TDECQ measurement procedure evaluation

– In the 802.3 SMF ad-hoc meetings and face-to-face discussions the possibility of creating a depository for waveform files was suggested.
  - The general intent:
    - Provide good test cases for anyone developing TDECQ measurement solutions
    - Allow collaboration to achieve measurement consistency across solutions
    - Identify difficult measurement scenarios
    - Insight into expected TDECQ performance and its impact on current TDECQ specs

Waveform submission details

– Waveform files can be generated from various sources:
  - Mathematical simulators
  - Actual waveforms from real transmitters captured with an oscilloscope
  - Others?
  - It is desirable to have a wide range of performance and we encourage good, mediocre, and bad TDECQ examples
    - Do we need a process to submit waveforms anonymously?

To allow use across platforms use the following guidelines

- Acquire ~ 40 or more samples per unit interval, ideally as a complete pattern record
- Use a .txt file format for the amplitude data values
- In the file, provide the following information:
  - Observation bandwidth (typically would be 19.34 GHz for 26 GBaud and 38.68 GHz for 53 Gbaud)
    - This is required by the sampling scope TDECQ measurement
  - The instrument channel noise (with no signal applied) for waveforms acquired with an oscilloscope
    - To be mathematically removed by the TDECQ process
  - Symbol rate and samples/UI
  - Pattern length
  - Time increment between samples and number of samples
  - Expected TDECQ value and equalizer tap values
    - Useful for to validate measurement of ‘designed’ simulations’

Example file

example file - Notepad

File Edit Format View Help

```
Expected TDECQ value dB

Tap1 value: x.xxx
Tap2 value: x.xxx
Tap3 value: x.xxx
Tap4 value: x.xxx
Tap5 value: x.xxx

Points, 2621400
Channel Bandwidth, 3.9E+10
Channel Noise, 2E-06
XOrg, 2.352941176470 59E-13
XInc, 4.705882352941 18E-13
Symbol Rate (Baud), 53125000000
Samples/UI, 40
Pattern Length, 65535
X Units, Second
Y Units, Watt

Data,
0.0003110853830275 57
0.0003147909080602 38
0.0003095474073309 92
0.0003134133338584 94
0.0003342833105234 74
0.0003341035174707 13
0.0003255813753928 61
0.0003275630500715 67
0.0003466262093403 65
0.0003677488388408 02
0.0003850424272709 41
0.0003331695673527 64
0.0004046254388723 24
0.0003875462903153 17
0.0004216624573733 63
0.0004009227366213 18
0.0004438347729067 27
0.0004386179503103 2
0.0004875608992363 46
0.0004960884305081 81
0.0005147143905665 59
0.0005199261512987 92
0.0004951411437232 1
```

Real-time scope waveforms

- The 40 samples per UI is difficult without interpolation
  - At 160 GSa/s, 6 samples/UI at 26G, 3 samples/UI at 53G
  - 200 GSa/s 8 samples/UI and 4 samples/UI

Appendix

Specific details for saving and loading waveforms into scopes that have TDECQ analysis capability

- Tektronix
- Keysight

Files can be easily captured and saved from a Tektronix scope for analysis using another TDECQ measurement

- The fastest way to create the waveform is to run the 80SJNB software application
  - Options needed: Advanced Trigger (mainframe); 80SJNB PAM4 (sufficient to capture the pattern)
  - To also run TDECQ: 80SJNB Advanced (the equalization features) and 80SJNB TDECQ license
- Run the 80SJNB with the appropriate Symbol rate, 40 Sa/UI
- To save the waveform in 80SJNB:
  File→Export Waveform →Acquired
  then select type .csv
- Zip the waveform for reasonable size
- As a backup, also save the Dataset: File→Save Data
  (this will allow you to reload all of the information, including PJ, RJ, etc.)

