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Instruction Manual

ENETbusD Decoder

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922665 Rev A
March 2013

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Introduction

About This Manual

Teledyne LeCroy offers different toolsets for decoding and debugging serial data streams. These toolsets may be purchased as optional software packages, or are provided standard with SDA and DDA model oscilloscopes.

This manual explains how to use the ENETbusD toolset.

Assumptions

This manual is presented with the assumption that:

- You have a basic understanding of the various serial data standard physical and protocol layer specifications, and know how these standards are used in embedded controllers.
- You have a basic understanding of how to use an oscilloscope, and specifically the Teledyne LeCroy oscilloscope on which the serial trigger and decode option is installed. Only features directly related to serial data decode are explained in this manual; please see the oscilloscope online Help file, Operator's Manual, or Getting Started Manual for other instructions.
- You have purchased and installed one of optional serial data decoders described in this manual.

Compatibility

Teledyne LeCroy is constantly expanding coverage of serial data standards and updating software. Some capabilities covered in this documentation may only be available with the latest version of our firmware. You can download the firmware update from teledynelecroy.com.

While some of the screen images in this manual may not exactly match what is seen on your oscilloscope display—or show an example taken from your protocol—be assured that the functionality is nearly identical, as much functionality is shared.

ENETbusD Option Overview

Teledyne LeCroy ENETbusD is a software decode option for 10BASE-T and 100BASE-TX Ethernet, low-speed serial data applications. With this software, you can easily decode 100BASE-T and 10BASE-T Ethernet signals to examine each frame within a given packet, debugging problems such as interoperability issues, uncertain error causes, and physical-layer issues.

10BASE-T and 100BASE-TX are Ethernet protocol standards used to send and receive data across computer networks. As more and more devices are making use of the Ethernet protocol to communicate in embedded systems, debugging the protocol becomes increasingly difficult. Engineers need fast, reliable tools for debugging these embedded systems communication links. ENETbusD decode offers color-coded overlay with easy-to-understand details on the data stream’s link layer. In addition, powerful search capabilities allow you to search the acquired waveform in a myriad of ways.

Serial Decode Technical Overview

The algorithms described here at a high level are used by all Teledyne LeCroy serial decoders sold for oscilloscopes. They differ slightly for serial data signals that have a clock embedded in data or a clock separate from data.

The first software algorithm examines the embedded clock for each message based on a default (or user specified) vertical level. Once the clock signal is extracted or known, the algorithm examines the corresponding data signal at a predetermined vertical level to determine whether a data bit is high or low. The default vertical level is usually set to 50% and is determined from a measurement of peak amplitude of the signals acquired by the oscilloscope. It can also be set to an (absolute) voltage level, if desired. The algorithm intelligently applies a hysteresis to the rising and falling edge of the serial data signal to minimize the chance of perturbations or ringing on the edge affecting the data bit decoding.

NOTE: Although the decoding algorithm is based on a clock extraction software algorithm using a vertical level, the results returned are the same as those from a traditional protocol analyzer using sampling point-based decode.

After determining individual data bit values, another algorithm performs a decoding of the serial data message after separation of the underlying data bits into logical groups (Header/ID, Data Length Codes, Data, CRC, Start Bits, Stop Bits, etc.) specific to the protocol.

Finally, another algorithm applies a color overlay with annotations to the decoded waveform to mark the transitions in the signal. Decoded message data is displayed in tabular form below the grid. Various compaction schemes are utilized to show the data during a long acquisition (many hundreds or thousands of serial data messages) or a short acquisition (one serial data message acquisition). In the case of the longest acquisition, only the most important information is highlighted. In the case of the shortest acquisition, all information is displayed (Header/ID, Data Length Codes, Data, CRC, Start Bits, Stop Bits, etc.) with additional highlighting of the complete message frame.

General Approach

The order of your interaction with the decoder software in many ways mirrors the order of the algorithms. You will:

- Assign a protocol/encoding scheme, an input source, and a clock source (if necessary) to one of the four decoder panels using the Serial Data and Decode Setup dialogs.
- Complete the remaining dialogs required by your protocol/encoding scheme to decode Transitions, Bits and Words.
- Work with the decoded waveform and result table to analyze the decode.

