TECHNOTE 005
COMPARISON OF NOISE FROM 3.3V REGULATORS

An investigation comparing an ADI LTC7151 to the modules used on the Clockworks PWR001 and PWR002 modules

Rev 1.0

13-June-2019

Signal Processing

http://clk.works/

Products referenced:

PWR001 triple output supply module
PWR002 seven output supply module

1. TABLE OF CONTENTS

1 INTRODUCTION

This report continues an investigation of power supply noise. Background material and motivation for this testing can be found in three other TechNotes and may be of interest before reading this one.

While the 3.3V supply in a SignalBlox system would ideally have no influence on input and output noise, all sorts of real world interactions can happen to degrade the system noise floor. Measurements of the Clockworks power modules on actual op-amp circuits has shown that a noise floor of < -120 dBV (1 uV RMS) is achievable without resorting to additional low noise linear regulators.

Some of the observations made during that process may help other system designers so Clockworks has put together this Technote to aid with system design. The three other TechNotes (at the time of writing) that may be useful for the noise topic are:

- TN001: Power supply noise sensitivity
- TN003: Power supply noise sensitivity in an op-amp circuit
- TN004: Power supply noise evaluation in the PWR002 seven output supply

Please check the Clockworks website for newer information.

1.1 SUMMARY

The PWR001 triple output module uses a CUI VXO7803-1000 1 amp switching regulator for 3.3V power. The PWR002 seven output module uses this part for the standby power supply, and adds a Murata OKR-T/3-W12-C module configured for 3.3V output at 3 amps, as well as a second one for 5V output.

A future planned Clockworks power module would offer 3.3V at 5A for larger system. Analog Devices graciously provided a modified LTC7151 EVM for Clockworks to evaluate.[1]

[1] Look for future TechNotes comparing other ADI parts.

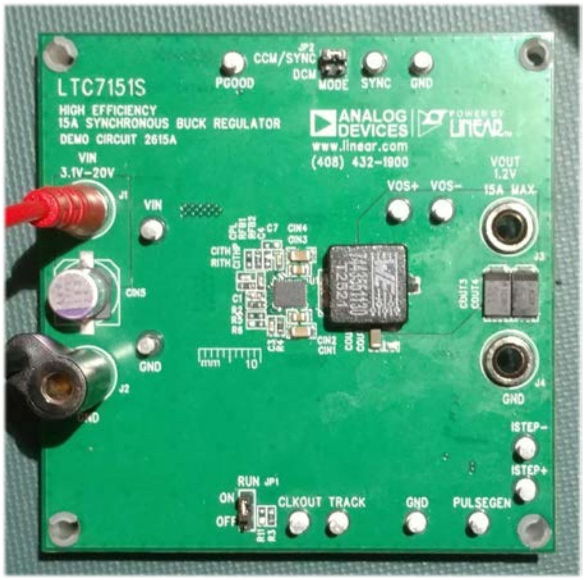

Figure 1 LTC7151 eval board used in testing

Normally these supplies are just used to power digital circuitry. Therefor the analysis in this report just looks at the measured noise under varying load conditions. Specifically, spectral spikes in the noise in the audio range could be of concern if they coupled in to the analog circuits, either magnetically or electrically. That latter, when once considers the size of parasitic capacitance between traces, may be of the most concern.

Not considered in this report are issues with ground loops that can occur when multiple systems are interconnected. Problems of this type are very dependent on system details. The philosophy here is that the quieter supply should offer less opportunity for problems.[2]

1.1.1 RESULTS SUMMARY

With the same post filter, under the 110 mA load case, RMS noise in 88 kHz was measured as:

- LTC7151: -75 dBV
- CUI VXO7803-1000: -68 dBV
- Murata OKR-T/3-W12-C module: -62 dBV

The LTC7151 output's spectral peaks were all lower than the other solutions.

On the assumption that the currently used 3.3 switching modules are not affecting system performance, then the LTC7151 would be fine for the 5 amp solution. It may also make sense to consider it for the 3 amp solution (basically drop the 3A solution) if the cost works out to be similar.

[2] Not always true, but that's what rainbow farting unicorns are for.

1.2 METHODOLOGY

All three boards used to measure the noise were powered with a CUI SW125-12-N wall wart supply

Audio spectrums were measured with an AverMetrics AverLab, with a 1 uF DC blocking capacitor added to the input. Wideband spectrums were measured with a Siglent SDS1204X-E scope.

Previous work has shown the noise from switching supplies can vary by quite a bit under differing load conditions; the measurements here are not intended to be exhaustive in that regard but do provide some sense of the power supply's behavior.

The PWR001 board used for the CUI module measurement is the rev 2.0 board, which includes an added 10 uH choke and 100 uF capacitor for noise reduction.

The PWR002 board used for the Murata module measurement is the Rev 1.0 board, which lack the additional filter.

There is some background noise on the bench that was not investigated for these measurements.

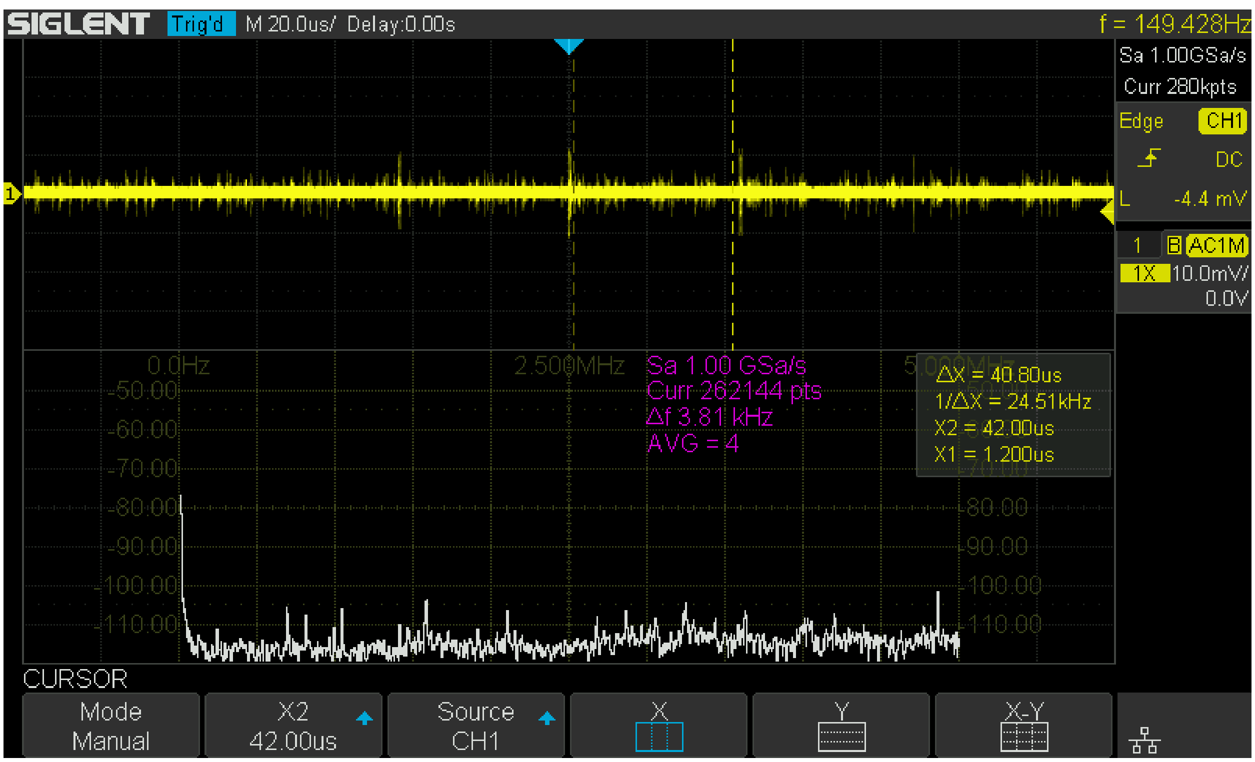

Figure 2 System background noise with scope connected but DUT not connected to primary power

2 MEASURED RESULTS

The scope captures include the scope's automatic frequency measurement in the upper right. For the type of waveform looked at here that value is usually not meaningful.