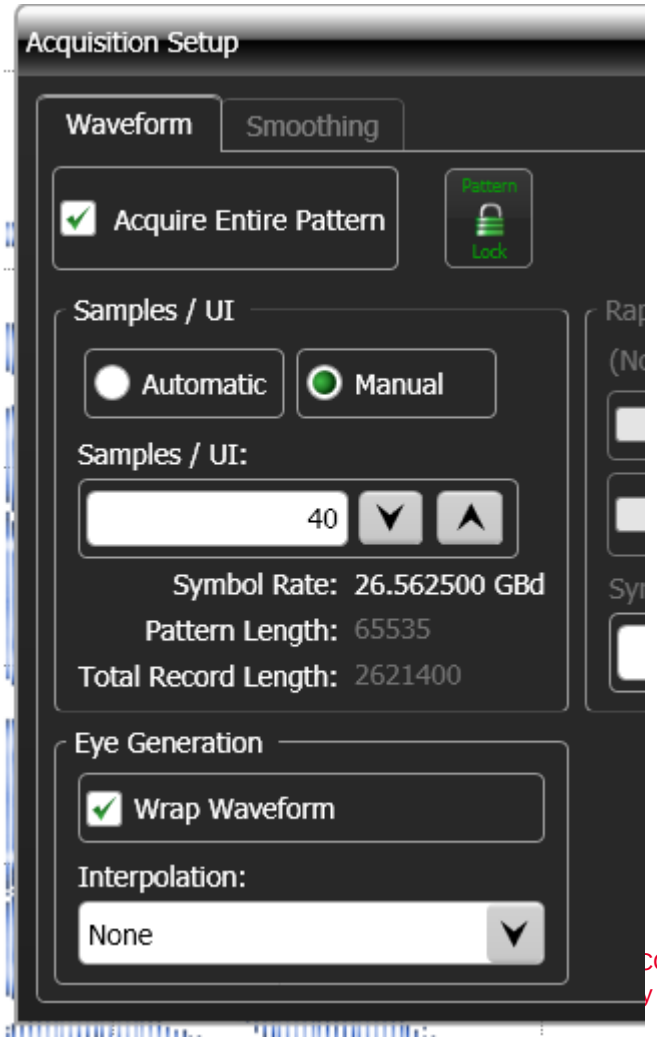
Files can be loaded into a Tektronix scope for analysis using the TDECQ measurement

– Currently only the Tek 80SJNB generated file (80SJNB: File →Save Data) can be read back in in the field

– The .csv or .txt files have to be sent to Pavel for processing

Setup to acquire a file using a Keysight DCA

- Go to Eye/Mask mode
- Setup/Acquisition setup
- Pattern Lock
- Acquire entire pattern
- Samples/UI: Manual: 40
- Wrap waveform (displays pattern as an eye)

