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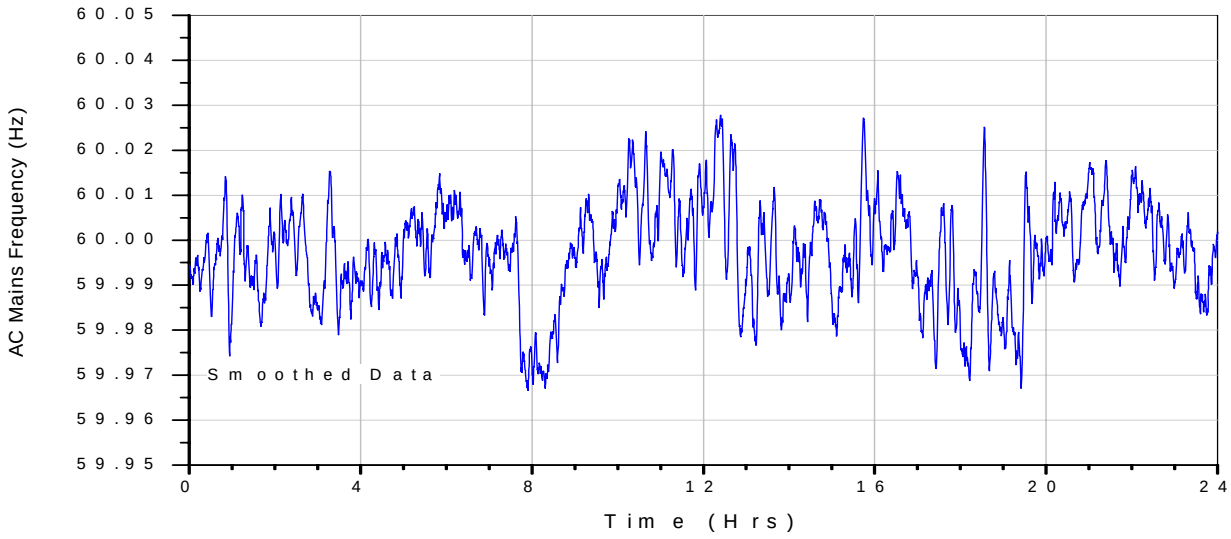
Everybody Knows About 60Hz

Everybody knows that the utility electric power frequency here in the United States is 60Hz. Like everyone, I have pretty much taken this for granted. A recent bit of work involving 60Hz/harmonics interference prompted me to take a closer look at the actual power line frequency and its stability.

