Notes for the design and construction of The “Two Mobile" receive VFO

A LITTLE HISTORY.

This design dates back into the late 60’s, early 70’s when …

I was becoming aware that single channel operation on the VHF bands was losing contacts. VHF operation in European countries like Germany and the Netherlands were steadily moving to fully frequency tuneable transmitters and receivers, going were the days of fixed frequency crystal controlled in the "BAND PLAN", operations, "tuning low to high" just HAD to go!.

Field Effect transistors (FET) had appeared in the electronics industry, these closely resembled thermionic valves in operation but without the high voltages needed for the latter. Circuit design for FET's was similar to valves in respect of the impedances presented to input and output circuitry, therefore a lot of designs used with valves found themselves with FET equivalents.

One of the newer designs of oscillator, the "VAKAR" was easy to implement with FET's and proved the easiest, the most stable and reliable circuit with a very wide range of component values allowing a handful of "Junk Box" parts to be employed with great success. (See Appendix 1)

By fine tuning the selected components for temperature stability, building SOLIDITY into the design, most of the frequency drift could be eliminated, or reduced to acceptable levels. This led to a number of complex designs with full thermal control and regulation, heated boxes insulated within other boxes to achieve stability suitable for narrow channel operation (5kHz AM).

So was born the G8AMG VFO.

Moving on a year or so and being involved with GAREX ELECTRONICS as a supplier of all things "PYE" I was presented with an opportunity to create a receive VFO for the up and coming range of 2M transceivers based on a PYE Radio phone transceiver that was produced for the early days of car phones in LANCASHIRE and LONDON areas, these radios were for use on 160MHz FM and being designed in modular form were ideal for conversion to 145MHz as each frequency dependant module could be re-worked easily using the data available for PYE gear for the 136-156 MHz bands.

Of course, the transmitters were still crystal controlled as they needed stability and reliability in the hands of the relatively non-tech public users. Radio Hams, the intended market for these conversions, were a different type of user and needed special features, the most important of these being a TUNEABLE receiver. Remember at this time and date the channelised FM boxes had yet to arrive in force.

Enter the G8AMG/GAREX receive VFO.

The receiver section of the "Two Mobile" used the standard PYE 10.7MHz and 455kHz intermediate frequencies (double superhet) so needed a first mixer injection of 144-146 - 10.7 viz. 133.3 - 135.3MHz. Getting stability and suitable components for a fundamental VFO at this frequency was a daunting prospect, but the PYE Cambridge design that the "Two Mobile" was based on used a lower frequency crystal in the 50MHz range with multiplier and filter on the front-end RF board, so what was needed here was a VFO to replace this crystal oscillator.

First designs.

The available test equipment at the time consisted of a frequency counter that would just get to 40MHz, a Hallicrafters S20 receiver around the same range so a VFO of 50MHz would have been difficult to test with the limited test equipment. Hence the solution was to adopt one in the 33MHz range and multiply by 4 to achieve the required 133MHz, multiplying by 2 in the box and then by two again in the front-end RF board.

This multiplication increase meant that the VFO stability requirements became more stringent as a drift of 1kHz at 33 meant a 4k shift in receive frequency. So started the quest to tighten up on the tolerance of the components and the general hardware design. At that time most radio constructors would use the ubiquitous "Die-Cast box" for anything needing solid assembly, this was the natural choice for this project, one such box nicely fitted behind the front panel of the radio and was easily drilled and machined to form a substantial screened enclosure for the VFO. GAREX electronics a long-standing buyer of surplus electronic components was a bit like an Aladdin's Cave with large stocks of hi-spec components to choose from, so designs were re-producible over a run of about 100 units without needing to re-source components with all the re-work that would require.

Prototypes.

