A 96MHz Direct Frequency Synthesis source
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One of the features of my home brew 23cm transverter is that it has the facility to connect an external high stability local oscillator at 96MHz in place of the built-in 96MHz OCXO. This could be a frequency locked source, such as one of the various Reflock units, another free running OCXO or a DDS based unit. However, I have been intrigued by the idea of the 'old' technology of direct frequency synthesis for some time and when Brian, WA1ZMS, described his DFS systems at the Martlesham RT; I thought it was time to try the idea for myself. This technique is capable of extremely low phase noise, coupled with high stability and 'unfussy' design.

The DFS is basically a fixed frequency generator. The need for extensive filtering can make frequency changing a real problem. A DFS can, in principle, be built for any frequency requirement. However, some frequencies can require extensive frequency manipulation, not to mention filtering. For this reason it may not be practical to design and build a DFS for, e.g. a beacon where the final frequency is an odd 'offset'. Most local oscillator base frequencies are relatively easy to generate from a 5 or 10MHz high stability source.

Figure 1 below, shows the block diagram of the 96MHz DFS while Figure 2 shows the circuit schematic of the DFS.

Figure 1:

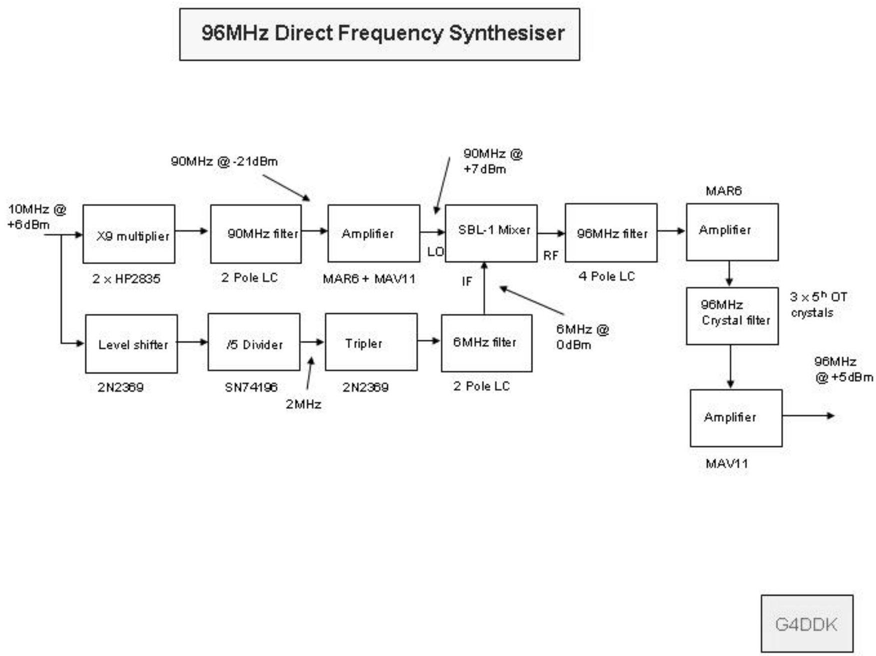
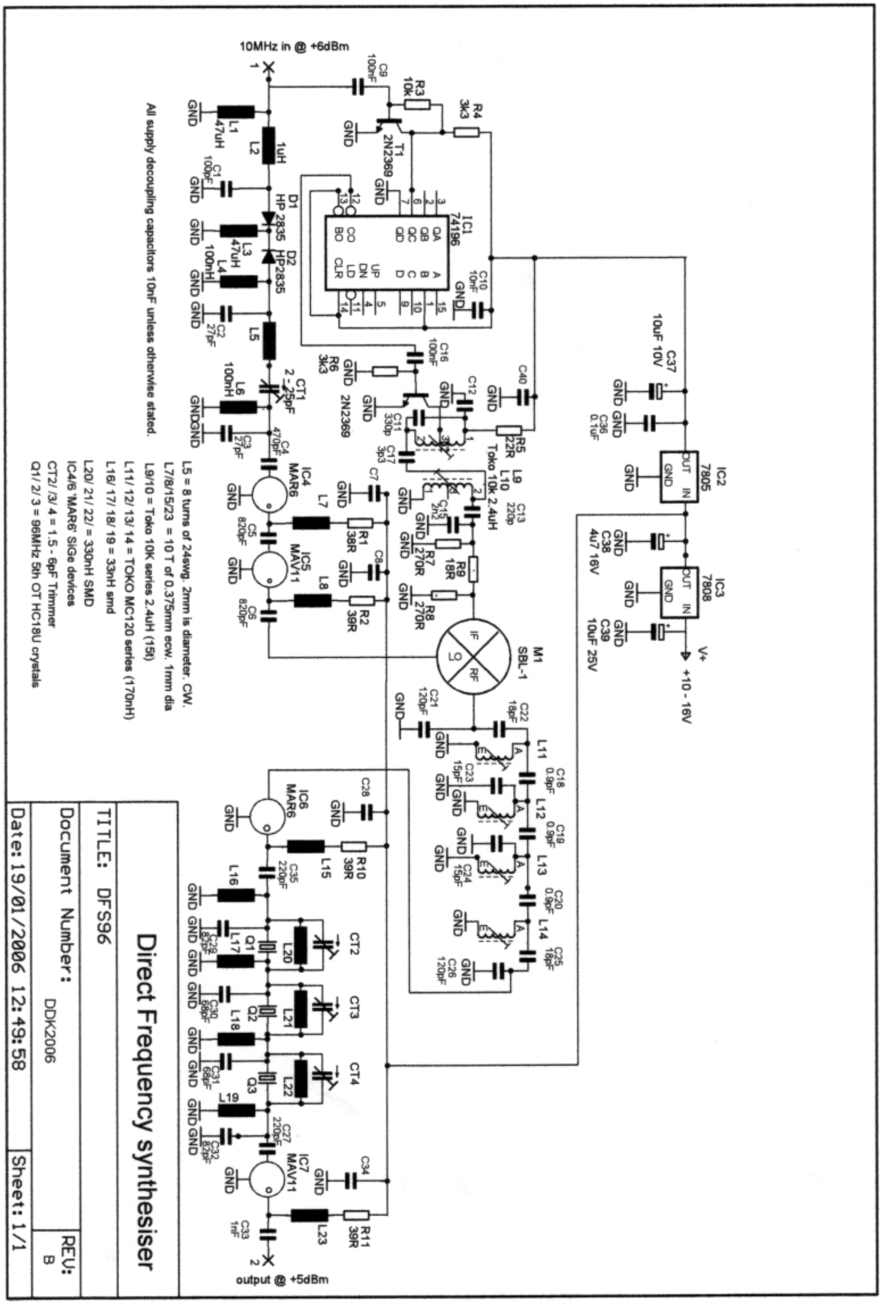