While not required, we recommend the following general approach to decoding:

1. Set up the decoder.
2. Acquire a single burst of relevant data, then run the decoder.

   NOTE: If the sampling rate (SR) is insufficient to resolve the signal adequately based on the bit rate (BR) setup or clock frequency, the protocol decoding is turned OFF to protect you from incorrect data. The minimum SR:BR ratio required is 4:1. It is suggested that you use a slightly higher SR:BR ratio if possible, and use significantly higher SR:BR ratios if you want to also view perturbations or other anomalies on your serial data analog signal.

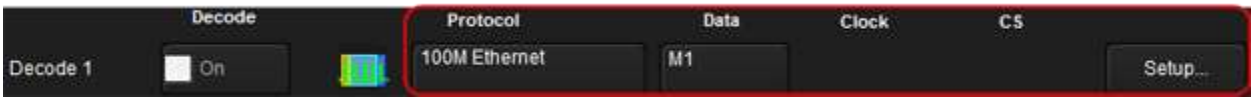
3. Use the various analysis tools to verify that transitions are being correctly decoded. Tune the decoder settings as needed.
4. Run the decoder on acquisitions of the desired length.

   You can disable/enable the decoder as desired without having to repeat the set up and tuning provided the basic signal characteristics do not change.

Setting Up the Decoder

You can preset up-to-four, independent decoders using the same or different protocols and data sources. These decoders can be enabled simultaneously or separately, and for each you can select what data appears on the display.

1. Touch the **Front Panel Serial Decode button** (if available on your oscilloscope), or choose **Analysis > Serial Decode** from the oscilloscope menu bar to access the Serial Decode dialog.
2. On the same row as the **Decode #**:
   - Select the desired **Protocol** to use. The selections will depend on the software options installed on your instrument.
   - Select the **(Source) Data** to be decoded. This can be any signal input channel, memory, or math function. Depending on your Protocol selection, you may be required to select more than one source. The requisite number of fields will automatically appear.
   - If required, select the **Clock and Clock Source (CS)**. These controls are available for certain protocols; they will simply not appear if not relevant.
3. Touch the **Setup button** to open the **Decode Setup** dialog. If you use this method rather than the tab, the correct decoder will be selected by default.



4. Go on to complete the settings required for the ENET protocol on the right-hand dialogs next to the Decode Setup dialog.

   Probe Selection - choose whether your signal input device is One Differential Probe or Two-Single Ended Probes. Depending on your selection, the left-hand side Decode Setup dialog will display either of the following entry fields:

   Dp-Dn - if you are using a single differential probe, a single entry field appears. Select the source input channel to which the probe is connected.

   Dp and **Dn** - if you are using two single-ended probes, two entry fields appear. Select the input channels for both the positive (Dp) and the negative (Dn) inputs.

   Detect AutoNegotiation (100M ENET only) - Check this box to mark on the decode trace occurrences of Auto Negotiation in the decoded signal.

TIP: After completing one decoder, you can quickly start setup for the other decoders by using the Decode # buttons at the left of the Decode Setup dialog. You don't have to step back to the Serial Decode dialog to start the setup. Controls with the same label on either dialog share the same function.

Enable/Disable Decoder

Once preset, the four decoders can be enabled simultaneously or separately as often as you wish, although this number may be limited depending on the type of source channels selected. Preset decoders can be easily disabled without disrupting the configuration.

To enable:

Press the **Front Panel Serial Decode button**, or choose **Analysis > Serial Decode**, to open the Serial Decode dialog, then check **Decode On** next to the respective decoder.

If **View Decode** is checked (default) on the Decode Setup dialog, a result table and decoded waveform appears for each enabled decoder. The number of rows of data displayed on each table will depend on the **Table#Rows** setting. The default is one, which can be increased, but doing so will decrease the amount of the screen available to display traces.

To disable:

Deselect the **Decode On** box individually, or touch **Turn All Off**.

Applying Measurements

After the decoder has been enabled on a valid acquisition, measurements can be applied to the decoded waveform. These measurements appear in a tabular readout below the grid (the same as for any other measurements) and are in addition to the result table that shows the decoded data. You can set up as many measurements as your oscilloscope has parameter locations.

