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The Fosse CW Transmitter

Introduction

This is a simple crystal controlled 1.5W CW transmitter for any band 20 to 80m. It is the matching transmitter for simple receivers such as the Ford, or Rockwell. The frequency is normally determined by a crystal or ceramic resonator, but it also has two dividers that can be used where division can be used sensibly for a lower band. TR control is semi-break in and includes an antenna changeover relay. There is also adjustable level muting of the receiver, with netting facilities, so that your transmitted signal can be monitored when netting RX and TX together. Given that you are now likely to be a more experienced constructor, these instructions are in a much shorter style; so take extra care to find the correct location for each part by comparison with circuit diagram as you progress. The circuit diagram is only provided with the kit of parts. Please read right through these instructions before starting assembly. Parts are numbered up from 1 with band dependent parts from 20.

Brief Technical Description

See the Block diagram in Fig 1 and the circuit in Fig 3.

Supplies – The output stage uses the main incoming supply (9-18v – see later) which is NOT reverse protected. The rest use a 78L05 5v regulator IC3.

TR Control – Closure of the key causes the gate voltage of TR3 to go towards 0 volts, and stay there after key up for up to about a second as the voltage rises slowly under the R7C8 time constant. TR3 off allows R10 to turn on TR4 which activates the relay and the RF oscillator.

RF Oscillator – IC1A oscillates when the control input point N is at 0 volts, usually under the influence of TR3/4 after key closure. If you wish to activate only this oscillator (to find the TX signal on your RX), then you can ground point N. A 14.06 MHz crystal or the 3.58 MHz is fitted at X20 depending on band. C1 permits a small frequency alteration when using a crystal, or a useful one with the ceramic resonator.

Dividers – The two dividers in IC2 are enabled when both control inputs of each are at 5 volts. When X20 is the 14.06 crystal, division by 2 yields the usual 40m QRP frequency 7.03 MHz. They can be stopped by grounding point F and or C.

Output stage – The driver gates IC1B/C/D are driven by either the oscillator gate IC1A or from a divider stage depending on the desired output frequency; three gates are used in parallel to overcome the high capacity of the output MOSFETs gates on the higher frequency bands – they only pass signal when the key is actually closed.

Muting – Key closure turning off TR3 allows R10 to also turn on TR5 before the nasty transients that arise from relay operation, so that they are masked in the RX audio chain by placing a low resistance (or short) across a suitable point. This might have a DC voltage on it, so C10 can be used to avoid a thump due to DC voltage changes. See later!

Assembling the TX

First decide how you will mount the PCB near to your receiver – but do not mount it yet! Four bolts can be used in the corners of the Fosse or it can be joined to the RX by soldering the two supplied PCB joining strips underside between the ground tracks across the joint. In the early stages of assembly take particular care to locate the correct holes – using the parts layout diagram Fig 2 and the circuit in Fig 3 - the right holes will become more obvious as the board is filled up. See also Photo 4. Tick them off as you progress. Start with parts that can only be fitted one way due to their pin layout:--

Stage 1 – Unambiguous parts – Fit:-

Two rubber feet underside in right hand corners – assuming you plan to join it against the RX			
Two screw antenna/earth terminal block			
RL1	12v DPCO relay		
Key socket	3.5mm stereo	Push it tight against PCB!	
C1	65 pF YL trimmer		
R12	10K preset		

Nothing to test here – so fit:-

Stage 2 – Supplies

C3	10 nF disc – 103		
C4	10 uF 25v electro	?Polarity	
C5	10 uF 25v electro	?Polarity	
C6	10 nF disc		
IC3	78L05 – CL Fwd	?Orientation	

I assume that you will not (at least normally!) use a PP3 battery supply because it will not last long! A bench type nominal 12 v supply or small NiCd battery will be more suitable for the higher consumption of the transmitter. Arrange to measure the 5 volt line on point 5 with your meter’s negative lead to any convenient ground E/0 volt terminal. Connect your supply (negative to E/0v and positive to point V) – check this again due to lack of protection! Switch on and the reading should be close to 5 volts. Switch off and start on TR control:-

