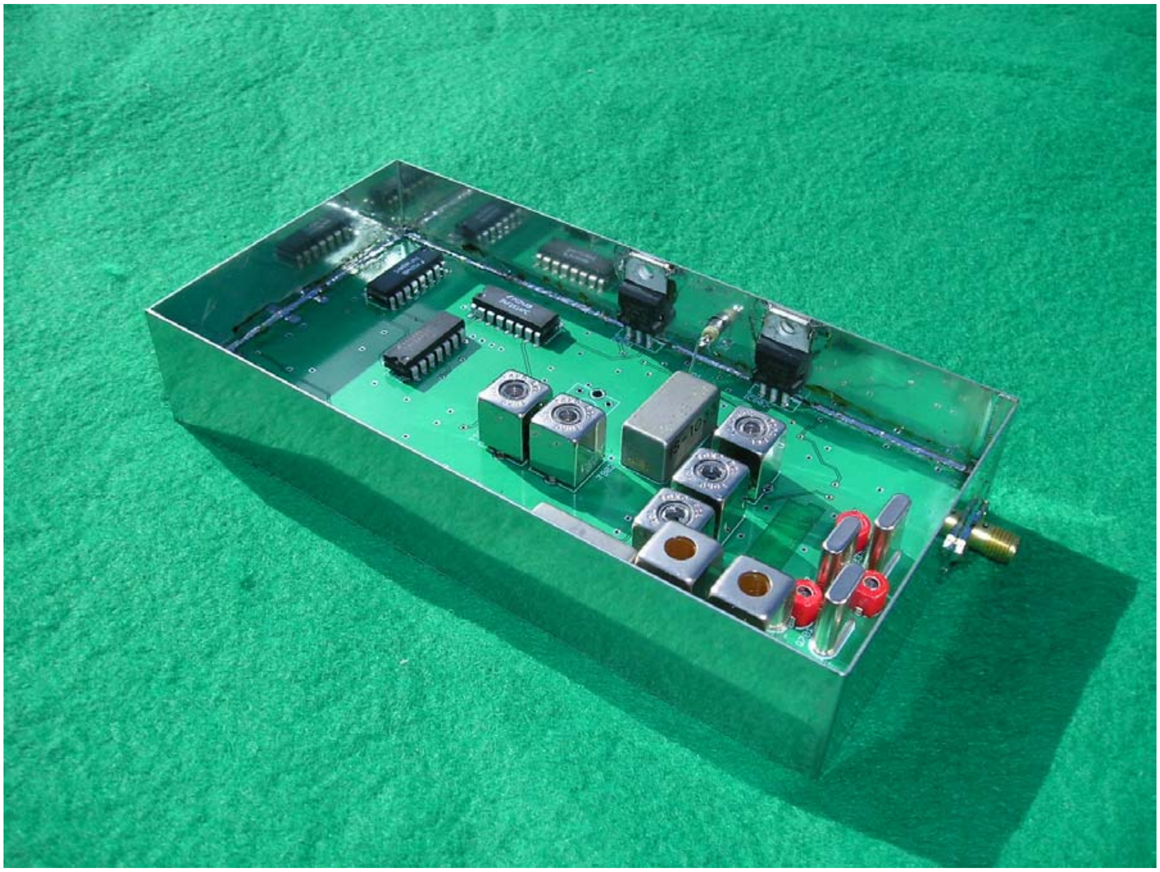

# The 'Flexible'
# Direct Frequency Synthesiser

*precision frequency generation for microwave operation*

G4HUP / ND8P

http://www.g4hup.com

Ver 1.0 Oct 07

# Direct Frequency Synthesis (DFS)

## What is DFS?

*DFS's are high resolution frequency generators used in the microwave region in such applications as comunication systems, radar and electronic warfare. They do not use VCO's or YIG's but rather generate the output frequency by a combination of multiplication and division of a low phase-noise reference signal – and are capable of switching between frequencies over a wide range in very short times – typically a range of 0.3 to 18GHz with a switching speed of 200nsec.* (Yaniv, 2006)

The technique of Direct Frequency Synthesis has been adopted in the amateur community to generate a precise output frequencies locked to a standard reference – often a GPS disciplined source or OCXO. Amateur DFS's are single frequency generators – most commonly employed for the LO generation of microwave transceivers. The frequency locking to the reference standard removes the risk of unkown offsets at the microwave operating frequency, and of variations due to temperature changes.

## The Amateur DFS

Frequency generation is by a combination of multiplication and division of the reference frequency. Resulting frequency components are mixed together and filtered to produce the wanted output signal. There are no phase locked loops, crystals heaters or ovens involved in the process (apart from the main oven in the reference source, outside the DFS). Thus a low phase-noise, accurately controlled reference source can be used to directly lock your transverters in frequency, improving the phase-noise of your system and removing any frequency offset or temperature drift.

## DFS History

Previous DFS publications within amateur literature include systems for 89.333MHz (WA1ZMS, 2005), 96MHz (G4DDK, 2006) and 90/90.6667MHz (WW2R/G4FRE, 2006). All of these use a 10MHz input source, for example an ex-industry HP Z3801A, and operate by multiplying the 10MHz signal to 90MHz, then mixing this with a divided signal. In some cases, multiplication of the divided signal is required before mixing, as in the G4DDK's 96MHz system – Fig 1. Dedicated filtering is needed in all these systems to ensure minimal feedthrough of unwanted components into the output – it is normal to implement a crystal filter at the oputput frequency to limit close in noise.

