Test time metrics for TP2 waveforms

- Two possible methods to examine pattern waveforms instead of eyes
- Factors that control test times
- Accuracy issues
- Post processing / Making measurements

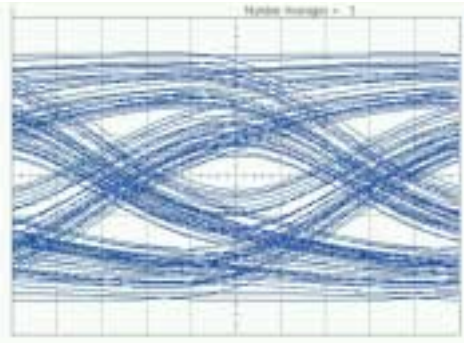
TP2 waveform capture

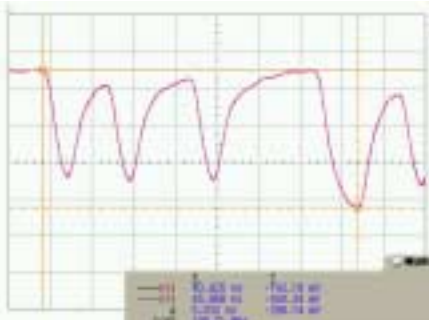
- Proposal in TP2 to test 384 bits from the 33792 bit BnBiBnBi pattern
  - Pattern waveform instead of an eye diagram
- These 384 bits include all the properties of a PRBS 7 pattern
- Unique 15 bit sequence identifies the location of the 384 bit sequence

Factors controlling acquisition times

- Pattern repetition rate
- Scope acquisition rate
  - Sample rate
  - Setup overhead
  - Trigger delay
- Number of samples per bit
- Number of averages (to remove random effects)
- I/O to transfer and process files

Pattern repetition rate





- Sampling scopes acquire one sample per trigger event
- Pattern or frame trigger occurs once per pattern repetition
- BnBiBnBi pattern length of 33792 bits at ~100 ps per bit
  - Pattern repeats once every 3.4 us
  - Scope sampling rates are slower, so BnBiBnBi pattern length is not a dominant factor in acquisition time
  - Caveat: If using a pattern generator, sometimes a pattern trigger is generated every x repetitions of the pattern. Also, scope may arm just after the pattern trigger arrived, requiring the pattern to repeat before a sample is taken. Effective sample rate should include ~half the time between pattern triggers (~1.7 us minimum case). Be careful...a pattern generator trigger rate could potentially dominate the acquisition time.

Scope acquisition

- 33792 bits at 16 samples per bit (540672 samples)
- Record length (samples per waveform) of 4096
  - 132 waveform records to capture the entire pattern
- Increasing trigger delay to look further into the pattern increases the time between samples by as much as 3.4 us (avg 1.7 us)
- Time to capture the full waveform roughly 10 to 20 seconds
  - Averaging factor roughly scales test time (30 to 50 seconds for 4 averages)
- Time to write to the hard drive and transfer to the PC 3 to 5 seconds

- Reference: Eye mask test (autoscale, acquire 200 waveforms, align mask) takes ~ 10 seconds (generally no averaging applied)