Stage 3 – TR Control

D1	1N4148	?Orientation	
R6	1K – BN,BK,RD		
R9	100K – BN,BK,YL		
D2	1N4148	?Orientation	
R7	100K		
C8	10 uF 25v electro	?Polarity	
R8	1K		
R10	1K		
D3	1N4148	?Orientation	
TR3	BS170 – CL Back	?Orientation	
TR4	BS170 – CL Back	?Orientation	

Connect your key to the 3.5 mm plug – between sleeve and tip – plug it into the key socket. Switch on and listen carefully when you press the key – the relay should click on; but on releasing the key, the relay should not click off until after a delay of approx 1 sec – this is the TR hang time to prevent it returning to reception between each Morse character. Switch off and fit the RF oscillator:-

Stage 4 – RF Oscillator

R5	100K		
R1	100K		
X20	See below		
C2	150 pF disc - 151		
R2	1K		
LK	Fit a wire between the E pads near R12 and R3/C2.		
IC1	74HC02	?Orientation	

X20 is band dependent and its frequency is not necessarily the same as your chosen band! For 20 and 40m, because I have lots of 20m QRP crystals, it is suggested you fit X20 with the 14060 KHz crystal that is supplied; for 40m, you then connect the dividers to divide by 2 to give 7030 KHz in the next step - for 20m the dividers are not needed. For 80m, you would normally fit the supplied 3.58 MHz ceramic resonator at X20 without division but you can alternatively divide the 20m crystal by four down for 3515 KHz. For other bands such as 30m and 50m, you will need to use your own crystal – most likely without any division.

Arrange to measure or observe the oscillator output on point 2, or listen for it on a general coverage RX – remember it will be at the crystal frequency without any division yet. If measured with a DC voltmeter, the reading on point 2 should be zero until either the key is closed or point N is grounded; it should then rise to about 2.5v being the average value of the 0 to 5v square that should be present on point 2. If you are using a scope or counter to observe point 2, connect them via a divide by 10 probe. Altering C1 should permit small changes in frequency – when X20 is a crystal the tuning range will be small – perhaps only one kilohertz; with a ceramic resonator, it should be a few tens of kHz! The oscillator IC1A is active until the hang time ends. Switch off and fit the dividers if required as explained above:-

Stage 5 – Dividers – skip this stage, leaving out all 3 parts, if they are not required

R3	100K		
R4	100K		
IC2	74HC74	?Orientation	

If division by 2 is required for 40m, use just IC2B but stop the second stage in IC2A by grounding point F. If division by 4 is required, do not fit any divider inhibiting links to points C or F. The output of the divider(s) can be checked in the same manner as the oscillator – when the key is down, or during the hang period, the output on point 4 or 8 should be a 0 to 5v square wave at the divided frequency. (Points 4 and 8 maybe a steady 0 volts or +5v when stopped because the key is up, or that stage of division is inhibited by a link to point F.)

Stage 6 - keying

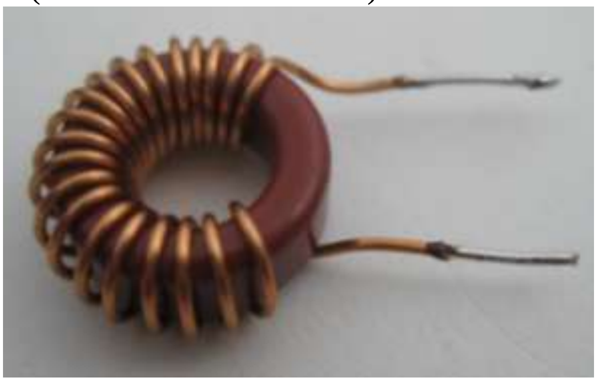
Fit a short wire link for the driving gate inputs between point B and which ever source is appropriate for your output band – B to point 2 for 20m, B to point 4 for 40m and B to point 8 for 80m. Now transfer the observing instrument to point D, key up it should always be 0 volts even when N is grounded to activate the oscillator or during the TR hang delay; but when the key is closed it should have a 0 to 5v square wave at the desired output frequency for your chosen band.

