MDIO Decoder, Documentation for Release 8.x

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Table of Contents

List of Figures

Introductions

Introduction

- The MDIO Decoder for Teledyne LeCroy oscilloscopes supports MDIO decoding of both formats described by Clauses 22 and 45.
- This document relies on the assumption that the reader is familiar with Teledyne LeCroy oscilloscopes in general, and also assumes some familiarity with the MDIO standard published IEEE 802.3.
- We also recommend http://www.totalphase.com/support/articles/200349206-MDIO-Background (cited with permission of Total Phase, Inc.)
- The following material will guide the operator through every step of the process.

Avant-propos

- Le décodeur MDIO pour oscilloscopes Teledyne LeCroy permet l'interprétation complète de l'ensemble des informations circulant sur le bus, dans les formats régis par les Clauses 22 et 45.
- La forme et le fonds de ce document partent du principe que le lecteur est raisonnablement familier avec les oscilloscopes de Teledyne LeCroy ainsi que la spécification du protocole IEEE 802.3
- La lecture de http://www.totalphase.com/support/articles/200349206-MDIO-Background est également recommandée (cité avec la permission de Total Phase, Inc.)
- Ce document guide l'utilisateur pas à pas, depuis les réglages de base jusqu'au décodage complet.

Einführung

- Der MDIO Decoder erlaubt eine vollständige Interpretation der Botschaften, in den Formaten beschrieben bei Clause 22 und Clause 45 of IEEE 802.3.
- http://www.totalphase.com/support/articles/200349206-MDIO-Background ist auch empfohlen (mit Erlaubnis von Total Phase, Inc.)
- Die Verfassung dieser Anleitung beruht auf der Annahme, dass der Leser Teledyne LeCroy Oszilloskopen schon kennt und dass er die IEEE Spezifikation des MDIO Protokolls beherrscht.

Introduzione

- Il decoder MDIO per oscilloscopi Teledyne LeCroy supporta la decodifica MDIO per entrambi i formati descritti dal Clause 22 e dal Clause 45.
- Questo documento si basa sul presupposto che il lettore abbia familiarità con gli oscilloscopi Teledyne LeCroy a livello generale, ed assume anche una certa familiarità con lo standard MDIO pubblicato dall' IEEE 802.3.
- Si consiglia anche di leggere quanto riportato al seguente link: http://www.totalphase.com/support/articles/200349206-MDIO-Background (con l'autorizzazione di Total Phase, Inc.)
- Il seguente materiale guiderà l'operatore attraverso ogni fase del processo.

Getting started

Once the oscilloscope is turned on, connect to the MDIO Clock and Data line to the input channels (i.e. C1 and C4), and navigate to the Serial Decode Tabs. Here you need to select the signal sources (i.e. C1 and C4 currently monitoring the signals), and the Protocol, “MDIO” from the list of protocols that are installed on this unit.

