of

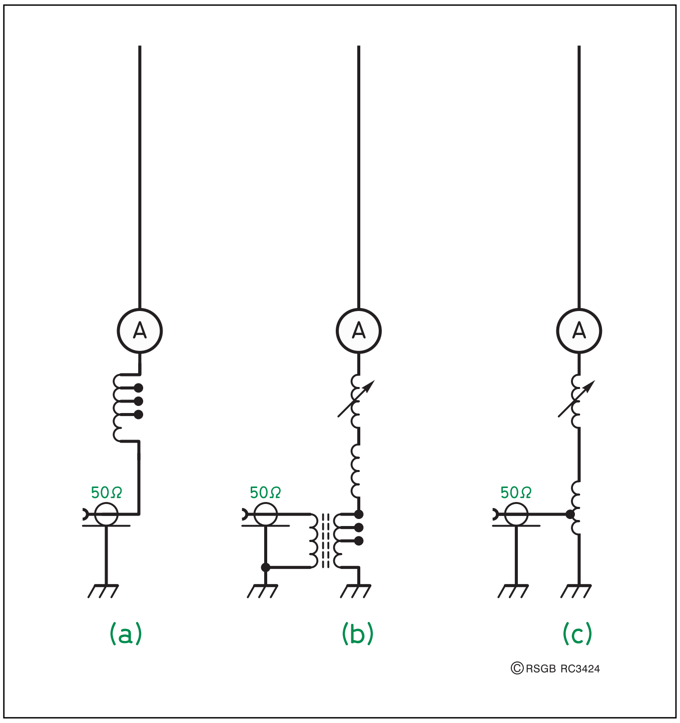


Fig 3: Antenna matching arrangements for LF.

COMPONENTS LIST

Resistors

R1, R2	10M	
R3, R4	22k	
R5, R12, R20, R21, R45	10R	
R6, R7, R31, R42, R43	1k	
R8, R9, R29, R39	10k	
R10, R41, R44	4k7	
R11, R33, R34, R36	12k	
R13	2k2	
R14, R15	680R	
R16	33k	
R17	1k5	
R18	3k9	
R19	150R	
R22	4k7	mounted off board
R23	4k7	mounted off board
R24	47R	
R25	R07	6W, RS Components.
R26		Shunt for 15A FSD
R27	47k	
R28	220k	
R30, R37	2k7	
R32, R35, R46	100k	
R38	5k6	
R40	100R	
RV1, RV2	10k	dual-gang potentiometer
RV3	10k	preset
RV4, RV5, RV6	22k	preset

Capacitors

C1, C3	1n	
C2, C4	33p	
C5, C8, C14, C15	10µ	
C17, C45, C46	10µ	
C6, C7	100n	
C9, C19	47µ	
C10, C11	1n	
C12, C29, C31	470n	electrolytic
C13	15p	
C16	4µ7	tantalum
C18, C32, C41, C42	100n	ceramic 50V
C20, C21	470n	polyester 63V
C22, C24	10n	50V pulse capacitors (polypropylene)
C23	470n	250V polyester
C25, C26	2µ2	100V polyester
C27	1000µ	63V - not on PCB
C28, C30	22µ	tantalum 16V
C33, C38	2n2	1kV polypropylene
C34, C37	10n	1kV polypropylene
C35	4n7	1kV polypropylene
C36	22n	1kV polypropylene
C39	2n2	polystyrene 160V
C40, C43, C44	100n	ceramic 50V

