UNIVERSITY of HAWAIʻI MĀNOA

Instrumentation Development Laboratory

KLM Negative rail testing

Negative power supply testing report on KLM carrier board

Author: Peter Orel
Tests by: Peter Orel, Isar Mostafanezhad
Checked by: Gary S. Varner
Approved by: Gary S. Varner

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1 Introduction

In this document we show the findings of tests done in order to investigate oscillations present on the negative -3.8 supply rail and its effects on the output signal.

The following figure shows the block scheme of the test setup:

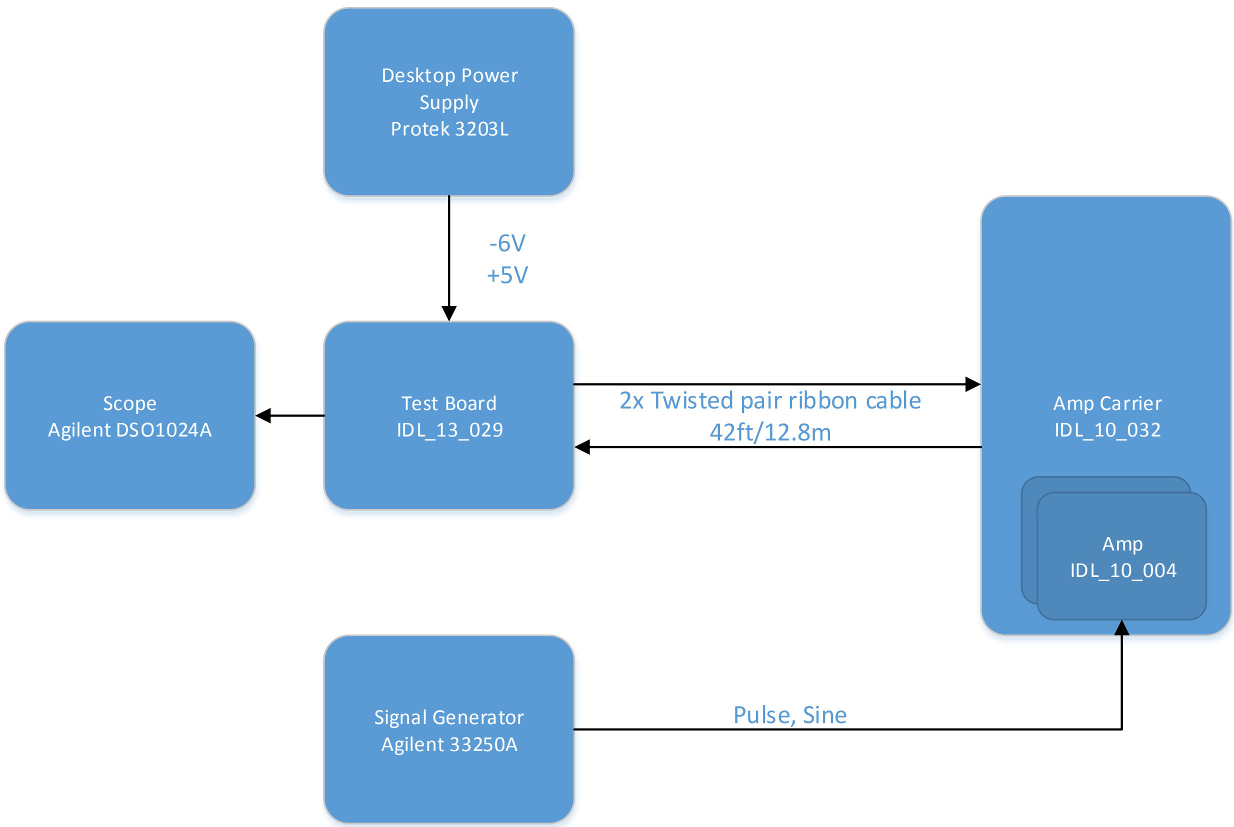

Figure 1: Test setup block scheme

Equipment used:

- Power Supply: Protek 3203L
- Signal generator: Agilent 33250A
- Scope: Agilent DSO1024A
- Multimeter: Fluke 79III

The results can be divided in two groups. The first shows the oscillation and its origin, the second shows its effect on the signal of interest.

