Comparation of two frequency synthesizer: LMX2531 and ADF4360

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1 Introduction

Recently Metsähovi got interested to purchase and study the performance of a frequency synthesizers based on integrated PLL circuits. This interest was specially motivated due to the upcoming use for the eVLBI, the so-called iBOB. This full-integrated processor boards are planned to substitute the existing receiver systems (Mark IV, Mark V, VSIB) into a small system which will record astronomical data and send it to the network at high transfer rates (up to 10 Gbps).

Befor the diliver of the new iBOB boards, and in order to fulfill the specifications announced in the pertinent documentation, Metsähovi has started to evaluate the constraints. To digitalize the data achieved, iBOB requires a clear sinusoidal signal as a reference, centered at 2048 MHz. Hence, the National Semiconductor LMX2531-LQ2080EVAL (High Performance Frequency Synthesizer System with Integrated VCO) and the Analog Devices EVAL-ADF4360-2EB1 (Integrated PLL & VCO Frequency Synthesizer) have been evaluated.

2 Installation and main configuration of the boards

Both devices require to install an easy software interface to control the boards. The communications to the computers is done across the parallel port. Both graphical interfaces are simply designed to allow to modify few parameters to make it work easily. It takes below a minute to set up the

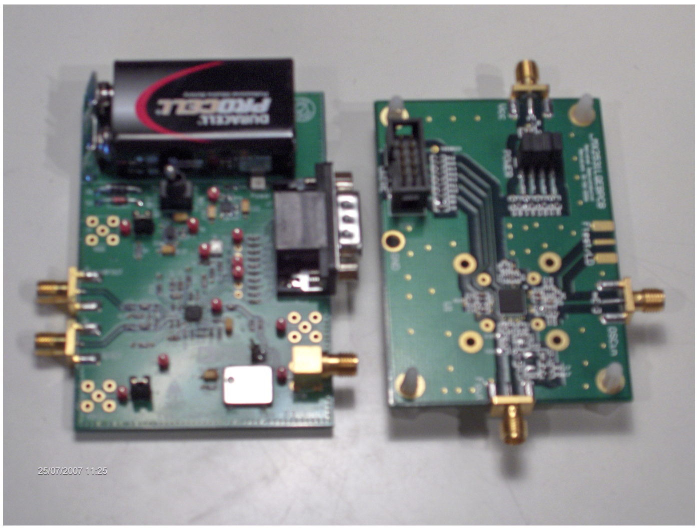

Figure 1: boards

desired output frequency of the synthesizer, the reference input frequency (in our case is 5 MHz, originated by a H-maser), the power requirements adjustments and finally, just load the data to the PLL's.

Obviously the interfaces also allows to get in deeper details concerning N and R counters, so we can have a deeper control of the internal registers used to synthesize the frequency. Both devices came with a basic manuals which must be read to avoid critical situations.

	LMX2531-LQ2080EVAL	**EVAL-ADF4360-2EB1**
$\mathbf{V}_{in}$	2.8-3.2V	9 V(int. battery)
$\mathbf{f}_{refclk}$	5-80 MHz	10-250 (square-wave)
$\mathbf{V}_{refclk}$	500-2000 mVpp	700 mVpp
$\mathbf{F}_{out}$	1904-2274 MHz	1850-2170 MHz
$\mathbf{P}_{out}$	0 .. 5 dBm	-13 .. -6 dBm
$\mathbf{P}_{in}$**ADC**	0 dBm (unattenuated)	0 dBm (G=+6 dB)
$\mathbf{L(f)}_{10}$[1]	-87 dBc/Hz	-83 dBc/Hz
$\mathbf{L(f)}_{100}$	-113 dBc/Hz	-110 dBc/Hz
Synthesizer	Fractional-N	Integer-N

To suit with the power restrictions of the LMX2531 device a few requirements is recommended. An attenuator of 6 dB is attached in the OSC input to avoid saturation on the PLL. Also the the output carries too much power to be handled by the spectrum analyzer, so another attenuator is needed in order to avoid OverRange problems on the signal. The LMX board needs an external power supply. The LMX2531 datasheet recommends 3.0V and tells maximum recommended Vcc is 3.2V. The iBOB board provides 3.3V and 5.0V. You can use an adjustable regulator (LM317) or other means to derive 3.0V from the iBOB board.

