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To: Mark 5 Development Group

From: A.E.E. Rogers

Subject: Updown converter notes

This memo updates the characteristics given in memo #059

1] Spurious signals

A full scan of the first L.O. was made with the spectrum analyzer looking at the I.F. from 0.5 to 2.5 GHz. The following spurs were noted with the 2<sup>nd</sup> L.O. at 22.5 GHz from the “max hold” on the analyzer:

- a. Spur at  $22.5 - 3 \times \text{Luff}$  falls in the I.F. range with Luff from 6.6667 to 7.3337 GHz corresponding to an input frequency range from 4.7 to 9.3 GHz.
- b. Spur at  $4 \times \text{Luff} - 22.5$  falls in the I.F. range with Luff from 5.75 to 6.25 corresponding to input range of 1 to 5 GHz.
- c. Spur at  $3.5 \times \text{Luff} - 22.5$  falls in the I.F. range with Luff from 6.57 to 7.14 corresponding to input range from 4.28 to 8.56 GHz.

All of these spurs are more than 50 dB below the normal total power. Spurs a) and c) could be reduced with additional filtering of the first L.O. multiplier chain. Spurs b) are the result of the L.O. signal leaking around the 21 GHz cavity filter and could be reduced by better shielding and/or the use of some microwave absorbing material. None of these spurs should pose a serious problem unless a spur falls on a frequency being used as a phase cal tone. This can be avoided by appropriate setting of the MHz digit of the Luff synthesizer. For example if the MHz digit is one the spurs will never fall on a harmonic of 5 or 10 MHz. If necessary the 100 kHz resolution of the Luff TLSD57508250/100 K synthesizer can be used in order to set an L.O. offset.

2] Compression and distortion

The 1 dB compression point of the updown converter occurs at input level of -20 dBm provided the output level is less than +12 dBm. If the attenuation is set less than 30 dB and there is a strong RFI signal within the Nyquist bandpass the output may saturate before the first mixer stage. The IP2 and IP3 points are at 30 and -10 dBm respectively referred to the input and again these intercept points are reduced if the attenuation is less than 30 dB and the RFI is within the Nyquist bandpass so that the intermodulation occurs first in the output amplifier. To summarize for saturation and intermodulation in the first mixer referred to the updown input:

1 dB compression	-10 dBm
IP2	+ 30 dBm
IP3	-30 dBm

To refer these to the updown output simply add the updown gain.

### 3] Manual Control

The fully populated Updown converter has 2 polarizations each with 2 Nyquist zone channels. Four separate digital attenuators control the gains for these channels. The current assignments are

Polarization	Nyquist zone	Attenuator
A	Low	1
B	Low	2
A	High	3
B	High	4

The Luff synthesizer and attenuator values are displayed on the front panel in the following time sequence.

	Display	Units
Luff synthesizer	A B C D.	MHz.
Atten 1 Atten 2	E. F G H	dB
Atten 3 Atten 4	I J. K L	dB
Luff synthesizer	B C D. M	

- A = Luff Thousands MHz
- B = Luff Hundreds MHz
- C = Luff Tens MHz
- D = Luff Units MHz
- E = Atten 1 Tens dB
- F = Atten 1 Units dB
- G = Atten 2 Tens dB
- H = Atten 2 Units dB
- I = Atten 3 Tens dB
- J = Atten 3 Units dB
- K = Atten 4 Tens dB
- L = Atten 4 Units dB
- M = Luff hundreds of kHz

(values of 0-9 – no letters are displayed)

Unlock or frequency out of range is indicated by all 4 decimal points lit.

Values can be changed manually by holding down button until the digit or digits you want to change are flashing then a short pulse of the button will increment the value. Holding down the button will cycle through all the fields until the first display of the Luff MHz is displayed. The Luff 100 kHz digit is the last field that can be selected for change.

### 4] Remote control

The updown converter can be set by sending the keyword updown (2400 band 8-bit no parity) Luff frequency as ABCD.M followed by the attenuator settings EF GH IJ KL. The updown will respond with the response updown ABCD.M EF GH IJ KL status N the updown can be

interrogated for its settings without changing the values by sending zero frequency. The status code is a 3 bit number where N=0 indicates all is ok.

N bit 2	1 <sup>st</sup> L.O. Unlock
N bit 1	2 <sup>nd</sup> L.O. Unlock
N bit 0	Frequency out of range

#### 5] Phase noise

The phase noise was measured using an Agilent E8257D signal generator set at 8.830 GHz as a signal source. The Luff was set at 7645 MHz and the output at 750 MHz was measured with a scope synchronized to 5 MHz as well as a spectrum analyzer. The Haystack 5 MHz was used to feed the updown converter and synchronize the scope. 10 MHz from the updown converter was used to provide a reference for the E8257D.