The 3.3V supply is not intended for use with analog circuits, so there's less concern than with the bipolar supplies intended for direct analog circuit use. However it's assumed that all other things being equal, a quieter supply will lead to less system level noise issues.

2.1 110 MA LOAD

As noted previously the PWR001 board used for the CUI module measurements has a 10 uH/100 uF filter; the Murata module results do not have this filter in the current board revision. To enable comparison the filter was added externally to the LTC7151 and Murata boards; measurements are provided both with and without it.

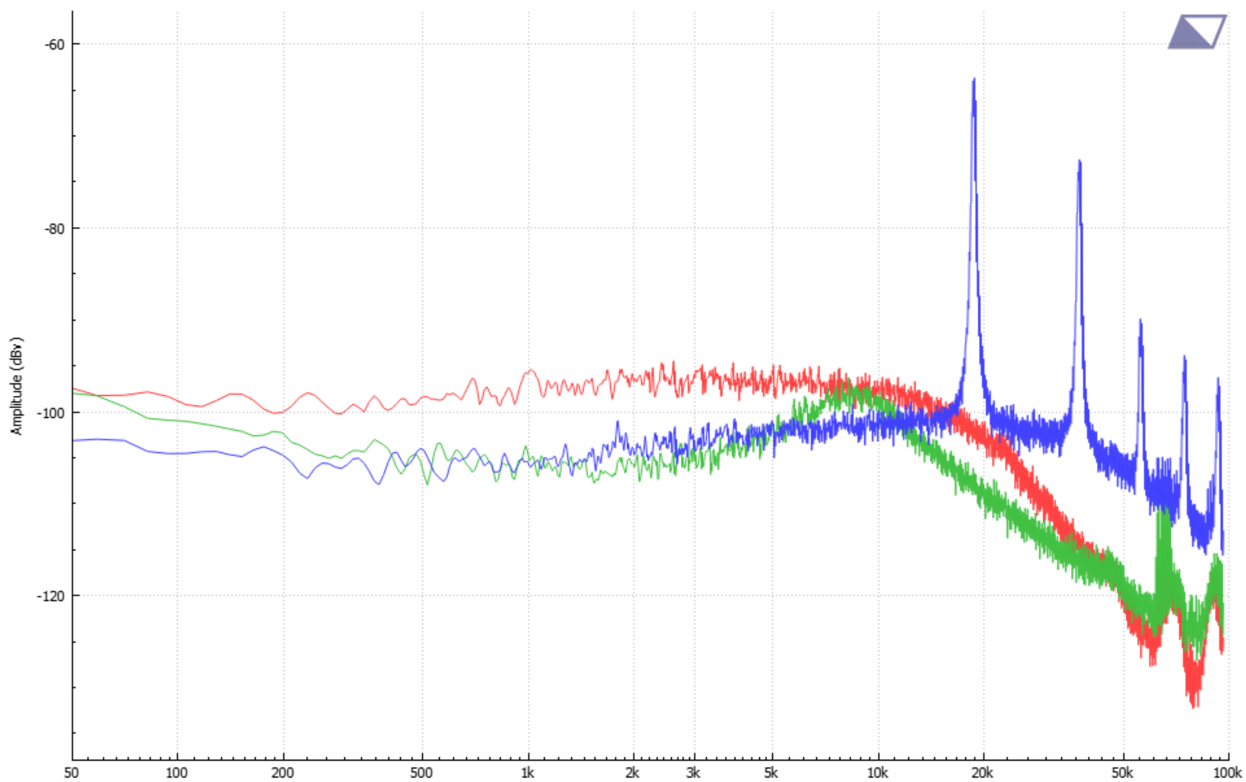

Figure 3 110 mA load LTC7151 (Green), CUI 1A module (Red), Murata 3A module (Blue)

Figure 3 compares the spectrum in the audio band (up to 88 kHz) for the three modules.

The subsections that follow provide a more detailed look at each regulator.

2.1.1 LTC7151 ON ADI EVAL BOARD

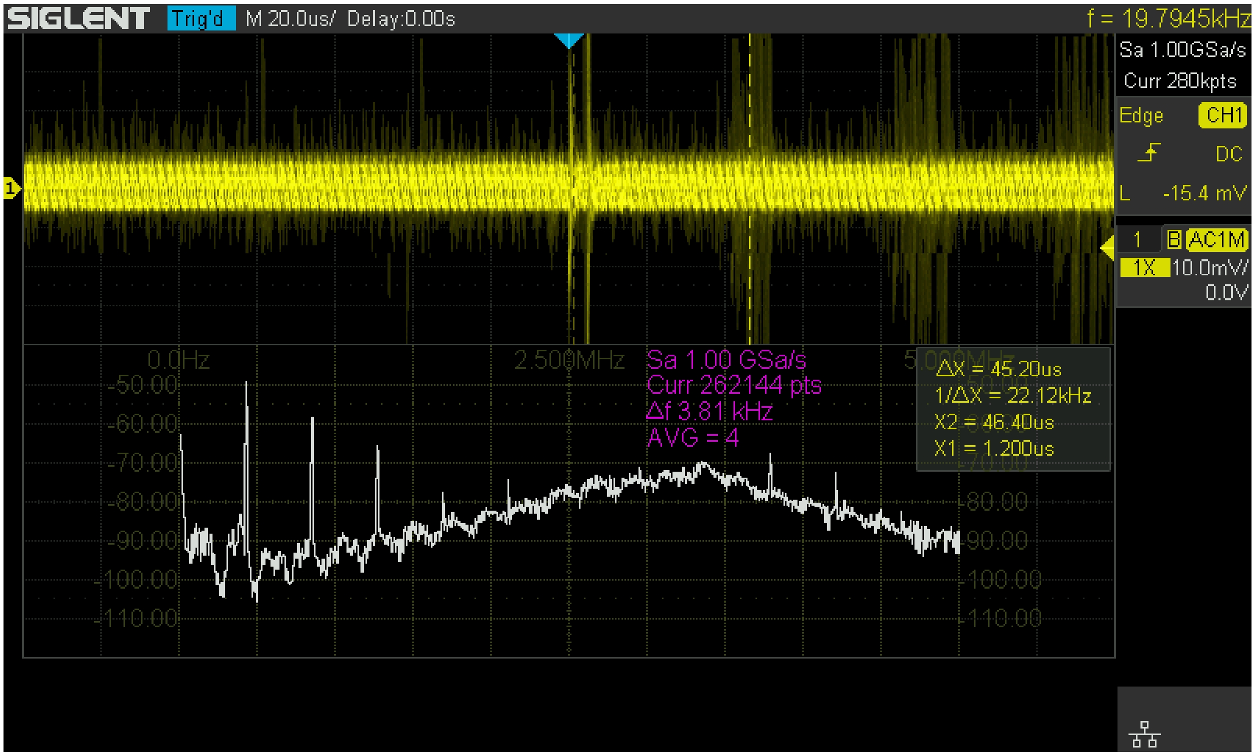

Figure 4 ADI LTC 7151 with 110 mA load

The large peak around 430 kHz is -50 dBV. Adding the same filter as used in the CUI module example reduces this peak to -75 dBV.

