Measurement & Identification – Lab 1

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1 Preliminary questions

What voltage swing corresponds to a LSB for the NI ELVIS II ?

With an input voltage range goign from -10 to 10 V and a 16-bits channel, the LSB is

$$\text{LSB} = \frac{10}{2^{16}} = 305.176\mu\text{V}$$

What is the dynamic range of the ADC ?

The dynamic range is the difference between the noise floor and the maximum possible output and is equal to $2^{16} - 1 = 96.6\text{dB}$.

Why is the accuracy affected by the crest factor ?

A huge crest factor limits the possible amplification of the signal and thus degrades the SNR.

Create multisine with constant, random and Schröder phase spectra. Discuss their differences and similarities.

The three signals have the same perfectly flat frequency content in the desired spectrum. However, the phase has a huge influence on the time domain signal. The constant phase has a very bad crest factor, while the two others have a significantly lower crest factor (very close but Schröder's is slightly better).

2 Usage of different excitation signals

Schröder phase with RMS value of 1mV **at 8**kHz**.**

There are 4096 samples and the sampling frequency is 8kHz. The requested frequency resolution of 1 Hz is not compatible with these values since the following relation must hold:

$$f_{\text{res}} = \frac{f_s}{N_{\text{samples}}} \tag{1}$$

The sampling frequency must then be reduced to 4096 Hz (adjusted to 4 kHz for a better precision).

Repeat the measurements. Can the quality of the measurements be increased ?

The measurements are still of very bad quality because of the low SNR. The signal should be amplified as much as possible, without going out of the range of the measurement chain ($\pm$5V for the acquisition of the output).

How can we ensure that the effect of the transient is gone ?

Multiple repetitions of the experiment are needed. The transient has vanished if two successive measurements yield identical results.

Multisine with constant phase. Even if the signal is identical in the frequency domain, the huge crest factor limits the SNR and thus degrades the quality of the measurements. The type of phase can have a huge influence.

Multisine with arbitrary phase. The crest factor is much smaller and the same power of the input signal as with a Schröder phase is achievable. The result of the identification is then identical to Schröder's.

Multisine with arbitrary phase, 512 samples only. The frequency resolution should be adapted according to the relation (1). This illustrates the trade-off between the length of the experiment (N_{samples}) and the frequency resolution.

Multisine outside the analysis band
This yields no usable result and illustrates the fact that an idea of the frequency band of interest is needed.

Multisine with Schröder phase, 0.5 and 3 V maximal amplitude This illustrates the importance of a good SNR as the results are better when the amplitude of the input signal increases.

Periodic noise signal This yields no usable result.

Aperiodic noise signal The results are good, but not as good as with a multisine since the excited frequency cannot be chosen and some energy is wasted.

3 Conclusion

1. Pay close attention to the instrumentation (max f_s, max amplitude)
2. Multisine with Schröder or random phase allows very good measurements
3. Equation (1) states the trade-off between length of the experiment and frequency resolution