Early versions underwent quite a few changes in the quest to achieve almost crystal stability, the first and most important of these being the use of a chip voltage regulator (723) as although the VAKAR VFO is a stable design, it is very dependent on a stable power supply, to allow for maximum regulation with a varying 12V power feed, a regulated 8-9V supply was chosen, the 723 was a complex design and could hold the output voltage within +/- 5mV for an input change from 11 Volts to 15Volts. The next aspect of the design was to use selected values of positive temperature coefficient silver mica with negative temperature coefficient (N150) ceramic capacitors to achieve a balance over a wide temperature range.

Hair dryers to the fore...

Most of the initial temperature drift checking was done using my then, Girl friend's hair drier (bless her) later we got up in the technology a bit by using a heated die-cast box, warmed up with OC35 power transistors bolted hard down on the sides and controlled by a solid state amplifier and an OC81 transistor with its copper bolt down fin, this device was as leaky as hell with it's base open circuited (a germanium trait) but in this case put to good use.

Getting it all going..

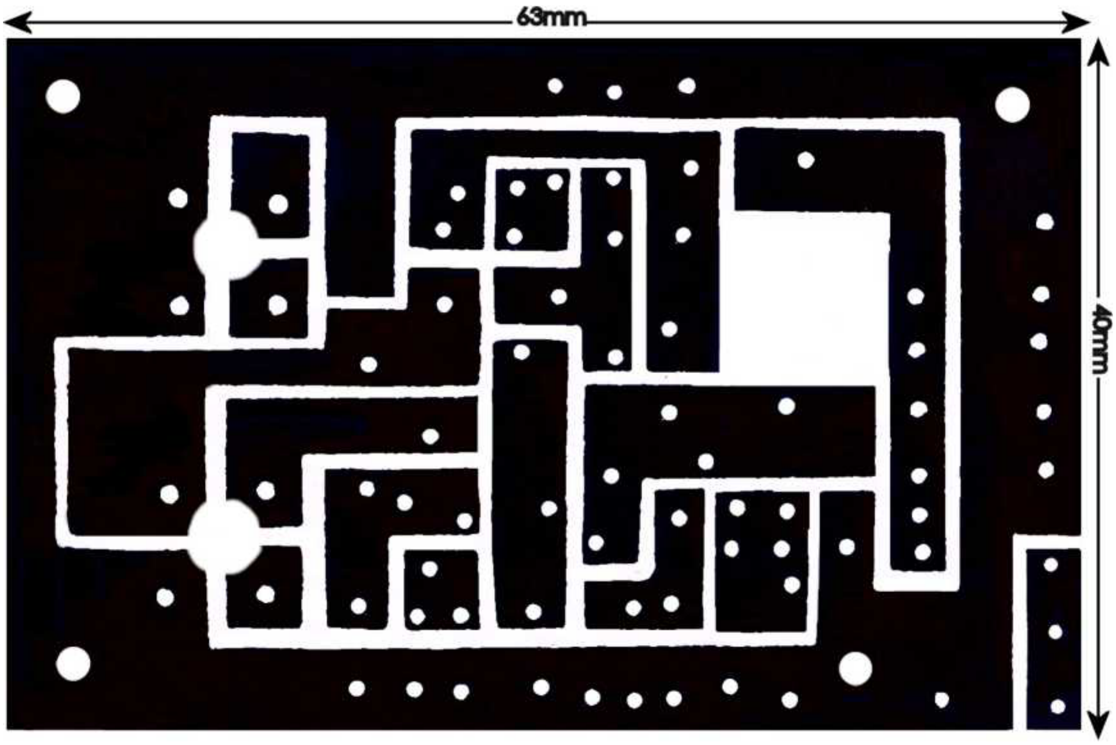
Over a frantic few months of construction early in the project I became quite adept at selecting the right range of components to achieve what was at the time considered to be an impossible frequency stability. Early designs of VFO used a single 12-15pF tuning capacitor, this limited the turn of the dial to 180 degrees only which meant for a cramped dial calibration, later we used a gear driven "Jackson" dual 15pF capacitor and by removing the stop in the vernier dial, achieved something like 340 degrees of usable rotation. Up to now all calibration was done on a per unit basis, with the standardisation of components, and the Jackson capacitor we were able to re-produce consistent calibrations which only needed the low and high settings adjusted by the mechanical relationship of the dial to the tuning spindle, with a small frequency calibration in-situ by a brass 6BA tuning slug entering the VFO coil.