2 Identifying the oscillation and it cause

The following figure shows a block scheme of the carrier board with the amplifier boards populated:

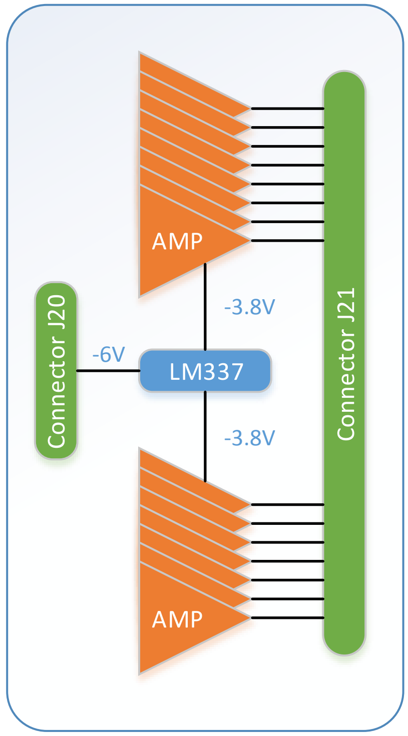

Figure 2: KLM Carrier and Amplifier boards block scheme

The -6V rail is fed through a 42ft/12.8m long ribbon cable into an LM337 Negative linear regulator to produce the -3.8V for the Amplifier bias. The input capacitance on the schematic is reported to be 1uF ceramic capacitor. The Voltage rating is not given. However it has been later reported that the input capacitors were modified to Tantalum capacitors with a value of approximately 4.7uF .

The following table summarizes the results of the tested boards:

Board	Input Cap [µF]	Oscillation	Frequency [kHz]	Amplitude [mVpp]
1	4.222	Not present		
2	4.023	Present	17	360
3	4.263	Present	38	180
4	4.470	Present	21.5	264
5	4.372	Present	27.8	232
6	4.292	Not present		
7	4.400	Not present		
8	4.307	Not present		
9	4.270	Present	19.4	284
10	4.267	Present	21.1	282
11	4.267	Not present		

The tested boards had all of the amplifier populated. The following figures show the oscillation measured at both the input and the output of the negative regulator:

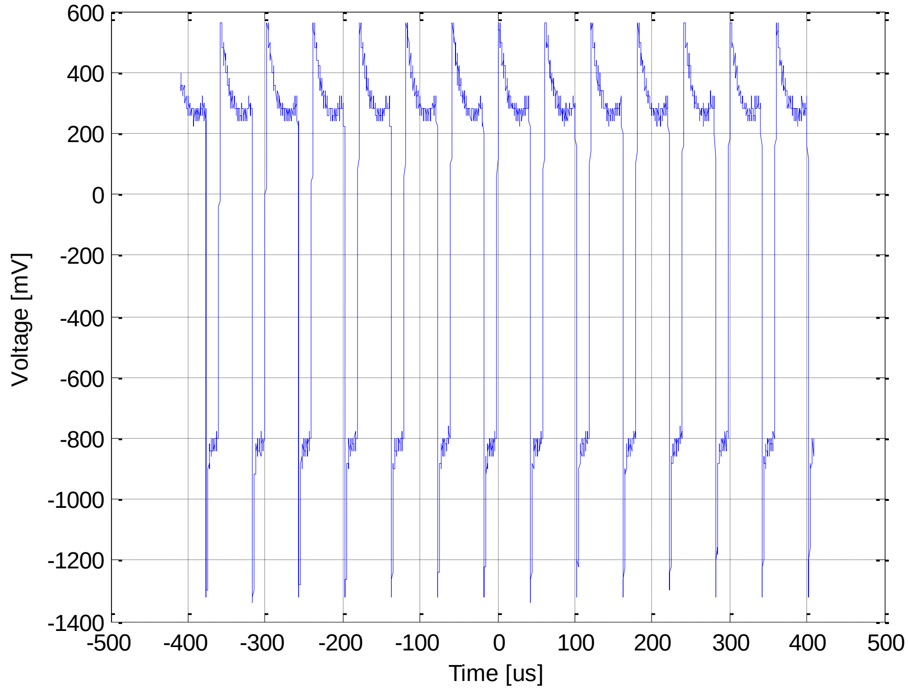

Figure 3: Oscillation at input of voltage regulator, all amplifiers populated:

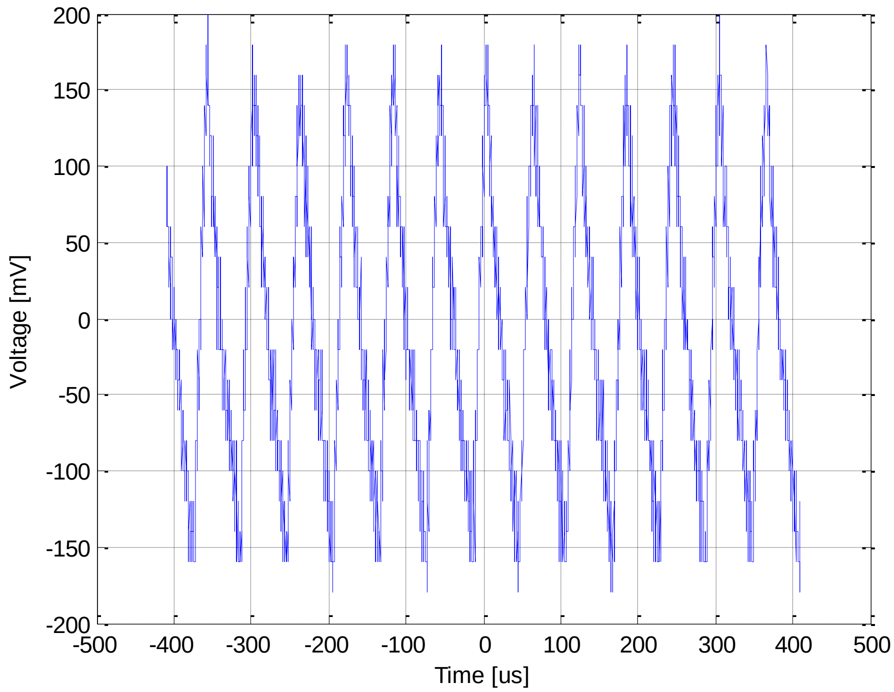

Figure 4: Oscillation at output of voltage regulator, all amplifiers populated

The oscillation was not present when the load was low. This was when only one amplifier board or none were populated.

However when we added the second the oscillation appeared but with a higher frequency and lower amplitude. The amplitude lowered by a factor 3 while the frequency increased from approximately 16kHz to 104kHz.

By adding the amplifier boards one by one we observed how the frequency decreased in increments and the amplitude increased likewise.

The following figures show the oscillation with lower load.