Semiconductors

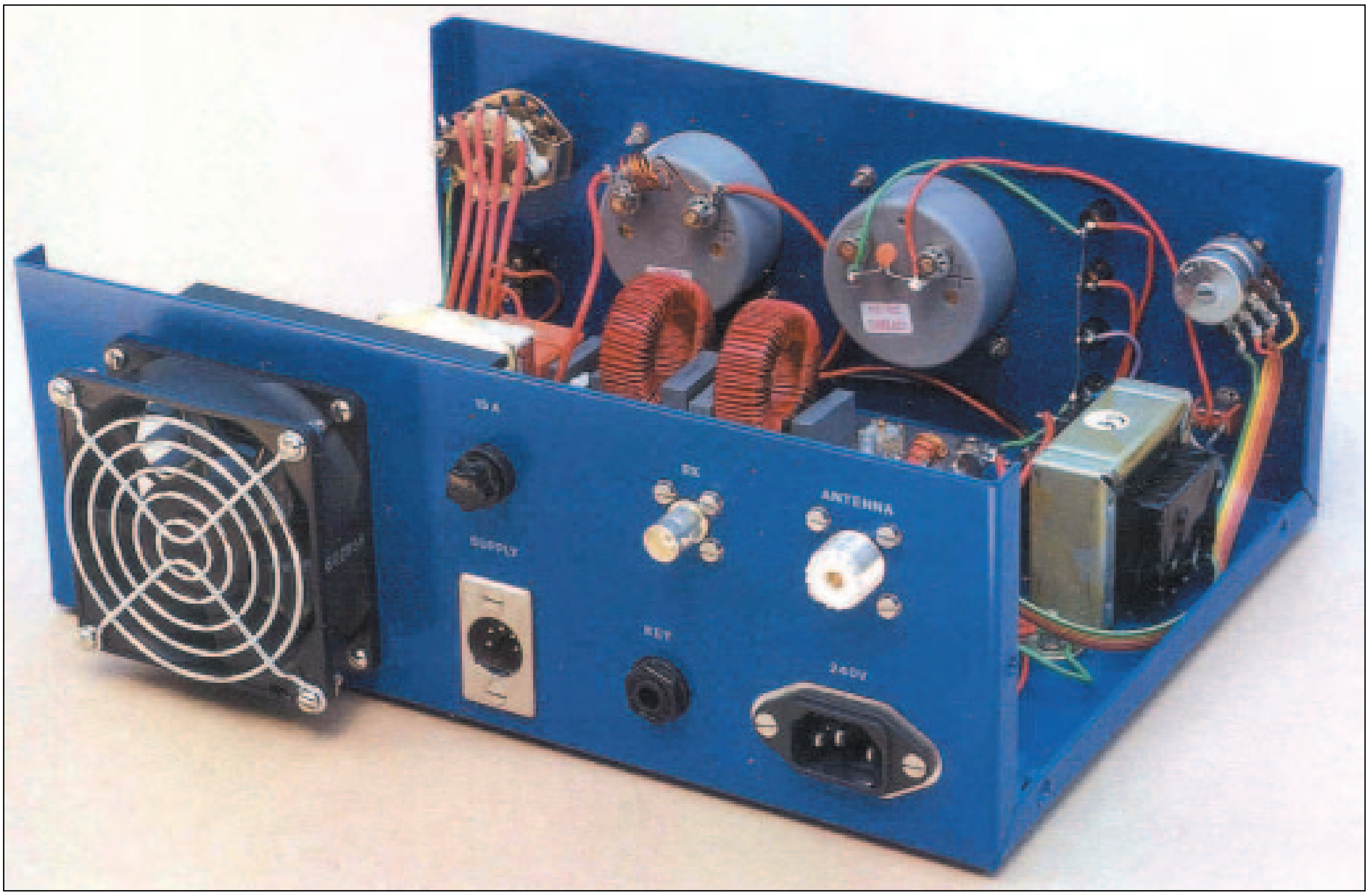
IC1	HEF4011B
IC2	TL071CN
IC3	HEF4013B
IC4	TC4426CPA
IC5	H11L1 Opto-isolator
IC6	HEF4538B
IC7	TL071CN
IC8	78L18AZ
D1, D2, D3	1N4148
D4, D5	MBR150
D6, D7	1N4944
D8, D9	BB405 varicaps
D10	1N4002
TR1	BD136
TR2, TR3	STW34NB20 MOSFET
TR4	2N5401
LED 1, LED 2, LED 3, LED 4	Two green for power: 12V and 40V. Two red ultrabright: VSWR and current trip.

Inductors

L1	470µH 7BA Toko
L2	54µH T157-2 powdered iron toroid. 59 turns of 0.8mm wire.
L3	54µH T157-2 powdered iron toroid. 59 turns of 0.8mm wire.
L4	11 turns 1.5mm on powdered iron toroid T94-2.
T1	Primary: 13 turns 0.4mm bifilar. Secondary: 1 turn (RG58 inner) on 15mm 3C85 ferrite.
T2	42mm 3C90 ferrite toroid Primary: 10 turns 1.5mm CT. Secondary: 21 turns 1mm with taps at 6, 10, 15, 18 turns.