The final design..

The simplicity of the design and its flexibility due to the hand made, hand crafted printed circuit boards being able to accommodate a variety of components allowed many different versions to be built, from 6M, 4M models special designs for driving high power cavity testing RF sources, and even one for the 10metre band. It became evident that in areas of HI-RF activity such as under the shadow of Crystal Palace TV transmitter where I lived at the time, that there were some problems with spurious responses.

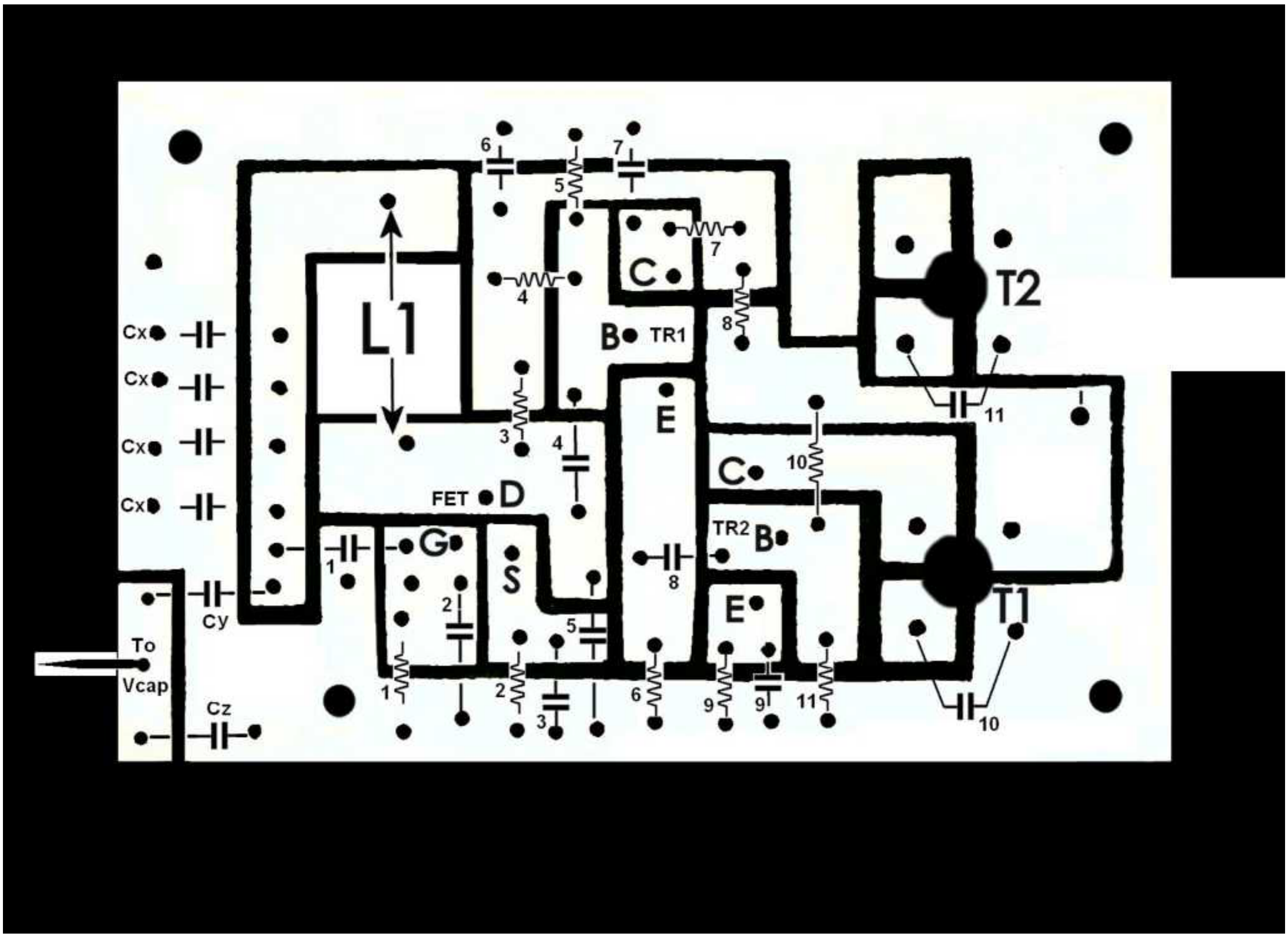
This led to the adoption of the 66MHz VFO with a twin tuned coupled output stage to feed the PYE front-end board, this time acting as a doubler instead of as originally a Tripler with the crystal oscillator. Using the same principal for temperature compensation the design was finalised and the unit remained almost unchanged throughout the production run. I still have variations of this basic design as test oscillators for driving RF units over a wide range of frequencies, one as a cavity sweeper driven from a scope time-base to sweep the cavities used in various repeaters, coupled with another used in a tracking receiver, in fact the cavities for the original London repeater, and my own local Corby (GB3CI) repeater were swept and adjusted using this set up.