Stage 7 – Output stage – Fit:-

L1	10 uH choke		
C7	100 nF Polyester		
TR1	BS170 – CL Fwd	?Orientation	
TR2	BS170 – CL Fwd	?Orientation	
L20/21	T50-2	See below	
C20/21, 22/23, 24/25 & 26/27	330pF – 331 & 470pF - 471 pF YL	See below	

The output Low Pass Filter L20/21 and C20-27, whose purpose is to remove unwanted TX harmonics, has to be built for your desired output band – so it may not be the same as the frequency of X20! L20 and L21 are wound as single layer windings with the 24 gauge enamelled wire on the red T50-2 toroids. Each time the wire goes through the centre of the toroid it counts as one turn. Take the suggested wire length below and slide the toroid to the middle of the wire – this is the first turn; then with one end put on the rest of the first half of the desired number of turns, and then with the other end put on the rest of the required turns. Wind the turns on tightly and spread or close up as required to occupy about three quarters of the circumference of the toroid. Trim the wires back to about 1.5 cm from the toroid and tin the ends by burning off the insulation with a hot iron (do not breathe the fumes!). Photo 1 shows an example completed toroid.

For 20m you need about 30 cm for each toroid with 10 turns,
For 30m you need about 35 cm for 12 turns,
For 40m you need about 40 cm for 14 turns,
For 80m you need about 50 cm for 20 turns.



The capacitors C20 to 27 are also band dependent – they are connected to make four similar value ‘filter’ capacitors by using two actual part values - either as a single capacitor, or two in series or in parallel. Not all are required for every band and when two are needed, they are wired in parallel for a low frequency band, or in series for a higher band. When a series connection is required, fit them with their common connection using the isolated pair of pads between each of the locations for C20/21, 22/23 etc. When either a single, or a pair are needed in parallel, do not use these isolated linking pads – use just the outer holes at each location! The value, and hence pattern, is the same for all four ‘pairs’ (C20/21, 22/23, 24/25, 26/26) for a given band:-

For 20m, fit each pair as 330 pF in series with 470 pF for effective 193 pF,
For 30m, fit just a single 330 pF,
For 40m, fit just a single 470 pF,
For 80m, fit each pair as 330 pF in parallel with 470 pF for 800 pF.

It is assumed that by now you will be using a 12v supply (mains PSU or battery) instead of the 9v PP3 in simple RXs – these will go flat too quickly when transmitting!

Connect a 50R dummy load between the A and E terminals, with some form of RF output power indicator. As a check, it is wise to connect an ammeter (about 2 Amp FSD) in the positive supply lead. Connect (and check!) your supply, then briefly press the key; the relay should click on and the RF output power should be about 1.5W (25v p-p or 8.66v RMS) when using a nominal 12 volt supply (drawing about 250 mA) – less on 9v or higher with increased supply voltages. Do NOT keep the key down continuously because TR1/2 will get pretty warm, especially when using a higher supply voltage - get used to how they heat up by feeling them often! Switch off and fit:-

Stage 8 – Muting

R11	100K		
C9	100 nF Polyester		
R13	1M – BN,BK,GN		
C10	10 uF 25v electro	?Polarity	
D4	1N4148	?Orientation	
TR5	BS170 – CL Fwd	?Orientation	

There is nothing that can be easily tested here so connect it to your receiver.

Connection to the RX

It is often easiest to mount the TX near the RX, before making the following connections. You can use bolts in the four TX corners or use the supplied PCB joining pieces; these need to be soldered to the underside ground tracks of TX and RX at both ends of the joint between the PCBs – you may need to move the two right hand rubber feet of the RX slightly towards the centre-line to expose the ground tracks edges right in the corners for soldering. See Photo 2. Then make these connections:-

Ground/0 volts – make sure the RX and TX ground circuits/tracks are well connected at both ends of the joint between the PCBs. Solder the PCB joining pieces underside astride the joint and between the nearby ground tracks of RX & TX. It is also prudent to fit the two (bare) ground linking wires that can be seen in Photo 3 – these are links are essential when using mounting bolts in a case etc!