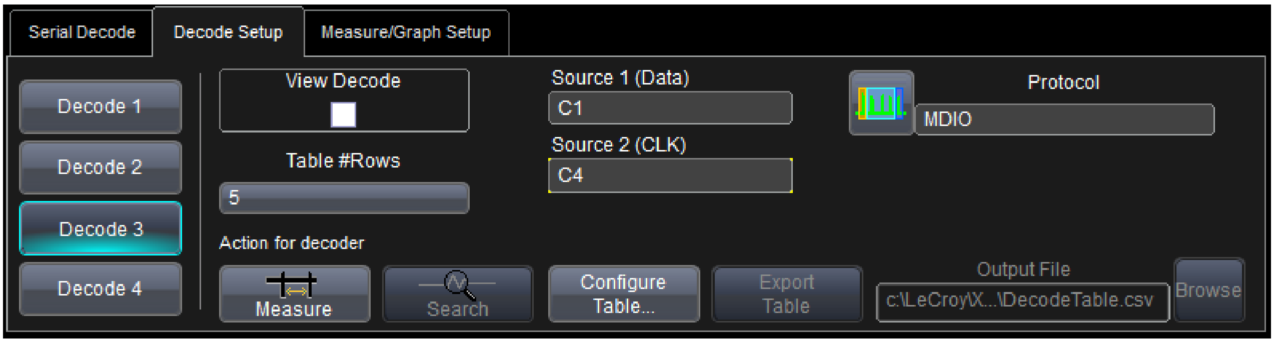

Figure 1 The selection of MDIO and Signal sources in the Decode Setup

Once the “MDIO” Protocol has been selected 2 staggered tabs will appear in the Right Hand Side Dialog: The **Basic** tab and the **Levels** tab**.**

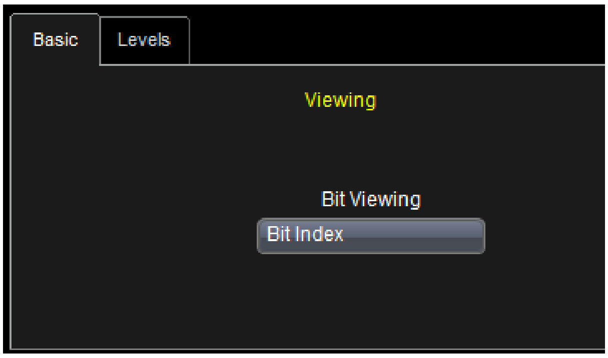

Figure 2 The protocol selection governs the appearance of the Right Hand Side tabs.

Once the “View Decode” check is set, in the left Dialog, the Data Signal in C1 will be annotated and decoded.

Decoding Messages

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As soon as the decoder is enabled, the MDIO transaction will be annotated. Since MDIO is a synchronous protocol, the interpretation of the data lines state occurs at every rising edge of the clock, regardless of the clock speed. No adjustments are needed, other than level and bit viewing (optional).

Verifying the correct behavior of the decoder

When starting to use the tool, the decoding will appear as on the following image, with more or less messages depending on the time base settings of the oscilloscope.

Figure 3 Initial decoding of 858 MDIO commands on 2 memory traces, M1 and M2

MDIO does not specify structural coherency checking such as CRC or Parity bits or Data length Predicate used by other protocols. The packets have a constant length of 64 bits (32 preamble bits and 32 payload bits) and constant decomposition into the fields listed later in this document. A few coherency check are applied to the individual fields by the decoder. This situation calls for a careful review, by the user, of the initial results to make sure subsequent decoded results can be fully trusted.

Using the zoom to verify the initial decoding of Clause 45

The zoom allows a more systematic verification of the decoding, explained here. Once the decoding is in engaged, the Table appears below the grid. When starting on a new signal, it is recommended to visually scrutinize a few MDIO commands and verify their contents against known values sent by the microcontroller or other components in the system. By clicking into the first columns (Line Index), a zoom of the trace corresponding to the selected line will appear. The zoom is a precious tool when studying a decoded trace because every packet can be rapidly analyzed, down to the bit level.