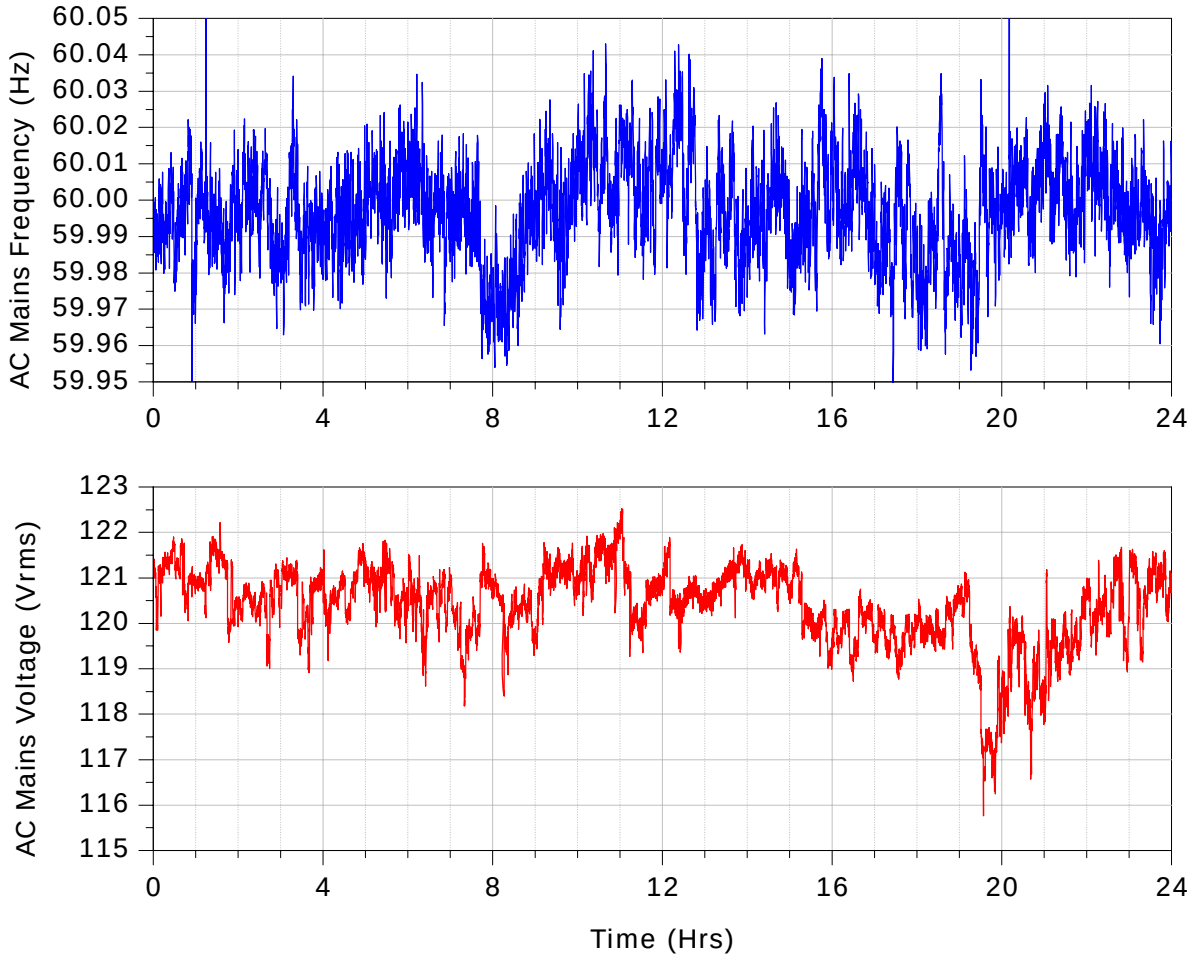


The remainder of this tech note presents the results of my quick look at the frequency of the electric power mains.

Since I am involved in the electronics (not power) industry, I tend to forget that the bulk of our electrical power comes from mechanical power generation. The frequency of the voltage delivered is affected by the balance of the power in-to/out-of the generators connected to the electrical grid. For a generator with fixed mechanical input power, an increase in the electrical load will result in a drop in frequency. Control systems are used to modify the mechanical input power to the generator to maintain the desired frequency output.

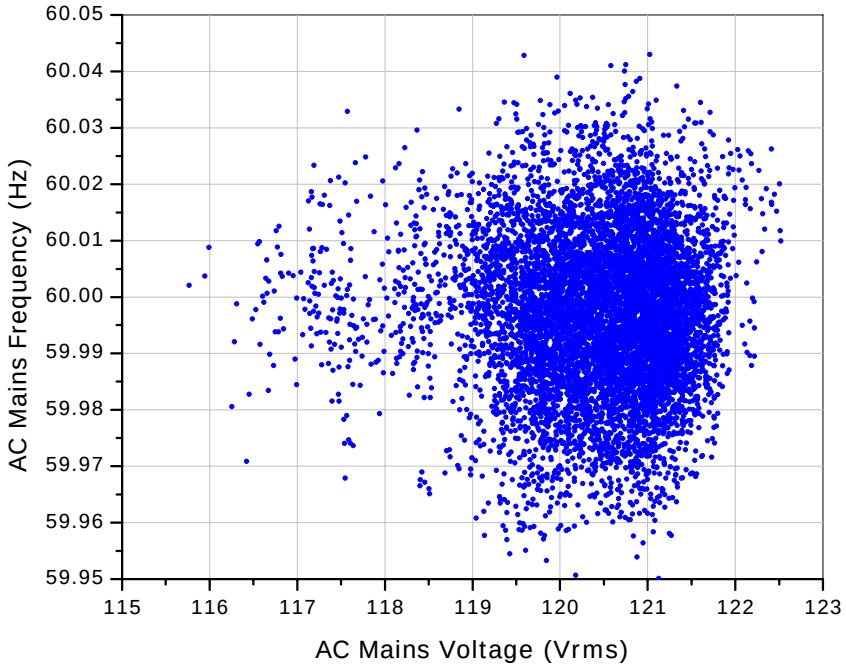
A quick web search turned up a few helpful pointers, [1], [2]. In [1], the authors state that the North American AC mains frequency normally remains within ±0.05Hz of the 60Hz nominal.