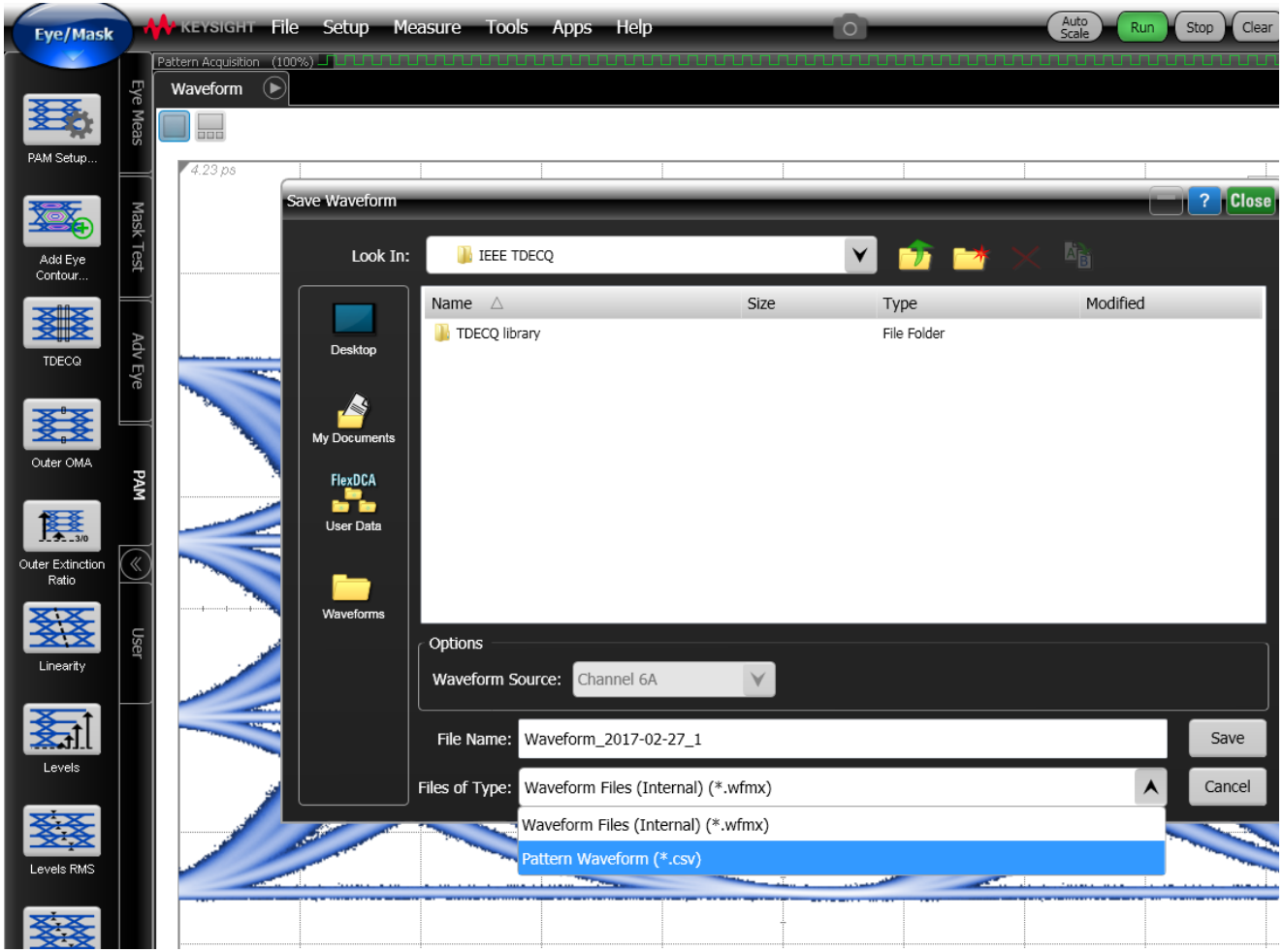


- Note: If working only with the DCA, leave samples/UI in automatic mode (highly preferred, much faster test times, smaller file size)

KEYSIGHT TECHNOLOGIES

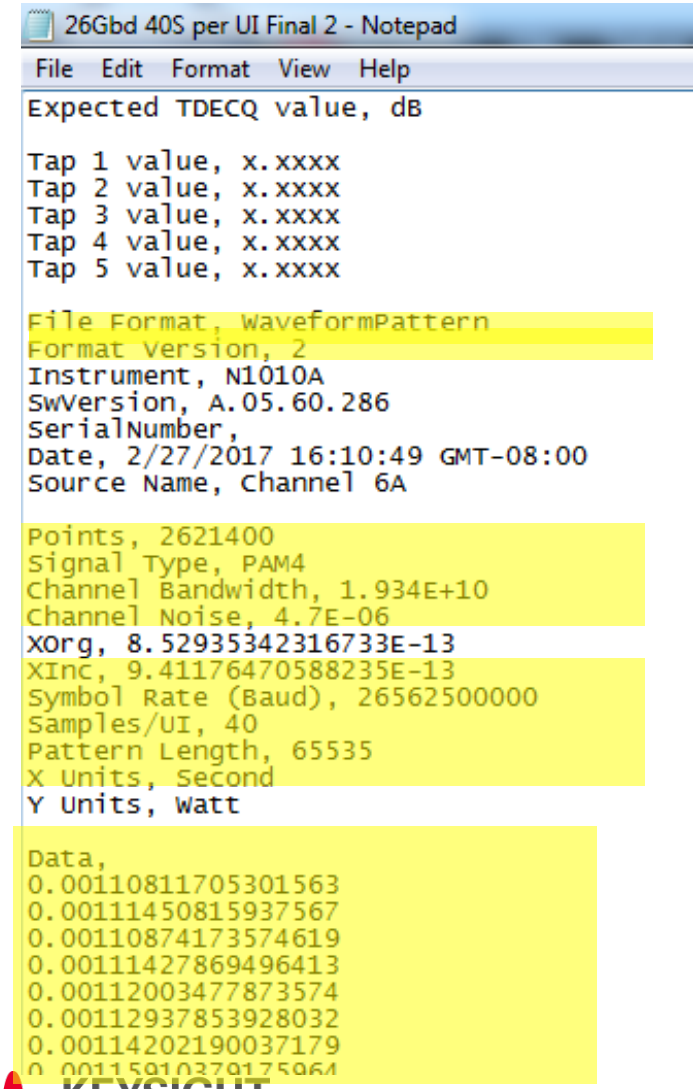
Files can be easily saved from a Keysight scope for analysis using another TDECQ measurement

- File/Save/Waveform
- Files of type .csv
- Save
- Files are large
- Note that a .csv file is easily converted to a .txt file in Notepad



Required format to load a file into a Keysight TDECQ solution using the FlexDCA interface (scope or scope simulator)