According to frequency synthesizer development, and what the specifications confirmed, the fractional-N frequency synthesizer in general can yield a superior performance in terms of phase-noise, PP lock time and also a comparison spur supression than the N-integer device. In the follow tests we would try to demonstrate this affirmation and realize which one suits more for our purposes.

3 Methodology of the tests

Tests have been mainly carried out using the Agilent N1996A CSA spectrum analyzer and the distributed signal at 5 MHz from the H-maser installed at Metsähovi Radio Observatory. Figure 2 shows the 5 MHz signal and the respective harmonics.To analyze in detail the behaviour of both synthesizers we tried to measured the output at high resolution close to the carrier frequency. According to the references the phase noise for ADF4360-2 is -83 dBc/Hz at 1 kHz offset from the carrier and for LMX2531 is -87 dBc/Hz at 10 kHz offset. Both are far from the experimental results.

To set up the ADF4360-2, as an Integer-N frequency synthesizer, the main parameters are Phase Frequency Detector, assigned to 200 kHz and the N-counter to 10.240 . As we have seen through the tests even modifying the values by default the performance of the synthesizer will not change in hefty way. The LMX2531 behaves at similar way. The PFD is locked to 5 kHz, N-counter to 409,6 and prescaled 16. Also, only slight variations on the output are noticed when the initial parameters are modified.

4 Comparation of the LMX2531 vs. ADF4360

At wider span (1 MHz and 100 KHz) both devices displays a clear peak centered on the carrier frequency and high rejection coefficient. It is easy to notice on the Figure 3 were both spectral outputs are displayed together.

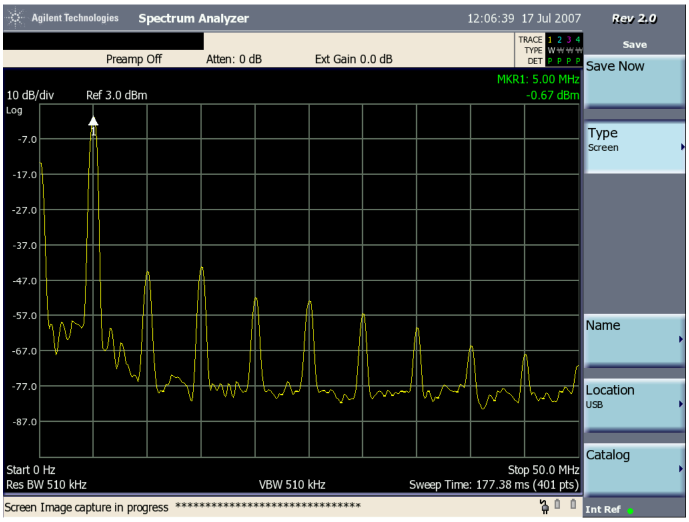

Figure 2: Frequency spectrum of the 5 MHz signal from Metsähovi H-Maser.

Excluding few peaks in general the average level is similar on the devices.

At 100 kHz the LMX2531 board shows a couple harmonics next to the carrier frequency, precisely at 20 and 25 kHz. As using other sources of frequencial signals, signal generator and a cristal oscillator, those has not appeared, we speculate that those are introduced due to the use of the H-maser, are not eliminated on the PLL filter and expanded on the spectrum analyzer due to FFT or A/D convertor. On the other hand on the Analog device for same conditions the output signal looks still perfectly clean.

We are quite suspicious of those two lobes distant 25 KHz from the main, since the level rejection is around 36 dB and probably could actually interferer for posteriorum use of the signal.

At narrower span both devices keep a great average level of rejection around -40 to -50 dBc. But several spikes interfer now with the carrier. The origin of them is not clear enough for us and they do not belong to the output signal, so we should not worry.

