Subject RE: 2004-F signal conditioner phase shift
Sender JOE@INTRONIX <intronix@bellnet.ca>
Recipient 'Nathan Hall' <njh5@cnbc.cmu.edu>
Date 08.31.2011 13:00

Hi Nate,

Had to bone up on my filter theory as well. It's been awhile since I had to deal with filters in the time domain. Hopefully I can provide the answers you need. My answers to your questions are shown in green in you text below.

Hope this helps and my explanation is not too comfusing.

Feel free to contact me if you have any further questions.

Thank you,

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-----Original Message-----
From: Nathan Hall [mailto:njh5@cnbc.cmu.edu]
Sent: Tuesday, August 30, 2011 11:07 AM
To: joe@intronixtech.com
Subject: 2004-F signal conditioner phase shift

Hi Joe,

My name is Nate and I work at the University of Pittsburgh. I called you yesterday about a huge phase shift from my signal conditioner. I played with my setup a bit and double checked my software and the problem seems to have gone away. However, I still have a couple questions about the phase shift that you may be able to answer for me.

I am feeding an analog voltage signal +/- 5 volts into the conditioner. I have the high pass filter off and am using only the low pass filter with a gain of 1. Now that my 700 ms phase shift is corrected I get phase shifts of about (by eyeball) 20 ms passing <10 Hz, 10 ms passing <25 Hz and 5 ms passing < 50 Hz. Besides whether this sounds correct and reasonable to you, as it currently does to me, I have 2 questions about these phase shifts.

This sounds about correct assuming that when you were testing the filters, the input signal frequency was close to the filter cutoff frequency.

At the cutoff frequency, the 2 pole Butterworth filters will have a 90 degree phase shift which is a quarter of a wavelength. The time delay can be calculated by the following equation. **Time delay (in seconds) = (1/f_c) * (phase angle / 360)**. Where f_c is the cutoff frequency. Eg. In the case of 50 HZ filter setting, cutoff frequency is 50 Hz and phase angle is 90 degrees at cutoff frequency. The expected time delay for a 50 Hz input signal would be: (1/50) * (90/360) or 5 ms which is shat you measured by eyeball. My calculations at your given values gave me 25ms delay @ 10 HZ, 10ms @ 25 HZ and 5 ms @ 50 HZ which is approximately what you measured. Keep in mind these calculations are for an ideal filter actual results may vary somewhat.

1) Should I expect them to be constant for a given low pass setting?

The delay would only be constant for a given lowpass setting if the frequency of the input signal doesn't change too much. Although depending on the frequency components of the input signal is may not necessarily be the delay calculated at the cutoff frequency as shown above. See below.

2) Does the shift depend on the frequency of the input signal?

The phase shift does depend on the frequency of the input signal. The phase angle for any given input signal frequency can be calculated by the following formula

Phase angle (in degrees) = $- \tan^{-1} [(\text{Ö}2 * w) / (1 - w^{2})]$

Where w is the input signal frequency divided by the filter cutoff frequency

The calculated phase angle at this frequency can be plugged into the time delay formula above to yield the time delay at any given input frequency.

Keep in mind that these calculations are for a single input frequency, a real world signal is usually a complex signal made up of many component frequencies making it difficult to predict actual time delays accurately.

Any other thoughts you'd care to share I would be happy to hear. My signal processing is pretty rusty and I haven't found good answers elsewhere.

Thank you so much for your time.

Regards,

Nate