The peak to peak phase noise was 36 degrees and the accompanying spectrum is shown in figure 2. Typical phase drift over a 10 minute period was under 30°. When the Haystack 5 MHz was replaced with 5 MHz from an oscilloquartz OCXO 8607 the phase noise improved by about 5 dB for a total peak to peak of 20° or about 5° rms.

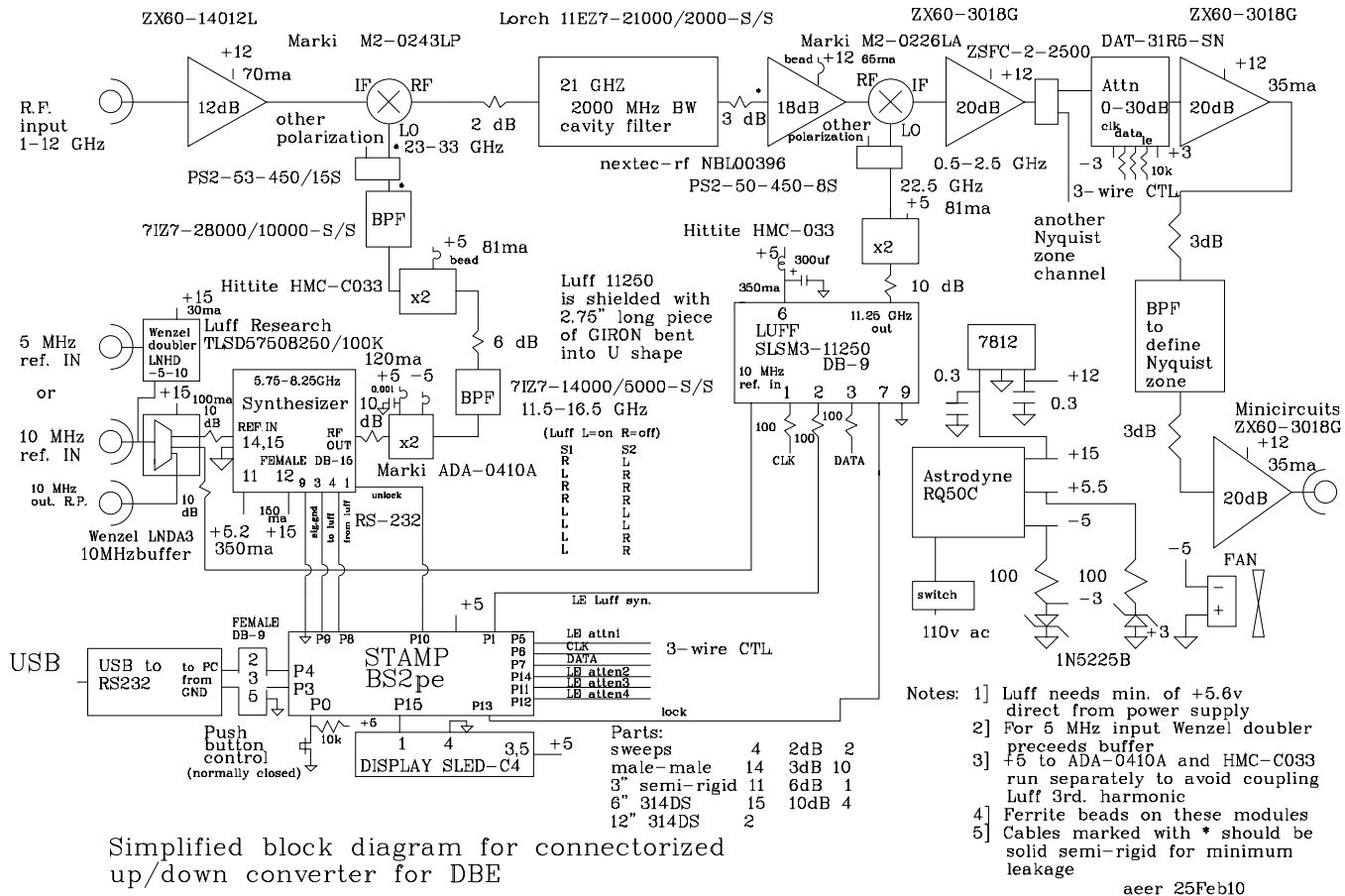
It was not possible to separate out the origin of the phase drift. All the drift appeared to be temperature driven and every piece has some sensitivity including the E8257D. There did not appear to be any sensitivity to mechanical tapping of components. The Wenzel doubler and buffer amplifier are sensitive to magnetic field which is not surprising as they contain ferrite cores.