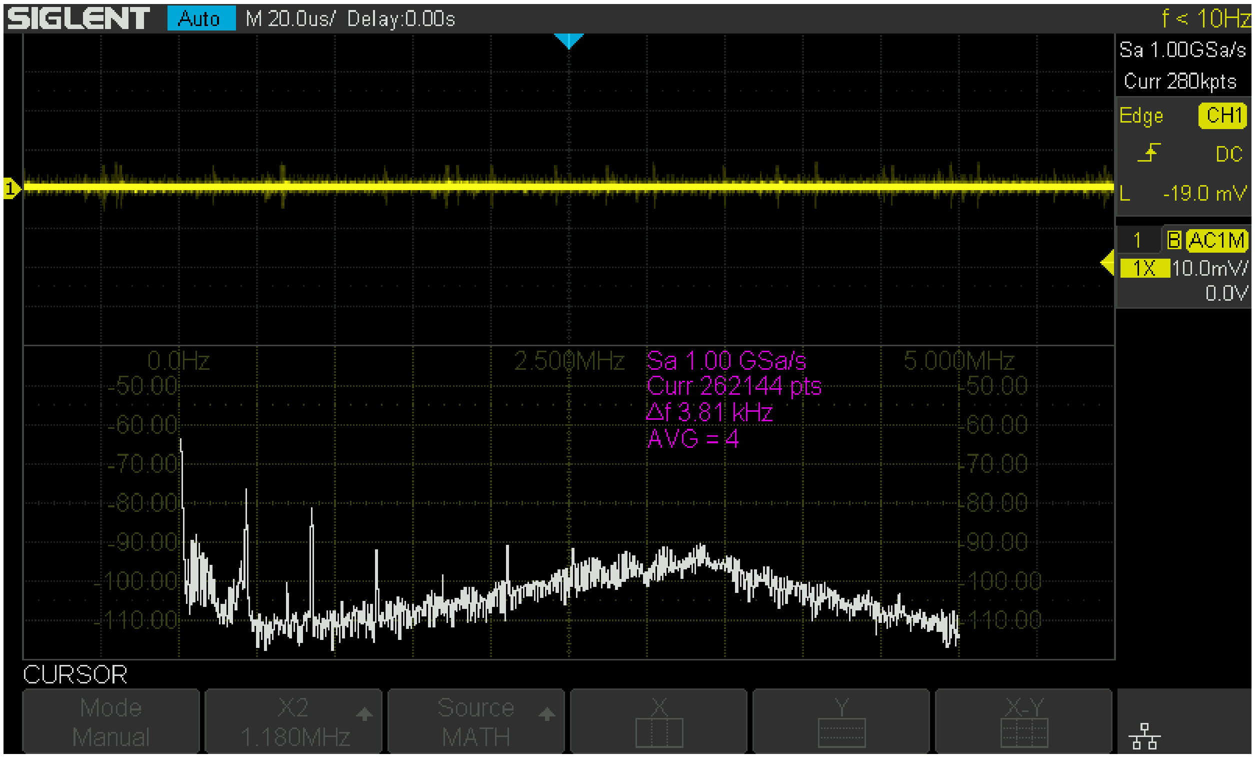

Figure 5 ADI LTC 7151 with filter and 110 mA load

This filter also helps in the audio band as well.

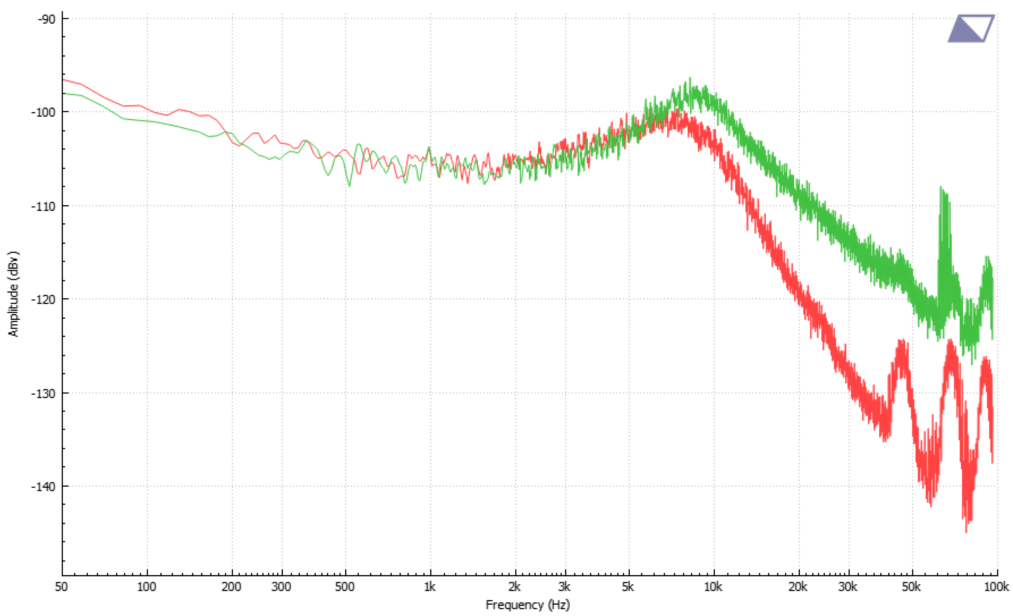

Figure 6 LTC7151 without extra filter (Green) and with filter (Red)

The RMS noise in an 88 kHz bandwidth for the LTC7151 with 100 mA load is around -72 dBV without the filter and improves to -75 dBV with the filter.

2.1.2 CUI VXO7803-1000 ON CLOCKWORKS PWR001 BOARD

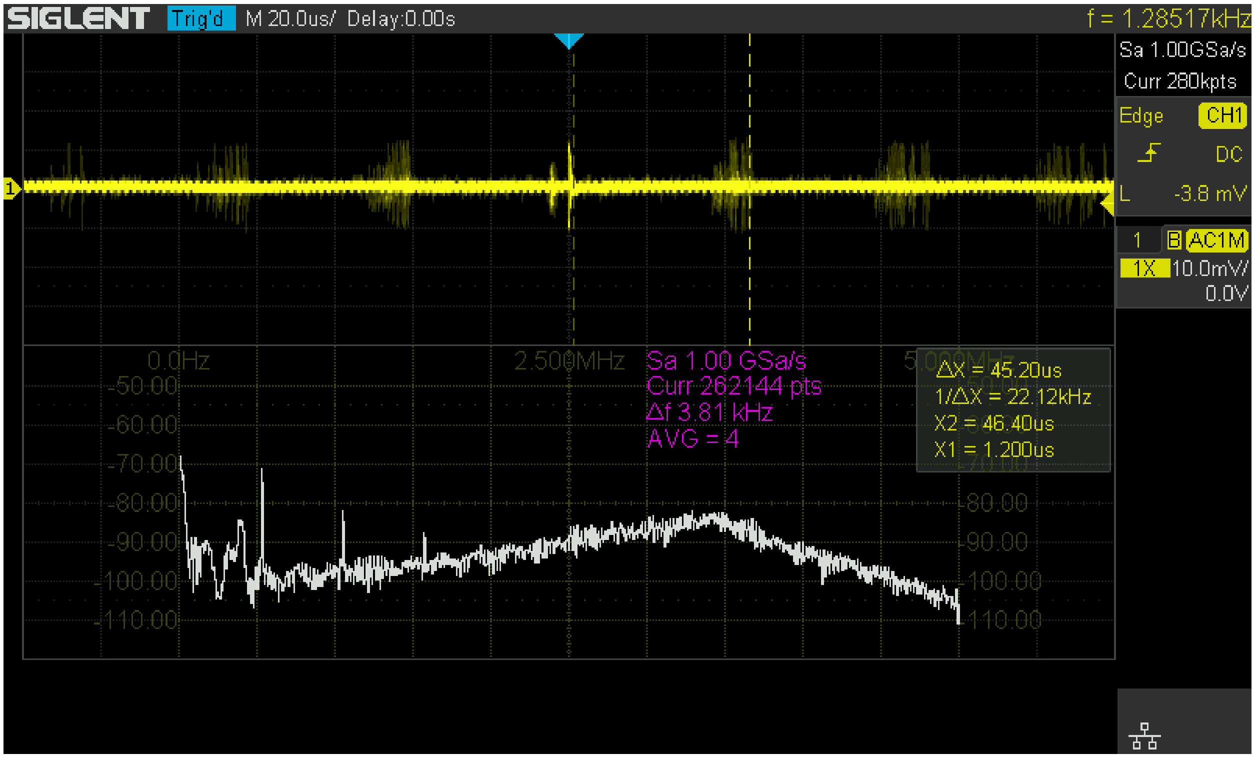

Figure 7 CUI module with 110 mA load

The CUI module on the PWR001 board includes the 10uH/100uF filter, so Figure 7 can be compared with Figure 5 and Figure 9. RMS noise in a 88 kHz bandwidth is -68 dBV.

