RADCOM TECHNICAL FEATURE

MSF Locked Frequency Reference

The conclusion of a two part feature by A. C. Talbot, G4JNT

BY USING THE INTERNALLY generated 60kHz, it is possible to set up the receiver chain without using an oscilloscope.

Firstly, set up the tone decoder by feeding the 60kHz signal present at pin 9 of the 74HC74 to the MSF input. Adjust the 10k preset until the carrier LED lights. Now the tone decoder itself may be employed to set up the ferrite rod tuning. Adjust the preset capacitor and coil position until the LED is flashing reliably. In areas of low signal strength the phase meter could be used to maximise the received signal to noise ratio by adjusting for maximum deflection at the maxima and minima of the beat signal.

OPERATION

WHEN FIRST SWITCHING ON, with the loop set to 'lock', the meter will be observed to swing with a cycle time of a few seconds. After 3 to 4 swings, the amplitude will die away and the meter should sit at mid scale. If the two signals present at pins 1 and 2 of the 7486 are examined on a dual beam scope, no movement between them should be seen.

If the switch has been set to 'free' and the system free-running, then it may be difficult or impossible subsequently to achieve lock without switching the unit off and waiting for a few minutes. This is because, whilst free-running, the integrator output will probably have ramped up to its maximum of around 10 volts.

When the loop is subsequently closed, this voltage pulls the VCXO frequency outside the loop lock range and a beat frequency of 1Hz or so may be seen, the loop never being able to lock up to this frequency error. The quick solution is to discharge both 470µF capacitors so that they ramp up from zero towards the nominal tuning voltage of around 3V as if the unit had just been turned on.

One other problem that may occur is if the programmable divider (**Table 1**) is set to give an output where a close harmonic falls at 60kHz. (15, 20, 30kHz etc) In this case there is likely to be enough 60kHz leakage to cause the MSF signal to be overridden, and allow the loop to lock to itself. Should this occur, the carrier light will remain on and the VCXO frequency will either ramp to its maximum or minimum values. If left unchecked, it is possible that the tuning voltage could rise so high that subsequent lock cannot be achieved, in the same way as described above.

The 108MHz output should be sufficient to drive a 1N23 type microwave diode to 10mA or more diode current. This will give strong enough harmonics to be heard easily at 10GHz. At this frequency, on an SSB receiver, the received note is 'clean' but it is unlikely to be completely steady. A randomly varying change in the beat note of some 30 – 100Hz, over a period of several seconds, will probably be observed, due to several reasons. The primary one is the characteristics and signal to noise ratio of the MSF signal. Interference will perturb the loop operating point and cause a frequency variation whilst the loop tracks the signal. Another cause is instability in the VCXO. This random variation is actually phase noise, although it is difficult to think of noise as being at fractions of a Hz!

An interesting test is to warm the crystal by holding it whilst listening to the beat note. As the crystal warms up the frequency will quickly (within 1 – 2 seconds) drift. Over a longer period this will be corrected by the loop and the original beat return. Good construction techniques around the crystal oscillator will minimise this effect.

LOOP DESIGN

THE PHASE LOCKED LOOP has a very demanding specification. It has to reject totally the 1Hz component caused by the carrier pulsing. The sample and hold significantly reduces this component, but considerable 1Hz sidebands are still present. To achieve this, the loop bandwidth has to be significantly less than 0.5Hz and a figure of 0.12Hz was chosen. To calculate the values for the integrator time constants the characteristics of the VCXO and phase detector must be known. The VCXO constant (Kv), when divided down to 60kHz, was measured and a figure of 0.13Hz / volt obtained.