The VFO Printed circuit board track side



Original hand cut prototype board photographed and processed with Paint Shop Board was made this way to allow many different sized components to be used.

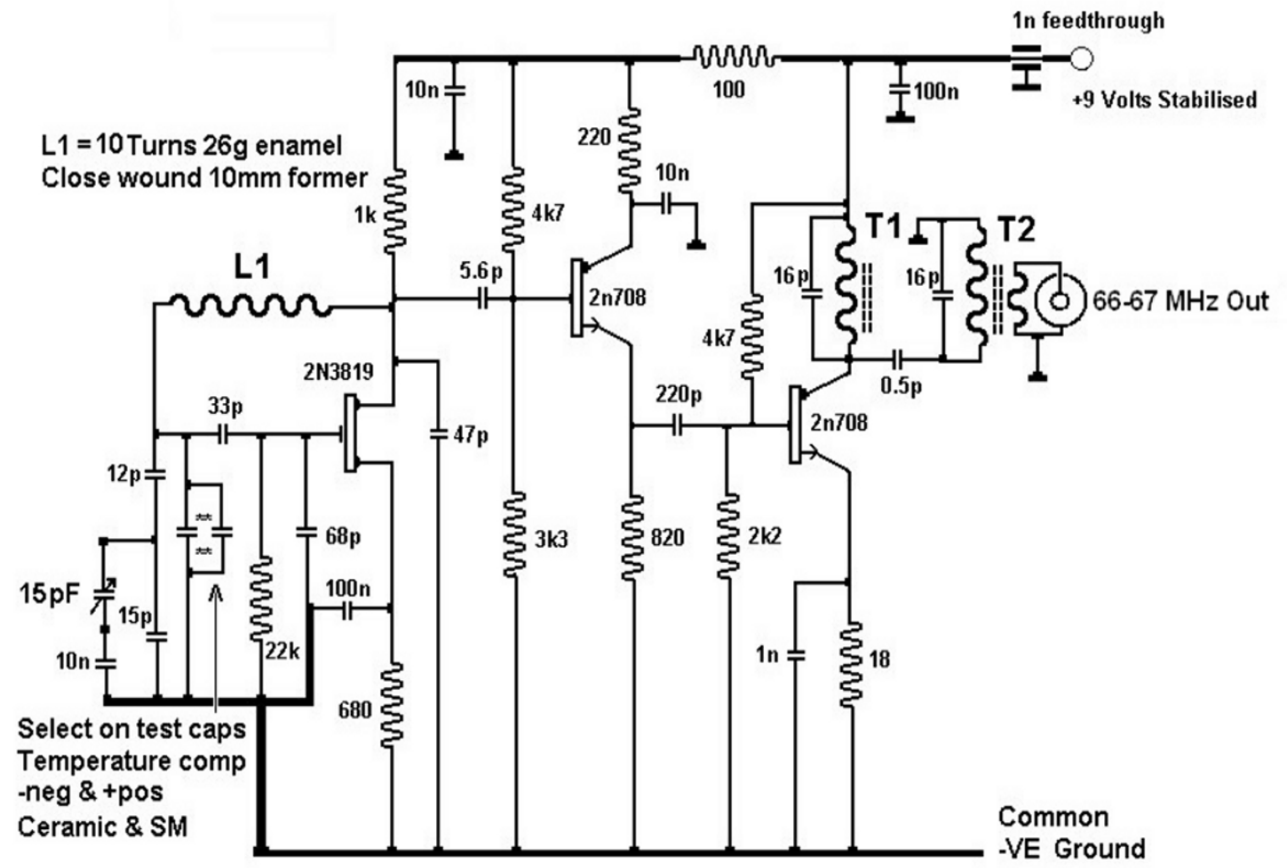
The VFO Printed circuit board Top view showing components