2.1.3 MURATA OKR-T/3-W12-C ON CLOCKWORKS PWR002 BOARD

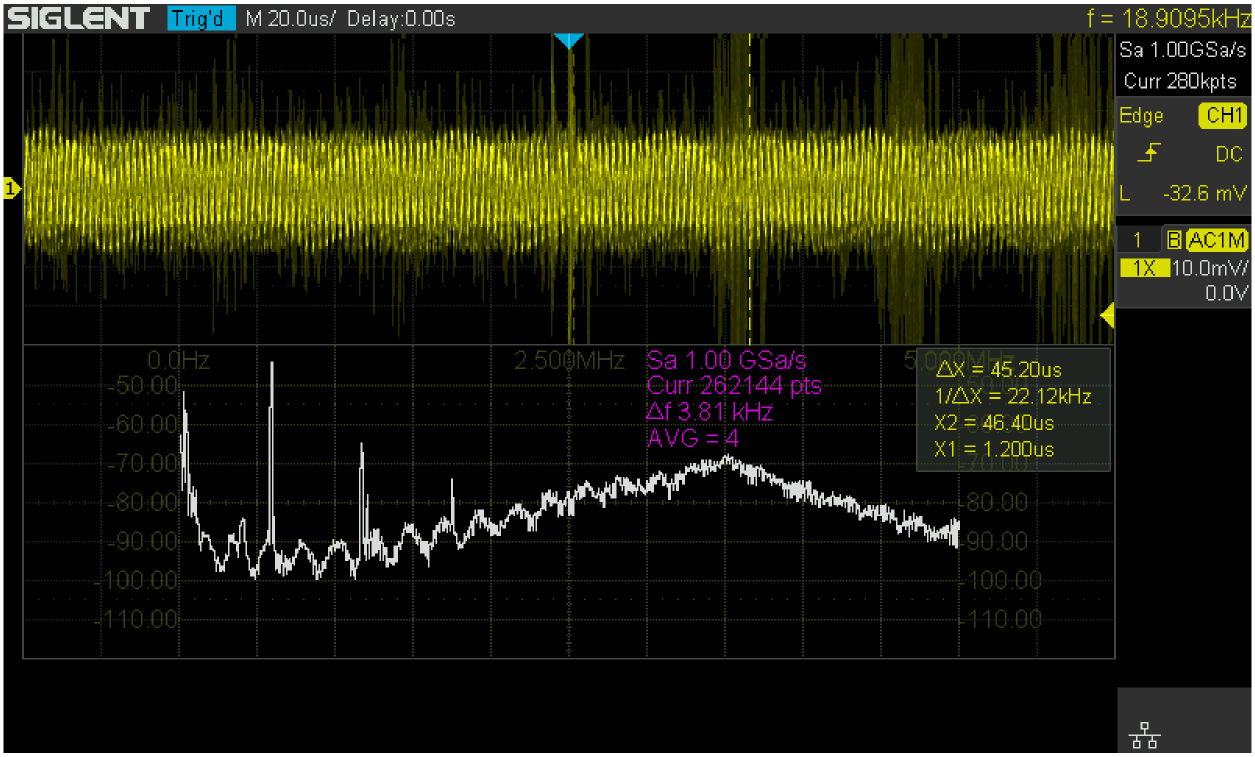

Figure 8 Murata module with 110 mA load

The largest peak is around 580 kHz at -45 dBV. With the same 10 uH/100uF filter added this peak is reduced to about -75 dBV (Figure 9).

RMS noise with no filter (88 kHz bandwidth) is -50.5 dBV. With the filter that improves to -62 dBV,