Scope acquisition

Precision issues

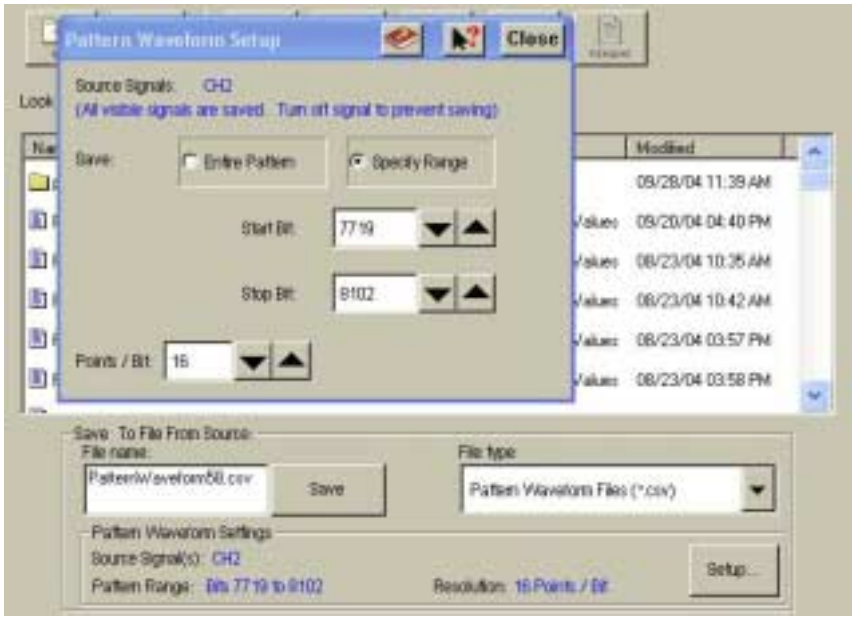
- **Timebase linearity and jitter**
  - **Samples taken far from the trigger point have noticeable time errors (samples taken at the far end of the pattern)**
  - **Can be mitigated through post processing (compare to a reference clock measured simultaneously or a virtual ideal clock)**

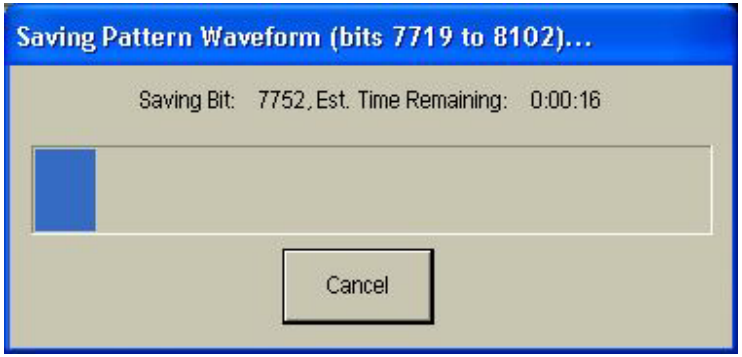
Increasing accuracy and efficiency

- Be smarter about capturing only the pattern section of interest
  - 384 bits at 16 samples / bit (6144 samples)
  - Only 2 waveform records
  - But.... need to see the whole pattern to know where to focus the acquisition
- Control the location of the pattern trigger (in the pattern generator or the scope) to minimize timebase error / jitter
  - Fix the timebase at minimal delay and walk the waveform across the scope

Metrics for capturing the 384 bits

- Identify pattern and derive pattern trigger from clock reference (using a coarse but fast waveform capture, ~2 s)
- Acquire 384 bit waveform
- Measure acquisition times for different samples / bit and averaging factor





Tests performed with a simulated BnBiBnBi pattern (arbitrary fixed pattern with length 33792)

Acquisition times (seconds)

	16 points / bit	32 points / bit	64 points / bit
No averaging	19	19	19
4 averages	22	23	25
8 averages	26	27	29

Time to lock on and locate the specific 384 bits is ~2 seconds. Time to acquire the entire 33792 bit pattern with this technique is about 1600 seconds. If the pattern trigger is from a pattern generator and must be sequenced through automation, an additional time penalty applies

