

# Simple and Cheerful L-Band Synthesiser

by “*Independent Microwave Radio*”

Here is a design for a simple synthesiser covering 1GHz to a little under 2GHz. It is based around an off-the-shelf Mini-Circuits VCO package and a PLL Synthesizer IC of the type used in low cost 2.4GHz Tx/Rx modules and cable TV decoders. The poor phase noise (due mainly to the small low-cost VCO package) makes it unsuitable for narrowband use, but as a microwave test source, or for TV or high speed data it is quite up to the job.

The circuit is shown in Figure 1 and could hardly be simpler. The U6239 synthesiser chip contains the crystal reference oscillator and a fixed reference divider, a prescaler and programmable counter combination for dividing the prescaled VCO input by any integer up to 32767, a phase/frequency comparator and interfacing logic. An external NPN transistor is needed to complete the loop amplifier assembly allowing a drive voltage higher than the 5V logic Vcc to be delivered to the VCO for extended frequency tuning range. With the 4MHz reference crystal specified, the loop operates at a comparison frequency of 7.8125kHz, which with the divide by 16 prescaler means the final output frequency can be set in steps of 125kHz. A 3.2MHz reference would give 100kHz steps, and pro-rata.

A 16F84 PIC microcontroller sends the divider values and set-up information to the U6239 chip at turn on. The values are stored in non-volatile EEPROM in the PIC and can be modified by connecting the module to a PC via an RS232 serial interface. A simple ‘operating system’ is stored on the PIC, allowing frequency codes to be set arbitrarily with simple hexadecimal values sent as ASCII characters from any serial control software such as *Hypertrm*, or from custom software. The operating system permits the non-volatile memory to be changed without having to use a PIC programmer, and also allows the synthesiser to be tuned in real-time for swept or stepped applications. When not under RS232 control, the PLL state is monitored and a LED is illuminated when the synthesiser is correctly locked.

The output from the VCO, after passing through a 3dB attenuator, is buffered by an ERA-5 modamp running into slight gain compression to give an output level of around 17 – 19dBm. The actual level obtained depends on supply voltage.

## Operation, Construction and Build notes

The loop-bandwidth of the PLL is only a few tens to a hundred Hz, so frequency modulation can be generated by applying a suitably attenuated voltage through capacitive coupling directly to the VCO control pin. The 10k collector load resistor ensures there is a reasonable impedance to inject against, and MHz FM deviation is typically generated at 1.3GHz from a 5V peak signal through a 200k level-setting resistor and DC block. The modulating frequency can extend to many MHz making FM TV modulation straightforward.

The reference oscillator circuitry is a little strange, and uses the 4MHz crystal in series resonant mode. This means that if the normal cheap-and-cheerful catalogue 4MHz device is used, the final output frequency ends up around 70 part-per-million high, ie with around 100kHz error at 1300MHz. With a 125kHz step size this is not tragic, and if accurate frequency setting is required, a proper series resonant crystal or external source should be used instead.

The supply voltage can range up to 20V (but beware dissipation in the ERA-5 and its biasing resistor) which would permit the full 1 to greater than 2GHz tuning range of the VCO specified. With a 12V supply, the upper frequency limit is typically 1.8GHz. The U6239 is specified to 2GHz and Mini-Circuits VCOs extend to this region.

A Printed Circuit layout is shown in Figure 2, using surface mount components (1206 size, nothing fiddly!) with a continuous groundplane on the underside. A few ground vias connect top tracks through to the groundplane. The supply resistor for the ERA-5 is made up from two parallel wire ended ones on the ground side of the board at this component dissipates around 0.5 watt.

## PIC Operating System.

If no RS232 lead is connected when the module is powered up (or reset) the synth chip is booted with the frequency and set-up information stored in EEPROM. The LED flashes four times and illuminates when the PLL achieves lock-up.

If a correctly configured RS232 interface is connected at turn on, the synth chip is booted with the stored frequency and programming mode is entered instead with no lock-monitoring performed – the LED remains off. RS232 parameters are 1200 baud, 8 bit data, no parity, 1 stop bit. If *Hypertrm* or similar software is being used on the host PC, an introductory message is presented :

## 6239 Control G/E/D/C/W/S/

Single letter commands are used to set-up the device:

- D Displays the current EEPROM contents
- E Allows four hex characters (two bytes) of frequency information to be entered when requested. NO carriage return is needed, the data is accepted as soon as four characters have been entered
- C Allows 2 hex characters (one byte) of configuration information to be entered when requested.
- S Sends these values to the synth chip WITHOUT writing to EE. The new frequency should appear immediately, but the LED will remain unlit even if the PLL is locked up
- W Writes these to EEPROM
- G Puts the synthesizer module into normal operation without any further writing to EEPROM, and exits command mode. The LED will now correctly respond to PLL lock status. To re-enter command mode the module has to be powered down or the PIC reset by briefly grounding the RST line while the RS232 interface is connected.