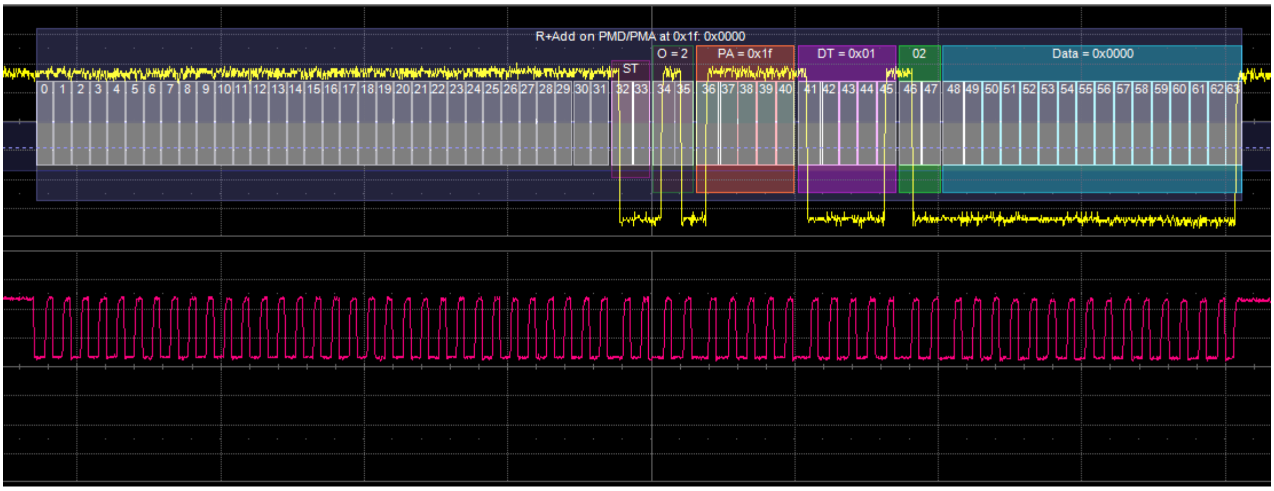

Figure 4 Looking at individual bits of the 64 bit packet.

The image above highlights the procedure. First select the Framing of the zoomed packets by adjusting the Left/Right padding. A 100% padding means that a full message length will be added right and left of the message zoomed at when clicking on any line of the table. Also turned on the Bit Viewing Mode by Index. In this mode every bit is numbered, from 0 to 63. Make sure the packets are 64 bits long. Make sure the bits are evenly spaced.

Clause 45

In order to address the deficiencies of Clause 22, Clause 45 was added to the 802.3 specification. Clause 45 added support for low voltage devices down to 1.2V and extended the frame format (figure 14) to provide access to many more devices and registers. Some of the elements of the extended frame are similar to the basic data frame:

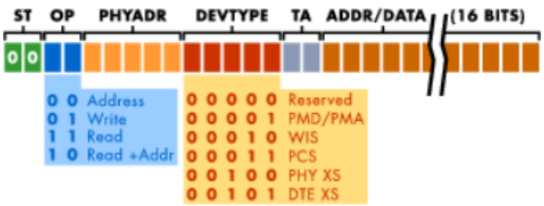

Figure 14: Extended MDIO Frame Format

ST	2 bits	Start of Frame (00 for Clause 45)
OP	2 bits	OP Code
PHYADR	5 bits	PHY Address
DEVTYPE	5 bits	Device Type
TA	2 bits	Turnaround time to change bus ownership from STA to MMD if required
ADDR/DATA	16 bits	Address or Data Driven by STA for address Driven by STA during write Driven by MMD during read Driven by MMD during read-increment-address

Figure 5 Structure of a Clause 45 message (reproduced with permission of Total Phase, Inc.)

Then jump to the very first decoded packet in the records by pushing the “N. Then, push 2 to “Play” through the entire record, jumping from one packet to the next, at a rate of approximately 1 image/second. Watch the packets while the play continues and make sure that the decoding is consistent with your expectations.

Using the zoom to verify the initial decoding of Clause 22

This is similar to Clause 45, and most of the explanations above apply as well. Clause 22 is historically the forefather of Clause 45 and is identifiable by the value of 01 in the Start of Frame field.

Clause 22

Clause 22 defines the MDIO communication basic frame format (figure 13) which is composed of the following elements:

Figure 13: Basic MDIO Frame Format

ST	2 bits	Start of Frame (01 for Clause 22)
OP	2 bits	OP Code
PHYADR	5 bits	PHY Address
REGADR	5 bits	Register Address
TA	2 bits	Turnaround time to change bus ownership from STA to MMD if required
DATA	16 bits	Data Driven by STA during write Driven by MMD during read

The frame format only allows a 5-bit number for both the PHY address and the register address, which limits the number of MMDs that the STA can interface. Additionally, Clause 22 MDIO only supports 5V tolerant devices and does not have a low voltage option.