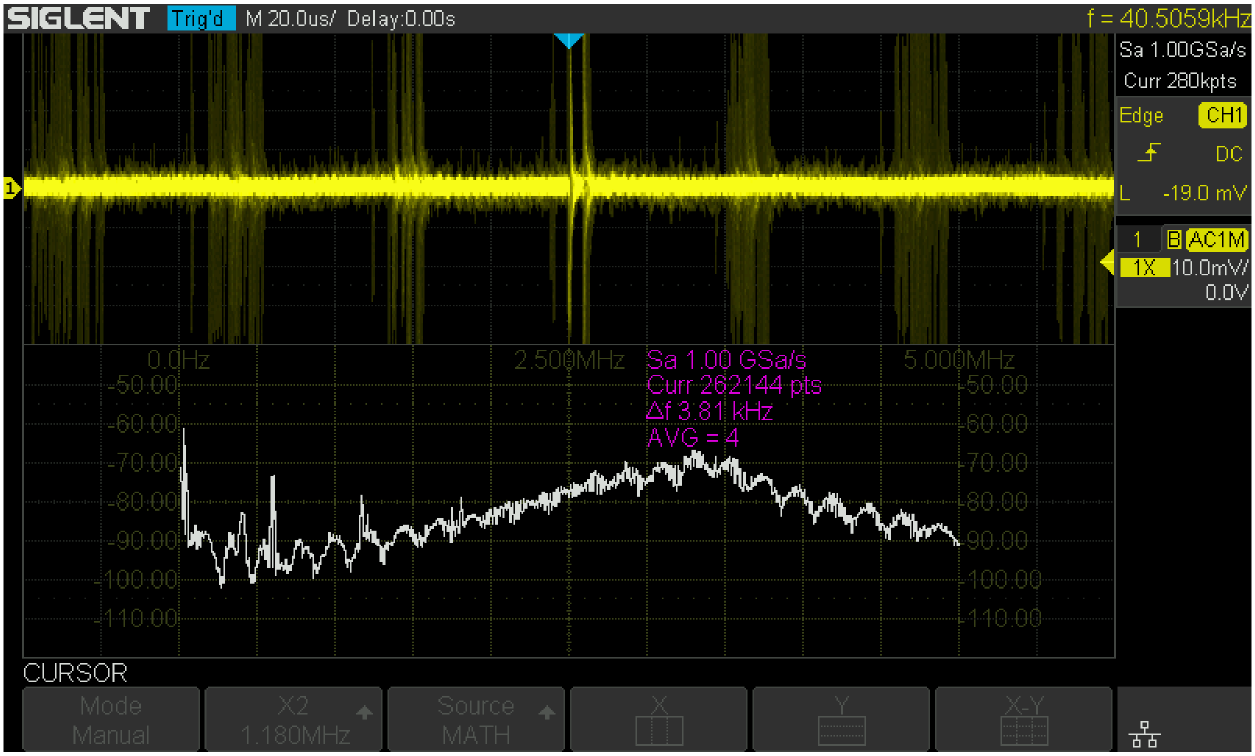

Figure 9 Murata module with filter and 110 mA load

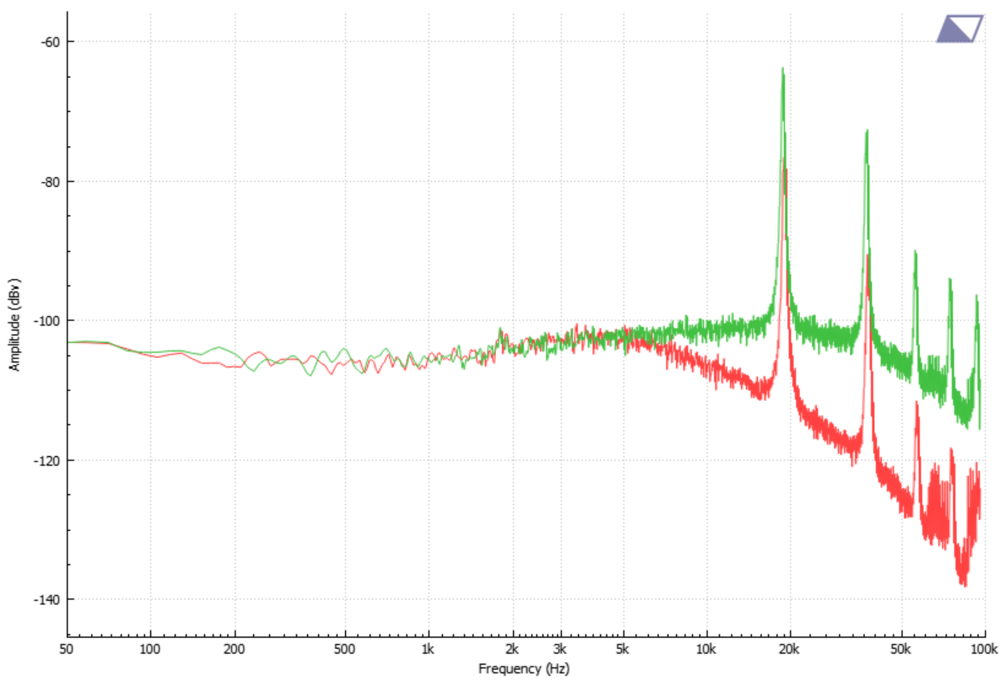

Figure 10 Murata module without filter (Green) and with filter (Red)

2.2 825 MA LOAD

As with the 110 mA case shown in Figure 3, the LTC7151 remains the least noisy supply.

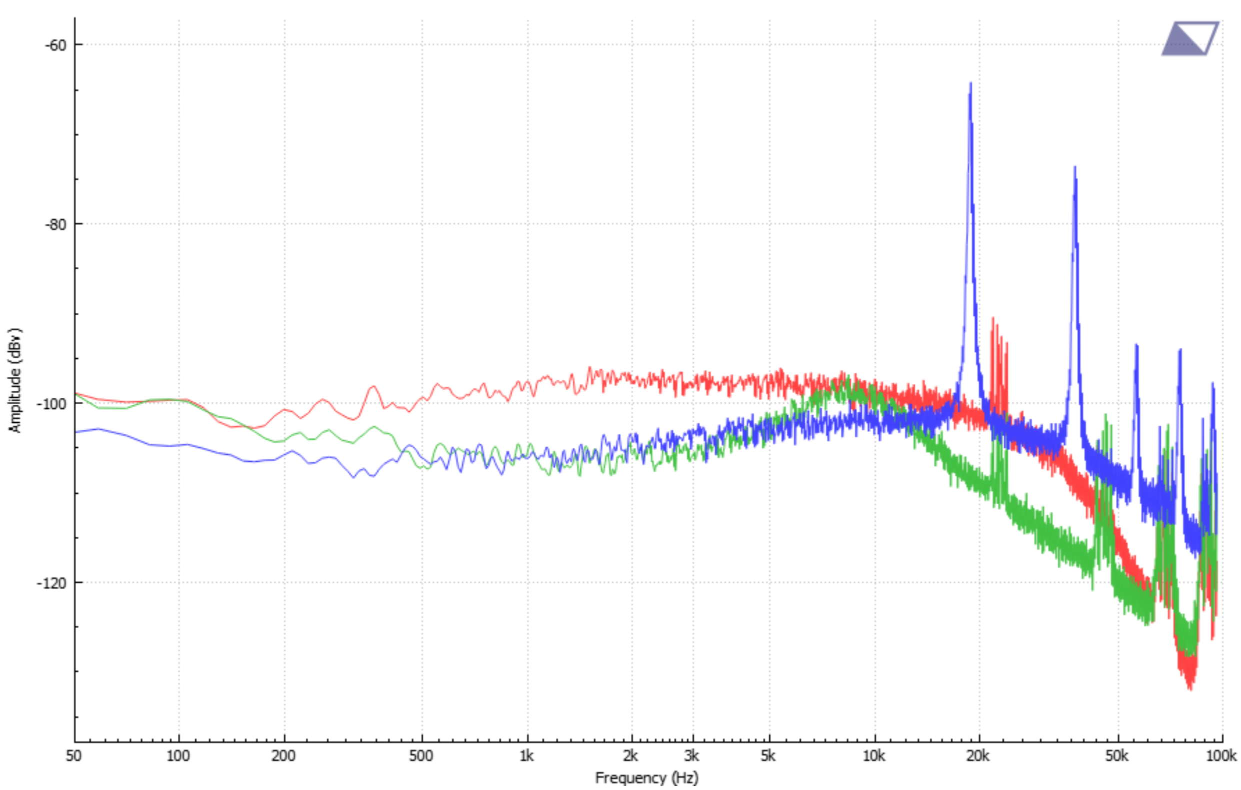

Figure 11 825 mA load LTC7151 (Green), CUI 1A module (Red), Murata 3A module (Blue)

The broader spectrum of the 3 modules were captured as well with the scope. The spectrum does not change much between the two load cases.