Supply – connect TX point V to the positive supply terminal of the RX, ideally after any protection diode. (But be aware its voltage drop will slightly reduce TX output).

RX Antenna – connect TX point R to the RX antenna terminal.

Muting – for Ford, Rockwell and other RX's that drive headphones without any LS output amplifier, connect TX point H to the audio pre-amp drain load – for the Ford this is the track between R13/R14/C13/drain of TR5 - there is not a suitable Ford hole so either drill one or connect this link underside direct to the tracks; for the Rockwell this is point L. For RXs with LM380 LS amplifiers, the Fosse coupling capacitor C10 is not needed so that point M can be connected to the track linking the series resistor on the output of the AFG pot to input of the LM380 amp - the Fosse ST level pot R12 will then not work – if R12 is required, put the link to junction of Fosse R13 and C10.

First check that the RX works normally as before, and then change back to the dummy load. Because the time constants of the muting circuits are long, it takes a minute or two for the voltages to settle after switch on, so do not be surprised if the first muting test gives some nasty thumps on key closure! Temporally ground Fosse point N to turn on the TX oscillator, and tune the RX so that you hear the TX oscillator on the RX. Reduce the RX gain right back and set the Fosse ST level preset R12 fully anti-clockwise for maximum attenuation or least audio output. Press the key and then gingerly advance the muting level preset R12 in the Fosse so that you can comfortably hear the TX carrier as you tune across it with the RX – but see later.

Using the Fosse

This is a simple low power transmitter, that may require a degree of patience to use effectively, but once mastered will be well worthwhile! All the usual comments about erecting good aerials apply equally when transmitting – get plenty of wire out, up high and ideally in a balanced arranged so that RF grounding issues can be avoided. An aerial matching unit (AMU) is also recommended to achieve a good match between TX and aerial. Do plenty of listening to check that band conditions are good, with much activity, when you first try for a contact. Given the ‘crystal’ controlled nature of the rig, you are almost certainly bound to have call CQ and hope for a response – hence the suggested crystals which will give you the commonly used QRP frequencies.

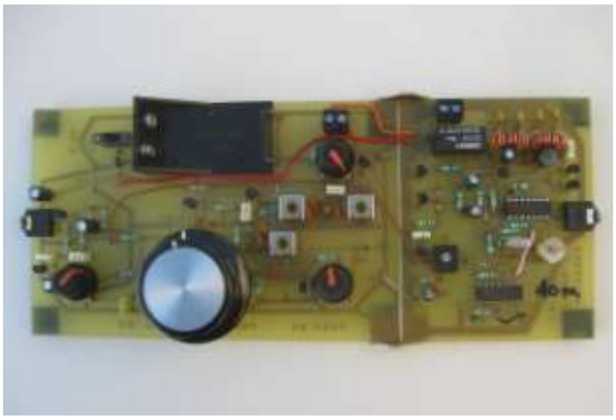
For simplicity, the TX does not have any RX sidetone but the muting circuits do enable you to ‘be aware’ of the transmitters RF output – with adjustment of the Fosse preset R12. If the RX VFO and TX oscillator/divider are within a few KHz of each other, you are likely to hear them beating against each other; this can be observed when you ground point N of the Fosse and then tune around with the RX. However, because the Ford and Rockwell RXs (those most likely to be used with the Fosse), have free running Local Oscillators, it is inevitable that the much larger RF signals present when actually transmitting (as opposed to just enabling the TX oscillator/divider by grounding point N), will swamp the RX oscillator and pull its frequency to that of the TX when their frequencies are close – in practice, the Ford or Rockwell is likely to be pulled to the TX frequency when they differ by less than about 5 KHz; unfortunately this means that listening to your normally transmitted signal cannot be used to provide RX sidetone. This effect is most easily demonstrated by listening to the TX oscillator by grounding point N and then tuning across its signal (through zero beat) with the RX for a beat note of say 1 KHz; then pressing the key will unfortunately stop the beat note because the RX oscillator has been pulled to the frequency of the transmitter. The RX tuning range where the beat note can be heard while transmitting will be somewhat wider with the pulling effect noticeable! Despite this limitation, the RX can be tuned to that of the TX by grounding point N alone and adjusting the RX tuning for a beat note of about 750 Hz. Due to the pulling effect this note will cease when transmitting properly. The setting of R12 may have a small effect on the level of the beat note in the TR hang period after key up. These limitations are the consequence of simplicity in RX and TX!