Figure 2 :


10MHz in @ +6dBm
output @ +5dBm
+10 - 16V
All supply decoupling capacitors 10nF unless otherwise stated.
L5 = 8 turns of 24swg. 2mm is diameter. CW.
L7/8/15/23 = 10 T of 0.375mm ecw. 1mm dia
L9/10 = Toko 10K series 2.4uH (15t)
L11/ 12/ 13/ 14 = TOKO MC120 series (170nH)
L16/ 17/ 18/ 19 = 33nH smd
L20/ 21/ 22/ = 330nH SMD
IC4/6 'MAR6' SiGe devices
CT2/ /3/ 4 = 1.5 - 6pF Trimmer
Q1/ 2/ 3 = 96MHz 5th OT HC18U crystals
Direct Frequency synthesiser
TITLE: DFS96
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In my unit, the 10MHz source is a high stability, low noise, GPS disciplined OCXO. The 10MHz signal is multiplied by 9 using a pair of Schottky diodes to produce 90MHz. The diodes produce a comb of frequencies at 10MHz spacing and the following filter selects the wanted harmonic at 90MHz. A two-stage amplifier increases the level to +7dBm (easily – some attenuation is needed). The first stage uses one of the ubiquitous 'MAR6' devices that were made available at a recent MUD and which are quite plentiful, even in the UK. These particular MAR6s are believed to be SiGe devices and have a very respectably low noise figure at 90MHz. This is followed by a MAV11 to increase the level into the SBL1 mixer LO input.

In parallel with the x9 multiplier the 10MHz is also fed to a 2N2369 level shifter (to TTL level) before driving the clock 2 input to the SN74196. Drive level is not too critical with this arrangement.

I used an SN74196 because I had some and SN7490s are getting hard to find! CMOS can be too noisy in this application. 74F series would be better for low noise but weren't readily available.

The SN74196 divides by 5. The resulting comb, with strong fundamental at 2MHz, is then tripled in the second 2N2369 stage before filtering to select the wanted 6MHz signal. This is connected to the IF input to the SBL-1 mixer.

The RF output from the mixer contains not only the wanted 96MHz (90MHz + 6MHz) signal but also the various other products of mixing. Two-stage filtering is used to clean up the spectrum. No attempt has been made to provide wideband termination of the mixer.

A four pole (three would do, but who's counting?) LC filter removes all products well-spaced from the wanted 96MHz prior to the first amplifier. The output of the LC filter is then amplified in another 'MAR6' before the signal enters the 3 pole crystal filter. This is the stage which intrigued me the most. I hadn't built a VHF crystal filter previously and I was keen to try out the technique. I exchanged many e-mails with Brian, WA1ZMS, about these filters and tried several techniques including the 'phasing' design used by F5CAU in his 96MHz DFS. Whilst the phasing filter gave similar filtering characteristics to the LC matched designed used, insertion loss was a major problem due to the high termination impedance.

One of the secrets to the filter is to use small value trimmers across the small inductance across the crystal. These trimmers need to be carefully adjusted for best filter response and each interacts with the others! Adjustment can be tedious, but it is worthwhile persevering. Finally the filter is followed by another MAV11 to achieve the desired output level of +5 to +7dBm.

The TTL chip and both transistors are fed from a 7805 regulator, whilst the MAR and MAV devices are fed from a 7808 regulator.

Construction does not use a PCB; instead a half Euro-card (160mm x 100mm) with copper ground plane on one side and with IC pads and power tracks on the other was perfect for the job. I housed the DFS in a Maplin extruded aluminium case with a BNC connector for the 10MHz input and an SMA for the 96MHz output.

References:

F5CAU Web page - www.perso.wanadoo.fr/**f5cau**/page_10.htm

WA1ZMS – ARRL Proceedings of Microwave Update 2004, Irvine, Texas