Tests of the ADC to be used by the DAQ Box

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Abstract

This note presents the tests made to select an ADC chip to be used on the DAQ box for signal acquired up to several hundred of kHz.

Summary

1 Introduction

The motivation for this test is to find an ADC chip to be used on the mezzanines of the DAQbox with a sampling rate of several hundred of kHz. They will be used for instance to monitor some of the low frequency signals in the audio band, usually with a large dynamic at low frequency (a few Hz or below), or to read slightly faster channel, typically 10kHz, like the LDVT of the suspended detection bench.

This ADC will replace some AD7674 boards developed for Virgo+ and therefore we look for an ADC with performances at least as good as the one of the AD7674. It is also the opportunity to find an ADC which does not have the extra noise of the AD7674 when reading a very low frequency signal with not too large amplitude (see VIR-0358A-11).

Since no forced cooling with fan is foreseen in the DAQbox, a key selection criterion is the power consumption of the ADC.

Two ADCs have been preselected on the basis of their data sheets which possibly might be as good as the AD7674 and which should have reduced power consumption: the AD7982 and the LTC2378. The first one requires 7 mW (to be compared to 100 mW for the AD7674) and could run up to 800 kHz while the second one requires 13.5 mW and could run up to 1 MHz.

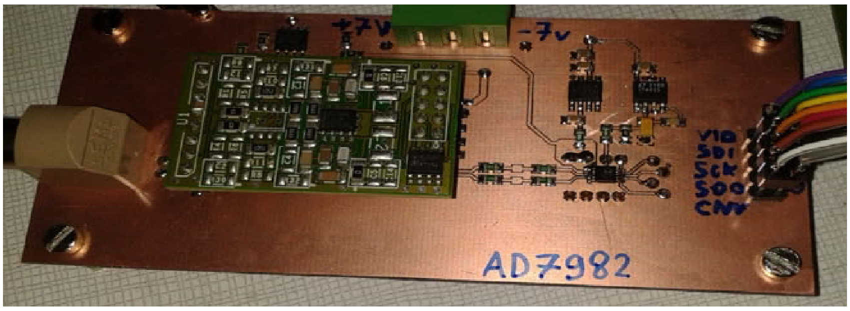
Unfortunately, the performance of the available ADC is poorly documented in the low frequency band which is the most interesting for us. Therefore test boards have been built to let us evaluate their performances.

Given the dynamical range of the ADC, absolute noise measurements are difficult to perform. Therefore, the focus of the tests is more on the relative performances, especially compared to the existing ADC7674 board. Tests are carried on without an input signal, with a input signal (single line) provided by a low frequency signal generator or with a more complex signal provided by a DAC (a low frequency white noise). Some of the measurements will be upper limits of the ADC performances because the input signal might have some intrinsic noise. Nevertheless, it will be possible to select the best ADC.

2 Test of the AD7982

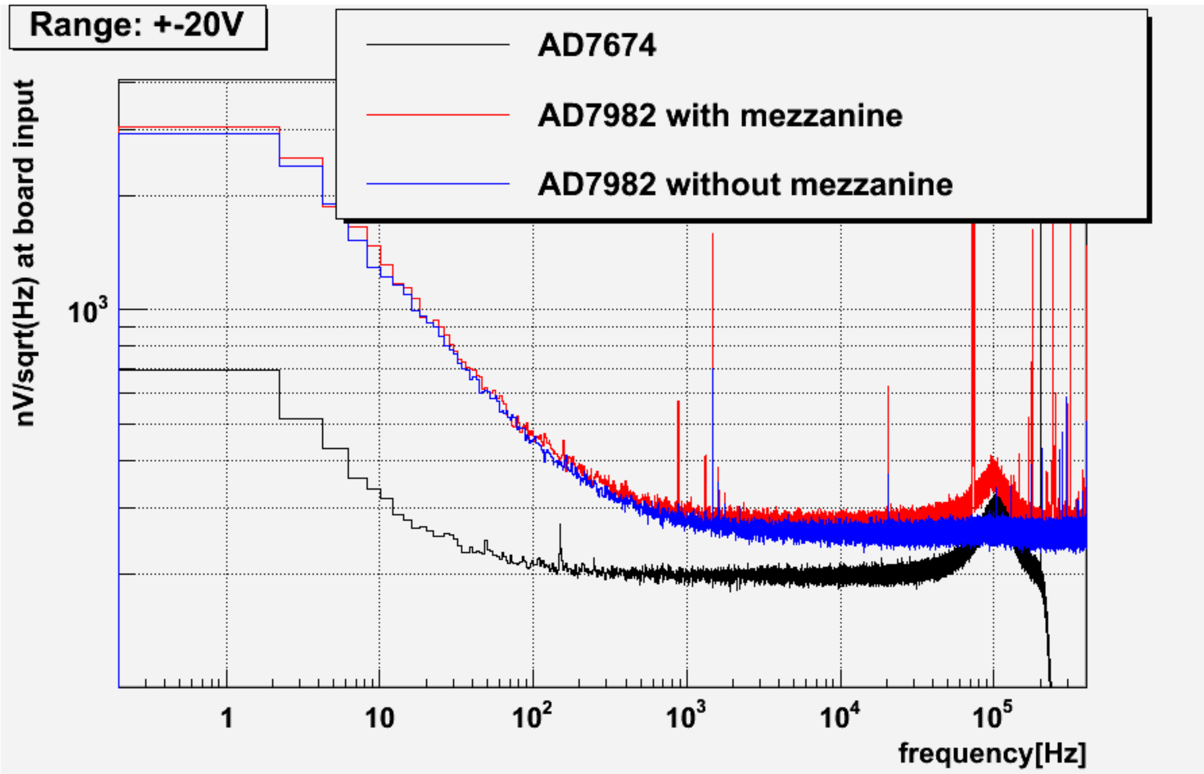
The following picture show the evaluation board made to test the AD7682. The analog input stage was the analog mezzanine described in VIR-0096A-12, without the shaping stage, but with the anti-aliasing filter with a 100 kHz cutoff frequency. This stage includes a gain of ¼, which was corrected when making the noise spectrum, or in other words, all noises reported in the document (except when doing the test without the ant-aliasing filters) are given at the analogue input of the test board and correspond to a +- 20 V range, which is the same normalization as for the Virgo+ ADC7674 board.

