Idea:
Schedule DOCSIS 3.1 Transmissions to Avoid Switching Regulator Noise

CableLabs has built a research tool called the Joule Tool. It captures upstream full-band time waveforms and integrates the energy over a selected frequency band for a period of 40us. See attached power point presentation on the idea. The reason for this testing strategy is to determine the interference during a 40us OFDMA symbol transmission in any receiver band. An upstream OFDMA receiver in a headend will use a FFT that spreads an impulse's energy to all subcarriers.

The Joule Tool reveals that there frequently seem to be statistically two noise floors on the blue histogram, which is associated with a full-band capture. One is with the switching regulators on, and one with the switching regulators off. Because of the AC power and the conduction angle of the full wave bridges in compact florescent (CF) and LED lamps, switching noise drops 120 times a second, then crests again.

The humps on the right side of the blue historgram are associated with the number of simultaneous upstream carriers being used, usually 1 to 3 (or 4).

So if the CMTS schedules packets to come at the quiet time they can have a higher modulation order and be received without error. (There is about 6dB energy difference between in peaks on the histogram). If we schedule the packets to come in while noise is strong, lower modulation order or more FEC should be used to preserve signal integrity.

Note that up around 30MHz (purple curve) this reduces to one noise hump on the left. So switching regulator noise is stronger at the low end of the band.
Note that other sources of noise, such as BPL (broadband over power lines) or HomePlug would not necessarily be correlated to the AC line frequency.

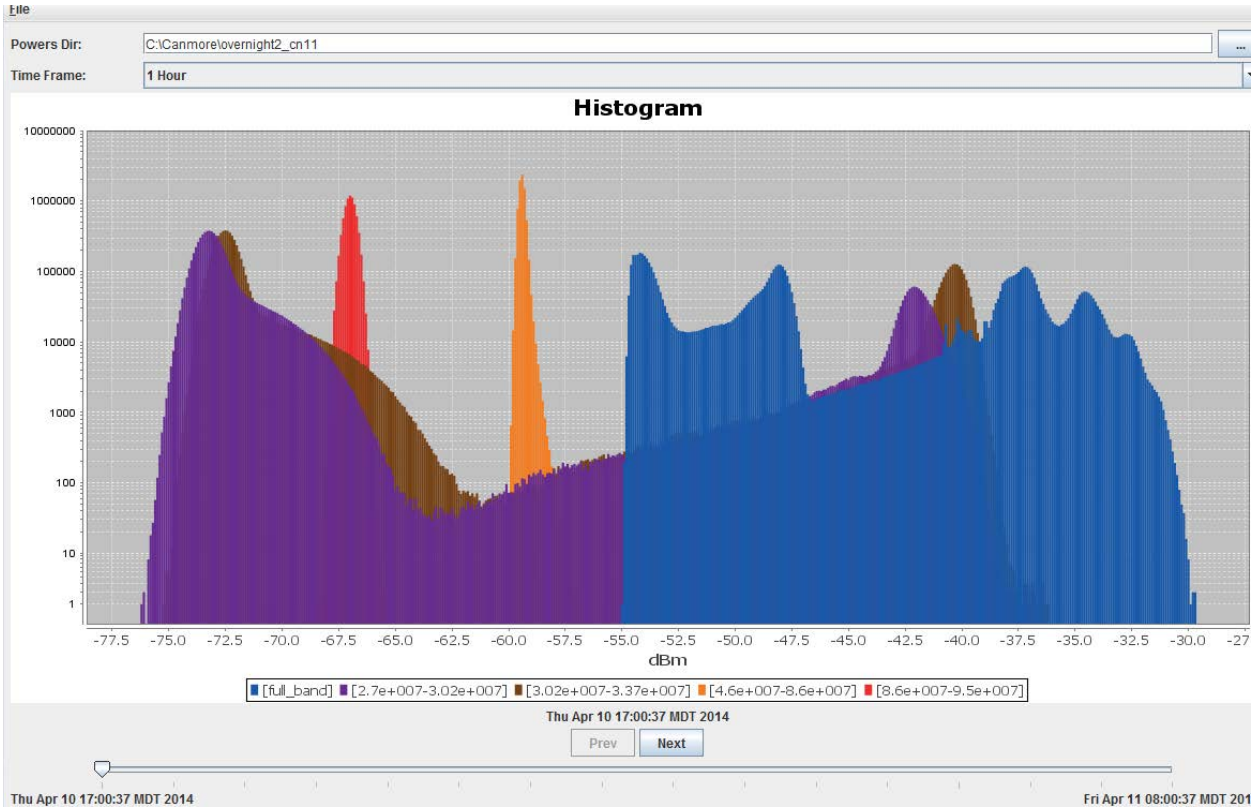


Fig 1. Joule Tool histogram showing 2 noise floors on the full-band capture (in blue). The far-left one is mostly background noise and the right one, 6dB to the left, is mostly switching regulator noise.