They do not appear using the cristal oscillator, but they do using the signal generator. Furthermore, using an old HP spectrum analyzer we could not reproduce them, due to the lower resolution of the equipment. Besides an attempt to use extra filters to eliminate possible harmonics from the reference signal had not help either. We are convinced the origine of the spurs

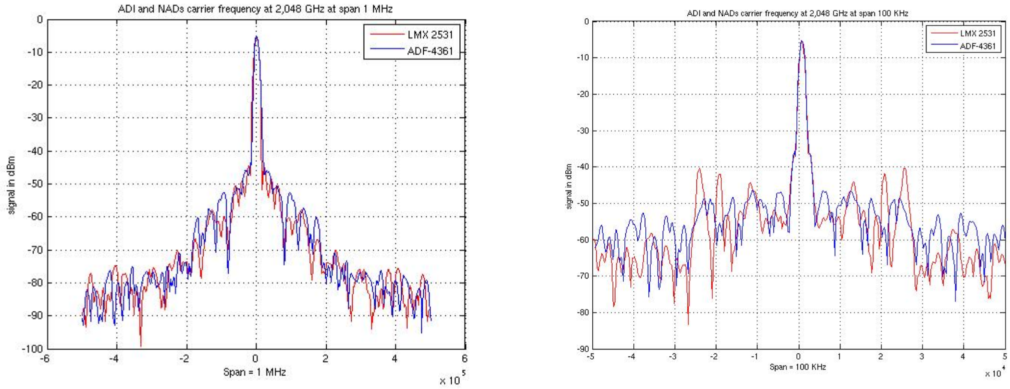

Figure 3: WideBand Comparation, for the synetizer boards National LMX2531 (in red) and the Analog ADF4360 (in blue) . Both are centered at 2048 MHz and displays the span at 1 MHz and 100 KHz.

is due to you cannot combine wide span, narrow resolution Bandwidth and high amplitude sensivity, so we assume those harmonics will not interfere at all to our main carrier.

Finally a common Figure 4 plotting on the same axis the spurs near the carrier has been done. As expected, the N-integer synthesizer appear to have higher levels of spurs. Even the spurs seems to not be synchronous, at least are displayed in different allocations for each device, but that can be caused by the RBW=10 Hz, so there is not enough resolution to ensure if they are randomly created for each device at different frequencies or instead they are caused by the use of the H-maser signal.

5 Comparing square vs. sinusoidals waveform

According to the Analog Device documentation the best performance of the board is achieved when the range of the signal is compressed between 10 to 80 MHz. At lower frequencies the board may also be full-operational, restricted to shape of input signal. It is recommended to use as a reference a square signal instead of sinusoidal waves. We proceed to perform some tests whether it is really needed to use 5 or 10 MHz signal and sinusoidal or squave waveform. In order to proceed the tests, an Agilent 33120A waveform generator was used.