The test board was connected to a prototype of the TOLM board which was used to collect data with the usual TOLM network and DAQ. Data could be acquired as regular frames, viewed with the dataDisplay or post processed to produce the plot reported here.



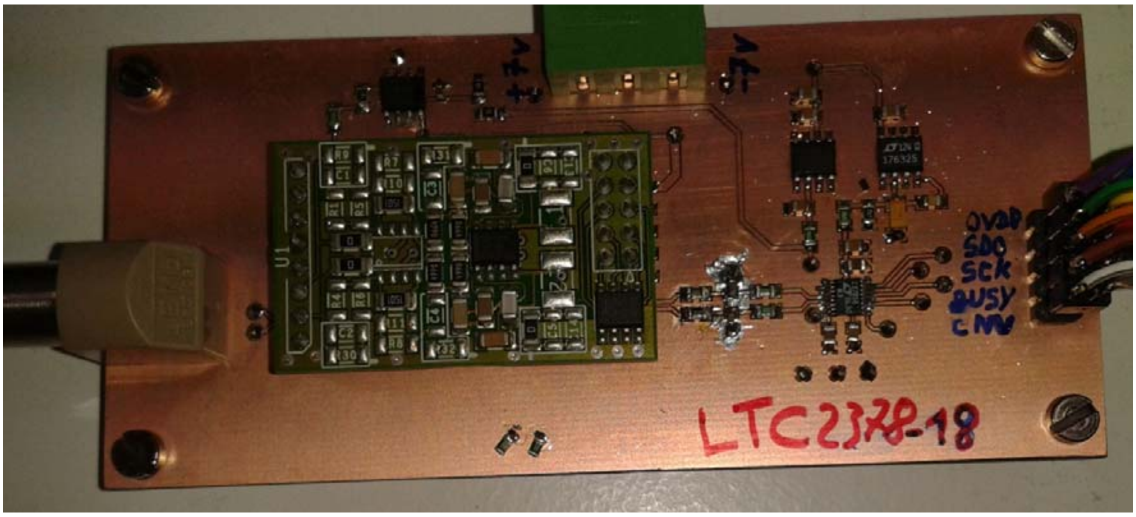
The following plots show a comparison of the ADC7674 and AD7982 ADC without any input signal. A measurement (blue line) was made also without the mezzanine used, but correcting for the ¼ scaling factor to provide consistent plots. The bump at 100 kHz is due to the mezzanine anti-aliasing filter.

As it can be seen, this new AD7982 has worse performances than the AD7674 in the full bandwidth and therefore has been rejected.



3 Test of the LTC2378

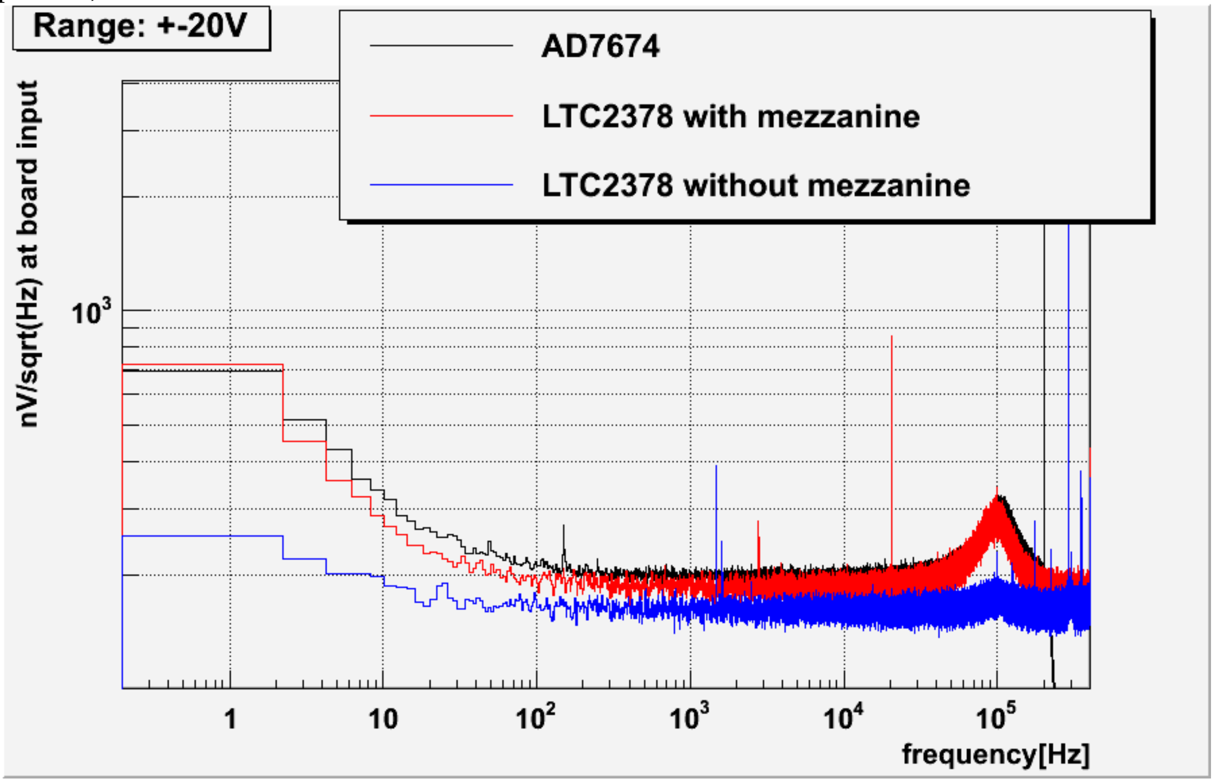
The following picture shows the evaluation board used to test the LTC2378. Like for the AD7982, the analogue mezzanine (VIR-0096A-12) which is implemented on the ADC7674 was used for the input signal conditioning and the data were read with a TOLM prototype board and stored as frames.