The phase detector figure can be calculated by assuming the output changes between the supply rails, ie from 0 to 5 volts, when the phase varies from 0 to 180°. Thus giving a phase detector constant of $5/\pi = 1.4$ volts / radian. A damping factor of 0.7 is used as giving an optimum compromise between loop tracking and lock up characteristics. The standard equations for phase locked loop lead-lag network time constants are employed:

$$t2 = \frac{2}{2\pi.BW} = 2.6\ s$$

$$t1 = \frac{(1 + KvKd.t2)^{\wedge}2}{4.2\pi.KvKd} \quad t2 = 3.56\ s$$

FREQ	XYZ	FREQ	XYZ	FREQ	XYZ	FREQ	XYZ
1.000	010	200.000	033	3.750k	150	62.500k	072
2.000	011	240.000	123	3.840k	127	75.000k	162
4.000	012	250.000	041	4.000k	045	80.000k	057
5.000	020	300.000	131	4.800k	135	93.750k	170
6.000	110	320.000	026	5.000k	053	96.000k	147
8.000	013	384.000	116	6.000k	143	100.000k	065
10.000	021	400.000	034	6.250k	061	120.000k	155
12.000	111	480.000	124	7.500k	151	125.000k	073
16.000	014	500.000	042	8.000k	046	150.000k	163
20.000	022	600.000	132	9.600k	136	187.500k	171
24.000	112	625.000	050	10.000k	054	200.000k	066
25.000	030	640.000	027	12.000k	144	240.000k	156
30.000	120	750.000	140	12.500k	062	250.000k	074
32.000	015	768.000	117	15.000k	152	300.000k	164
40.000	023	800.000	035	15.625k	070	375.000k	172
48.000	113	960.000	125	16.000k	047	400.000k	067
50.000	031	1000.000	043	18.750k	160	480.000k	157
60.000	121	1.200k	133	19.200k	137	500.000k	075
64.000	016	1.250k	051	20.000k	055	600.000k	165
80.000	024	1.500k	141	24.000k	145	750.000k	173
96.000	114	1.600k	036	25.000k	063	1000.000k	076
100.000	032	1.920k	126	30.000k	153	1.200M	166
120.000	122	2.000k	044	31.250k	071	1.500M	174
125.000	040	2.400k	134	37.500k	161	2.000M	077
128.000	017	2.500k	052	40.000k	056	2.400M	167
150.000	130	3.000k	142	48.000k	146	3.000M	175
160.000	025	3.125k	060	50.000k	064	6.000M	176
192.000	115	3.200k	037	60.000k	154	12.000M	177

X Divide by 6 selector — Switch A
Y Divide by 5 selector — Switches B,C,D
Z Divide by 2 selector — Switches E,F,G

Table 1: Frequencies available from programmable divider.

Choosing a capacitor value of C = 470μF gives the necessary values of the resistors around the integrator to meet these time constants:

$R1 = t1 / C \qquad R2 = t2 / C$

Taking the nearest preferred values gives the values shown in the circuit diagram. A final network is added at the integrator output to give further attenuation at 1Hz. A time constant of 1.2s, formed by 56k and 22μF gives a further 19dB reduction in this component, whilst the time constant is fast enough not to affect the loop tracking performance. Without this extra filter, around 10Hz of frequency shift (at 10GHz) was noted every time the carrier was switched off. With the filter no shift was discernible.

CONCLUSIONS AND FURTHER MODIFICATIONS

THE FREQUENCY REFERENCE generated is more than good enough for 24GHz narrowband work in CW bandwidths! The unit has been designed so that different parts may be used separately as individual constructors wish. If other output frequencies are desired the following modifications could be made:

1) A 30MHz VCXO could be used instead of 12MHz, with a division ratio of 500 to give 60kHz. This would give access to 10MHz and 5MHz, not available from the unit described.
2) An output level of +10 dBm at 96MHz has been obtained from the multiplier, by changing the capacitors across the tuned circuits to give a quadrupler followed by a doubler stage.

There is further scope for optimising the loop feedback function. If the loop bandwidth could be narrowed still further, it would be less susceptible to noise and interference (but more so to oscillator stability). It would then probably be necessary to employ non-linear techniques to improve lock up time and pull in range.

If it is intended to use this unit portable, it may be necessary to temperature stabilise the crystal oscillator to prevent it moving outside the pull in range at temperature extremes. One way to do this would be to use the crystal heaters supplied by the RSGB's Microwave Component Service [Note 2].

NOTES

1 No components list has been provided as this article is intended as a source of ideas, rather than a perfectly reproducible construction project.

2 The RSGB Microwave Components Service can be contacted c/o Mrs P Suckling, G4KGC, 314A Newton Road, Rushden, Northants NN10 0SY; tel: 0933 411446.

