A look at the phase noise performance of a range of synthesisers and references

Part 1.

The move away from the traditional crystal oscillator / multiplier, to frequency synthesisers, has not been all beneficial. The improvement in getting directly to the required LO frequency, and stability when a good reference is used, has been offset by poorer, and often much poorer noise performance. Now a range of very good synthesiser chips have become available, from the likes of XXXX.

Although the chips are capable of good performance, to obtain excellent performance required great attention to detail. The good news is that low cost boards and complete units are available on ebay starting at around £15. There is a whole range of synthesisers with maximum frequencies of 4.4, 6.8 & 13.6GHz. The higher frequency units being particularly attractive to multiplying up for the millimeter bands. If, and that's a big if, the noise performance is good enough.

One of the big problems with wideband synthesisers is the gain of the VCO (sensitivity). If for example the VCO covers 6GHz with 6V, then the gain is 1000MHz / volt. So just 10uV of noise on the control line will FM modulate the VCO 10kHz. Thus ultra-low noise voltage regulators are required. This together with non-optimal layout and grounding, is where many of the low cost ebay synthesisers fall down.

The other problem is the accuracy, stability and noise performance of the reference. To obtain the best noise performance form the synthesiser, requires the use of high frequency references. The on-board references are not good enough for the higher microwave bands, or digital modes on the lower bands. The use of high performance external references is a way forward. Although some of the on board oscillators are on 'odd' frequencies. A good low phase noise reference should give the performance that we require inside the loop bandwidth of the synthesiser. This is often the only region we are really interested in. However when the noise is already on the control line, rather than within the oscillator, the best reference in the world, is not going to give the required noise performance.

It is intended to look at a number of commercially available synthesisers, and reference oscillators, and compare their noise performance. At one end of the cost range being a £15 ebay board, with an ERA 16GHz crowd funded signal generator at the other end at $750 (when available). Somewhere in the middle being the ZL 14G board, and the Kuhne 13.6GHz synthesiser. For the higher bands in

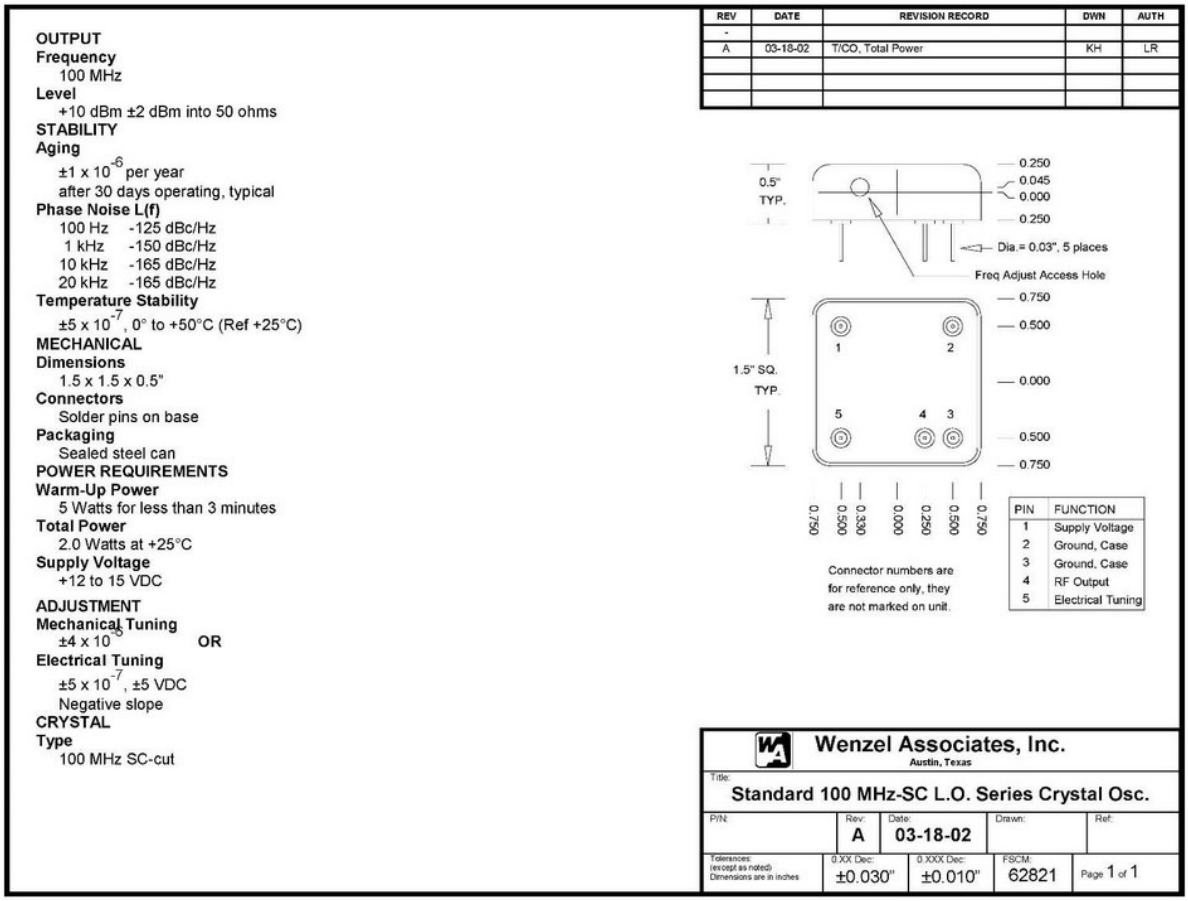
particular what is required is a replacement for the much used Elcom synthesisers, which have become scarce. Preferably with the option of external reference and more frequency setting versatility, and lower noise.