3.1 Noise floor without input

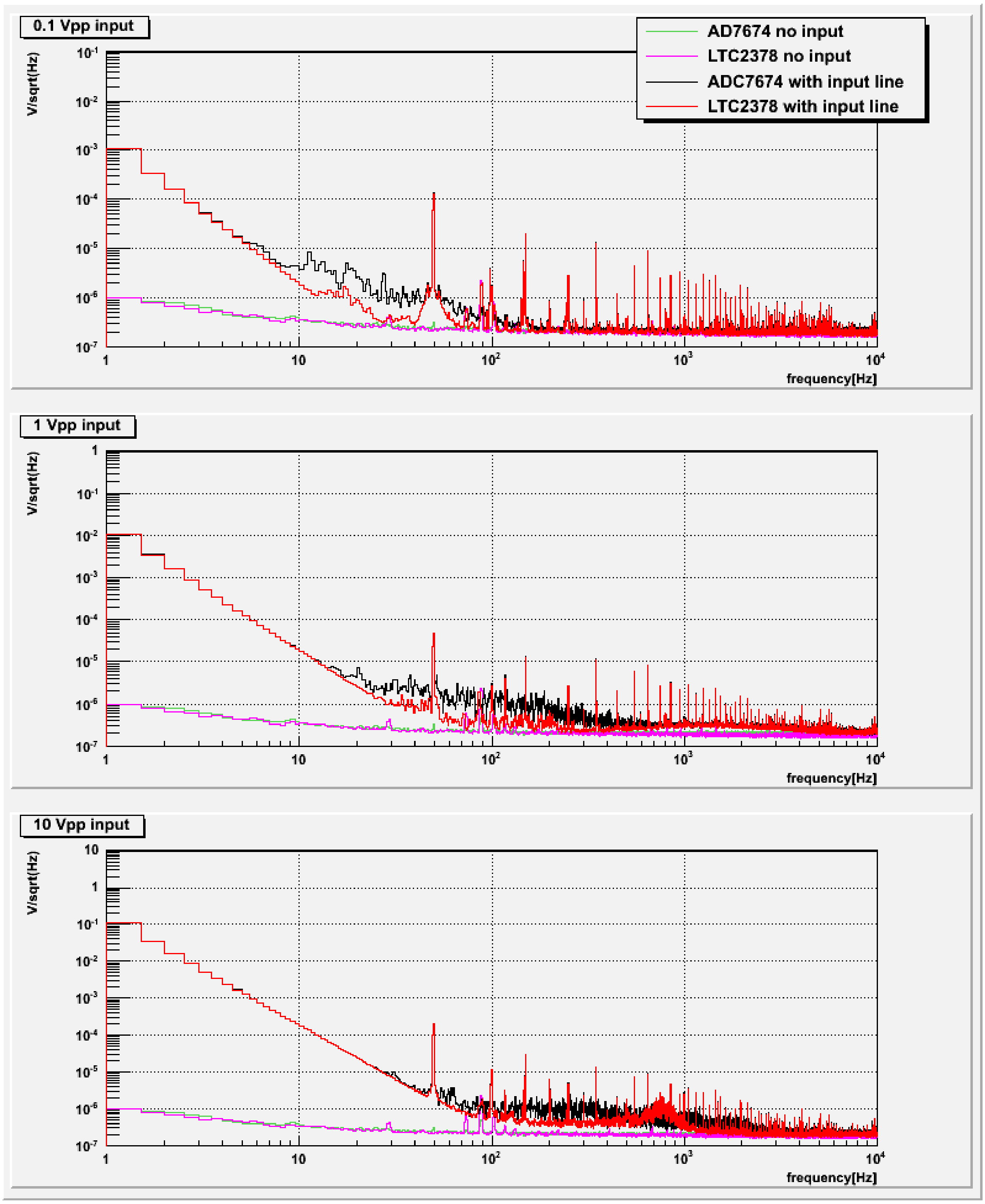
The following figure show the noise level when no single was feed to the ADC (input = 50 ohms terminator). Both ADC were run at 800 kHz for this test.

The LTC2378 performed better than the AD7674 in the full bandwidth. The performances at low frequency are actually limited by the noise of the analogue input mezzanine. Since this first result was positive, further tests were carried on.