VFO Components Notes.

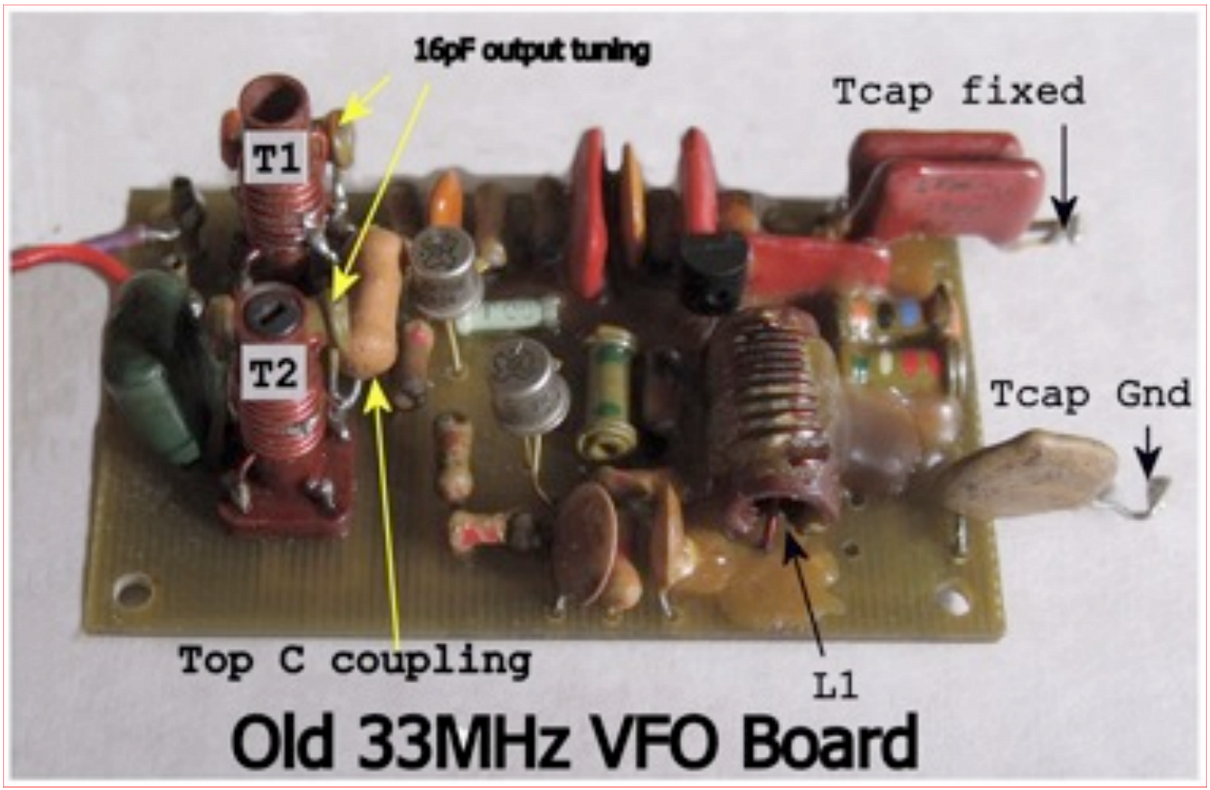
L1 (for 33MHz) 10 turns 22swg enamelled copper on a 7mm paxolin former L1 (for 66MHz) 6 turns, adjust turn spacing to set range T1 8.5 turns WDS, tapped at 1.75 earthy end for collector, 5mm former+slug T2 8.5 turns WDS, with overlaid 2 turns output coupling, 5mm former+slug Cx are all select on test capacitors both -ve & +ve temp to set range & drift Cy is adjusted to set the tuning range provided by the variable capacitor Cz is selected to set the linearity law of the tuning capacitor.
FET is any VHF N channel junction device 2N3819, 2N3823 etc. TR1-2 are 2N918 or similar VHF NPN transistors.