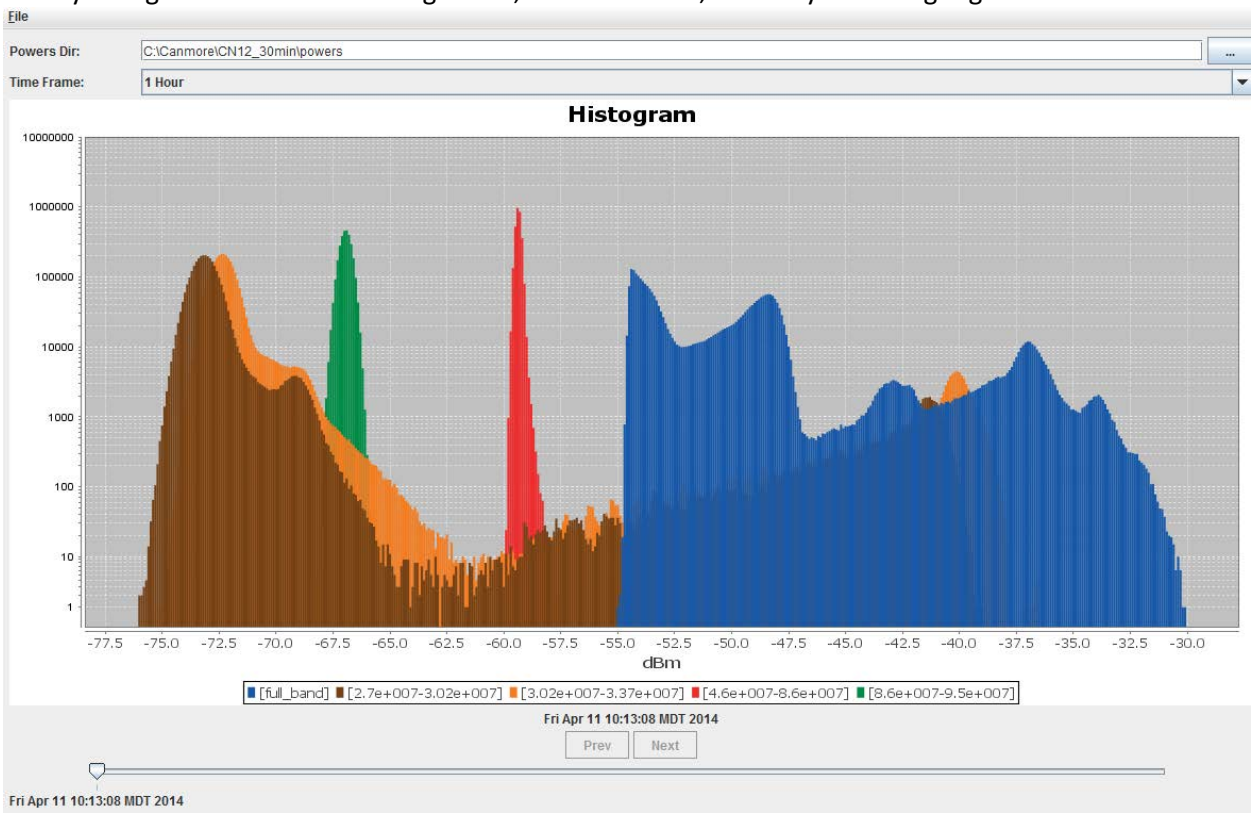
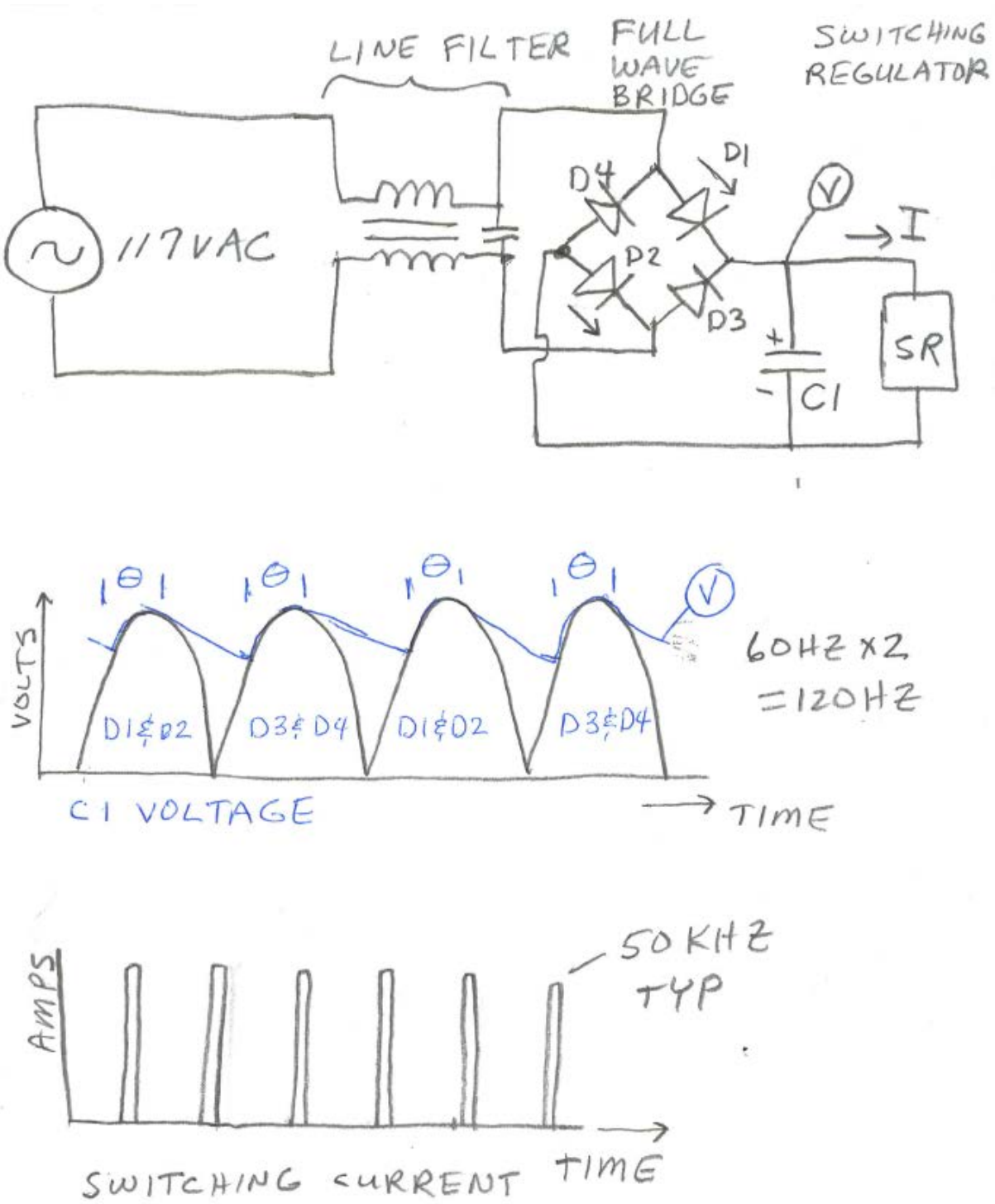