So, as a quick check, I monitored the AC mains frequency. Since we know of a relationship between mechanical input power and electrical output power, I also monitored the mains voltage as well. A 24 hour weekday datalog, start time of 11:30AM, of the electrical power frequency and voltage at my location plotted:

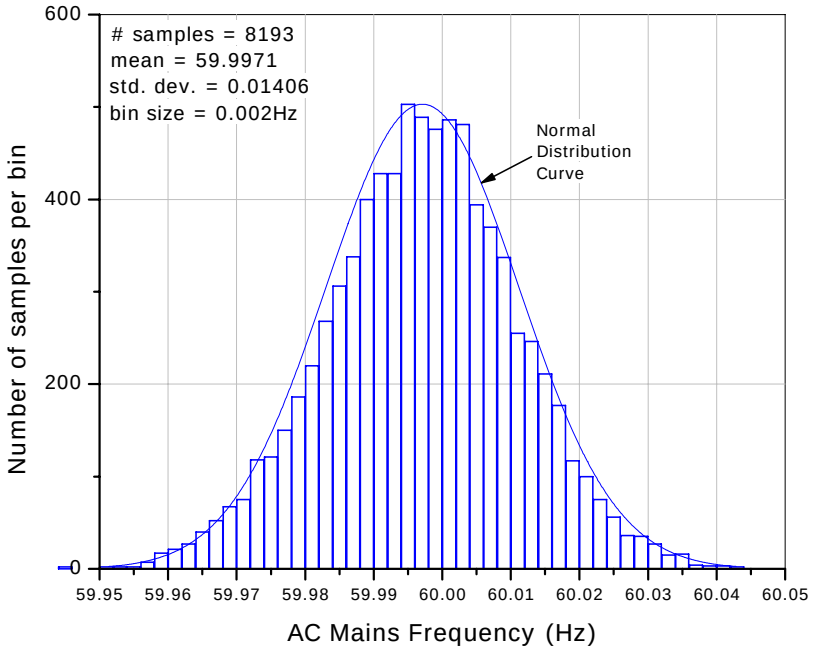


Note: The frequency was measured using a ten second gate period.

At my location, there are 5 users on my side of the distribution transformer. This dramatically reduces my ability to monitor the voltage on the grid, due to local I*R voltage drops on my section of line. This is made abundantly clear from the scatter plot below, showing the measured voltage and frequency:

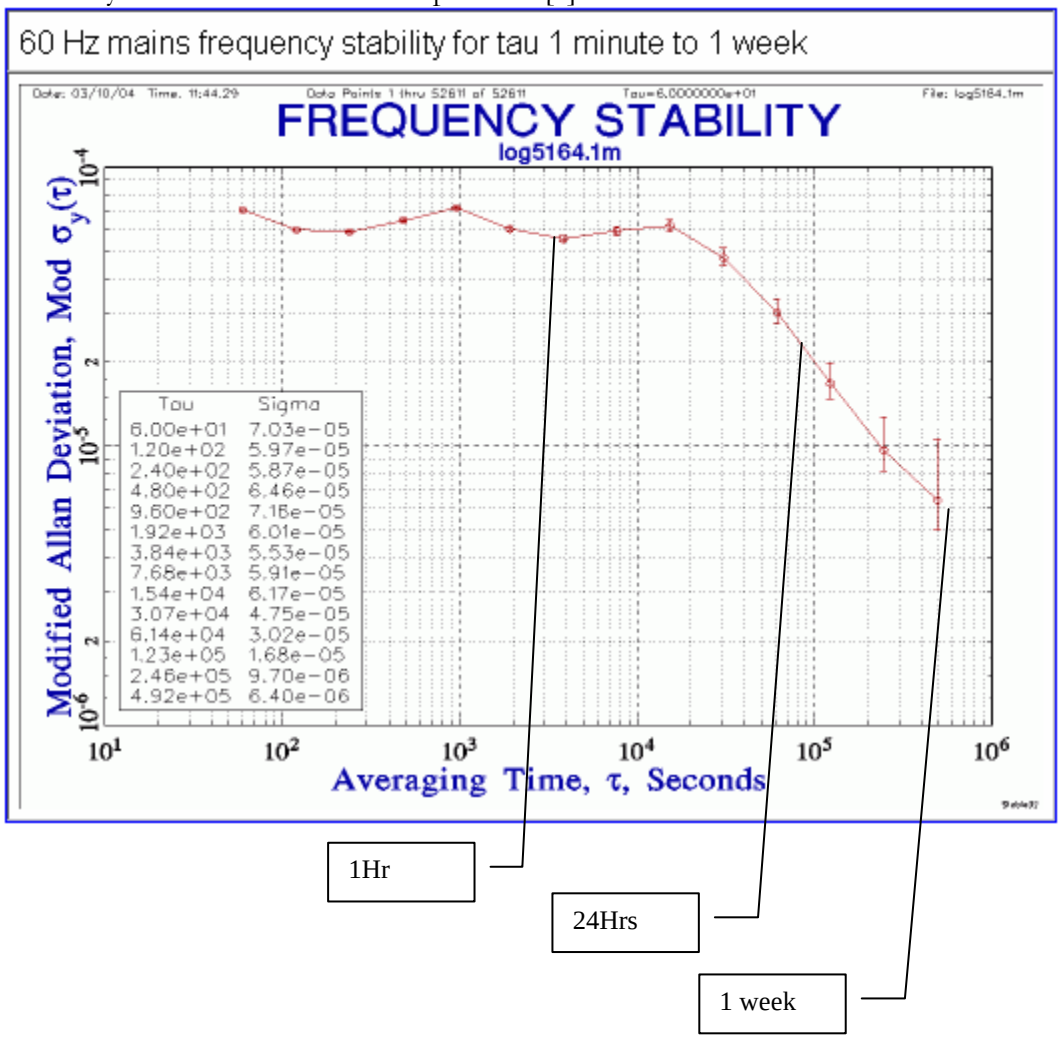


From the previously shown plots, the frequency varied during the 24 hour datalog, with no obviously identifiable patterns. When we look at the frequency samples statistically, the frequency measurements do look normally distributed:



Thankfully, I am not the only one who has taken a look at 60Hz. Tom Van Baak of Leapsecond took the time to measure the AC mains frequency over a one week time period. An Allan deviation plot provides an immediate appreciation of the 60Hz stability characteristic. In brief, not so good over a period of hours, but not too bad over a week. Of the more than 20 clocks (dedicated clocks, clocks in test equipment, etc.) here, the only synchronous motor clock that remains is on the front of a 20yr old kitchen range. It's good to know that I can trust its timekeeping when I check the time once a week.

Allan Deviation courtesy of Tom Van Baak at Leapsecond [3]:



[1] Kirby, Martinez, Shoureshi and Dagle, Frequency Control Concerns In The North American Electric Power System, Oak Ridge National Laboratory, December 2002.

[2] http://en.wikipedia.org/wiki/Utility_frequency

[3] http://www.leapsecond.com/pages/mains/