Miscellaneous

X1	8.000 MHz crystal
X2	8.275 MHz crystal, QuartSlab. Fundamental mode, 20pF parallel load
RL1, RL2	12A relay. Single-pole change-over
VC1	5-57pF 809 series PTFE 300V trimmer, Farnell.
M1, M2	1mA FSD meter
S1	Rotary ceramic switch, single-pole 5-way, break-before-make.
S2	Forward / Reverse switch, single-pole 2-way switch.
S3	2-pole, centre-off toggle
Heat sink.	Single-sided 1.2°/W
Isolating washers	TO247
PCB	
Fan	80mm 12V, Farnell / Rapid / RS Components / Maplin, CPC, etc.



Rear view of the transmitter.

impedances. These latter two also have the important safety advantage of having a DC path to earth to discharge static. A thermocouple or RF ammeter can be used to monitor antenna current. Loading coils for LF are big, with a typical value between 1 and 10mH. They should be constructed from insulated wire because, at this power level, enamelled wire will fail as the insulation between turns is insufficient. Resonating the antenna system can be achieved by using a series of taps, or by making a small proportion of the inductance variable by including a variometer.

Finally, a word of caution: An electrically-short antenna will have very high voltages present - 20kV is not uncommon! Many antennas and kites have fallen from the sky at the instant the key is pressed. Use high quality materials, especially for the insulators and ensure that high-voltage sections are safely out of reach of family members and pets.

More information on LF antennas and operating techniques is available [4 - 6].

JOINING IN THE FUN

A GOOD GUIDE to LF reception in the UK is to listen for the German data transmitter, DCF39, on 138.83kHz. With a resonant antenna it should be S9+. The propagation characteristics of LF are broadly similar to topband. During daylight, the ground-wave predominates and, with a few hundred milliwatts ERP, it will be possible to work CW within the UK and into western Europe. At night, ground-wave and ionospheric propagation coexist. Alan Melia, G3NYK, has a website [7] which has a series of graphs showing the signal strength of the Canadian CFH transmitter on 137kHz, as received in the UK, and DCF39 as received in Portugal by CT1DRP. Most activity on the band is at the weekend, with normal CW operation taking place below 137.2kHz.

Finally, if you have a computer with a sound card, you can take part in some very weak-signal working. The upper and lower portions of the band are used for a technique known as QRSS or 'visual CW'. All the long-haul contacts have used this technique. By using either of two programs [8], you can use a computer to analyse the audio from your receiver. The computer uses a fast Fourier transform (FFT) to display very weak signals on the monitor. Speeds are very slow - a CW dot may take several seconds to send, but the technique is valuable, as the ability to turn your computer into a CW filter less than 1Hz wide allows you to see signals clearly that are many dB below the normal noise level.

A kit of parts for this project, or a PCB, is available from the author [5].

ACKNOWLEDGEMENTS

I WOULD LIKE to thank the following members of the LF community for their assistance: Dave Pick, G3YXM, and Peter Dodd, G3LDO, for circuit ideas; Bob, G8RW, André, N4ICK, and Mitch, VE3OT, for beta-testing prototypes; John, G4CNN (SK), for constructing a 400W version and producing the original circuit and component overlay drawings. Photographs by Maurice de Silva, G0WMD.

REFERENCES

[4] Dave Pick, G3YXM
www.wireless.org.uk

[5] G0MRF projects
www.g0mrf.freeserve.co.uk
Tel: 020 8572 8615.

[6] *Low Frequency Experimenter's Handbook*, edited by Peter Dodd, G3LDO (RSGB Shop).

[7] Alan Melia, G3NYK
www.alan.melia.btinternet.co.uk

[8] Two Windows-based programs can be used for weak signal reception. *Argo* or *Spectran* by I2PHD and IK2CZL, are available as freeware
www.weaksignals.com
QRS by ON7YD is used for transmitting slow CW.
All three programs from
www.wireless.org.uk/software.htm ♦