Fig 2. A different node with same 2 hump noise floor.



Schematic diagram showing how switching power supplies work. Switching noise passes through the diodes D1-D4 best during the conduction angle, Θ.

Joule Tool Browser (JTB)

PNM

Tom Williams

April 2, 2014

Joule Tool

- C++ program that runs on a PC unattended for long term tests
- Triggered or immediate data capture and analysis
- Goal is to process captures quickly to get maximum upstream full-bandwidth monitoring time
- Currently at 7% of full-time
- Has 5 programmable digital filters for energy integration
- Optionally captures trace file for use by JTB
  - Interesting (high energy in some band)
  - none
  - all

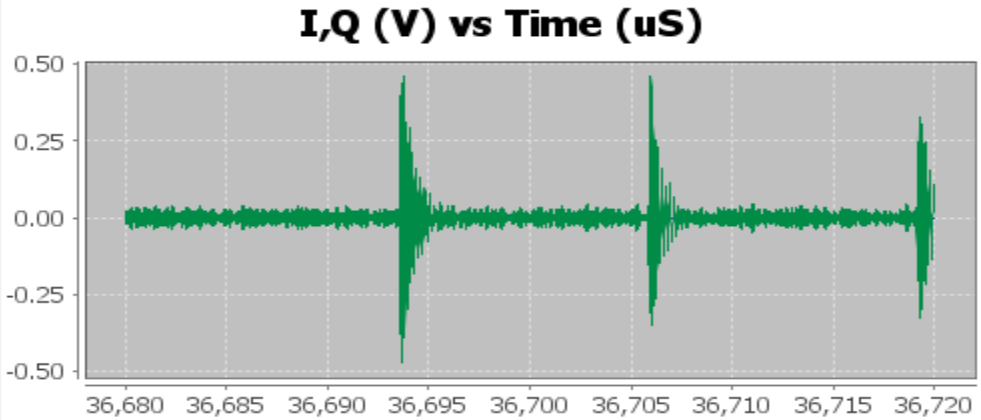
NI PCI-5124 DAQ Card Inside PC

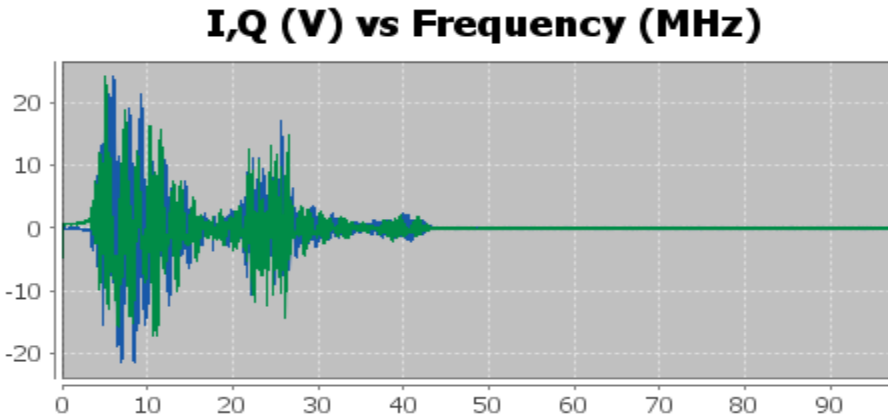
Joule Tool Browser

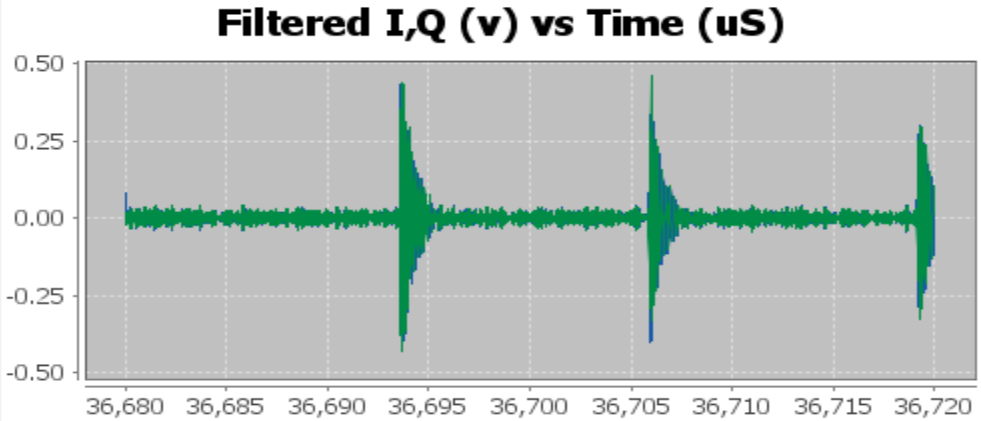
- Java software to look at traces captured by NI-PCI5124 card that are “interesting”
  - Clipping
  - Cross-compression
  - Find new sources of interference
  - Show upstream loading
  - Show upstream headroom
- Only has one programmable filter before digital integrator
- Also can process traces from LeCroy digital O-scope

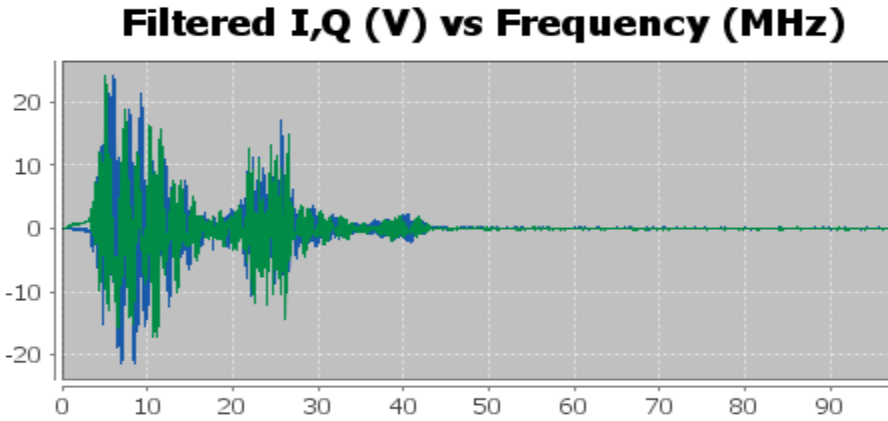
LeCroy HDO-6104 Digital O-Scope

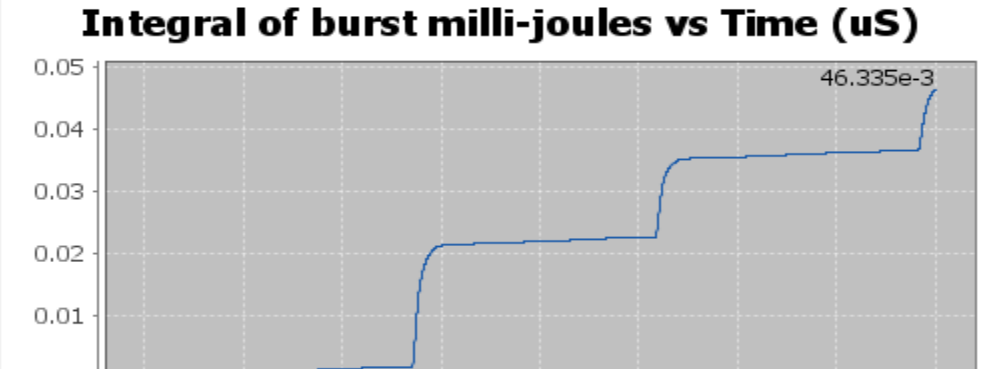
Noise Burst Landing on DOCSIS Transmission @23MHz