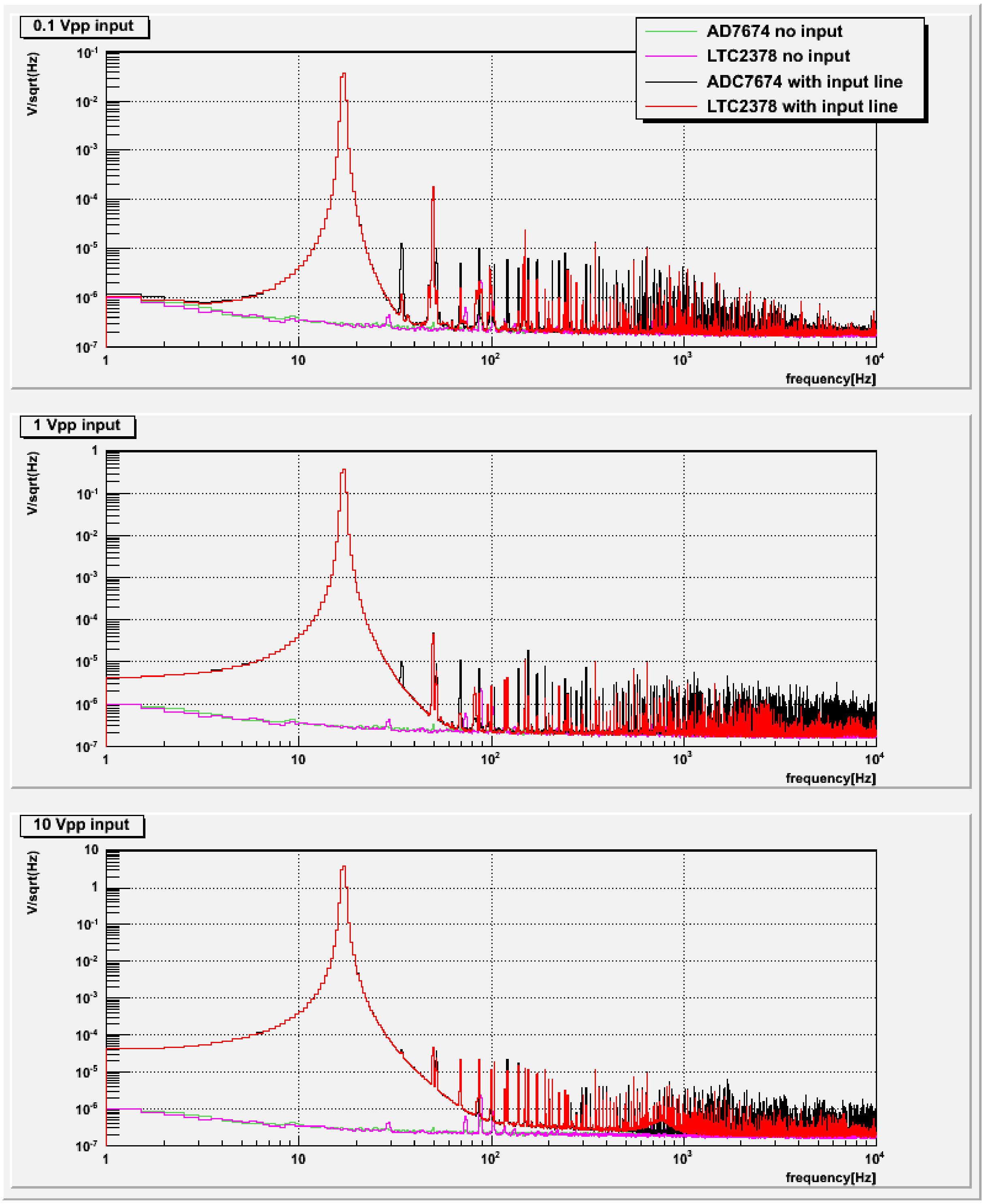
3.2 Test with a 0.33Hz line at various amplitudes

The following plots shows the results of a 0.33Hz line with three different amplitudes: 0.1Vpp, 1Vpp and 10Vpp.The signal was provided by a Stanford SRS DS360 signal generator which was simultaneously feeding both ADC channels. For these tests, the LTC2378 was running at 1MHz and the AD7674 at 800 KHz.



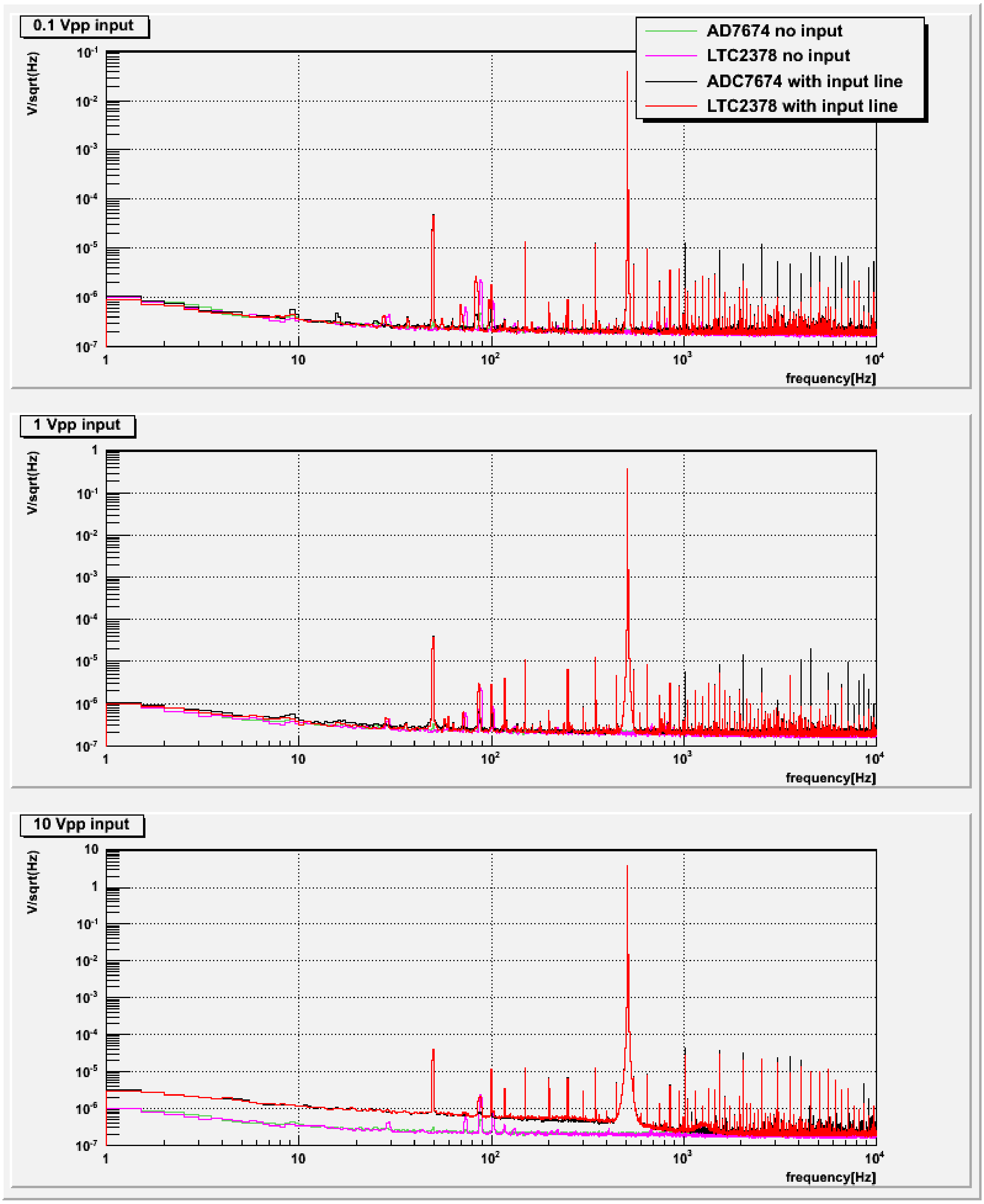
The extra noise of the ADC7674 is well visible in the ten to several 100 Hz band, especially for low amplitude signal. In all cases, the LTC2378 performed better than the ADC7674. A small bump is observed in the LTC2378 spectrum around 700Hz.