From the Result Table

The decoder offers a sub-set of measurements designed for serial data analysis. To quickly apply these measurements:

1. Touch any **data cell** of the decode result table.

   NOTE: If you're running more than one decoder simultaneously, be sure to select a cell from the correct table, as the measurement source will be whichever waveform belongs to the table you touch.

2. From the pop-up menu, select **Measure** to display the Select Operation... dialog.

3. Touch any measurement operation to select it. Options are:

    - **View Serial Encoded Data as Analog Waveform** - Automatically sets up a Message to Value parameter and then tracks the assigned measurement. In doing so, a Digital-to-Analog Conversion (DAC) of the embedded digital data is performed and the digital data is displayed as an analog waveform.
    - **Message to Value** - Extract and convert a specific portion of the data/payload in the message and display it as an analog value.
    - **MsgToAnalog (Message to Analog)** - Computes the time difference from a protocol message to the crossing of a threshold on an analog signal.
    - **AnalogToMsg (Analog to Message)** - Computes the time difference from the crossing of a threshold on an analog signal to a protocol message.
    - **MsgToMsg (Message to Message)** - Computes the time difference from one protocol message to another protocol message.
    - **DeltaMsg (Delta Message)** - Computes the time difference between two messages on a single decoded line.
    - **Time@Msg (Time at Message)** - Time from trigger to each protocol message (meeting specified conditions).
    - **BusLoad** - Computes the load of user-defined messages on the bus (as a percent).
    - **MsgBitrate** - Computes the bitrate of user-specified messages on decoded traces.
    - **NumMessages (Number of Messages)** - Computes the number of messages which match a user-specified definition in decoded traces.

4. On the next dialog, choose a **parameter** location (P1-Px) in which to run the measurement.

    NOTE: If you choose a location that already stores a measurement, this selection will overwrite that setup.

From the Decode Setup Dialog

You can also access the Select Operation... dialog of serial data measurements by touching the **Measure button** on the **Decode Setup** dialog. Follow Steps 3 and 4 above to set up the measurements. Measurements are set on the source of whichever Decoder (1-4) is currently selected on the Decode Setup dialog.

From the Measure Menu

The full menu of available measurements can be accessed through the menu bar. Choose **Measure > Measure Setup** and follow the usual procedures for setting up a measurement. In this case, you will have to manually choose the source to measure.

Working with the Decode Trace

Serial Decode Annotations

When a decoder is enabled, an annotated waveform showing the results of the decode appears on the oscilloscope display.

A colored overlay marks significant transitions in the source signal. The overlay contains annotations corresponding to the data itself, any pre/post-message padding, inter-burst periods, etc. Each set of annotations is customized to the protocol or encoding scheme. The amount of information shown on an annotation is affected by the width of the rectangles in the overlay, which is determined by the magnification (scale) of the trace and the length of the acquisition.

These overlays appear on the decoded ENET waveform or its zoom trace to highlight key portions of the decoded signal.

Frame - Dark green overlay, indicating single Ethernet frame (packet) decoded.

Idle - Bright aqua overlay showing idle time between frames.

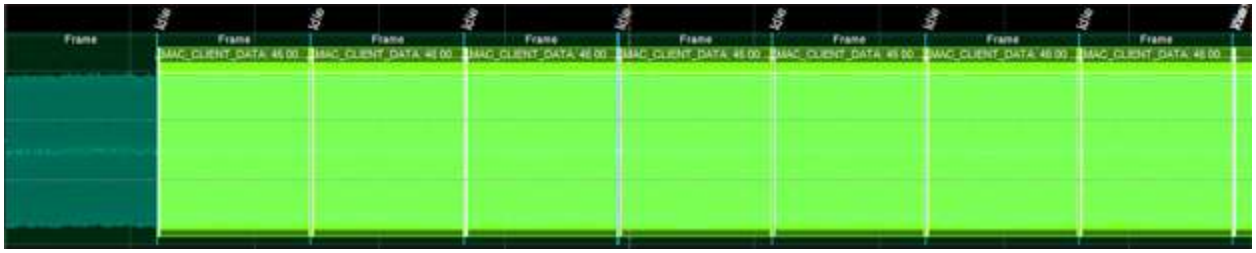
Destination and Source Addresses - Gray overlay to left of Type, showing 48-bit MAC addresses of destination and source nodes.