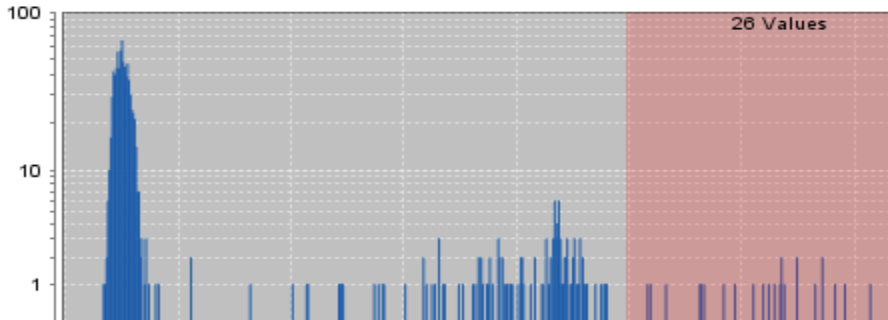




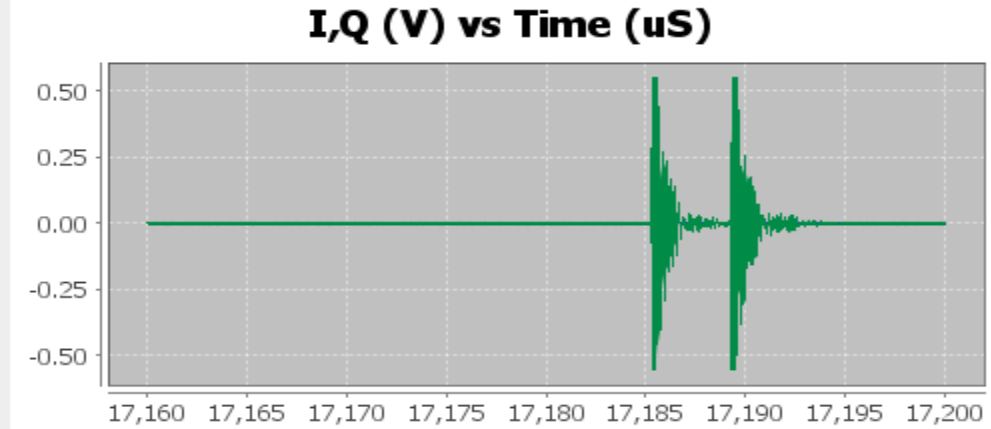


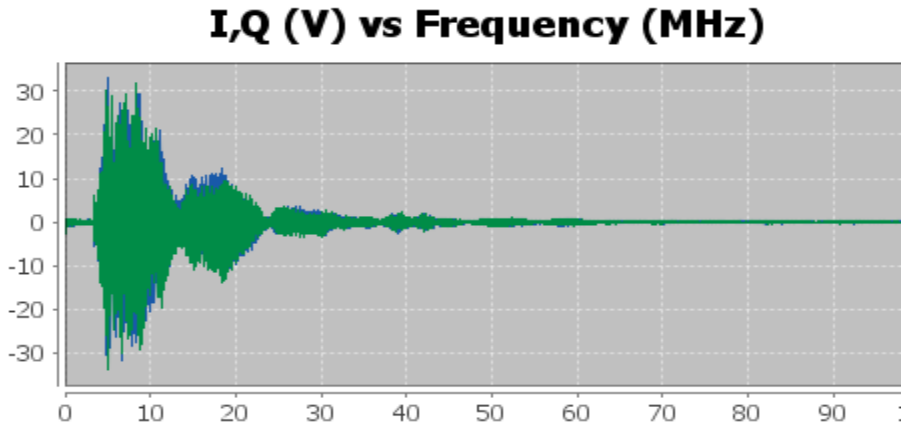