2.2.1 LTC7151 ON ADI EVAL BOARD

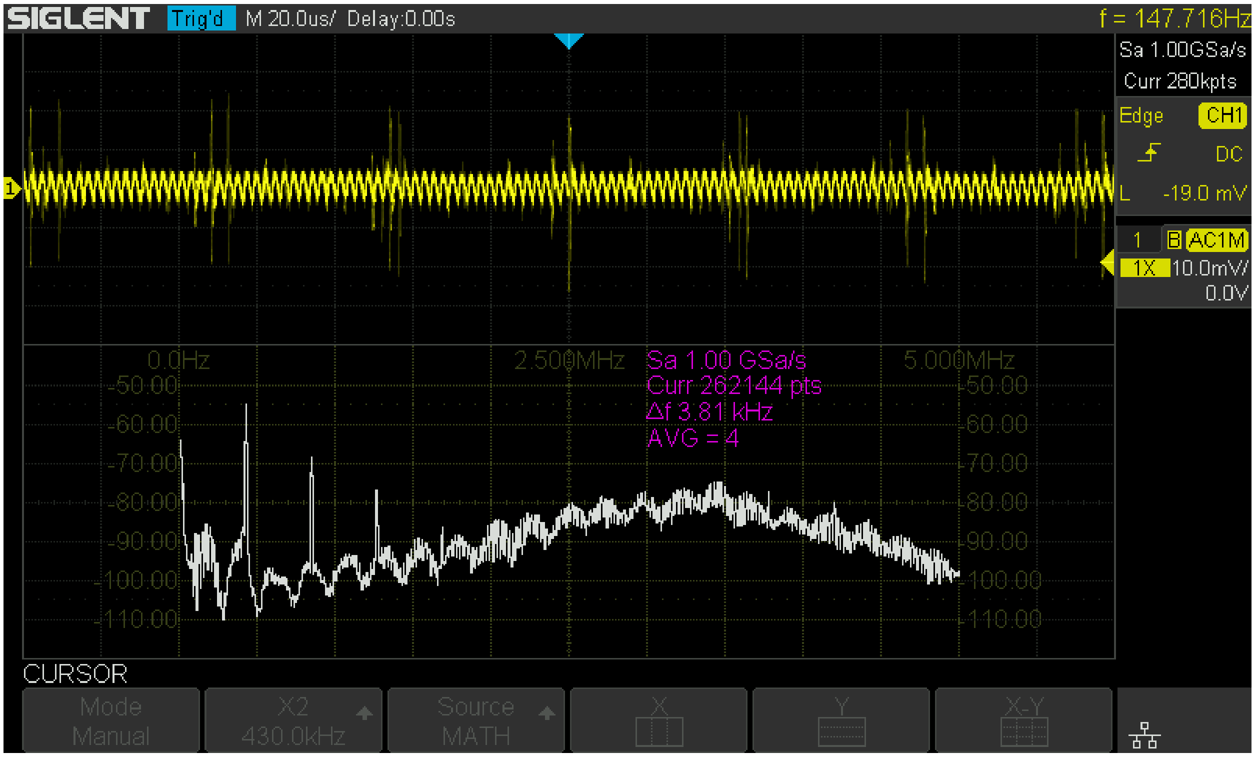

Figure 12 825 mA load on LTC7151

2.2.2 CUI VXO7803-1000 ON CLOCKWORKS PWR001 BOARD

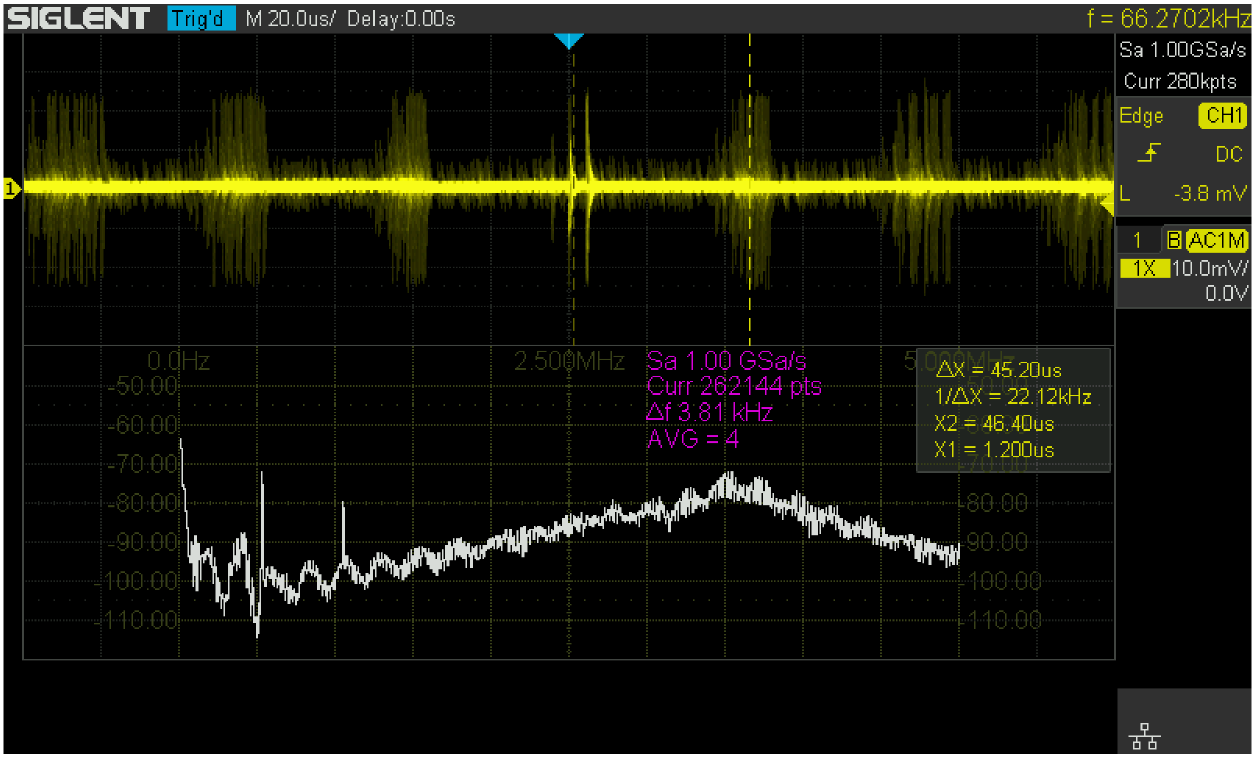

Figure 13 825 mA load on CUI module

2.2.3 MURATA OKR-T/3-W12-C ON CLOCKWORKS PWR002 BOARD

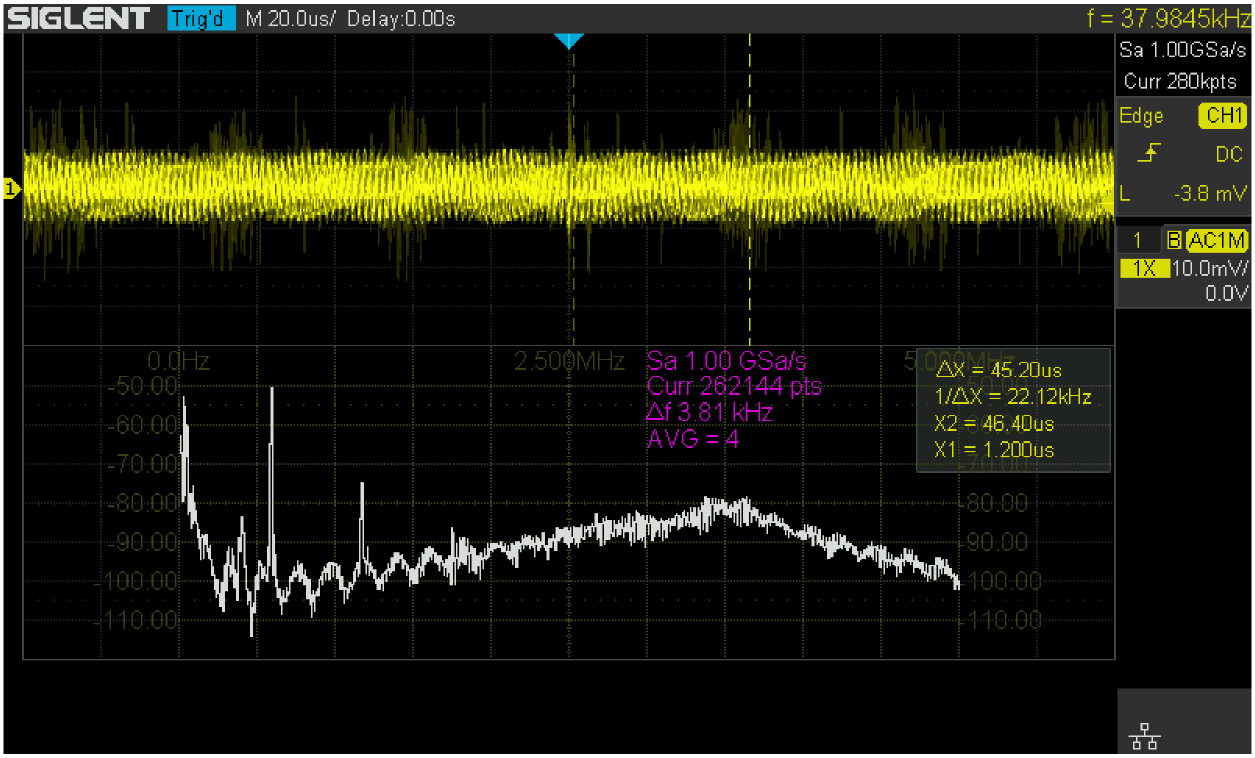

Figure 14 825 mA load on Murata module

2.3 1.65 AMP LOAD

The CUI module is limited to 1 amp so does not appear in the higher current tests.

The LTC7151 remains quieter across the audio band (Figure 15) than the Murata module (compare with Figure 3 and Figure 11).