Create a text file (example from Notepad file: notepad.txt)



26Gbd 40S per UI Final 2 - Notepad

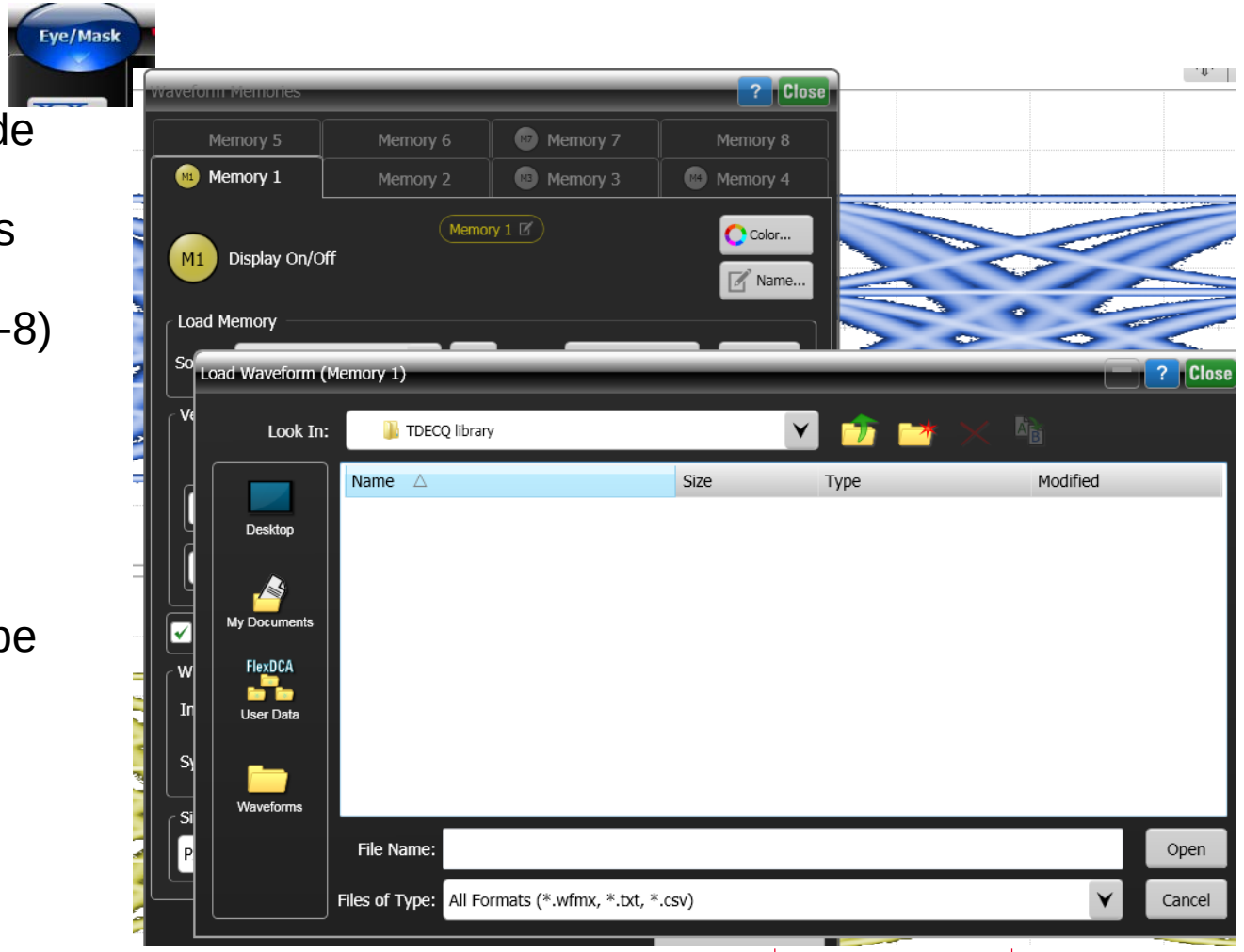
File Edit Format View Help

```
Expected TDECQ value, dB

Tap 1 value, x.xxxx
Tap 2 value, x.xxxx
Tap 3 value, x.xxxx
Tap 4 value, x.xxxx
Tap 5 value, x.xxxx

File Format, WaveformPattern
Format Version, 2
Instrument, N1010A
SwVersion, A.05.60.286
SerialNumber,
Date, 2/27/2017 16:10:49 GMT-08:00
Source Name, Channel 6A

Points, 2621400
Signal Type, PAM4
Channel Bandwidth, 1.934E+10
Channel Noise, 4.7E-06
XOrg, 8.529353423167 33E-13
XInc, 9.41176470588235E-13
Symbol Rate (Baud), 26562500000
Samples/UI, 40
Pattern Length, 65535
X Units, Second
Y Units, Watt

Data,
0.00110811705301563
0.00111450815937567
0.00110874173574619
0.00111427869496413
0.00112003477873574
0.00112937853928032
0.00114202190037179
0.00115910379175964
```