Figure 6 Structure of a Clause 22 message (reproduced with permission of Total Phase, Inc.)

Controls of the Basic Tab

Due to the clear specification of MDIO, only few controls are required in the Basic Tab.

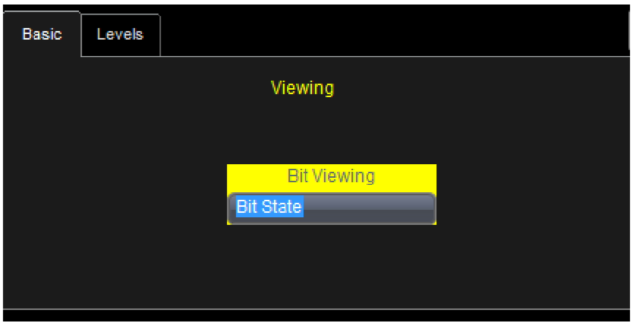

Figure 7 The Basic Tab and its Controls

UI control	Function	Range	Default
	Viewing		
Bit Viewing	Allows the display of individual bits if desired. Bits can be overlaid to the annotation, either labeled with their index or their state	None, Bit Index, Bit State	None

Figure 8 List of controls in the Basic Tab

Controls of the Level Tab

The second tab of the decoder controls the levels used for determining the edge crossings of the MDIO clock and data signals. The default settings of Percent level = 25% and Hysteresis = 15% are usually appropriate for most signals. However certain signals can require other settings.

A known case is signals with a varying DC component, either because the probing is incorrect or because the signal is really floating. In this case the level Type Absolute allows a fixing of the threshold level, so that messages can be decoded without having the dynamic change due to the floating behavior.

Another case is very noisy signals, where a combination of level and hysteresis can be used to overcome the noise impact. Note that in this case some upstream filtering in the channel menu can also help.

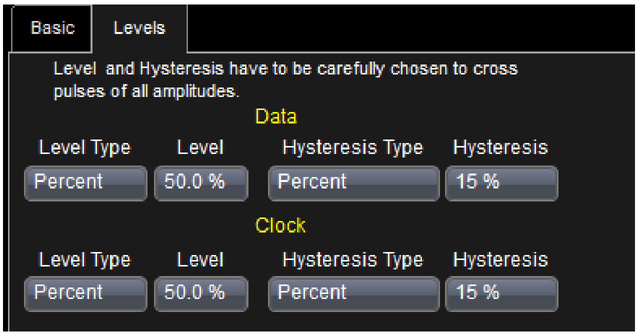

Figure 9 The MDIO Level controls for Clock and Data

Columns Contents of the Decode Table

The table below explains every column of the table, and its meaning. Note that the table can be configured on the screen and columns can be turned on or off to help the operator.

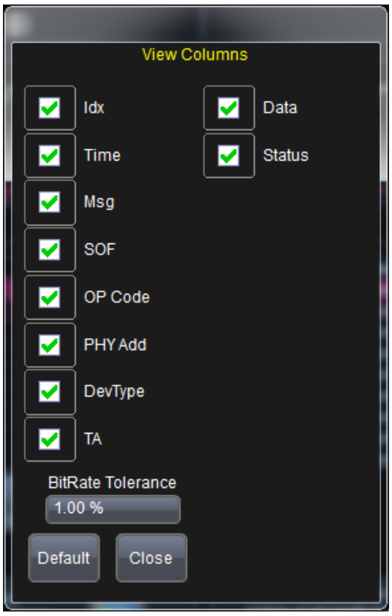

Figure 10 The columns of the MDIO decoder

As all the other settings in the scope, the table can be configured remotely for Automated Test Equipment (ATE) on large test setups. The screen visibility of the columns also drives the Export of the Table to a file. The table is always exported WYSIWYG (What you see is what you get) to the CSV file. Also refer to the general Serial Decode Manual more details on the export, such as Auto-Export at every acquisition, Export with file auto-numbering and more.