Consult the data sheet for the U6239 (or any other synth chip) to find the options possible by altering the programming of the Configuration register. The synth chip specified does have 5 Optional I/O lines which can be used as required for controlling (or reading) external functions. Apart from bringing the pin connections out to pads on the PCB, they are not used in this module and the Operating System provides no access to the P register.

The default values for the pic code as supplied are 125kHz steps and a nominal frequency of 1296.25MHz based on a 4MHz reference crystal.

### Component availability.

The U6239 chip was used because a number of samples were to hand. From the author's memory, these devices were not available from any supplier in small quantities, although it may be worth asking. However, the SP5055 device is functionally similar, as is the TSA5511 1.3GHz device, and all should directly work as a drop-in replacement, although other devices have not been tested here. (Routines in the PIC code were taken from a design that *did* use the 5511 chip). It might be worthwhile looking at junked RF modules at rallies etc for surplus devices. As different synth chips appear to require the same circuitry and control codes, there may well be yet other types out there that will work – perhaps a bit of web searching in this area may prove fruitful!

For the VCO, other Mini-Circuits VCO packages that are pin compatible will work, and the chip/module will function down to 300MHz with suitable choice of VCO. Mini-Circuits are quite smaller-user-friendly and credit card orders are accepted against a not unreasonable minimum order charge of £20; the VCO with a handful of modamps to keep as spares will reach this target.

The PIC code is available in the package called *SynthMdlPic.ZIP* available from [www.~~~~~](http://www.~~~~~) The source code is included, as well as the .HEX code for downloading directly to any PIC programmer. Feel free to play with the source code and do whatever you want with it. If there is sufficient demand, it may be possible to organise the supply of programmed PIC devices through the UK Microwave Group