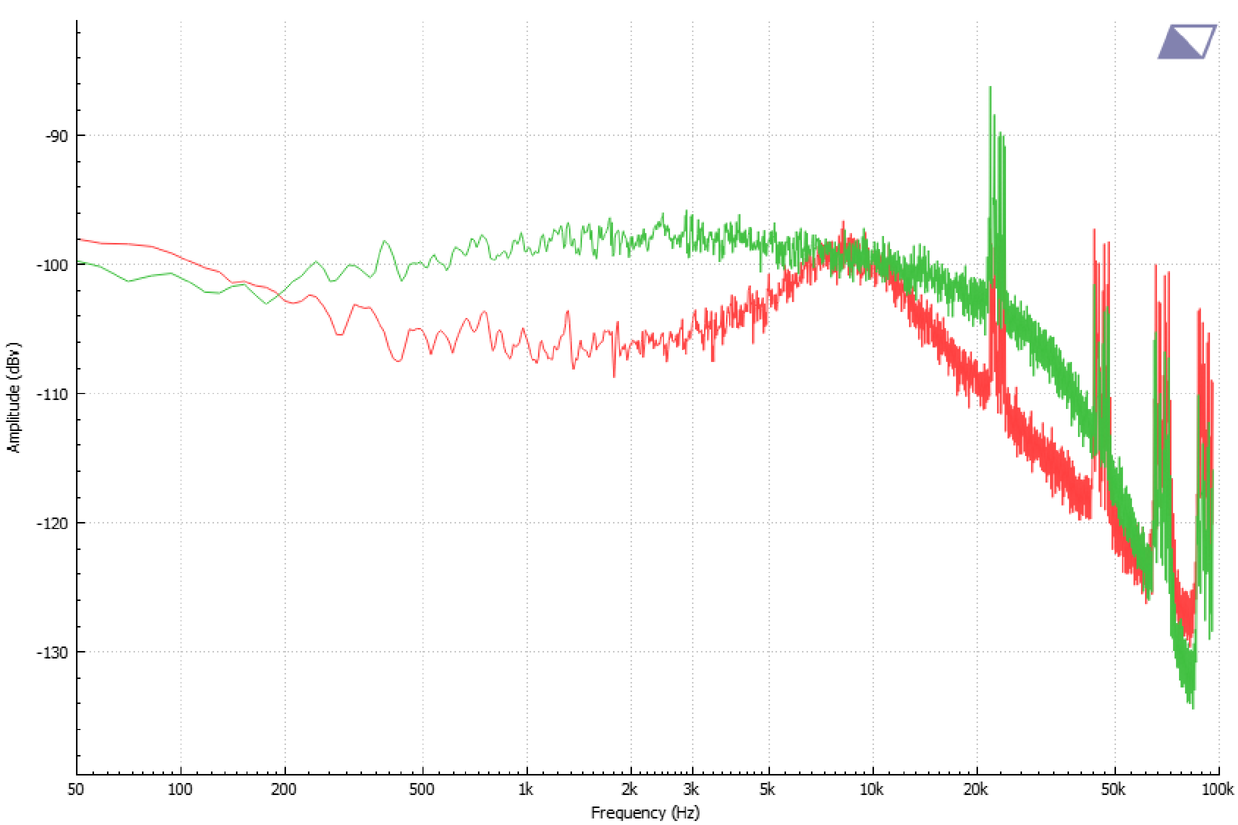

Figure 15 LTC7151 (Red) and Murata module (Green)