- Channel Bandwidth refers to the bandwidth setting of the oscilloscope (e.g. 19.34 GHz for a 26.56 Gbaud reference receiver, automatically saved if from a Keysight DCA)
- Channel noise refers to the intrinsic noise of the oscilloscope (with no signal input, automatically saved if from a Keysight DCA)
- Yellow highlighting indicates essential documentation for loading a text file into the Keysight DCA

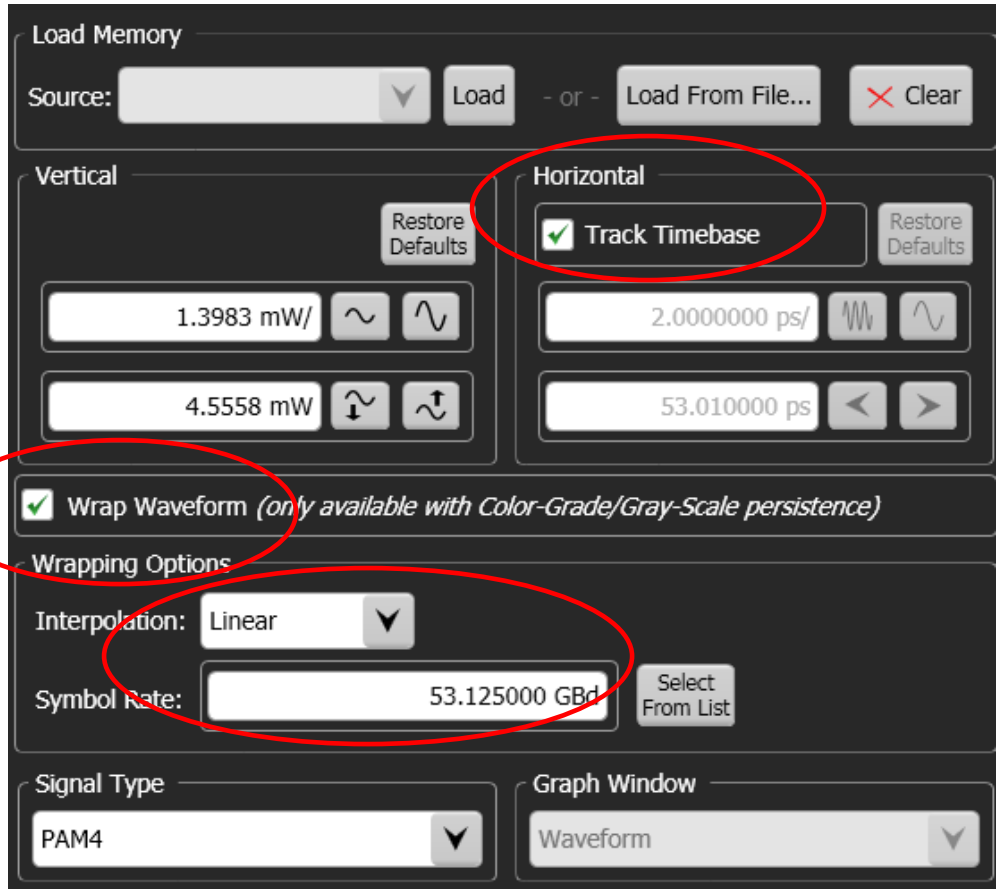
TDECQ library files can be loaded into a Keysight sampling scope or laptop running the FlexDCA simulator for analysis using the TDECQ measurement

- Switch to Eye/mask mode
- File/Waveform memories
- Select which memory (1-8) to use
- Load from file
- File type: Pattern waveform (typically will be *.txt)
- Display On/Off: On