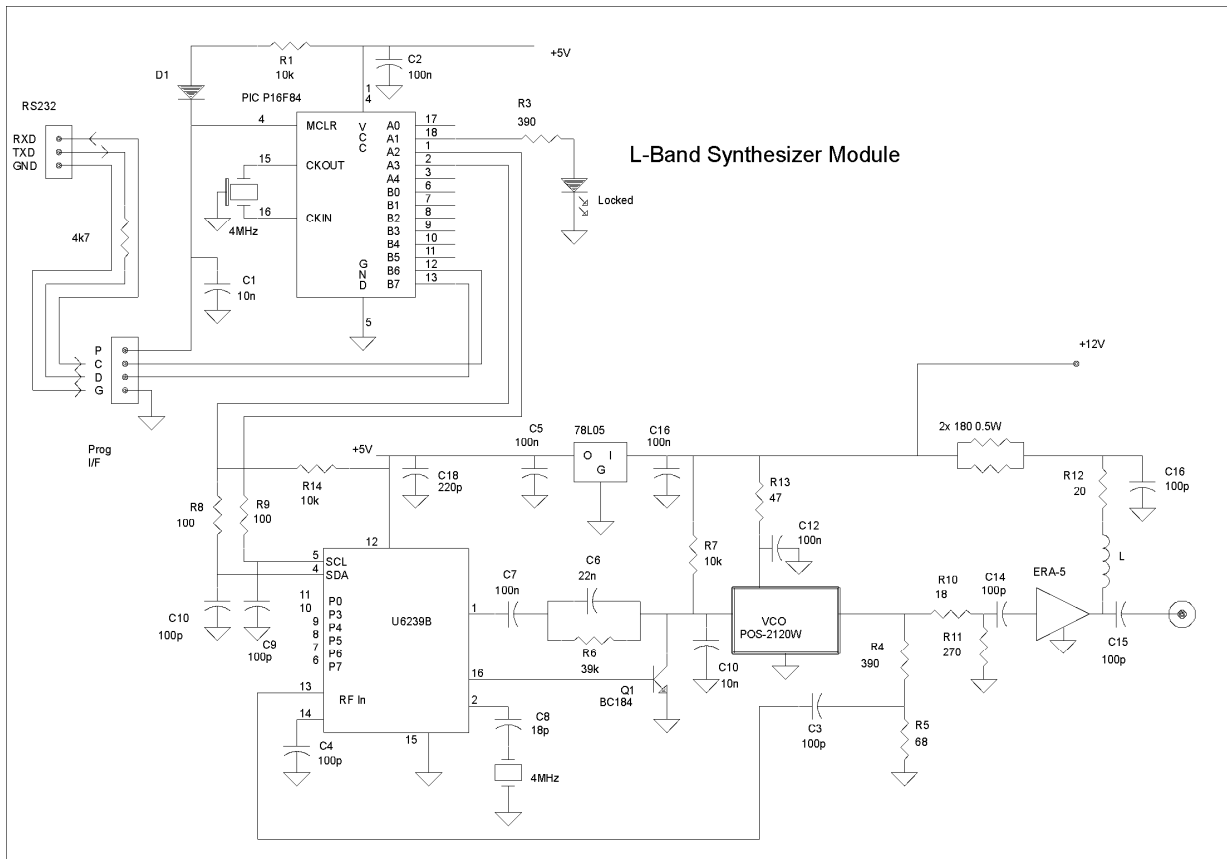


Figure 1

Synthesizer Circuit Diagram

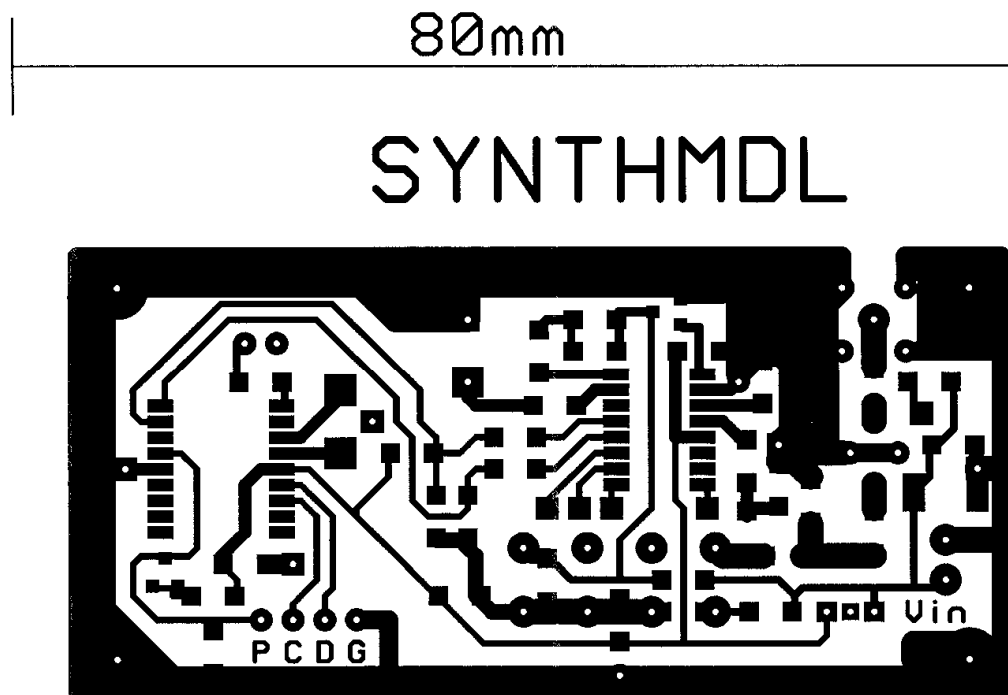


Figure 2 Topside PCB Copper Pattern

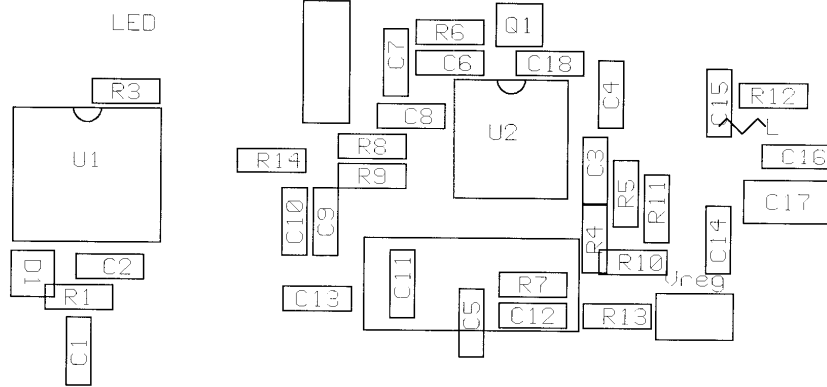


Figure 3 Component layout