2.3.1 LTC7151 ON ADI EVAL BOARD

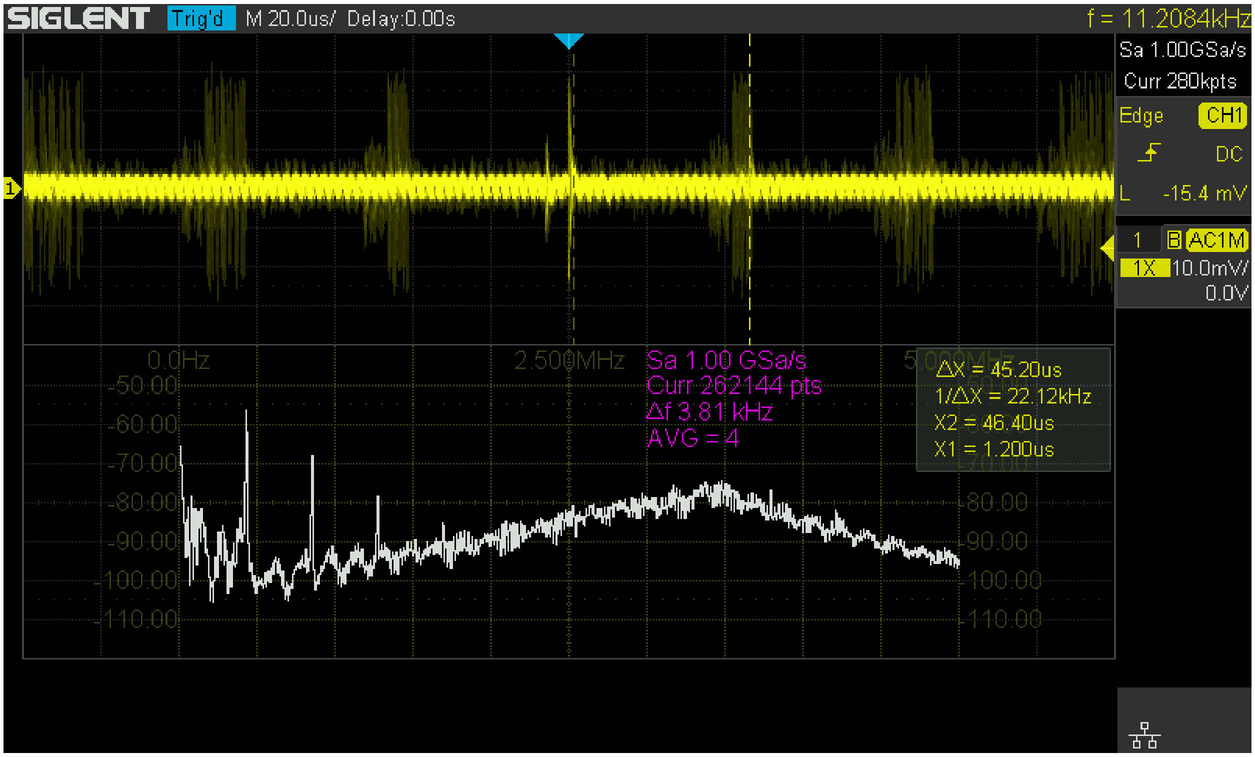

Figure 16 LTC7151 with 1.65 amp load

2.3.2 MURATA OKR-T/3-W12-C ON CLOCKWORKS PWR002 BOARD

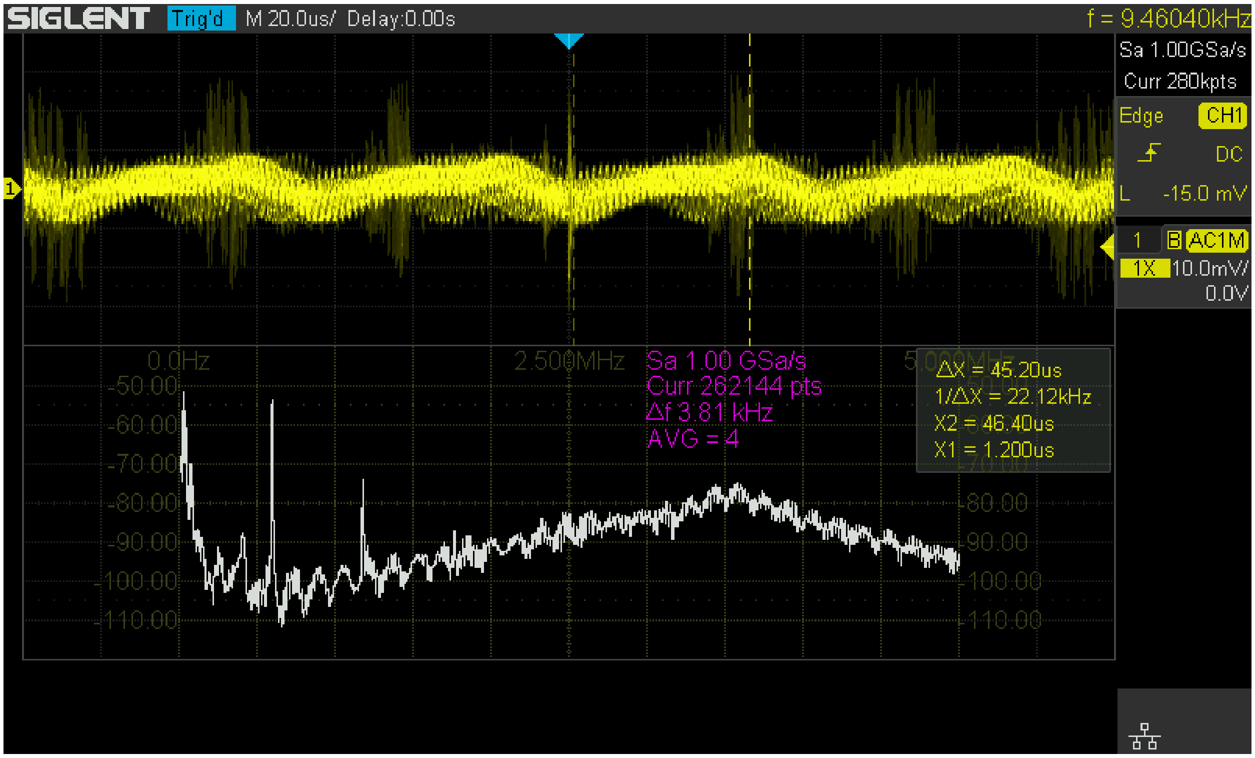

Figure 17 Murata module with 1.65 amp load

2.4 4.25 AMP

The last test case can only be done with the ADI LTC7151. Figure 18 compares the 4.25 amp load case with the 110 mA load case; the general noise floor shape is about the same, with the change in switching characteristics with load current manifesting itself with the broad peaks.

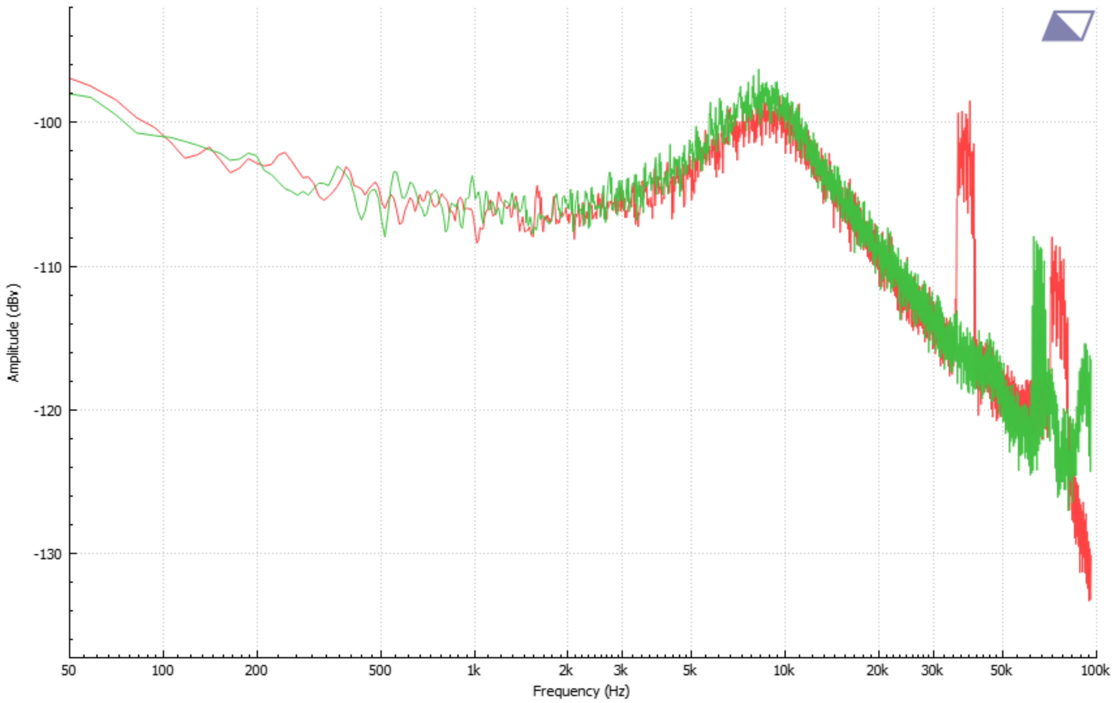

Figure 18 LTC7151 with 4.25 amp load (Red) and 110 mA load (Green)

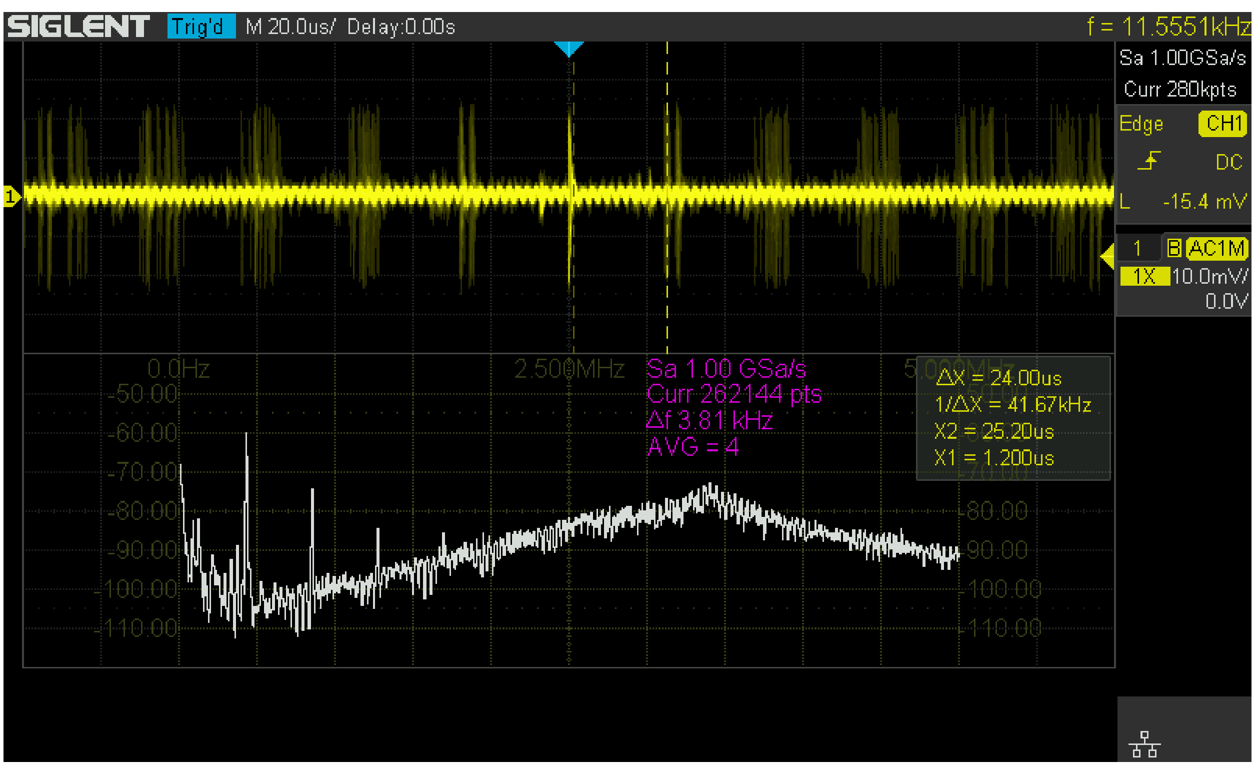

Figure 19 LTC7151 with 4.25 amp load