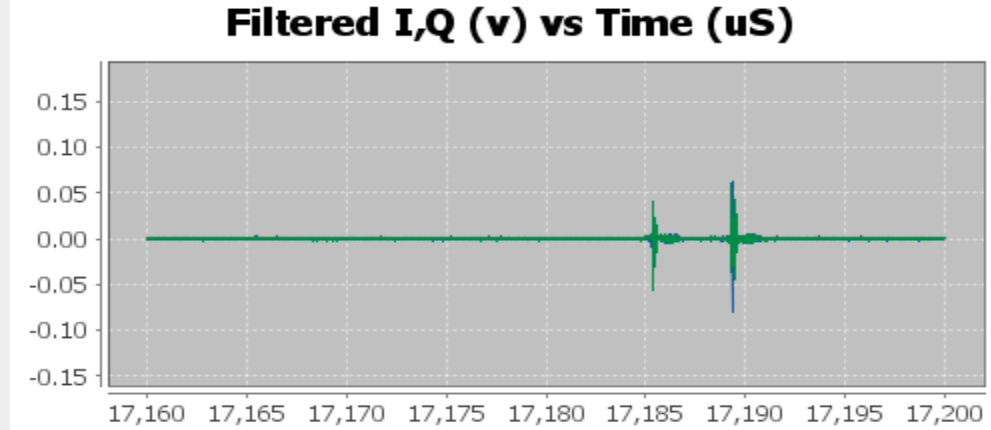


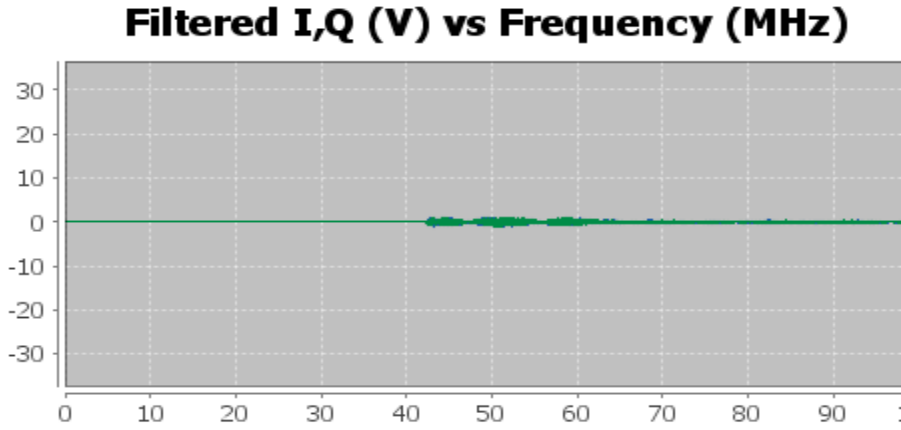


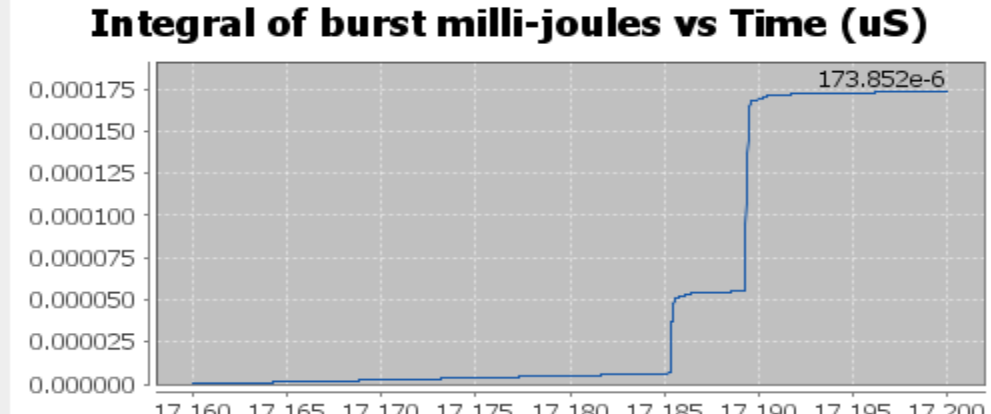
Clipping Event Revealed by Harmonics >42MHZ

