

Epistles to Michael Klemen and all good people who want to know how things work

Part I

How I measure wind speed.

by

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Dear Michael,

I am 'with you' in your interest in how things work; that is why I ended up a scientist, because I kept asking questions until I could not find anyone willing or able to answer all my questions. So I figured I should arm myself with the tools to figure things out for myself. So if at least one person beside you reads this then I figure the effort is worth it. I use a general purpose data logger, a Personal DAQ3005. I selected it because it offers a very high sampling rate and a combination of 16-bit digital analogue channels, digital output, and counter/timers. My NRG anemometer works like a mini-turbine, i.e., it puts out variable voltage and variable frequency as a function of wind speed. The frequency is quite a linear function of wind speed.

The counter/timers measure frequency by counting clock-ticks, where each tick duration,  $dt$ , is programmable with certain allowed values. The counter/timers can be configured as 16 bit or 32 bit timers. I use 16 bit because it is good enough. A 16-bit timer can count up to  $2^{16}-1$  starting from zero. So that is from 0 to 65,535. I used a programmable tick time of  $dt = 20.833 \mu\text{s}$  (= one of the allowed values). I programmed the timer to start timing when the rising edge of the signal from the anemometer is detected and it continues to time until the next rising edge passes.

So what is the frequency for 1000 ticks of time  $dt$ ? That equals a 20.833 ms period and that corresponds to a frequency of 48.00 Hz with a resolution of 0.1%. My NRG anemometer has a factory calibration of  $\text{m/s} = 0.765 * \text{Hz} + 0.35$ . So I can measure a wind speed of 37.07 m/s with a resolution of 0.1% (=  $\pm 1$  tick out of 1000). So if the reader follows this then you will realize that if I try to measure twice the wind speed I have 500 ticks which I can measure to 0.2%. Basically I never get winds that fast. So what about the lower speeds?

The lower the speed the more ticks I have. So at 10,000 ticks I am measuring 3.707 m/s. With a 16-bit timer I can measure a maximum of 65,535 ticks which corresponds to a wind speed of 0.566 m/s with a theoretical resolution of about 0.002%. The ticks come from a crystal clock which is subject to temperature which changes the basic oscillation speed. When you take that into account, I think my lower wind speed measurements are probably 'accurate' to only 0.008% (more or less).

I could measure to lower wind speeds by using a 32 bit timer but I decided it probably was not worth the effort because cup anemometers, like turbines, have a minimum start up speed that is typically a few tenths of a m/s. But I haven't checked out the specs of very many cup anemometers so I might be wrong. A sonic anemometer would give better measurement accuracy\* (see footnote) at low speed AND a much better time resolution, but the disadvantage of sonic anemometers is: (1) price = more expensive and (2) errors in readings when it rains or snows.

My DAQ3005 is programmed to sample the counter/timer once per second. What I don't know is if it feeds my database the mean of all readings it can squeeze into one second or the last reading at the end of the second. And what happens if the frequency is 0.5 Hz? Does it give the same reading for two consecutive 1 s readings or what? I don't know and the manual does not say. I am not sure it is important for me to know. But all cup anemometers are basically counters of revolutions. I would probably have to get into proprietary information to find the answer for any given anemometer packaged with measuring electronics or a logging system. If anyone knows and can share the information please contribute. I am a scientist and hence always curious.

Best regards,  
Mel

Ps- I am willing to write other epistles, but we should keep it simple, i.e., select one topic at a time. If you want to continue I will eventually describe all I know about my logger, my sensors, and all I know about electronics!

Footnote:

\* Accuracy is not the same as measurement resolution. Accuracy is determined by the factory calibration or an independent calibration, which is usually done in a wind tunnel. The accuracy of these calibrations is probably limited to about 1% or better. The calibration factor of a cup anemometer can be calculated within

about 5% based on wind forces applied to the convex and concave sides of the cups and for first 100 years cup anemometers were used without a means of independent calibration. Check out the history on Wikipedia. See also R#27 in SWIEP.