For the really high bands above 76GHz, good phase noise of the LO becomes difficult to obtain. We are fighting against the increase of noise with multiplication of 20 log n. Where n is the multiple in frequency. Thus without any additional noise contribution noise at 10GHz will be 60dB higher than 10MHz, and 80dB higher at 100GHz.

If starting at 10MHz an ultra-low noise reference is required. Talking with Brian Justin WA3ZMS, who holds many of the American firsts and records for the millimetre bands. He said he purchased two 10MHz references to his specification very early on, at an equivalent cost of a quality HF transceiver and linear!

A number of manufactures make low phase noise reference oscillators. Wenzel in particular make some superb units, but at a cost.

Recently a small quantity of Wenzel 100MHz units appeared on ebay from Israel. The noise performance is very good, using an SC cut crystal. Stability is not as good as a 10MHz oscillator, but may well be good enough for many applications. For ultra-stability, phase locking to 10MHz with a low loop bandwidth, may be required.



REV	DATE	REVISION RECORD	DWN	AUTH
-				
A	03-18-02	T/CO, Total Power	KH	LR

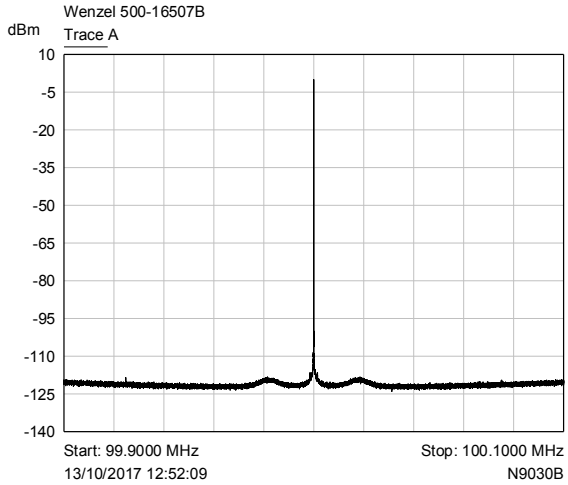
OUTPUT
Frequency
100 MHz
Level
+10 dBm ±2 dBm into 50 ohms
STABILITY
Aging
$\pm 1 \times 10^{-6}$ per year
after 30 days operating, typical
Phase Noise L(f)
100 Hz -125 dBc/Hz
1 kHz -150 dBc/Hz
10 kHz -165 dBc/Hz
20 kHz -165 dBc/Hz
Temperature Stability
$\pm 5 \times 10^{-7}$, 0° to +50°C (Ref +25°C)
MECHANICAL
Dimensions
1.5 x 1.5 x 0.5"
Connectors
Solder pins on base
Packaging
Sealed steel can
POWER REQUIREMENTS
Warm-Up Power
5 Watts for less than 3 minutes
Total Power
2.0 Watts at +25°C
Supply Voltage