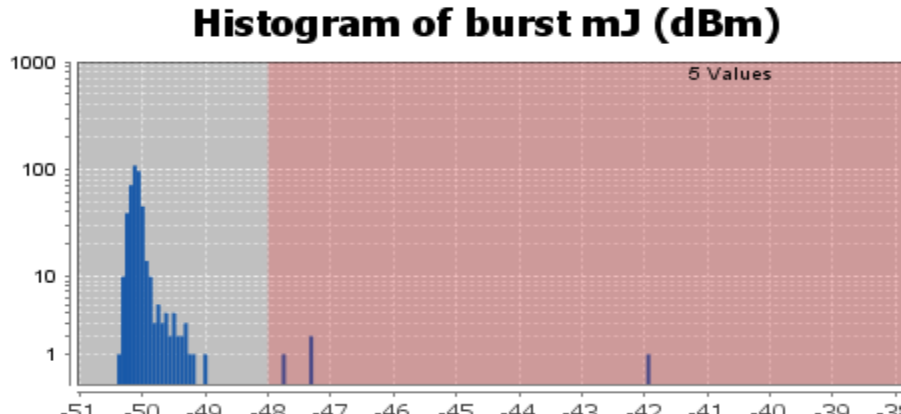




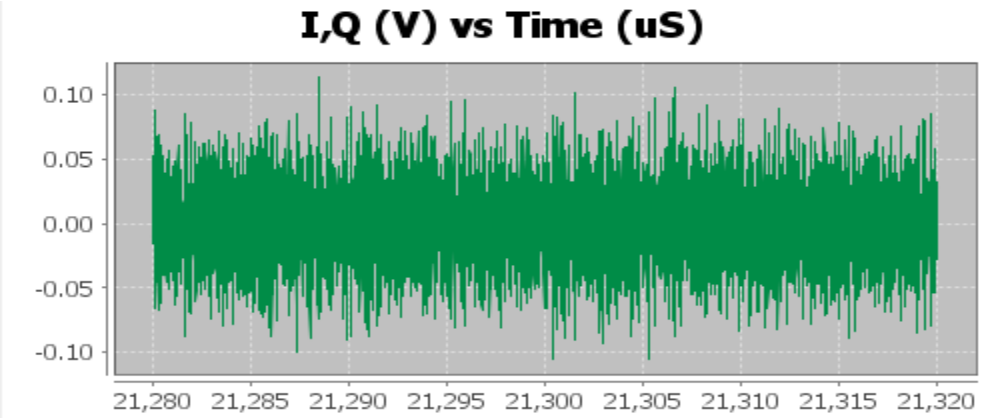


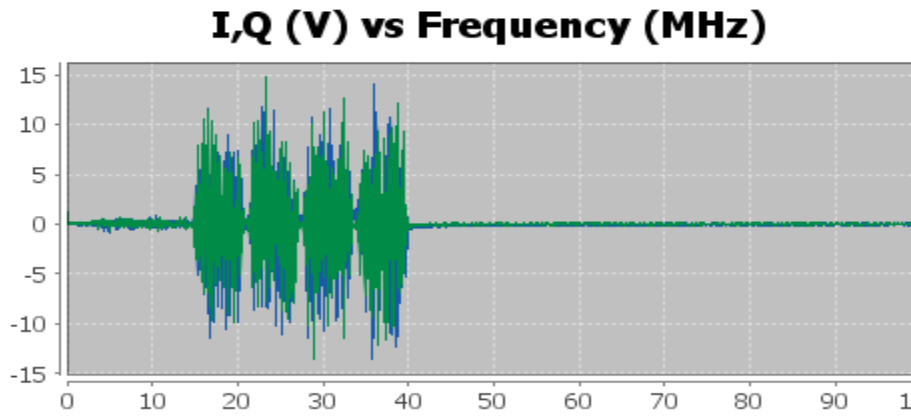


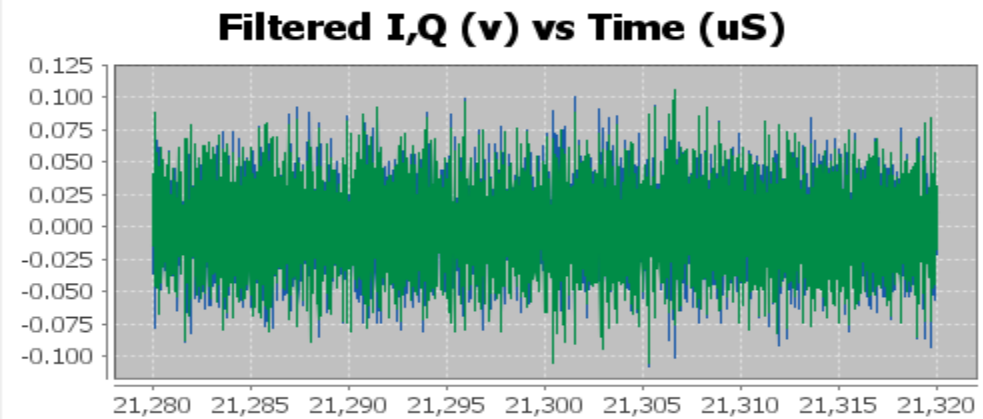


