From:	Norbert Breyer
To:	mark@whiteboxsolar.com
Cc:	"John Monteith"; "JShen"; r.emberger@acam.de
Subject:	AW: New test data for discussion
Date:	Thursday, March 07, 2013 2:52:08 AM

Hello Mark,

Please double check your data or maybe send me the original data. It looks like you mix up ns and ps (e.g you say DIFF R0 is in nanosecond but you calculate *0.25 which would give µs. In general the data do not fit to the ones you sent before.

But generally, I think the way you look at drift is not the right one. When looking at drift you should look at long term behavior. Therefore it is best to analyze data with high averaging (e.g. 100 or even higher). Then you get rid of the noise effects. You understand as drift the difference between each subsequent measurement. This underlies the noise and therefore is not helpful. If you take your data and add a column with a rolling average the you see very stable behavior.

Best regards,
Norbert

Norbert Breyer, Dipl.-Phys. ___| Phone: +49 7244 7419-21, Fax: -29
EMEA Sales & Marketing Manager
____
acam-messelectronic gmbh ______| Geschäftsführer/Management:
Friedrich-List-Str. 4 _________| Augustin Braun, Andreas Larsch
76297 Stutensee-Blankenloch ___| Registergericht Karlsruhe, HRB 7682
Germany _______________________| UID / VAT: DE 181 394 354

Von: Mark Richards [mailto:mark@whiteboxsolar.com]
Gesendet: Mittwoch, 6. März 2013 17:00
An: nbreyer@acam.de
Cc: John Monteith; JShen
Betreff: New test data for discussion

Hello Norbert,

Thank you for your prior comments.

My test routine ran for many hours over the evening. A sample of this data is below with the entire set attached. Note that it is a no flow condition.

What I wish to understand - and make certain of - is that the drift that is present from cycle to cycle is acceptable. I know you had mentioned that in the order of a few hundred picoseconds is OK. As you can see from the data, it is much more than that. I am not certain it will be good enough for a revenue-grade application. This is the biggest concern. Without such stability it will be difficult to move forward.

You mentioned temperature. The temperature conditions are very stable with no flow. The water bath for test is at 23.75 Degrees C +-0.5 C. With flow, due to the nature of my test setup, the temperature of the water does go up (it is a small loop with a rather poor pump that cools itself in the water). When temperature rises, if I understand the ratios properly, the speed of sound should increase, correct? If so, then the time difference should reduce. Your plot of my prior test data shows a slight increase over time, which may not be applicable to the temperature I suppose. It may instead be simply that the pump flow increases gradually. My test setup is not the best, and certainly not worthy of anything other than "go/no-go" testing :)

To better understand the data below, here is how I get it.

- At each cycle, read R0, R1, R2, and R3 and convert to a floating point. We store each of the Downstream and Upstream registers to a floating point array consisting of 8 elements (4 registers each).
- DIFF R0 is equal to R0 Upstream - R0 Downstream. This is presented in nanoseconds by multiplying each value * 0.250. The same is done for DIFF R1 and DIFF R2. It is interesting to see these three registers become smaller, and closer to one another, as the stop pulse selection is increased. This is something I am wishing to understand better from a timing perspective, so I hope we can discuss.
- DIFF R3 is equal to (R3 Upstream / 3) - (R3 Downstream / 3). This is presented in microseconds by multiplying * 0.250.
- The second and third DIFF R3 are provided in different units of time. The second DIFF R3 column presents the DIFF R3 result in nanoseconds by multiplying * (0.250 * 1000). The third presents the DIFF R3 results in picoseconds by multiplying (0.250 * 1000000);
- Drift is presented in nanoseconds and is the result of the previous DIFF R3 minus the current DIFF R3 measurement.
- Gal/Min is a relative Gallons per minute value which is computed using DIFF R3 * a multiplication factor.
- Signal is the GP22 relative signal strength ratio.
- There is no HS clock calibration factor performed here. This may also account for the upward drift, although it seems too much for that. The ambient temperature environment is very stable for the testing.

DIFF R0 ns	DIFF R1 ns	DIFF R2 ns	DIFF R3 us	DIFF R3 ns	DIFF R3 ps	Drift ns	Gal/Min	Signal
-1507.8125	-1265.625	-1250	-1.328125	-1328.125	-1328125	218.75	-0.041496	0.765625
-1617.1875	-1367.1875	-1078.125	-1.359375	-1359.375	-1359375	-31.25	-0.042472	0.765625
-1796.875	-1765.625	-1437.5	-1.671875	-1671.875	-1671875	-312.5	-0.052236	0.773438
-1507.8125	-1609.375	-1687.5	-1.609375	-1609.375	-1609375	62.5	-0.050283	0.773438
-1421.875	-1320.3125	-1109.375	-1.289063	-1289.0625	-1289062.5	320.3125	-0.040275	0.765625
-1296.875	-921.875	-1304.6875	-1.179688	-1179.6875	-1179687.5	109.375	-0.036858	0.765625
-1593.75	-1664.0625	-1562.5	-1.609375	-1609.375	-1609375	-429.6875	-0.050283	0.765625
-1734.375	-1437.5	-1601.5625	-1.585938	-1585.9375	-1585937.5	23.4375	-0.049551	0.773438
-1851.5625	-1476.5625	-1453.125	-1.59375	-1593.75	-1593750	-7.8125	-0.049795	0.765625
-1562.5	-1406.25	-1476.5625	-1.476563	-1476.5625	-1476562.5	117.1875	-0.046134	0.765625

-1562.5	-1296.875	-1625	-1.507813	-1507.8125	-1507812.5	-31.25	-0.04711	0.773438
-1335.9375	-1289.0625	-1546.875	-1.382813	-1382.8125	-1382812.5	125	-0.043204	0.773438
-1742.1875	-1421.875	-1414.0625	-1.53125	-1531.25	-1531250	-148.4375	-0.047842	0.765625
-1679.6875	-1585.9375	-1515.625	-1.59375	-1593.75	-1593750	-62.5	-0.049795	0.765625
-1351.5625	-1304.6875	-1296.875	-1.320313	-1320.3125	-1320312.5	273.4375	-0.041252	0.765625
-1609.375	-1265.625	-1234.375	-1.375	-1375	-1375000	-54.6875	-0.04296	0.773438

On 03/06/2013 03:39, Norbert Breyer wrote:

Mark,

I looked at your second data and they look very good. I added diagrams in the Excel sheet.

The pure ToF data for up and down show naturally a drift because the speed of sound changes with temperature. Maybe you remember the presentation where I showed the change of ToF for a range of 5°C to 80°C.
The important information is that the difference is stable for zero flow. The average could be closer to zero. This might change with the selected pulse series, but this really depends on the spool piece and transducers, not the GP22.. The noise is in an expected range.

The first data confuse me a little bit. Anyway, with flow the difference is unequal to zero and therefore you see the effect of temperature, giving a drift. To get rid of this your software has to do some temperature compensation.

Best regards,
Norbert

Norbert Breyer, Dipl.-Phys. ___| Phone: +49 7244 7419-21, Fax: -29
EMEA Sales & Marketing Manager

acam-messelectronic gmbh ______| Geschäftsführer/Management:
Friedrich-List-Str. 4 _________| Augustin Braun, Andreas Larsch
76297 Stutensee-Blankenloch ___| Registergericht Karlsruhe, HRB 7682
Germany _______________________| UID / VAT: DE 181 394 354