The Fosse can be used on higher supply voltages which will give a higher output, but do get used to how quickly TR1/2 heat up – feel them often!

That’s enough from me! I am always glad to have any feedback.

Tim G3PCJ Dec 1st 2018, updated Mar 3rd 2019

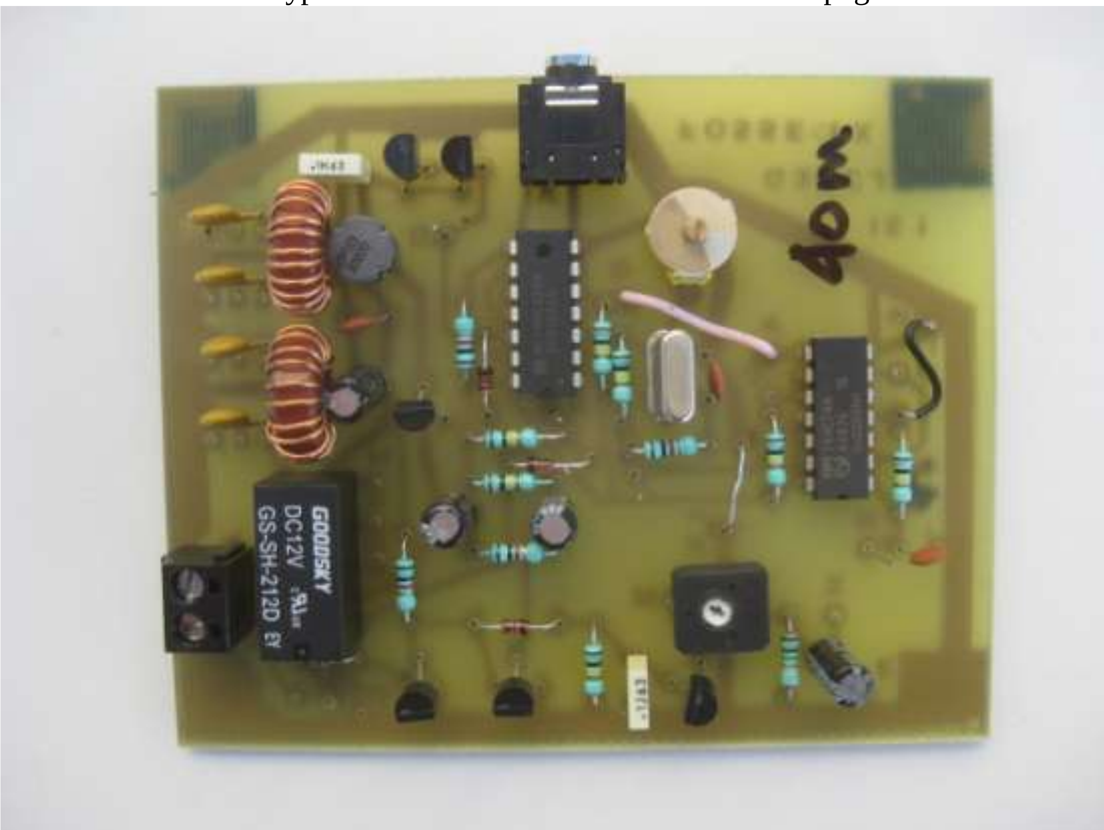
Photo 2 – joining the TX & RX with PCB strips, Photo 3 with RX