3.3 Test with a 17.33 Hz line at various amplitudes



Again, the LTC2378 shows a better noise level, less harmonics, except in the case of the loud line, were again a slight bump around 700Hz is observed

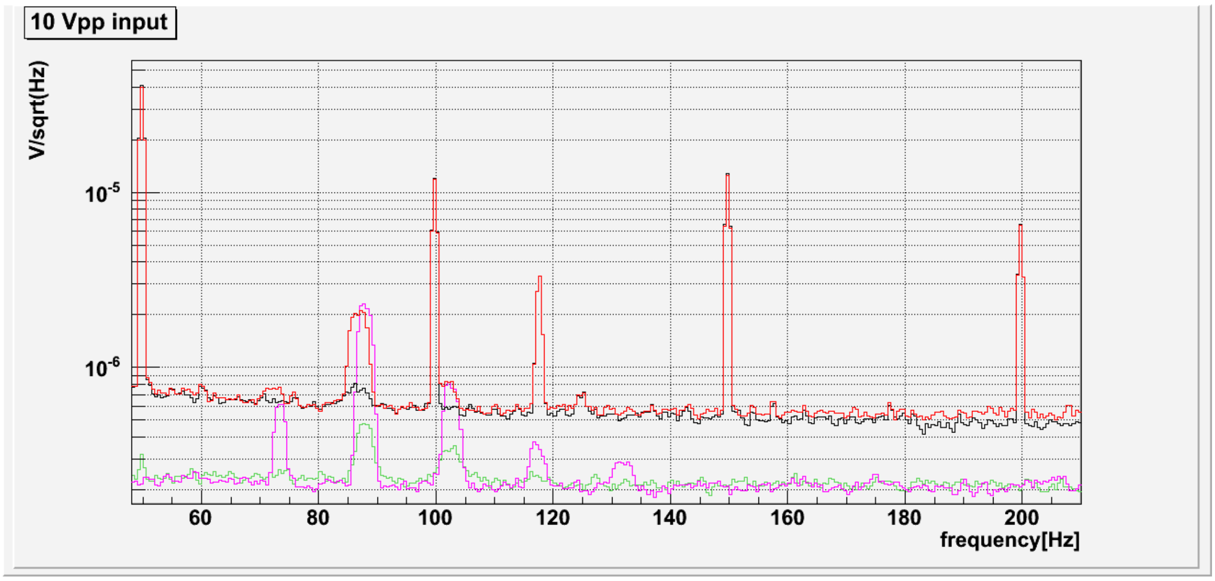
3.4 Test with a 513.11 Hz line at various amplitudes