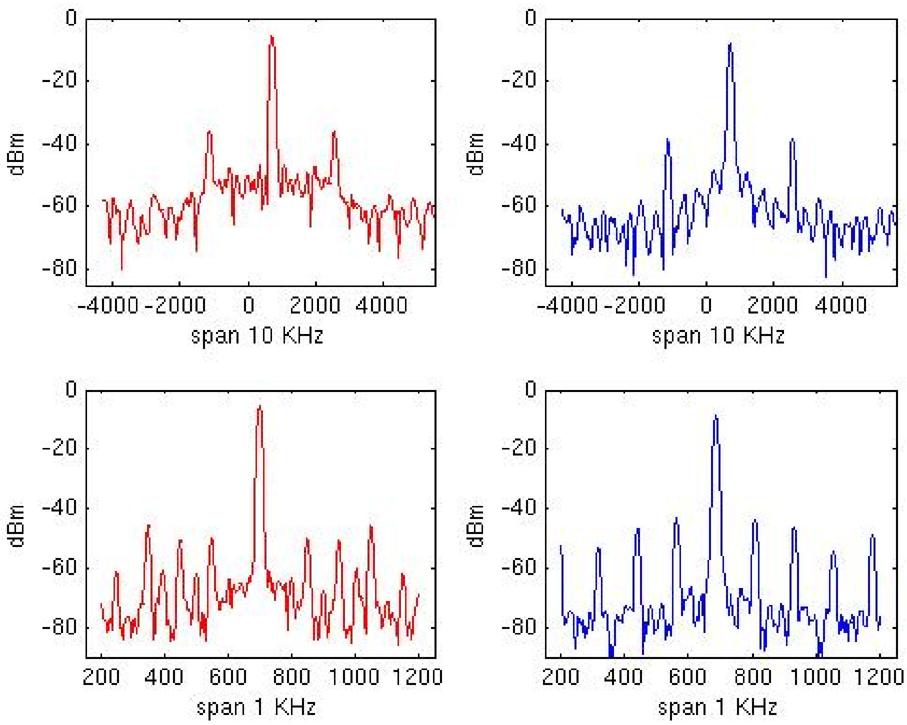

Figure 4: NarrowBand Comparation, for the synetizer boards National LMX2531 (figures left side) and the Analog ADF4360 (figures right side) . Both are centered at 2048 MHz with a bit offset to correct the center position of the carrier and displays the span at 10 KHz and 1 KHz.

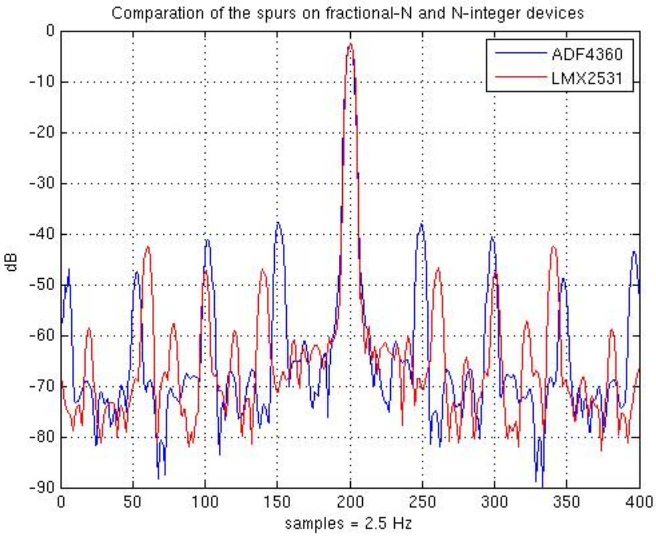

Figure 5: Comparasition of both output signals at span equivalent to 1 KHz

Regarding the first restriction, we tested both boards first at 10 MHz and subsequently at 5 MHz. All situations seemed to have similar behavior. Therefore, mainly for comodity reasons, it has chosen to work with the pure 5 MHz signal from the H-maser. The tests involved comparing the behavior of the ADI and NAT boards when the input signal was set up to 5 MHz and 1.5 Vpp and sinusoidal or square shape. Again we tracked all the unwanted peaks which appears in the wideband and narrowband range. Hence, it was analyzed the carrier frequency centered at 2048 MHz from an initial 1 MHz span up to 1 KHz and RBW[1] of 10 Hz. The results are shown in the Figure 6, using the ADI's board as an example. Both cases gave measurements enough similar to summarize all in one.

The LMX2531 board presented almost the same performance for the sinusoidal than the square signals. No such difference in any of the cases compared have been noticed. Only in high resolution, were span is 1 KHz, the level of the first spurs for the square signal appeared to be 1-2 dB rather high than the sinusoidal case. So we can not remark that the performance is improved at all by the square wave.

For the ADF4360 case, the output shows also a bit of improvement at higher span resolution between the square and sinusoidal case. The gain on