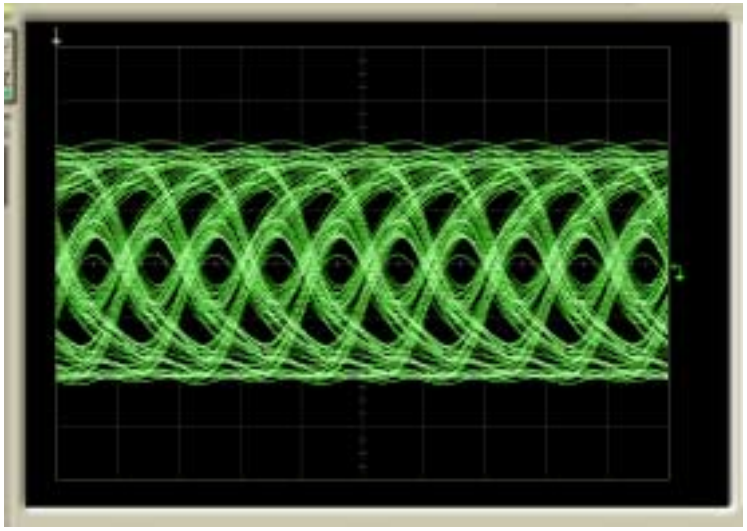
Understanding the acquisition times

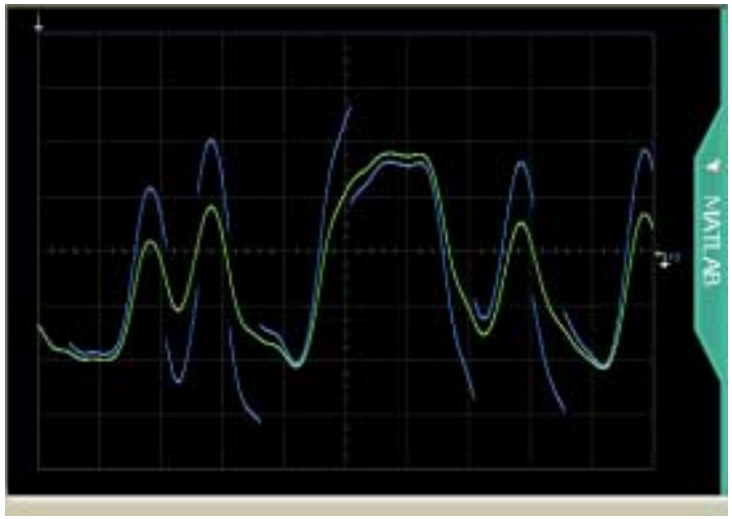
- **Why is there only a 50% time penalty for 32X more data?**
  - **Acquisition time dominated by scope overhead associated with manipulating the internally generated pattern trigger and keeping the time base positioned at minimal delay (minimum timebase distortion / jitter)**
  - **The current approach acquires one bit at a time. Reducing this overhead is straightforward (these times could be reduced 5 to 10X).**
- **In the interim, a middle of the road hybrid approach is to lock the scope pattern trigger to the location of the bits of interest (~2s) and acquire the 6144 samples in two records (total acquisition time <3s) with approximate scaling for averaging. Fast with minimal timebase error.**

Making measurements on the data

- In general, analysis takes much less time than acquisition or writing the data to a file and transferring to a PC
- Consider analysis within the scope
  - Scopes are now all built on top of a PC
  - Virtual fibers and equalizers through Matlab in the scope

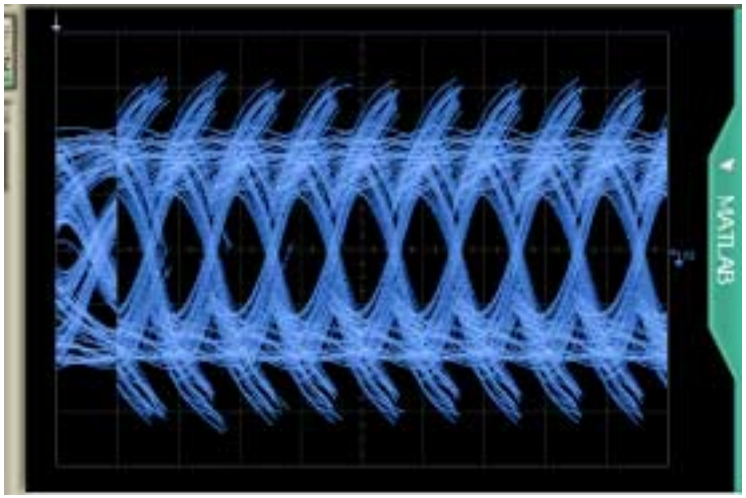
Example: Virtual DFE (continuous sampling, infinite BW model)