A potential limitation of the previously published designs is that the output frequency range is limited to frequencies that can be synthesised from a multiple of the input frequency mixed with a single division product.

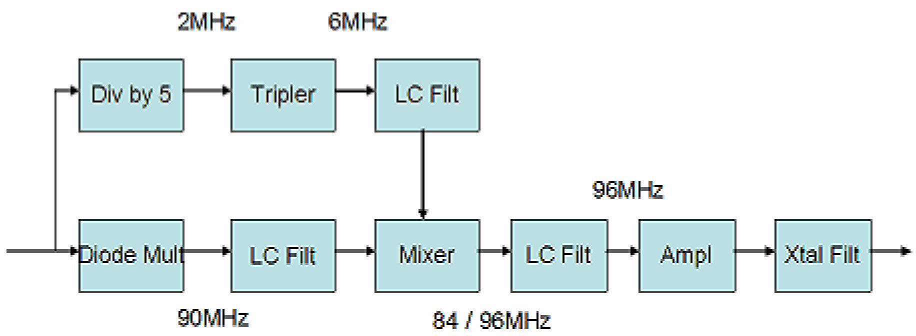


Fig 1 – G4DDK 96MHz synthesiser

## The 'Flexible' DFS

A far wider range of output frequencies can be produced by introducing a second divider and mixer into the chain.  Not only can the input frequency be divided a second time to give more choice, but also the input to the second divider can be instead driven by:

- The output of the first divider
- The output of a multiplier, following the first divider, or
- The output of the main multiplier (typically 90MHz)

This approach gives rise to a two-loop synthesiser design – Fig 2.

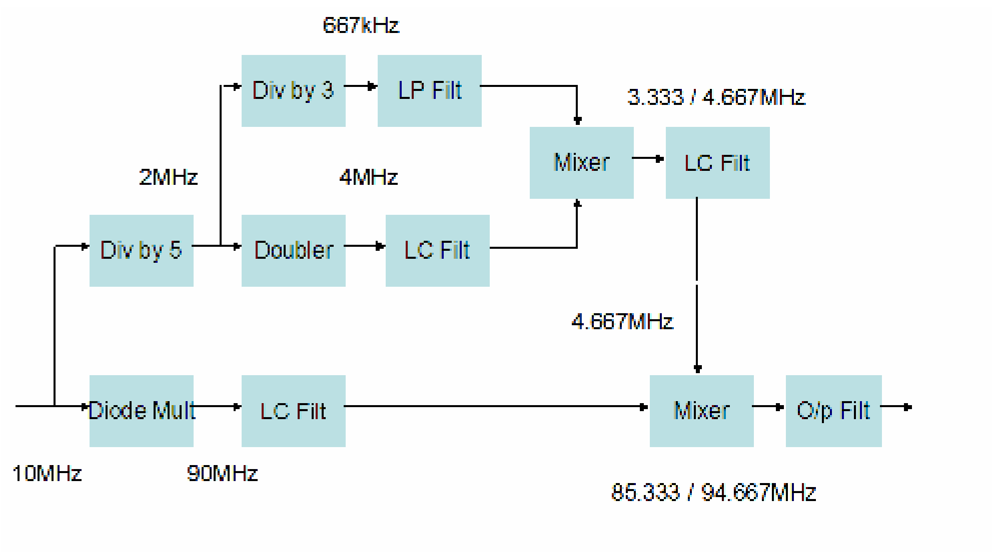


Fig 2 – Two Loop DFS – G4HUP

A further flexibility can be derived by changing the input frequency – eg 15MHz instead of 10MHz.

## A Practical Implementation – the DFS PCB

The PCB is even more flexible than the two loop synthesiser it supports – since, of course, any single loop design can also be implemented on it! Specific flexibility on the PCB inlcudes:

- Slave output from input frequency – for onward connection to other DFS modules, for example
- Programmable division ratios on both dividers
- Programmable output select on both dividers
- Selectable LPF or amplifier/multiplier options on both divider outputs
- Attenuators throughout to allow optimisation of performance.

## Technology

DFS units are relatively complex – but the return is a precise, low phase-noise signal output, with good spectral purity. The G4HUP PCB is designed to fit a standard 148 x 74 x 30mm tin-plate box, and makes extensive use of 0805 size SMD parts.. However, the assembly of a synthesiser to this design is well within the capabilities of a microwave constructor with some previous experience of SMD usage – eg pre-amp or transverter building etc.

## Performance

Due to the specific nature of DFS designs, it is not possible to give guaranteed limits for the spectral purity, harmonic content or phase noise – however, typical examples of performance achieved can be quoted:

Prototype breadboard:

Wanted output, $f_c$: typ -5dBm
Spectral content: all components < 45dBc
Phase noise: -115dBc @10kHz

94.667MHz fully engineered unit:

Vcc: +13vDC, I: 380mA
Wanted output, $f_c$: +2dBm
Spectral content: Spurii < 60dBc
Harmonic content: $f_2$ -45dBc

## Further Information – http://www.g4hup.com

## References

Jewell, Sam G4DDK,96MHz DFS Mar 2006
Justin, Brian WA1ZMS, 89.16667MHz DFS Sep 2004
Robinson, Dave, WW2R/G4FRE, DFS 9096 May 2006: http://g4fre.com/dfs9096.pdf
Yaniv, U. When Switching Speed is Important, http://mwrf.com/Articles/Index.cfm?Ad=1&ArticleID=12527 Accessed 7 Oct 2007

 