Type - Olive overlay to left of client data indicating the EtherType/Length of the encapsulated payload message.

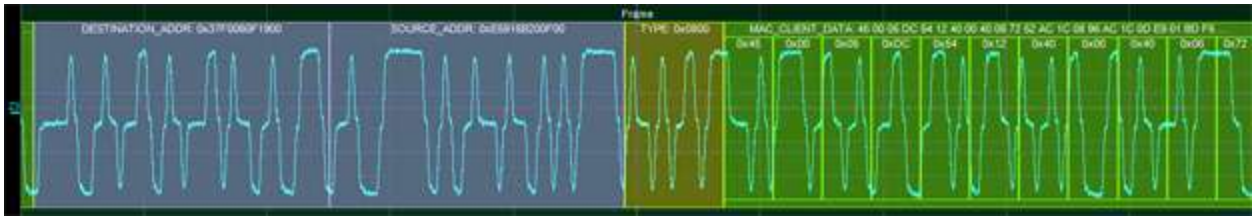
MAC_Client_Data - Green or bright green overlay, showing payload data . At sufficiently zoomed resolutions, this overlay will show all the decoded bits.

Pre-Amble (not shown) - Green overlay showing Pre-amble bits.

FCS (not shown) - Tan overlay showing Frame Check Sequence bits.



Decoded waveform. At this resolution, very little information appears on the overlay.



Zoomed waveform, showing annotation details.

Search Waveform

Choosing **Search** on the Decode Setup dialog opens a Zoom of the original decoded waveform and displays the corresponding Zoom dialog with the standard rescaling controls.

Use the **<protocol> Search** right-hand dialog to enter the search criteria. Then, use the navigation buttons on the Search dialog to find the previous or next event in the trace that matches the search criteria.

NOTE: If the match is found in a message currently displayed on the result table, that row will be highlighted. However, if it is not displayed, the Search navigation buttons will not automatically bring up that table row, although they will navigate the trace. Use the scrollbar at the right of the result table to find the row containing the search result.

The default Zoom always presents the found event at the full width of the grid. Use the Zoom dialog controls to rescale the Zoom to the desired level of magnification.

Choose from the following options on the ENET Search dialog.

Any - Any Ethernet protocol element (frame or idle time). This option finds the next row in the result table, so you can use the Search navigation buttons to scroll the table (up to the number of rows displayed).

Frame - Next frame. Also choose either:

Don't Care(default) - any frame

Type (Hex) - next frame of this EtherType/Length. Clear Don't Care to activate this field, then enter the hex code for the desired type. Refer to IEEE standard 802.3 for a list of valid codes.

Src_Address - MAC address of node from which packet sent. Also either:

Enter the **Address Value**, or

Touch **Copy From Frame** to copy the value from the highlighted table row and search for that.

Dest_Address - MAC address of node to which packet sent. Also either:

Enter the **Address Value**, or

Touch **Copy From Frame** to copy the value from the highlighted table row and search for that.

TP_Idle (10M ENET) or **Idle** (100M ENET) - Next idle time between frames.

Link Integrity Test (10M ENET only) - Next link test signal.

FLP Burst - Next fast link pulse burst.

Electrical Idle - Next drop in electrical signal.

Protocol Error - Next error. Also choose the **Protocol Error Type** from among:

Any

Missed Terminate

Missed Start of Frame

4B5B Error

(continued next page)

Frame Length Error

Preamble Value Error

SDF Value Error

CRC Error

Data Size Error

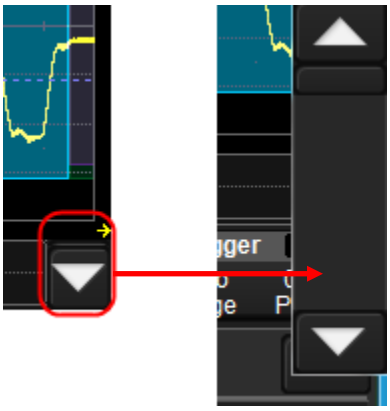
Unknown - Next occurrence of an unknown frame type.