Columns	Meaning of the columns contents
Idx	Line index in the table
Time	Start time of the message listed in the line. The start of the message is the start of the first bit in that message. For MDIO the first bit is the first bit of the 32 bit preamble.
Msg	A textual description of the message.
SOF	The value of the Start of Frame, 0 for Clause 45 and 1 for Clause 22.
OP Code	The OP code.
PHY Add	The Physical address for which the message is intended.
DevType	The Device type (see Figure XX).
TA	The turnaround delay of 2 bits.
Data	The 16 bit Data field representing either an address or a data value.
Status	Error description when the message has an error.

Figure 11 List of MDIO Columns in the table

Note: BitRate Tolerance is not used by the MDIO decoder since the clocking is governed by the clock line.

Error Messages emitted to the Status column

The Status column contains all of the error messages emitted by the decoder. The presence of text in the Status columns will cause the corresponding message to be colored red.

Field analysed	Error description	Error message
Start of Frame (2 bits)	The MDIO Start of Frame can take either value 0 (Clause 45) or value 1(Clause 22). Any other value is deemed incorrect	“Must be Clause 22 or 45!"
OP code(2 bits)	For Clause 22, only values 1 and 2 are acceptable, any other value will trigger the emission of an error message. For Clause 45 any value is acceptable and no check is performed	"OP code must be 1 or 2"
Device Type/Regaddr (5 bits)	For Clause 45, only values from 0 to 5 are accepted. , any other value will trigger the emission of an error message. For Clause 2 any value is acceptable and no check is performed	"DEVTYPE > 5!"
Number of bits in message	MDIO only defines message of 64 bits. Any message of a different length is deemed incorrect.	"NumBits != 64"

Figure 12 List of Error Messages emitted to the Status column

APPENDIX A MDIO Examples

The images in the Appendix document various topologies of MDIO signals.