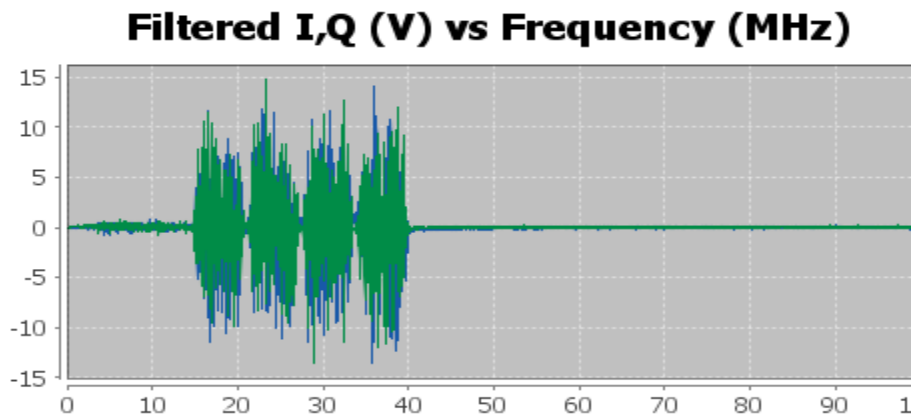


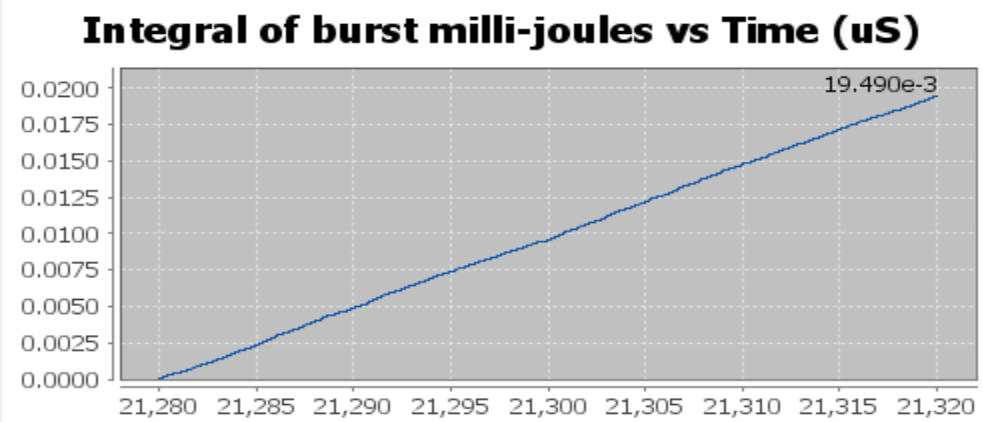
5 Histograms Showing 0-4 Carriers

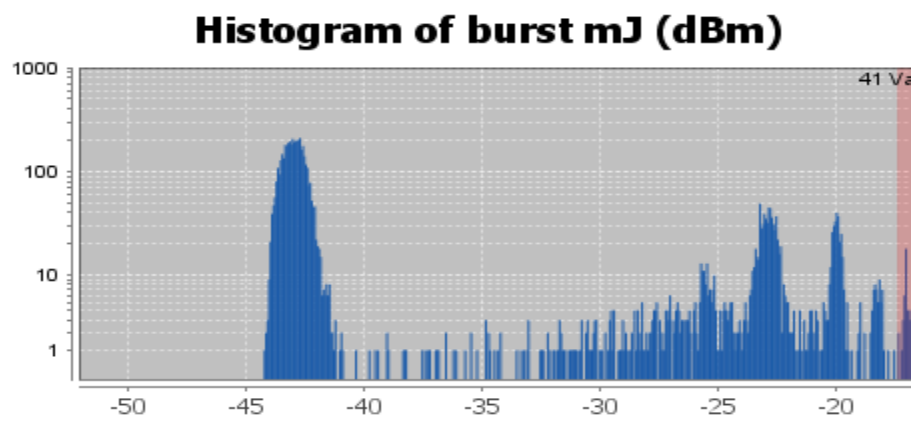