#### 6] Revised block diagram

Figure 1 shows the revised block diagram.

#### 7] Phase noise at the Westford site

Phase noise at the Westford is dominated by 60 Hz in the 5 MHz from the maser. After changing the cable from the maser from a single shielded RG-213 to a double shielded LMR-400 the coherence loss from the 60 Hz sidebands was reduced to 0.5%. Coherence loss from the high frequency phase noise was estimated to be about 0.2%. The quality of the 5 MHz is critical to obtaining low coherence loss from the updown converter (UDC).



Simplified block diagram for connected up/down converter for DBE

Figure 1 shows the revised block diagram.

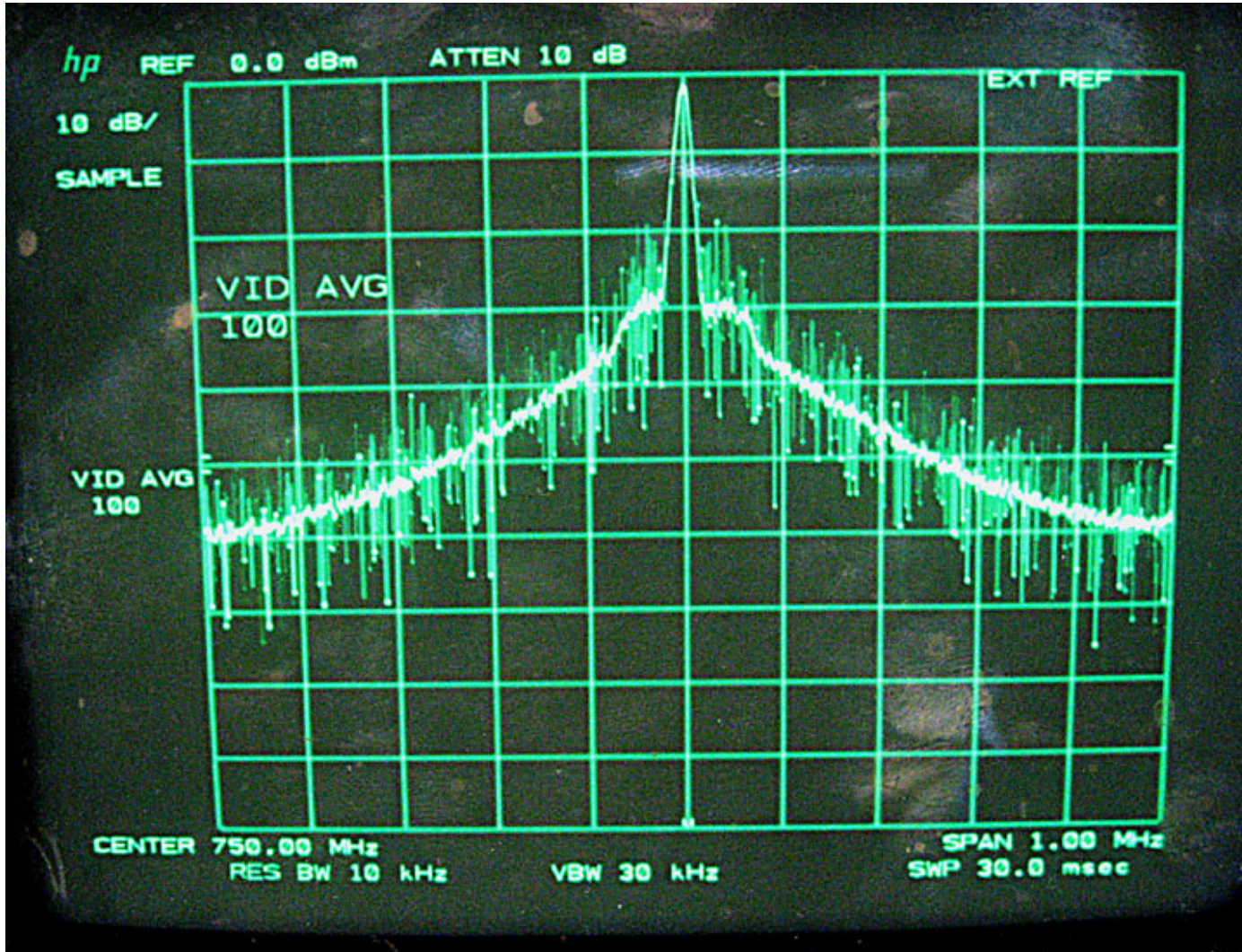


Figure 2. Spectrum of test signal at 8380 MHz after updown conversion. The pedestal at  $\pm 50$  KHz drops by about 5 dB when 8607 is used