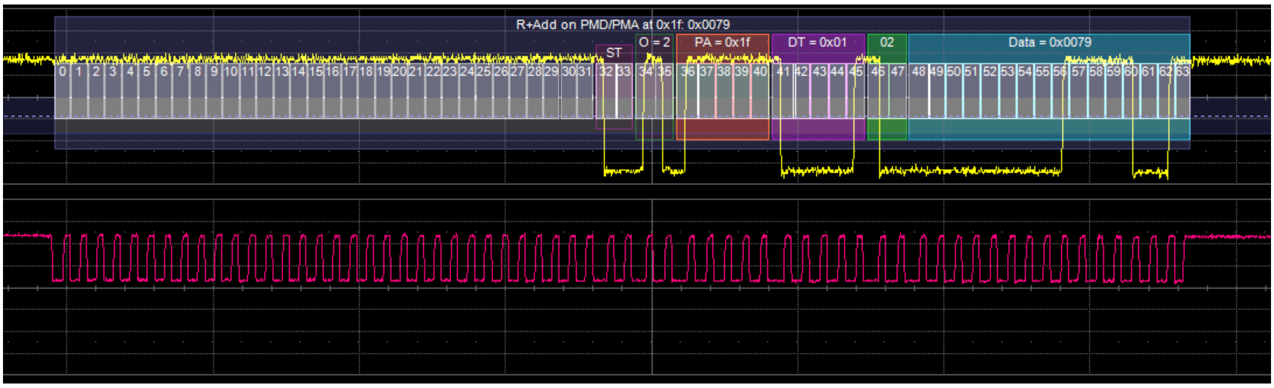

Figure 13 Example of MDIO signal, Clause 45, packetized clock

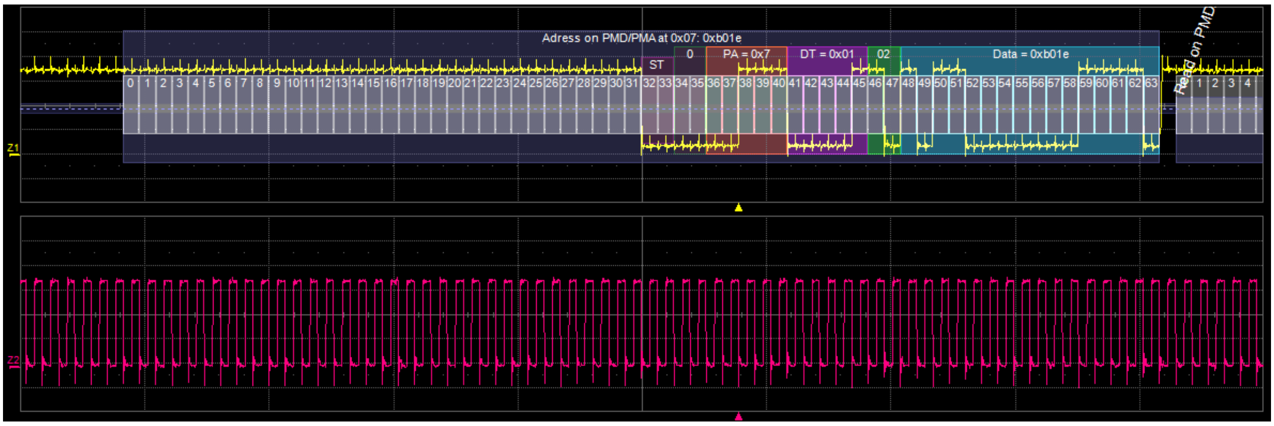

Figure 14 Example of MDIO signal, Clause 45, continuous clock

APPENDIX B Using Level and Hysteresis for difficult signals

Please refer to the ARINC 429 web page for an example of this functionality:

http://www.lahniss.com/_p/_parinc429/arimg/decodewithtunedlevels.png

The method described uses 2 levels instead of one level with hysteresis. The goal is to set levels and hysteresis in such a way that the noise is ignored. The principles explained on this avionics protocol are applicable to any other protocol regardless of its physical layer definition.

APPENDIX C: Exploiting the memory Depth and optimizing for speed

Teledyne LeCroy oscilloscopes have large or very large memories. This memory depth allows capture of **long time spans of signals**. The long time spans can allow the observation of the message payloads over seconds, sometimes minutes. When used on sensors this can help in monitoring the sensors behavior. The very useful option called ProtoBusMAG (Protocol Bus Measure Analyze and Graph) yields excellent results on long traces.

Another approach consists in using the sequence mode. In sequence mode, the acquisition memory is segmented and allows the non-contiguous capture of the signals. Interesting event can be captured minutes apart, over long periods of time, hence saving memories during times intervals without interesting events. The decoders can be used on the segmented waveforms as well. The messages times reflects the absolute times of the segments.

Automation access to relevant parameters

In many cases the decode results need to be exploited via a host computer. The following image illustrates the syntax for accessing the table values of any decoder at any position in the table.

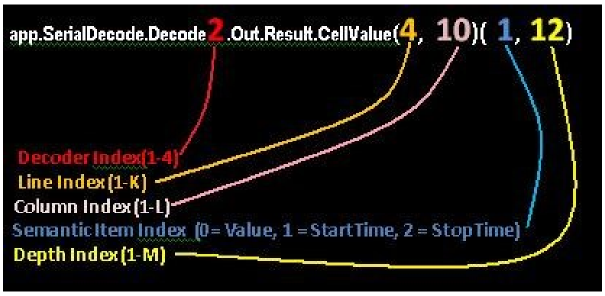

Figure 15 Accessing Table values through automation commands

Comments on Acquisition window and statistics

An oscilloscope repeatedly captures **windows in time**. Typically for MDIO the window is 20 to 70% of the time. The remaining time the instrument is blind due to the processing of the previous acquisition.