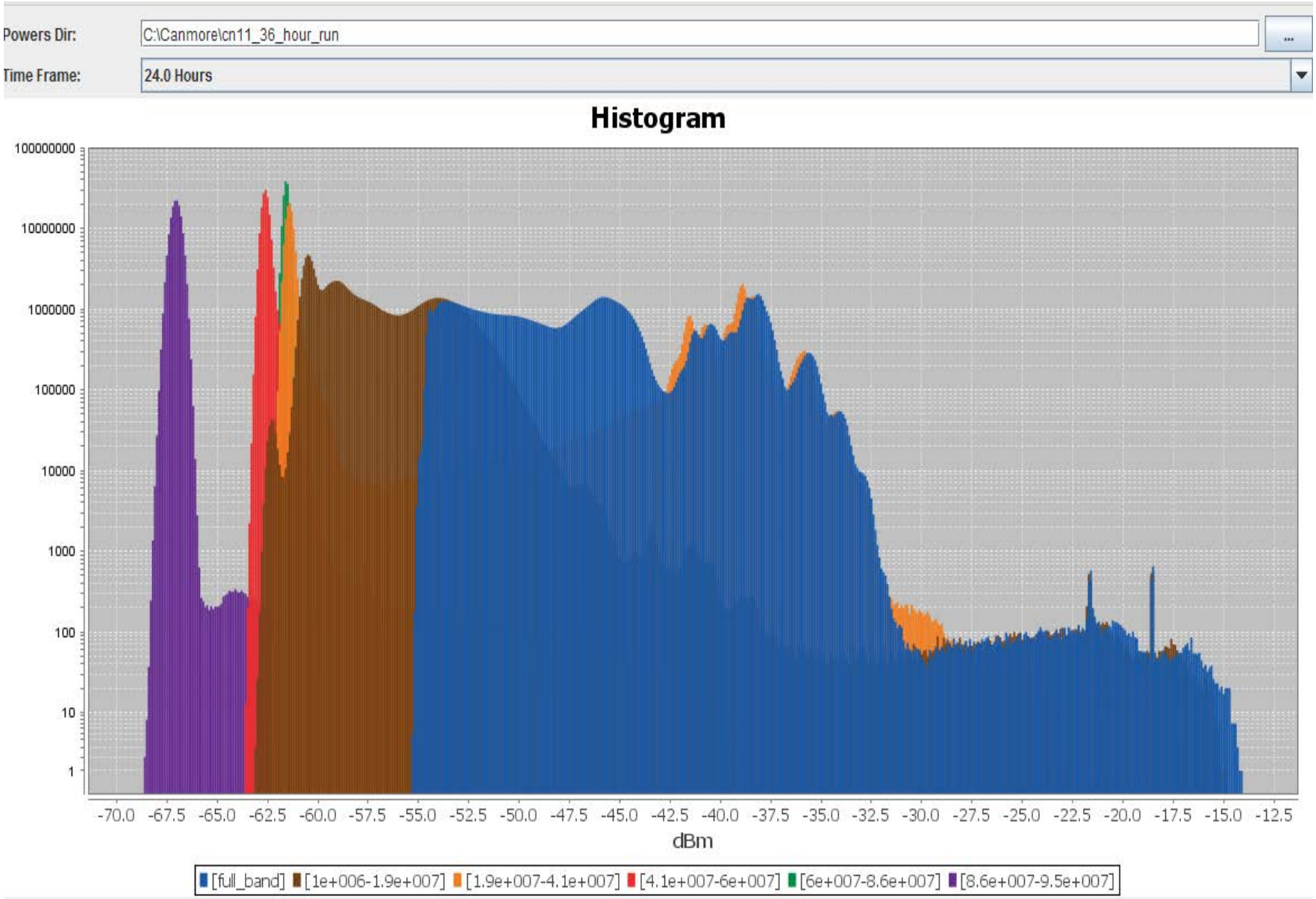








Full-Band Histogram in Blue (behaving badly)



Full-Band Histogram in Blue (well-behaved)