Working with the Results Table

By default, a table summarizing the decoder results appears below the grids whenever a decoder is enabled. The decode result table provides a view of message data as decoded by the oscilloscope during the most recent acquisition, even when messages are too compact to allow annotation on the waveform trace.

The table is displayed only when the **View Decode** checkbox is marked on the Decode Setup Dialog *and* a source signal has been decoded using that protocol.

You can customize the result table, changing both the number of rows and the columns displayed. The default is one row. A scrollbar at the right of the table lets you display the previous or next row of table data.



On a single-row table, touch the Down arrow to open the scrollbar.

You can also export result table data to a .CSV file, and the table itself provides a useful tool for navigating and measuring.

Customize Decode Result Table

Follow these steps to change which decode values appear in the result table:

1. Press the Front Panel **Serial Decode button**, or choose **Analysis > Serial Decode**, then open the **Decode Setup tab**.
2. Touch the **Configure Table** button.
3. On the **View Columns** pop-up dialog, check boxes for the columns you want to appear in the table. Clear boxes for any columns you wish to remove. Only those columns selected will appear on the oscilloscope display.

   To return to the preset display, touch **Default**.
4. Optionally, set a **BitRate Tolerance** percentage. This value will allow for signal jitter correction while decoding.
5. Touch the **Close** button when finished.
6. Optionally, on the Decode Setup dialog enter the **Table # Rows** to display. Each row will contain data from one decoded message.

   NOTE: Keep in mind that displaying several, multiple-row tables will reduce the amount of screen space available for the waveform grids.

You may display or hide these columns on the ENET result table.

- **Time(us)** - Time (in microseconds) of the beginning of the frame, with respect to the trigger time of the acquisition.
- **Type** - Frame or Idle time.
- **Dest Addr** - Packet destination MAC address.
- **Source Addr** - Packet origination MAC address.
- **Details** - Decoded data (type and payload), or type of protocol error if decode failed.

100M Ethe...	Time(us)	Type	Destination Addr	Source Addr	Details
0	-500	Frame			Missed start of Frame;
1	-378.47245	Idle			
2	-377.568117	Frame	0x37F0060F1900	0xE5916B200F00	Type/Length = 0x0800; Data payload [length = 1500]
3	-255.421384	Idle			
4	-254.541826	Frame	0x37F0060F1900	0xE5916B200F00	Type/Length = 0x0800; Data payload [length = 1500]
5	-132.39481	Idle			

Section of typical ENET result table.

Navigating with the Result Table

Besides displaying the decoded serial data, the result table enables you to quickly Zoom regions of the decoded waveform and control decoder dialogs.

The **first column heading** (top, left-most cell of the table header) bears the name of the corresponding protocol, and the cell's fill color matches the color of the input source. Touching this cell opens the Decode Setup dialog if it has been closed.

Touching the **row number** in the first column opens a Zoom of the corresponding region in the decode trace.

Touching any other **data cell** in the table opens a pop-up menu with several choices of action:

- **Off** turns off the decoder.
- **Zoom** creates a zoom of the region where the data appears (same as touching the row number).
- **Setup** opens the Decoder Setup dialog (same as touching the first column heading).
- **Export** exports the decode results table to a .CSV file.
- **Measure** displays a dialog of various measurements that can be made on the source signal.

Export Decode Result Table

You can export the decode result table data to a **.CSV** file.

Export files are by default created in the Xstream\Applications\<protocol> folder, although you can choose any other folder on the oscilloscope, or any external drive connected to a host USB port. The data will overwrite the last export file saved in the protocol directory, unless you enter a new filename.

To export the result table:

1. Press the Front Panel **Serial Decode button**, or choose **Analysis > Serial Decode**, then open the **Decode Setup tab**.
2. Optionally, touch **Browse** and enter a new **File Name** and output folder.
3. Touch the **Export Table** button.

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