VFO Circuit diagram



Early "Twomobile" 33 MHz VFO with 66 MHz output

Early VFO (33-66 MHz) PCB picture



Old 33MHz VFO Board

Something to note here, the components around the actual oscillator and the turns on the coil are sealed with a resin-wax compound to stabilise them, this helps protect them from individual movement due to expansion and contraction with temperature, the capacitor bank remains more thermally stable and

humidity is prevented from causing changes by ingress into the ceramic coating of the silver mica capacitors.

The design of the original PYE Cambridge radio allowed it to be used with a mobile power supply of either negative or positive ground, so all the internal transistor circuitry was floating from the chassis work. This is the reason the VFO board was mounted floating from ground, and the reason the RF ground on the tuning capacitor which was also chassis ground, is linked to the PCB ground with the 10n disc ceramic.

Today (2010)

This would be built with surface mount technology (SMT) probably no larger than a "Large 1st class stamp" Tuning would be by Vari-cap diodes, temperature compensation by a thermistor bridge with an OP Amp controlled analogue function generator.. Go to it !!

Appendix: 001

Here are some notes from my original design documents, discovered while clearing out the loft.

VAKAR oscillator.

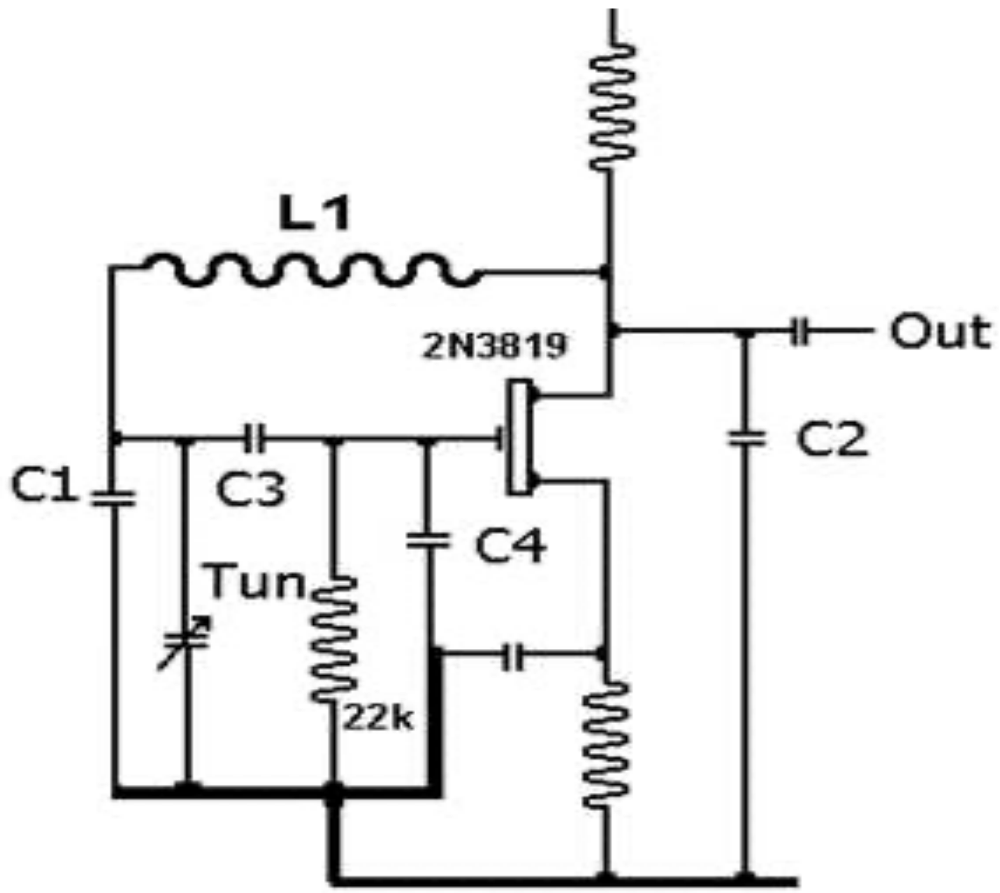
This design of oscillator uses a single inductance, no taps or coupling coils, so easy to physically set up, unlike the Colpits design.

The resonant circuit is formed from a synthesised transmission line consisting of the main inductor (L1) and two shunt capacitors C1,2 both of these capacitors go one end to ground, so development is really easy using adjustable trimmers. A small matching network consisting of 2 more capacitors (C3,4) allow a match to the gate of the FET (see Fig 1)

Adjusting the ratio of these sets the right amount of feedback to maintain stable oscillation, too much coupling causes a noisy oscillator, too little and the oscillator will stop under load.