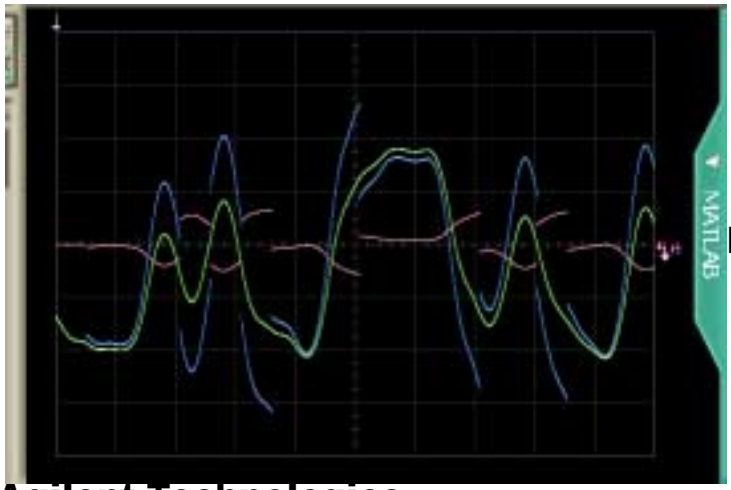




MatLab DFE output

MatLab DFE input





DFE threshold voltage

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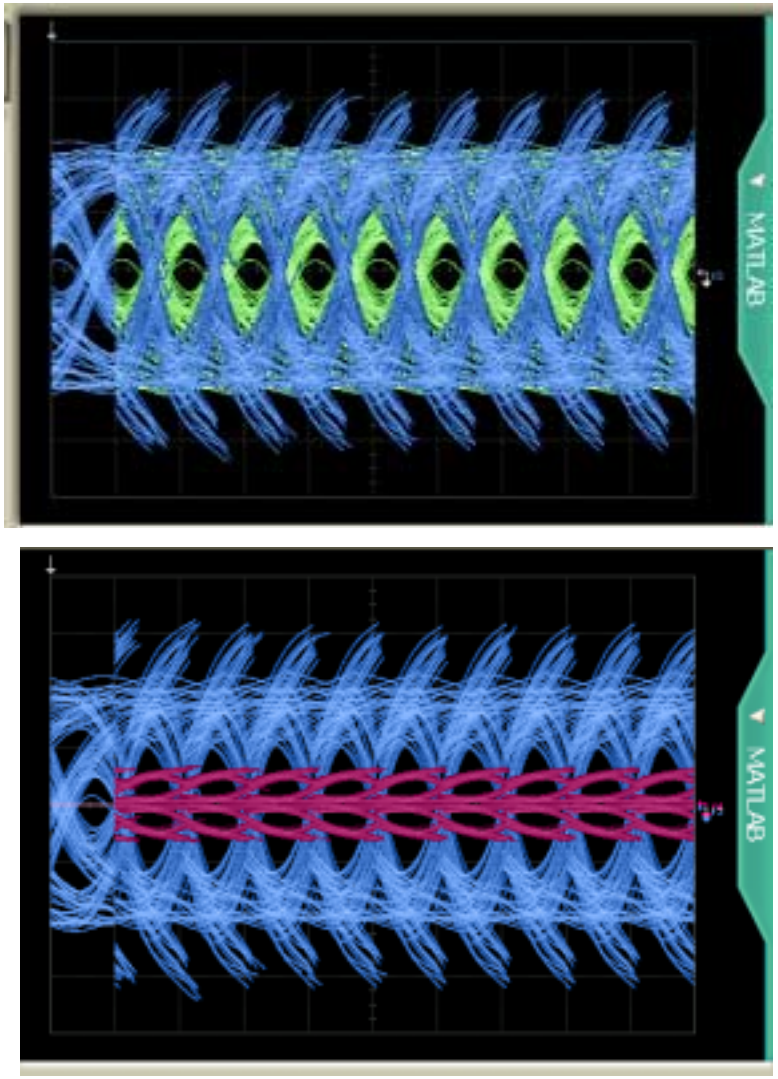
Conclusions

- Test times for a TP2 test likely to be similar to a conventional eye mask test
  - But there are factors which can begin to inflate acquisition rates
  - Even complex analysis likely not ‘expensive’ compared to acquisition times (to a point).
- Future work: build a virtual fiber and equalizer and analyze the resultant waveform
  - Appropriate metrics?
  - Test times

Example: Virtual DFE backup slide



MatLab DFE output

MatLab DFE input

DFE threshold voltage

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