Timing Calibration Updates

Kurtis Nishimura
April 6, 2011
Last PSEC3 Data Anomalies

Last time, found some strange behavior in fits at cells 50-60, 170-190.
Last PSEC3 Data Anomalies

- **Fundamental cause is still unknown, but more data under different conditions (varying input frequency, different PSEC3 channels) may help resolve it.**
Timing Calibration w/ Scope data

• Last set of PSEC3 data:
  – 5 GSa/s
  – CH3 (256 sample cells)
  – 1200 events (1000 usable) of:
    • 100 MHz

• Took roughly equivalent set of Tektronix data (TDS6804B):
  – 5 GSa/s
  – 500 sample cells
  – 2000 events of:
    • 100 MHz input (from an Agilent E4432B)
  – Some other sampling rates, frequencies taken, but no analyzed yet.
Example Fit (PSEC3)

Data and fit
samples 2 and 12

Residuals in x, y
samples 2 and 12

V_{1} - V_{2} (ADC Values)

V_{1} + V_{2} (ADC Values)
Example Fit (TDS6804B)

Data and fit

- Fits very well behaved. No obvious outliers, no fit failures. Very small residuals.
Derived Distributions of $\Delta t_{i,i+1}$

- **Last PSEC3 Data (1000 events)**
  - $dt1-dt2 \{\text{status1} == 0 \&\& \text{status2} == 0\}$
  - Entries: 189
  - Mean: $1.961e-10$
  - RMS: $7.51e-11$

- **TDS6804B Data (1000 events)**
  - Entries: 490
  - Mean: $2.006e-10$
  - RMS: $1.82e-12$
  - $\chi^2 / \text{ndf}$: $40.03 / 39$
  - Constant: $20.36 \pm 1.25$
  - Mean: $2.006e-10 \pm 1.419e-13$
  - Sigma: $2.788e-12 \pm 1.265e-13$

- **TDS6804B Datasheet**

  - Aperture uncertainty, typical
    - Short term:
      - $\leq 1.5 \text{ ps rms},$ records having duration $\leq 100 \text{ ms}$ or $\leq 800 \text{ fs}$
      - records having duration $\leq 10 \mu\text{s}$
    - Long term:
      - $\leq 15 \text{ parts per trillion rms},$ records having duration $\leq 1 \text{ minute}$

- **Still seem statistics limited on scope data.**
- **Could be a valuable resource for studying optimal sampling rate to input frequency, error distributions, etc.**
Timing Calibration w/ Correlations

• Plot correlations between pairs of samples:
  – To determine $\Delta t_{ij}$, plot $V_i - V_j$ versus $V_i + V_j$

Input signals given by:
$V_i = A \sin(\omega t_i + \phi)$
$V_j = A \sin(\omega t_j + \phi)$

Effectively rotate by 45°:

$x = V_i + V_j$
$y = V_i - V_j$

$\frac{x^2}{4A^2 \cos^2(\omega \delta t/2)} + \frac{y^2}{4A^2 \sin^2(\omega \delta t/2)} = 1$

i and j can be adjacent (or not), but should not be > 1 period apart.

*Method and results from Andres-Romero Wolf and myself, with data from LAB3. Planning as TIPP submission(?)
Timing Calibration w/ Correlations

- Plot correlations between pairs of samples:
  - To determine $\Delta t_{ij}$, plot $V_i - V_j$ versus $V_i + V_j$

Input signals given by:

$$V_i = A \sin(\omega t_i + \phi)$$
$$V_j = A \sin(\omega t_j + \phi)$$

Effectively rotate by $45^\circ$:

$$-x := V_i + V_j$$
$$-y := V_i - V_j$$

$$\frac{x^2}{4A^2 \cos^2(\omega \delta t/2)} + \frac{y^2}{4A^2 \sin^2(\omega \delta t/2)} = 1$$

i and j can be adjacent (or not), but should not be > 1 period apart.

*Method and results from Andres-Romero Wolf and myself, with data from LAB3. Planning as TIPP submission(?)
Timing Calibration w/ Correlations

• Ellipse features:

1) Different $\Delta t$ (for known sampling frequency) give different major/minor radii.
2) Noise makes ellipse “fuzzy”
3) Nonzero pedestals shift origin
4) Difference in gain between two cells causes a rotation.

➔ We have written an ellipse fitter to perform this method.
➔ Even without fitting, it provides nice qualitative check on results.

*Method and results from Andres-Romero Wolf and myself, with data from LAB3. Planning as TIPP submission(?)