To set the operating level I found a good check was to insert a brass rod into the L1 former, if the oscillator stops, adjust the matching network so it maintains oscillation with this brass slug fully entered. A frequency shift of some 10% is possible using this method of fine tuning, the fine set slug in the Garex Twomobile is a simple brass 6BA threaded rod which was generally only used to offer a shift of 1% to avoid thermal instability due to the housing expansion/contraction causing the slug position to change relative to the coil.

Figure 1.



For more references checkout VA3DIW's notes at

http://www.qsl.net/va3diw/vackar.html

Please note: This is NOT meant to be a fully documented construction article, to re-create this project, a certain amount of basic electronic knowledge is required as is PCB constructional expertise, ability to use resonance formulae, an understanding of RF design will be an essential pre-requisite.

CREDITS PAGE

(To be included with any copy or distribution)
This document was produced from the original notes created when the project was current it has been prepared to help those that wish to research the development of the "GAREX TWOMOBILE" Which, up to now have had somewhat sketchy information about the receive VFO.

Acknowledgements

To all company's mentioned for the use of their names in this document, whether they be current or no longer operating as a company, without you and your product this would not have happened.

PYE Telecommunications for the LC10 FM car phone.
Jackson Capacitors.
Garex Electronics, (Rex Browne G3MMJ) (Pete Longhurst G3ZVI)
The original writer on the design of the "VAKAR" oscillator (QST)
Prepared with MS Word, MS Paint, Paintshop pro, MS Windows XP
By Mike Foster (G8AMG) February/March 2010 from work started Over 40 years ago.

Issue 002 (Added appendix and other revisions)
Issue 003 (tidied up text and pictures)