The capture however can then be **repeated over a long time**, with the result that the percentage of the coverage will extend to the entire measurement session. For example, assuming the oscilloscope is set to 100ms per division, (therefore 1 second per acquisition window) and the same amount of processing time. This is a 50% time coverage. If the test is repeated over an hour the same proportion will apply and the test will have covered about 30 minutes. This is largely sufficient to meet the test requirements in most cases and has the great advantage over any other system that if and when errors occur they can be analyzed immediately **down to the signal level**, and easily using the large tool-box on-board the oscilloscope.

Depending on the requested processing load, the time coverage might vary between 10% and 70 %.

Parallelizing tests using all of the oscilloscope channels

The tests could be parallelized using all 4 channels of the oscilloscope. In that case All 4 channels would be fed into each of the available decoder, and the processing chain above would be cloned 4 times. This mode is statistically interesting because multi-channel acquisitions occur in parallel. The processing is serialized, but i.e. in 80/20 % mode the monitoring of one more sensor only requires 20% additional time. This property could be used for production tests to validate more sensors in less time.

Hints to optimize for speed

Depending on the regime of operations several tricks can be used to speed up the acquisition/processing/display loop. These tricks are independent of one another and might be combined.

Avoid oversampling

It is not necessary to oversample the MDIO signal to decode it. 20 to 50 samples per pulse are sufficient. Having too many samples slow down the processing chain.

Optimize for Analysis and not for display

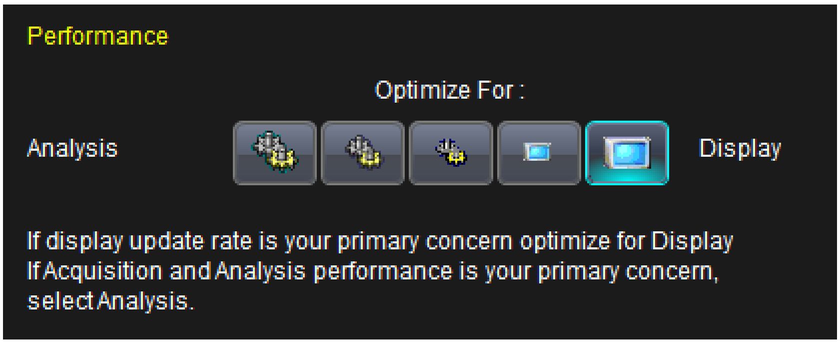

Figure 16 Performance selection control, Analysis vs. Display

This feature allows the user to have a certain control over the CPU time allocated to Display versus Analysis. It can help in certain cases.

Turn off all traces and annotators

As strange as it seems, the decoder can work **without showing its results**. The mere fact that a Parameter (MessageToValue or ColumnToValue in our case) is connected downstream from the decoder will force the decoder to remain instantiated. However, it will save CPU time, because the annotation display is not requested, and therefore accelerate the processing loop.

There are 2 items possible in this category: Turn off the decoded trace and reduce the decode table to a single line.

It is possible via automation to turn the entire table off also but still keep the computation active (app.SerialDecode.Decode1.View = 'false')

Decrease number of columns in Export of Tables

If the Decode Table needs to be exported, it is best to decrease its number of columns to the minimum necessary. The export time to the file is proportional to the amount of data exported. Fewer columns consequently translate into a faster export. Generally speaking, anything that can be computed on-board the oscilloscope accelerates the whole test.

Resources for optimizing performance

While most of the suggestions above relate to the decoders, a number of other useful suggestions and ideas, not related to the decoding, can be found in this document.

http://cdn.teledynelecroy.com/files/appnotes/an_019_techbrief_optimzg_perf.pdf

In any given ATE context, some of these suggestions might be applicable and others not. The applicability of the ideas largely depends on the oscilloscope utilization pattern for the tests at hand.