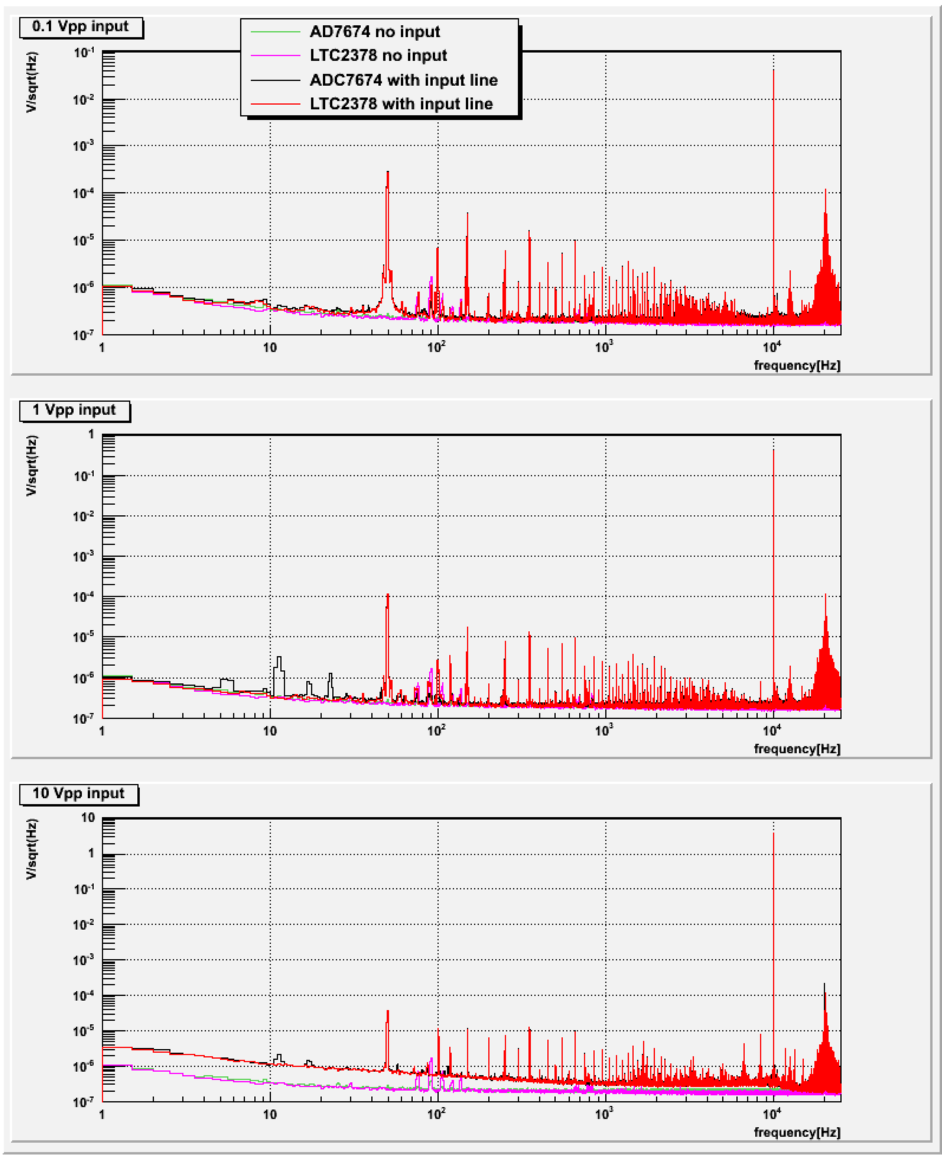
The behaviour is similar to the previous case. The bump in the LTC2378 has been moved around 1200Hz (513+700).

Below the frequency of the injected lines, the two ADCs see the same lines coming from the signal generator. This is well visible on the following figure which is a zoom from 50 to 210Hz. The red and black lines overlap perfectly at 50Hz and the harmonics.

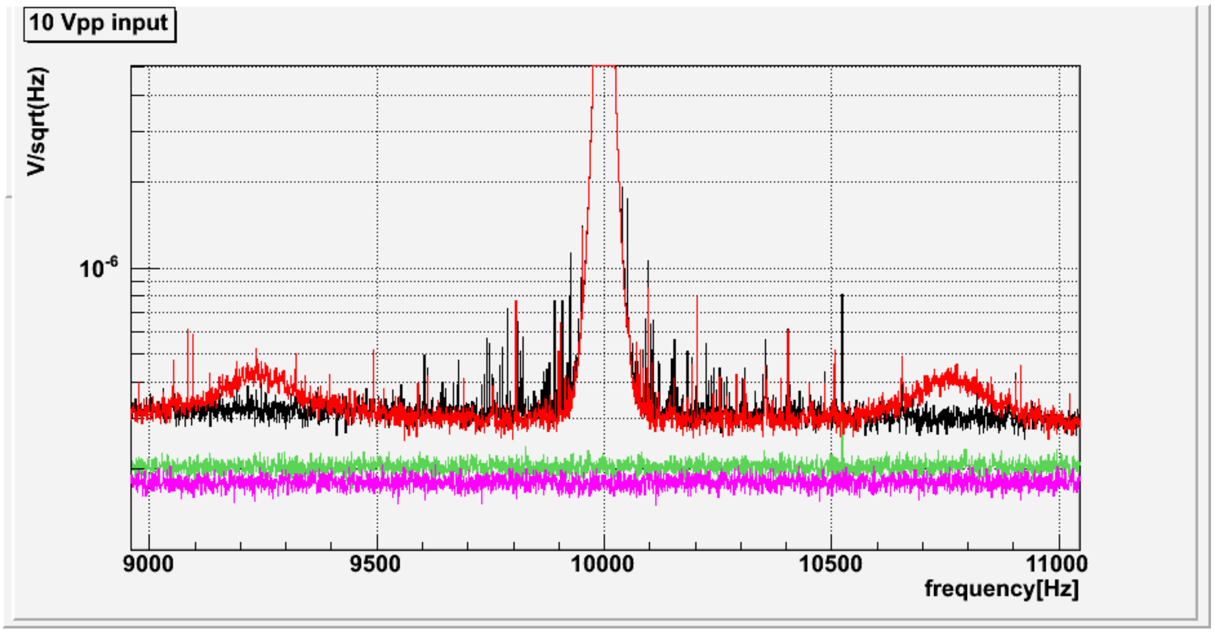
The set of lines at 72, 88, 102, 118Hz visible on the spectrum without input signal are due to a cross talk with the IRIG-B timing signal on the LTC2378 test board. This effect should disappear on the production mezzanines.