PCB SERVICES FOR *RADCOM* PROJECTS

PCBs

THESE PCBS ARE NOT AVAILABLE FROM RSGB HQ, BUT DIRECT FROM BADGER BOARDS

Description	RadCom	Part no	Price
RSGB Morseman		MMPCB	£10.00
Morseman EPROM		MMEPROM	£5.00
GW4HWR 12V 1A PSU	(May/June 91)	99137	£3.25
ICOM IC725/735 Controller	(Oct 92)	ICREMPCB	£10.00
IC725/735 Ctrlr EPROM		EPROMICOM	£5.00
Wobbulator	(Nov 92)	WOBB	£4.95
Wobbulator ready built		RBWOBB	POA
Simple Spectrum Analyser	(Nov 89)	1189SSA	£16.00
Oscilloscope Probe Tester	(Nov 91)	OSCPRO	£4.50
G3TSO 5-band Transceiver	(Sep 88)	TSO07	£28.00
G3TXQ 3-band Transceiver	(Feb/Mar 89)	TXQ7	£23.50
G3TSO Miniature 80m Tcvr	(Jun/Jul/Aug 91)	G3TSOMIN	£8.00
G4WIM 50/70MHz Transceiver	(May - Aug 1990)	WIM10	£52.00
2m noise eliminator	(Apr 92)	2MTRRF	£9.00
Ultimate keyer	(early 80s)	ULTKEY	£6.00
White Rose Receiver	(Feb 90)	WRMAIN	£4.25
White Rose Plug-in converters	(each)	WRCONV	£2.00
White Rose Case		WRCASE	£15.75
G3PCJ 160m Transceiver	(Jan/Feb 93)	TOP160	£7.50
Direction Finder	(TT Apr 91)	VHFDF	£3.75
AF Oscillator	(Sep 90)	AFOSC	£4.95
Synthesiser	(Jul/Aug 92)	SYNCPCB	POA

Add £1.50 to all prices for postage and packing

Available from:
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KIT SERVICES FOR *RADCOM* PROJECTS

KITS

JAB's aim is to have kits available off the shelf. Sometimes, especially following publication, demand is unknown so you are advised to check availability or allow 28 days for delivery. Kit contents vary, the contents are given, eg 1+2 means that PCB parts and PCBs are supplied. Price shown is the price you pay except that if the order value is under £15.00, please add £1.00 towards P&P.

Contents Codes:
1 = PCB Mounted Parts Only
2 = PCB Only
3 = Case Mounted Parts
4 = Ready Punched Case
5 = Case Un-Punched

Exclusions Codes:
A = Air Spaced Variable
B = Crystals
C = Display

Notes:
SF = State Frequency or Band
POA = Price on Application

Author	Date	Kit	Contents	Price	Notes
G3TSO	1088	Multiband Tx/Rx		POA	
G4PMK	1189	Spectrum Analyser	1+3	£55.65	
G3TDZ	0290	White Rose Radio		POA	
G4WIM	0590	Dual Bander 50+70MHz		POA	
G3BIK	0990	AF Oscillator	1+2+3+5	£25.00	
G3TSO	0491	Digital Freq Display	1-C		
G3TSO	0691	80m SSB Tx/Rx	1-A	£77.00	
G3BIK	0192	HF Absorb W/meter		POA	
G4SGF	0492	A Novice ATU	1+2+3+5	POA	
G4ENA	0592	QRP+QSK Tx/Rx	1+2+3+4	£45.05	SF
G3ZYY	0992	4m/6m IRS		POA	
G7IXK	1192	Wobbulator	1+2+3+4	£21.50	
G3VML	0493	2m SSB/CW Transceiver		POA	
G3ROO	0493	6m Converter	1+2	£11.85	SF
G4ENA	0593	Direction Finding Kits 160m:-			
		DF Receiver	1+2+3	£32.50	
		DF Transmitter	1+2+3	£25.30	
G3TDZ	0793	Phasing Transceiver:-			
		Receiver	1	£27.00	
		Exciter	1	£24.10	
		Converter	1-B	£11.40	SF
		Power Amp	1	£18.60	SF

Available from:
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