Details to display the loaded file

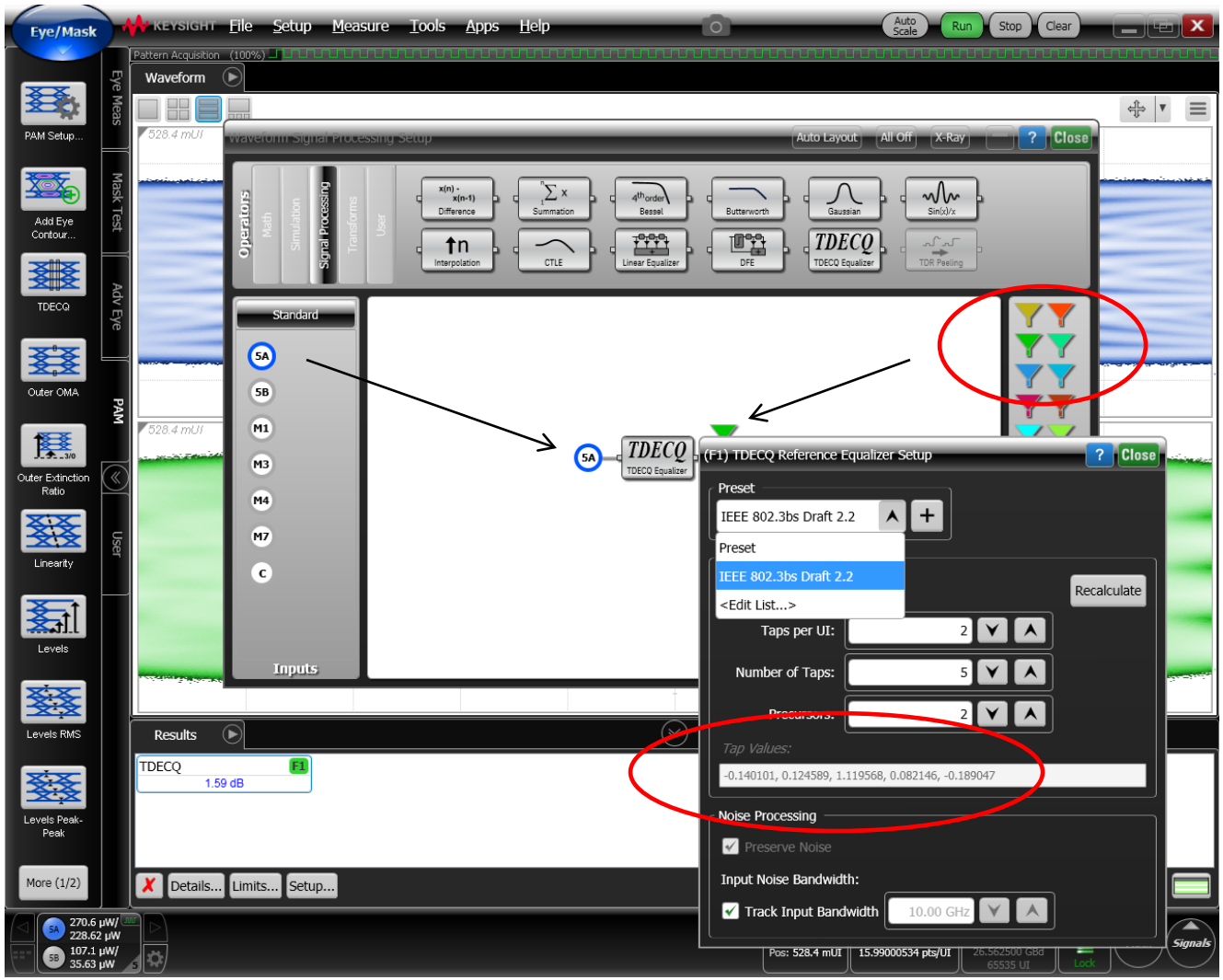
- Check ‘Track Timebase’
  - Allows time scale adjustment
- Check ‘Wrap Waveform’
  - Create PAM4 eye from long waveform pattern
- Choose interpolation option
  - Generally does not have much impact on TDECQ result at 40 Samples/UI
- Verify symbol rate is correct



FlexDCA simulator: keysight.com/find/flexdca_download
Contact greg_lecheminant@keysight.com for any licenses

TDECQ measurement with a Keysight scope or simulator

- Eye-Mask mode
- Set up the TDECQ equalizer:
  - Measure/Waveform signal processing/ Operator: Signal processing
  - Pull down the TDECQ equalizer
  - Connect the signal to be equalized (active channel or memory)
  - Connect a trace color for the output waveform
  - Click on equalizer to configure (and view tap settings)



TDECQ measurement process

- Pattern lock the system
- Select PAM menu
- Select TDECQ measurement for the equalized signal