Parts List for the Fosse TX

Resistors			Capacitors		
4	1K	R2,6,8,10	1	150 pF disc	C2
7	100K	R1,3,4,5,7,9,11	4	330 pF YL disc	C20,22,24,26
1	1M	R13	4	470 pF YL disc	C21,23,25,27
			2	10 nF disc	C3,6
1	10K Preset	R12	2	100 nF Polyester	C7,9
			4	10 uF 25v electro	C4,5,8,10
Inductors					
1	14.06 xtal	X20	1	65 pF YL trimmer	C1
1	3.58 cer res	X20			
1	10 uH choke	L1			
2	T50-2 toroid	L20,21	Miscellaneous		
1m	24G enam wire	For L20/21	2	Rubber feet	
1	12v DPCO	RL1	1	2 screw block	
			1	3.5 PCB stereo skt	For key
Semiconductors – in antistatic bag			1	3.5 plug	
4	1N4148	D1 - 4	2	PCB joining strips	
5	BS170	TR1 - 5			
1	74HC02	IC1	Fosse PCB		Is 1
1	74HC74	IC2			
1	78L05	IC3	Tim Walford G3PCJ Dec 1st 2018		

Photo 4 - Fosse Prototype – turned anti-clockwise to best fit the page!



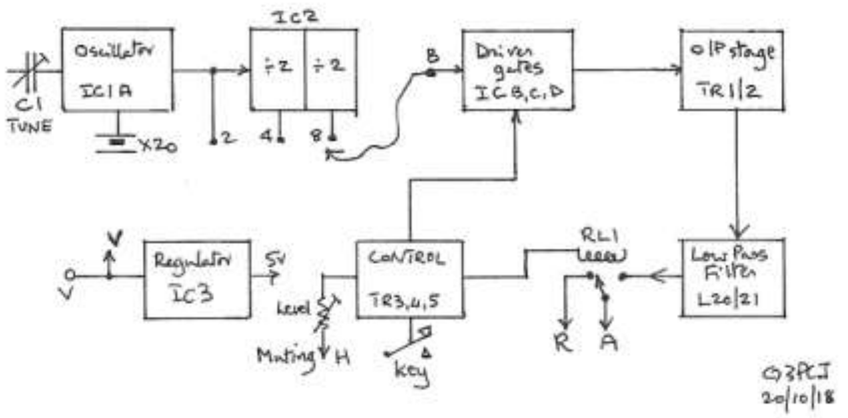


FIG 1: BLOCK DIAGRAM OF FOSSE

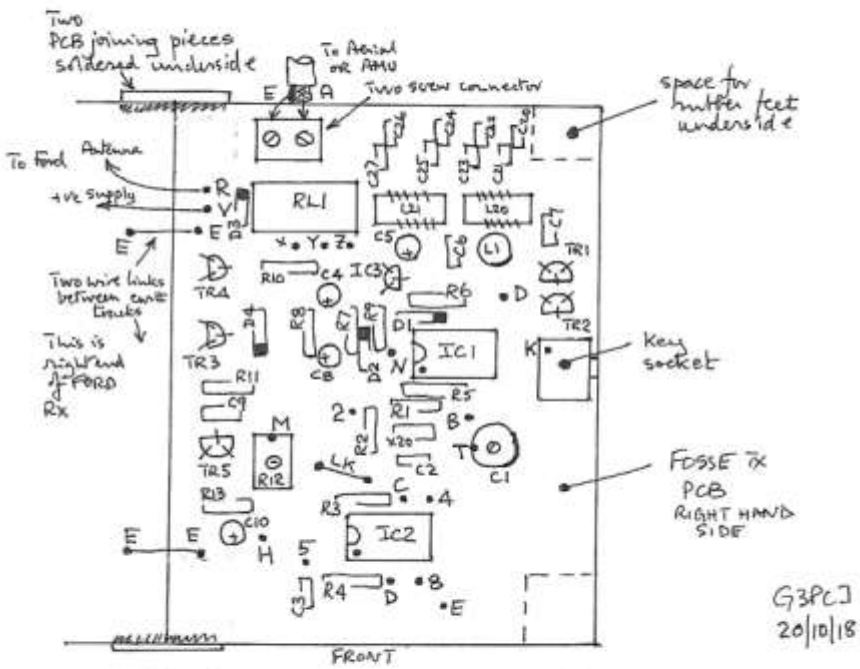


FIG 2: PARTS LAYOUT OF FOSSE