+12 to 15 VDC
ADJUSTMENT
Mechanical Tuning
$\pm 4 \times 10^{-6}$ **OR**
Electrical Tuning
$\pm 5 \times 10^{-7}$, ±5 VDC
Negative slope
CRYSTAL
Type
100 MHz SC-cut

0.5" TYP.
0.250
0.045
0.000
0.250
Dia.= 0.03", 5 places
Freq Adjust Access Hole
1.5" SQ. TYP.
0.750
0.500
0.000
0.500
0.750
1 2 5 4 3
0.750 0.500 0.330 0.000 0.250 0.500 0.750
Connector numbers are for reference only, they are not marked on unit.

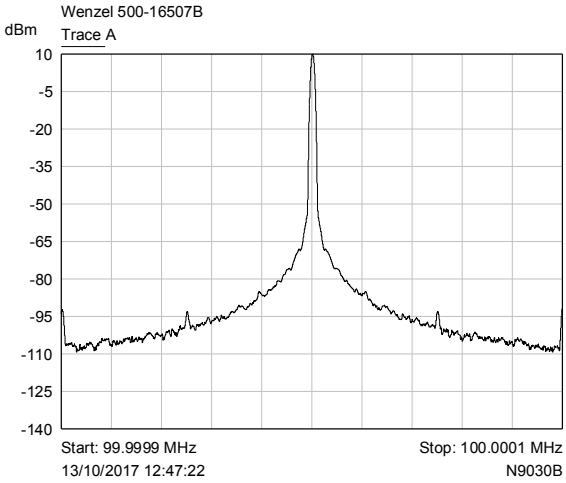
PIN	FUNCTION
1	Supply Voltage
2	Ground, Case
3	Ground, Case
4	RF Output
5	Electrical Tuning

Wenzel Associates, Inc.
Austin, Texas
Title: Standard 100 MHz-SC L.O. Series Crystal Osc.
P/N: | Rev: A | Date: 03-18-02 | Drawn: | Ref:
Tolerances: (except as noted) Dimensions are in inches | 0.XX Dec: ±0.030" | 0.XXX Dec: ±0.010" | FSCM: 62821 | Page 1 of 1

Specification as shown with the crystal as advertised. The 500-16507B supplied, had electrical tuning which I suspect is 0 to -5V. On frequency is approx. -2.0V.



Noise as measured in dB/Hz with 200kHz span, note reference is +10dBm so wideband noise displayed is circa -130dBc/Hz, this is limited by analyser noise performance



Noise in dB/Hz 200Hz span. Spurs at 50/100Hz are pickup on the bench. Ignoring those noise measured is circa -120 dBc/Hz down on the fundamental at +/- 100Hz.

Equivalent noise at 10MHz would be -140dBc/Hz.

To get stability a regulated supply is required. Specification is 12 – 15V, although measurement by John G8ACE suggest operation down to 9V. A low drop 10V regulator is the answer for portable operation from 12V. A negative voltage is required for the tune pin. This can easily be obtained in a low noise way, by using a small 3.6V lithium battery, as minimal current is required.