

## Re: Q about noise in time interval measurement averaging

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- *From:* [bill.sloman@xxxxxxxx](mailto:bill.sloman@xxxxxxxx)
  - *Date:* 9 Apr 2007 08:44:27 -0700
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On Apr 7, 2:44 am, "colin" <colin.ro...@xxxxxxxxxxxxxxxxxxxxxx> wrote:

<bill.slo...@xxxxxxxx> wrote in message

[news:1175902280.854739.222930@xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx](mailto:news:1175902280.854739.222930@xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx)

On Apr 6, 8:42 pm, "colin" <colin.ro...@xxxxxxxxxxxxxxxxxxxxxx> wrote:

Hi,  
I have a PIC measuring a time interval to 25ns resolution,  
the interval is totally asynchronous to the PIC clock.

So say if I average over 25000 measurements that will give  
me a limit of  
1ps  
resolution.

Im trying to do a system noise analysis and im wondering  
how to work this  
out,  
I cant seem to recall how the noise reduces with increasing  
samples,  
is it  $1/\text{samples}$  ? this would be too good to be true,  
or  $1/\sqrt{\text{samples}}$  this seems rather low.

Noise decreases as one over the square root of the number of samples,  
if the noise on successive samples is uncorrelated.

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The square root of 25000 is 158.1, so you'd reduce your 25nsec quantisation error to 158psec rather than 1psec, if you averaged 25000 independent samples.

Ah yes ofc I must of forgoton how to think for a while,  
I was getting mixed up with the number of available bits for resolution.

there is also a lot of noise in the signal as it is from an optical encoder,  
seems mostly mechanical, I need to reduce this by averaging over a long time too.

I'm trying to work out the optimum rate of pulses per revolution to use.

The optimum number of pulses per revolution is probably one, unless your need to know the sense of the rotation as well as it's speed.

not too worried about the sense of rotation as I know that anyway,  
however im seeing a standard deviation of about 10ns per revolution averaged over 2000 pulses per rev,  
Im working on fixing the mechanics to reduce this,  
but 1 pulse per rev would give me 25ns error,

im looking for .1ps resolution,  
to reduce my SD of 10ns to this amounts to  $100000^2$  revolutions wich would take 3 years at 6000rpm  
id rather it only took a few days, as im not quite that patient.

The advantage of one pulse per revolution is that you are looking at one fiduciary mark on your shaft, so you don't have to worry about the spacing of the fiduciary marks around the shaft, or the centering of a radially striped disk on the shaft. and the interval between the signal edges that define the period of rotation is as long as possible, so your quantisation noise is 10nsec in 10msec, rather than 10nsec in a shorter period.

If you put an array of detectors around the shaft, so you get one pulse per revolution from each sensor, you end up with more

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observations per revolution with independent quantisation noise on each value for the period of rotation,

Obviously, if there is noise on the rate of rotation – such as might be caused by a minimally elliptical shaft rotating in a minimally elliptical journal bearing – at a frequency that isn't an integral multiple of the frequency of rotation, the noise on the output of each sensor in the array would be correlated with the noise on the output of its nearer neighbours, and averaging wouldn't do as much good as it would on uncorrelated noise.

My own inclination would be to go for a faster clock – using Motorola's ECLinPS emitter-coupled logic you could build a very wide synchronous counter (you'd need 23 bits – four MC100E016) that could follow a 500MHz clock, which would give you 2nsec of jitter rather than 25nsec, and drop your three years down to a week.

Peter Alfke of Xilinx – a guru on comp.arch.fpga – programmed a Xilinx programmable logic device to work as a 1GHz counter a few years ago – and this might be a better way to go.

If you were in a position do a serious amount of work, you could combine a fast clock with a time-to-voltage converter, and get the timing resolution down to around a few tens of picoseconds. Some years ago, when I was working on a stroboscopic electron microscope with a digital timebase, we set up such a system that digitised time intervals with a resolution of 10psec. Our 800MHz clock was not crystal-controlled, and our jitter never got better than about 50psec before the project was cancelled. I believe that John Larkin (Inland Electronics) sells toys that can do better.

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Bill Sloman, Nijmegen

3 days would mean i would have to get my SD down to 500ps per rev wich is probably highly optimistic and id need at least 625 pulses per rev too.

I could try timing both edges and see how the SD changes with twice as many samples.

I tried feeding the same signal into both A and B, and the SD came out at about 25ps

wich is lower than one would expect but its probably not a valid thing todo.

the error also seems proportional to 1/shaft speed.

Colin =^.= Hide quoted text –

– Show quoted text –

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