3.5 Test with a 10 kHz line at various amplitudes



The behavior is similar to the previous case. The following figure show a zoom around the 10 kHz line



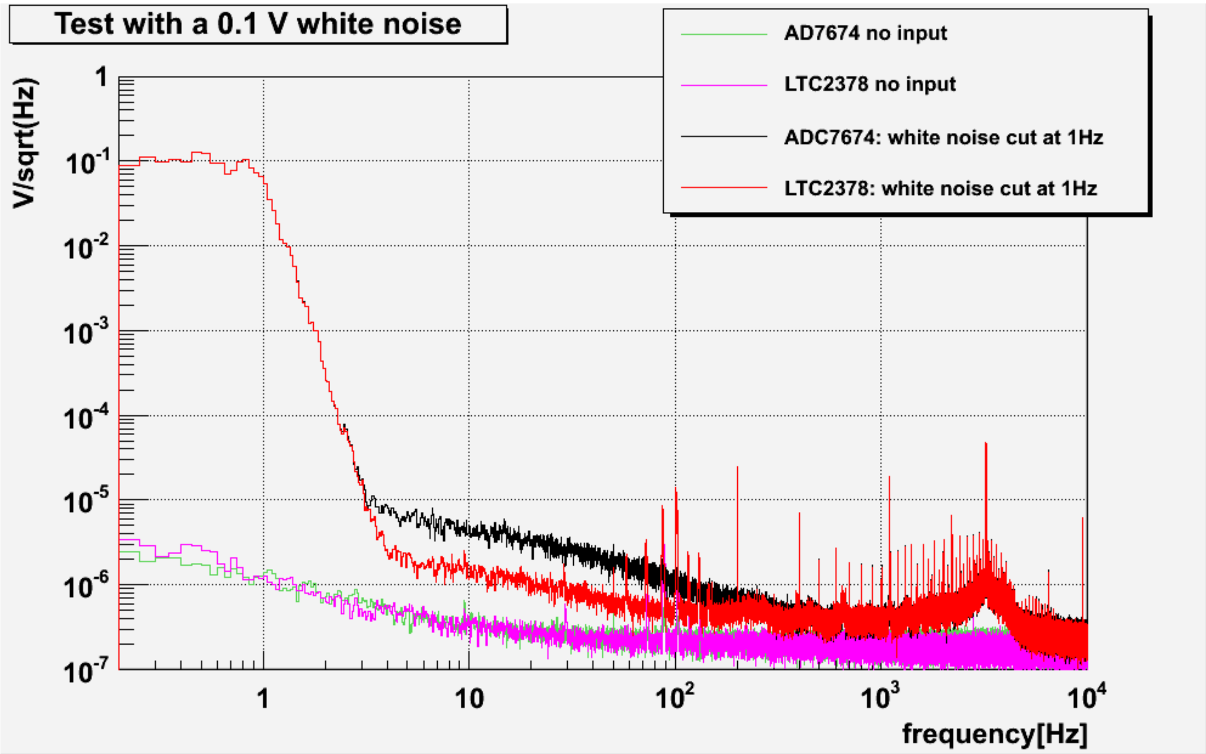
Two bumps at ±700 Hz around the main line are again visible. This suggests an amplitude or phase modulation of this ADC. This might be due to an imperfect power stabilization of the test board, or any others unknown reasons. This small disturbance is likely to disappear when moving from the test board to the full fledge production mezzanine with a more carefully designed PCB. In any case, these bumps have very low amplitude (140dB smaller than the main line) and will not disturb our measurements given our signal spectrums.

3.6 Test with a low frequency white noise

This test is an extension of the low frequency line test presented in section 3.2. It is design to evaluate the effect of the low frequency signal which is producing some extra noise with the Virgo+ ADC7674 boards (see VIR-0358A-11).

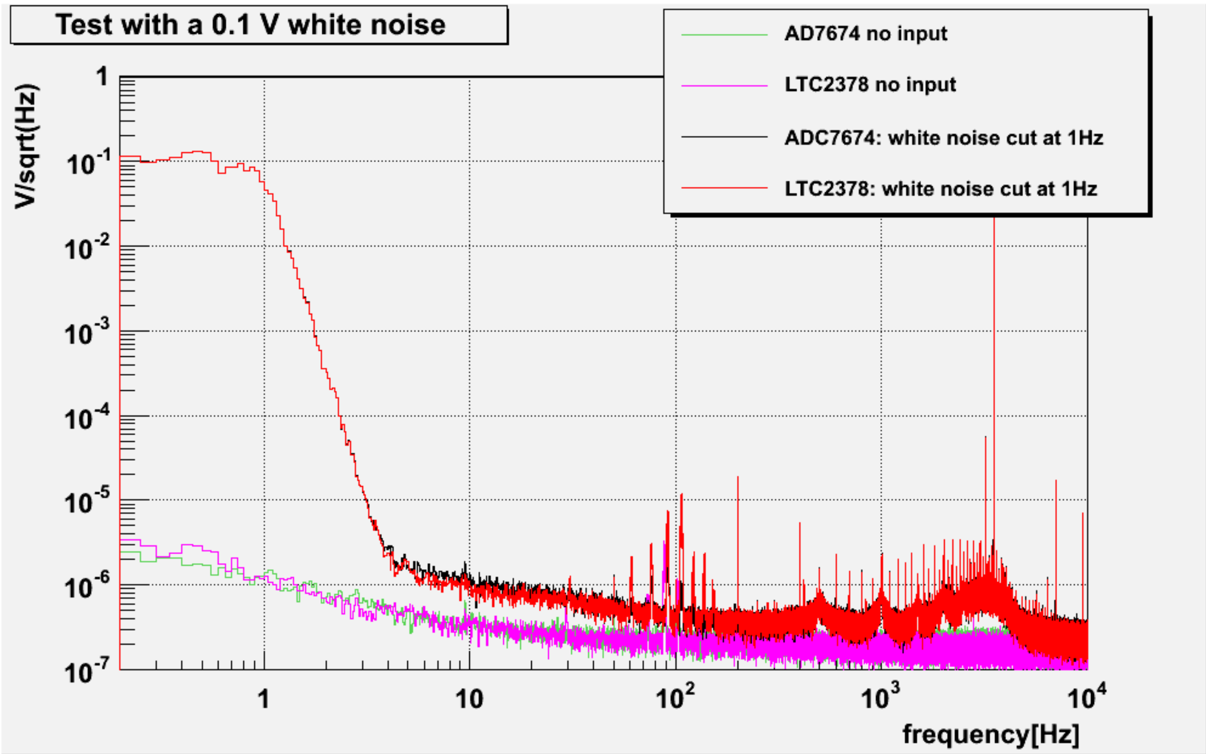
In this case, the signal is generated by the "Pisa" DAC 820d running at 20kHz and feed with white noise of 0.1V of spectral density filtered by an 8th order Butterworth filter cutting the noise at 1Hz. This is to generate the signal similar to the Virgo conditions. A line at 9450Hz is added to reduce the low frequency noise of the DAC. This line is not visible by the ADC since it is canceled by the analog anti-image filter of the DAC board.