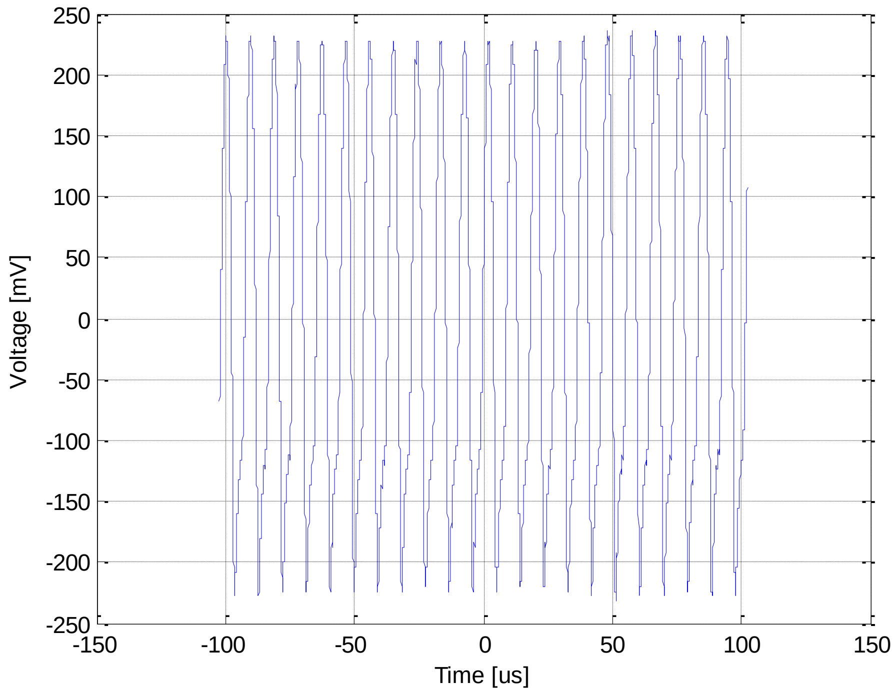

Figure 5: Oscillation at input of voltage regulator, two amplifiers populated

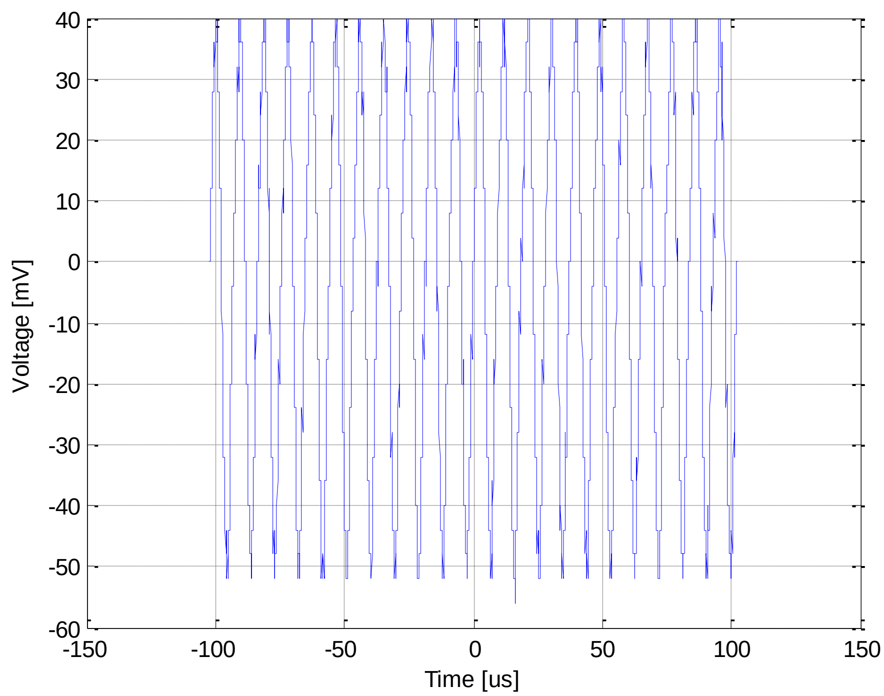

Figure 6: Oscillation at output of voltage regulator, two amplifiers populated

It has been concluded that due to the length of the cables the resistance and inductance became big enough so that the stored energy on the carrier side was marginally not sufficient thus causing the instability in the regulator feedback loop.

The next step was to add a 10µF capacitor to the input of the regulator to all of the boards that showed the instabilities. All of the modified boards were retested and there was no oscillation present.

The modified boards have been marked with a “IO“red mark.

3 Effect of the oscillation on the signal of interest.

To test the effect of the oscillation we used a signal generator to input a pulse in the amplifier. The pulse characteristics were as follow: Amp: 40mVpp, Freq: 1MHz, Width: 83ns, Rise/Fall times: 11.5ns.

The output has been measured at the single-ended 50Ω terminated output on the test board.

Two different boards have been tested

The worst case output is shown in the following figure:

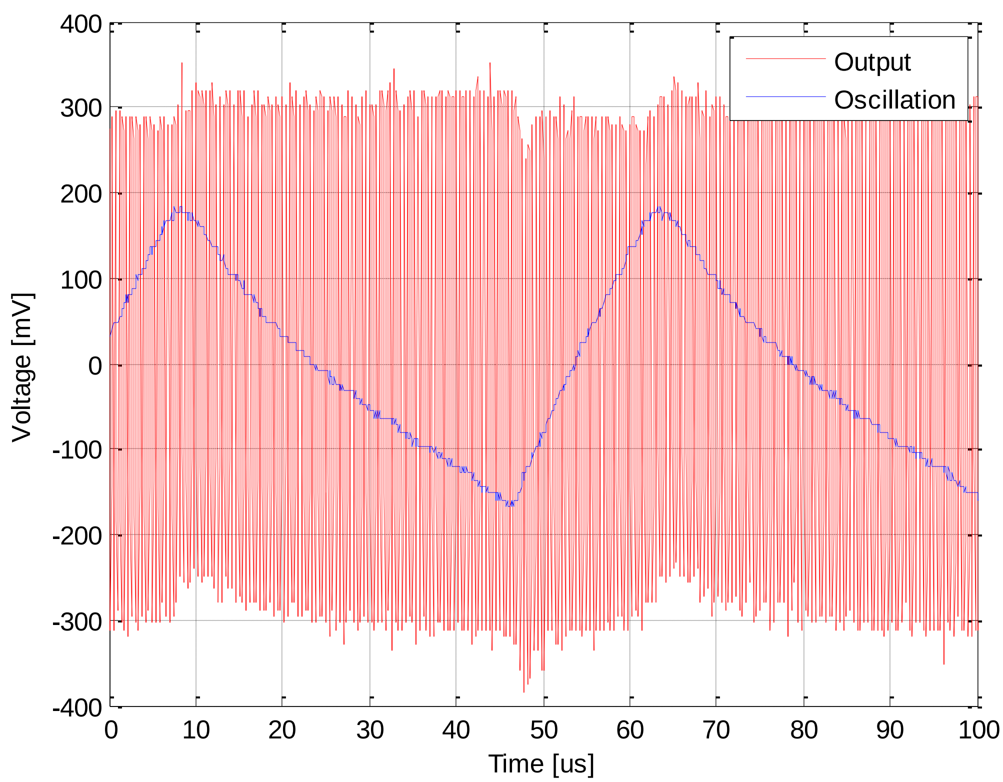

Figure 7: Output of amplifier compared to the oscillation of the negative rail, worst case

Another example is shown in the following figure:

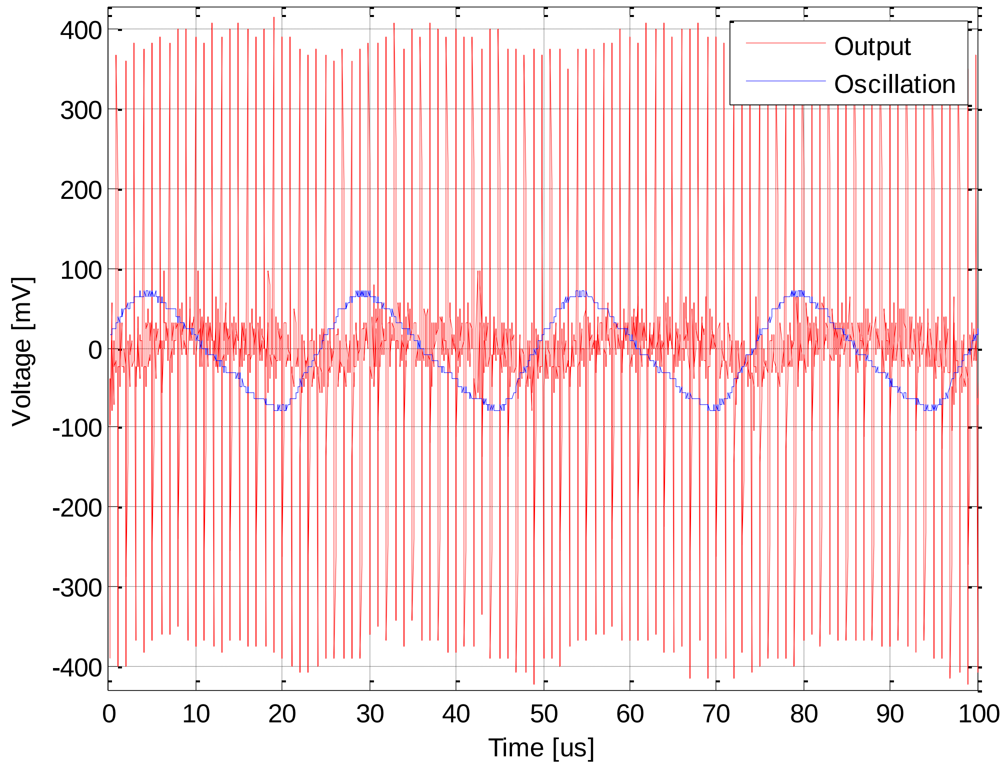

Figure 8: Output of amplifier compared to the oscillation of the negative rail

It can be seen that the oscillation affects the signal, however it is not clear whether it modulates the amplitude and the baseline or just the baseline. To have a better approximation an FFT has been done over the signal:

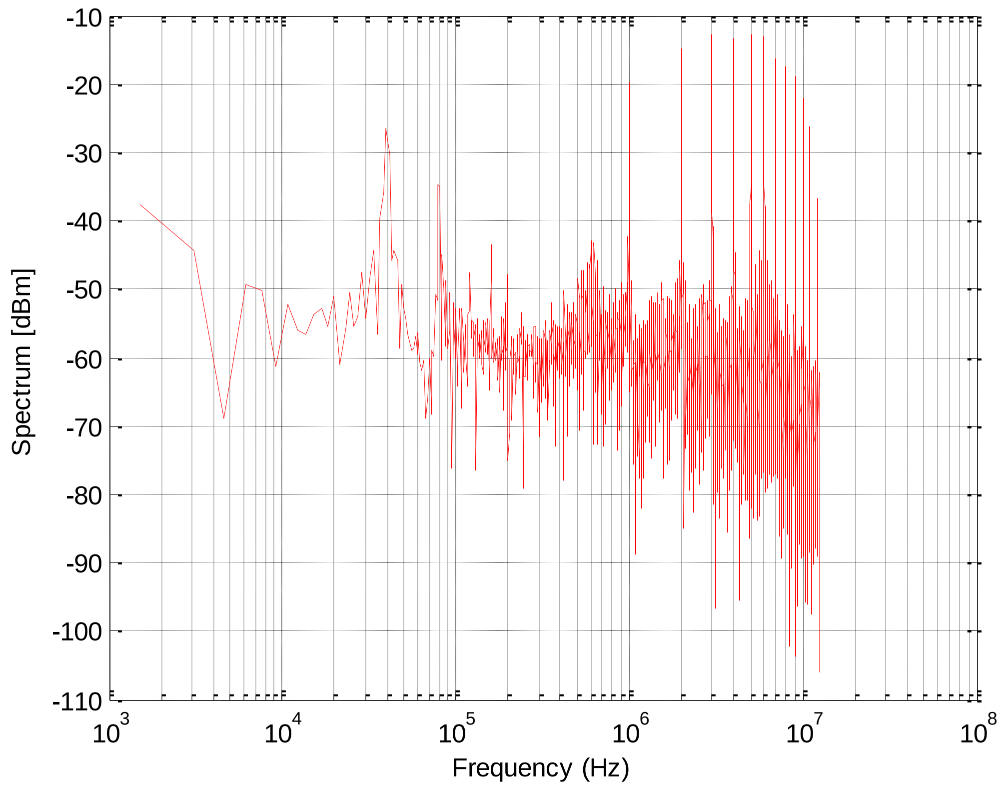

Figure 9: FFT of the Output signal

The vector length of the signal was limited thus the FFT is not very accurate. However it does gives us a more clear insight into what is happening.

The baseline oscillation is clearly seen at apr. 40kHz. On the other hand the amplitude modulation close to the fundamental tone is barely recognizable thus presenting a low modulation depth.

4 Summary

As we can see the oscillation modulates the signal baseline primarily. This can be filtered by adding a high pass filter at the far end.

The cause of the oscillation is insufficient capacitance on the input of the regulator. Also it is worth noting that with shorter cables the capacitance can be lower. A 10µF capacitor seemed to have been sufficient for this case.

The minimum recommended is to add a 10µF/10V tantalum capacitor. The current footprint is 0603, however the layout is done such that a bigger capacitor can be connected between the ground pad of the existing capacitor and the pad 4 (big one on the back) of the regulator. For example a 22µF/16V 1206 Digi-Key: 493-4276-1-ND.