[1] Resolution BandWidth

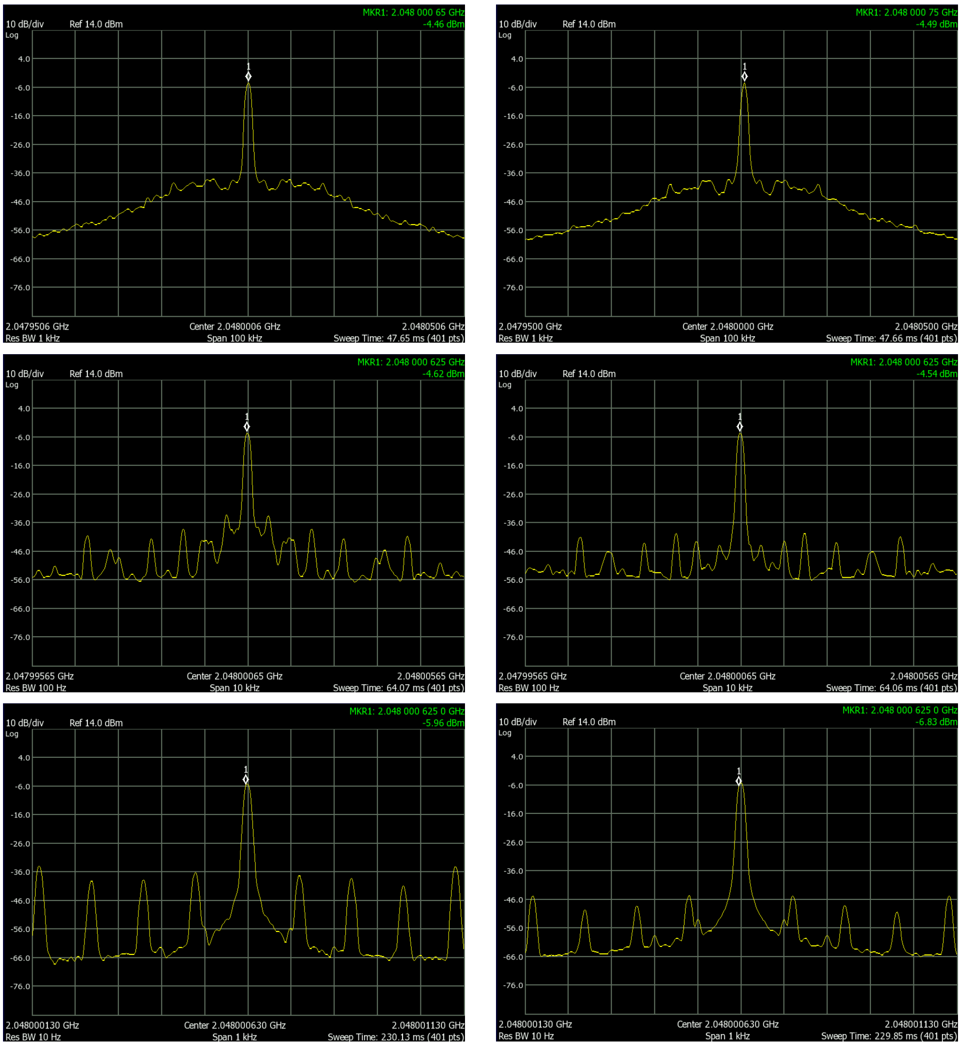

Figure 6: Comparation at narrow and wide band of the National LMX2531 and Analog ADF4360 board behavior when the input switches between a sinusoidal and sqare wave. In both cases the input signal was centered at 5 MHz and Vpp=1.5V. The target was verified on the Analog specifications which recommends to use a square signals when the input reference is below 10 MHz.

the phase noise is noticeable on the small peaks close the carrier frequency, but not in the average level of the signal.

As the spikes at widest span are considered harmless, it seems to us that there is not need to develop any sinusoidal to square transformer in order to subministrate square signals to any of both boards. Mainly because the carrier frequency at 2048 MHz outputs enough clear and clean to work properly for iBOB purposes and it does not seem worthful to invest hour to get a small improvement.

6 Conclusions

The main conclusions of our tests are as follows:

1. Both devices have similar performance to achieve a single sinusoidal at 2048 MHz. Also, the impact of phase noise on the spectrum is pretty similar on both.

2. LMX device have a lower power consumption. It is supplied by 3 external Volts, instead of the 9 V battery used on ADI synthesizer.

3. ADF4360 is a bit cheaper model than the LMX, but the cost of its products is quite irrelevant comparing with the whole system.

4. ADF4360 includes an extra on-board quars cristal which offers a really good performance, mainly regarding the phase noise. But obviously the 5 Mhz signal of the Maser will be used instead the on-board clock.

5. Both graphics interfaces offer strong and weak points. But, in my opinion, both are user-simple oriented. Controlling it with the serial port from the iBOB will be next challenge to face up.