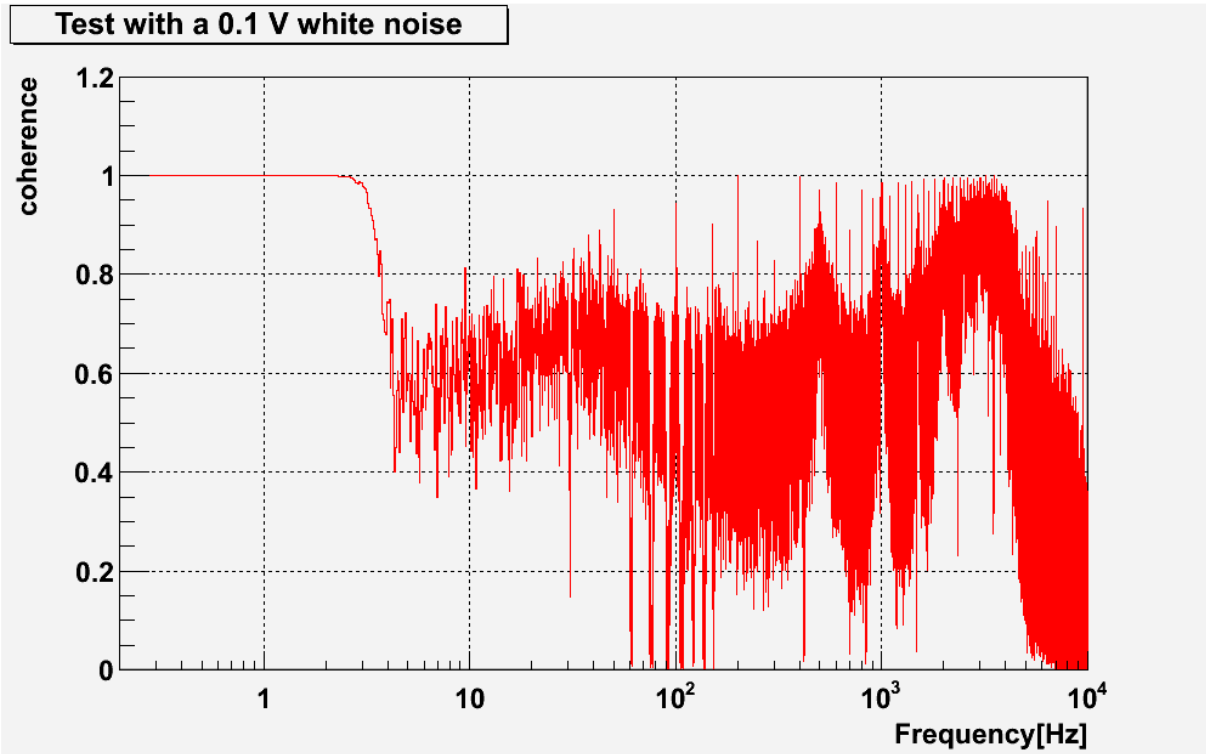
The following figure shows the result, the AD7476 exhibit the usual extra noise already observed, while the LTC2378 is much cleaner. The lines around 100Hz in the LTC2378 spectrum have been identified as coming from the timing signal, which is not properly shielded on this evaluation board.



Since this noise is probably due to non linearity of the ADCs, adding a high frequency line in the simulated "noise" spectra help removing this noise by smearing this noise. This result is presented in this next figure where a 2450Hz line was added and the low frequency noise around 10Hz much reduced.

This figure is followed by the coherence of the signals measured by the two ADCs, which demonstrated that the remaining noise of the spectrum is coherent between the two ADCs and therefore is coming from the signal generator, here the Pisa Dac820d.


Test with a 0.1 V white noise
AD7674 no input
LTC2378 no input
ADC7674: white noise cut at 1Hz
LTC2378: white noise cut at 1Hz
V/sqrt(Hz)
frequency[Hz]


Test with a 0.1 V white noise
coherence
Frequency[Hz]

4 Summary

Overall, the LTC2378 has better performances than the existing ADC7674. The main benefit is the noise in the 10-100 Hz which is much reduced. During the test, small amplitude side bands at ± 700 Hz around a very strong line were observed. This effect might disappear in the production board and is anyway a small drawback compared to the improvement observed gain in the 10-100Hz band.

Since the LTC2378 has also a power need reduced by a factor 7.4, it is selected as the ADC chip to replace the AD7674 on the DAQbox mezzanines.