BitScope Logic User Guide

BitScope Logic is a timing and protocol analyzer for BitScope.
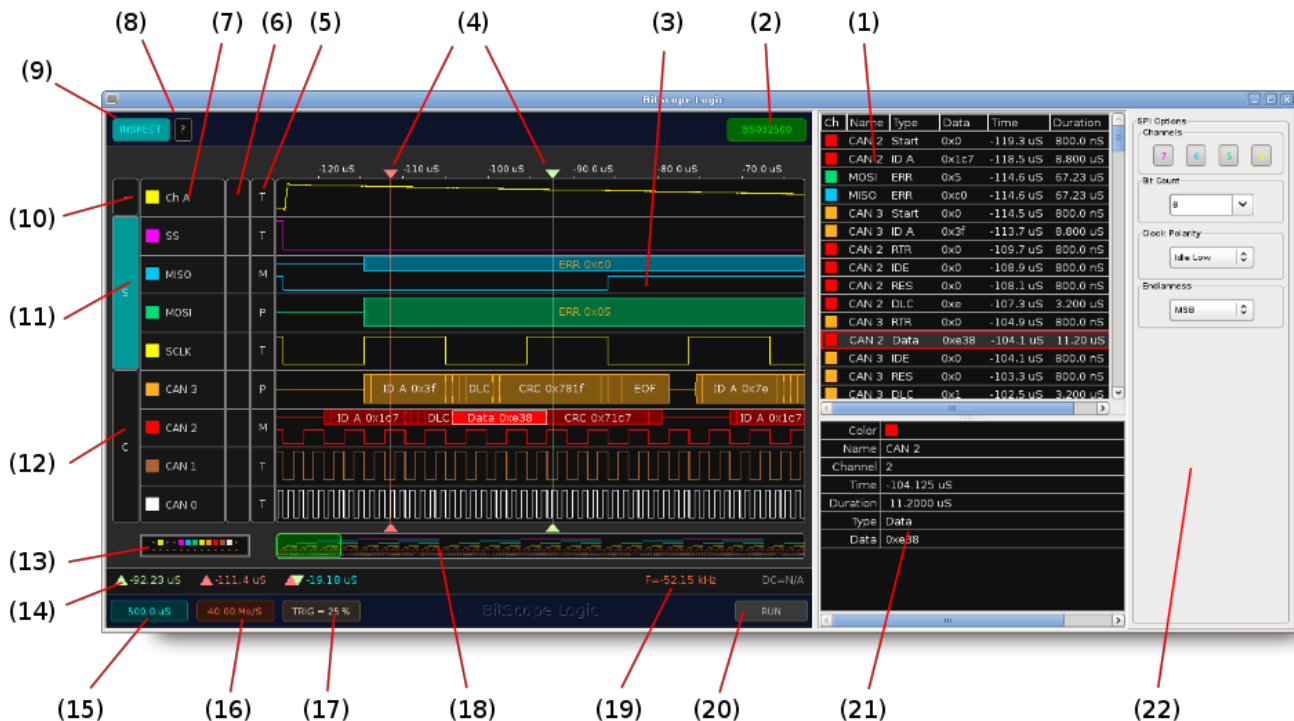
ID	FEATURE	DESCRIPTION
(1)	Packet Log	Decoded data packets on enabled channels in chronological order.
(2)	Setup/Connect Buttons	Configures Logic and connect to the BitScope.
(3)	Timing & Data	Logic level and decoded packet shown on the time grid.
(4)	Cursors	Relocatable cursors for edge-to-edge-to-packet timing measurement.
(5)	Display Mode	Select between timing or packet display, or both simultaneously.
(6)	Trigger	Trigger condition widget; rising, falling, high, low or don't care.
(7)	Channels	Colour coded user (re)definable channel labels.
(8)	Help Bar	Reports quick tips when enabled as the mouse moves over widgets.
(9)	Inspect Button	Activates the packet inspector mode (see packet log).
(10)	Analog Nybble	BitScope's analog channels (up to 4 depending on the model).
(11)	High Nybble	High (protocol decoder) nybble logic channels (D7..D4)
(12)	Low Nybble	Low (protocol decoder) nybble logic channels (D3..D0)
(13)	Channel Key	Graphical pin diagram & connection key of BitScope's POD connector.
(14)	Time Measurements	Point and Mark cursor and cursor (time) difference measurements.
(15)	Capture Time	Total time duration of the current capture frame.
(16)	Sample Rate	Sample rate used to capture the current frame.
(17)	Pre-Trigger	Percentage of capture buffer dedicated to capturing before the trigger.

(18)	Navigator	Navigable overview of all channels of the current capture frame.
(19)	Implicit Frequency	Reports the frequency implied by the current cursor time difference.
(20)	Capture Button	Frame capture control. One-shot or continuously repeating capture.
(21)	Packet Inspector	Shows a single decoded packet or packet fragment in detail.
(22)	Protocol Options	Selected protocol options, bits, endianess, levels etc.

Table Of Contents

1. Introducing BitScope Logic

BitScope Logic is a mixed signal logic timing and protocol analysis application for BitScope.

It features customizable logic triggers, cursors, zoom controls, timing diagrams, and packet decoding.

Protocols supported for decoding and analysis include CANBus, SPI, I2C and UART.

BitScope Logic comprises three main displays.

DISPLAY	DESCRIPTION
Main Display	The primary and default logic level, timing and decoded packet timing display.
The Packet Log	Chronological ordered decoded packet listing for all enabled channels (1)
Packet Inspector	Detailed packet information for a single selected packet (21)

For logic timing and simple protocol analysis the timing diagram is often all you'll need. The packet log and inspector are convenient when trawling through more detailed capture data when looking for protocol errors.

1.1 Operational Overview

BitScope Logic is typically used following four step::

Connect -> Setup -> Capture -> Analyze.

Connect

To connect to a BitScope, optionally click Setup (See Chapter 2). Make sure the settings are correct, and then click Connect. The Connect button should turn green if connection was successful. The Connect button will turn red if connection was unsuccessful. If you cannot connect to a BitScope, then you may have problems with your Probe File. Please see Connecting To A BitScope for more details.

Setup

Once connected, a Protocol can be selected for a Protocol Nybble. The protocol details can be configured with the Protocol Options menu. A Trigger can also be setup on any combination of Channels.

Capture

With a protocol selected, we are ready to Capture. First we will need to setup the capture from the Control Panel, to select the sample rate, capture time and pre-trigger. To start the capture, press the Capture Button. This will tell the BitScope to trigger on the signal, then capture, download and decode the data. Once this is complete, the application will display the data and the decoded packets on the main display.

Analyze

Once the data has been captured, it can be analyzed. First select an appropriate Display Mode, depending on whether you wish to see edges or packets or both. Next, use theNavigator to scroll around to find a region of interest. To analyze packets and logic signals further, use the Cursors, Packet Log and Cursor Measurements.

2. Connecting with BitScope

At the top right of the Timing Display are two buttons:

| BUTTON	DESCRIPTION
SETUP	Configure connection to BitScope (usually optional).
CONNECT	Open the connection to BitScope.

Click CONNECT to open the connection to BitScope and start using the Logic. If only one BitScope is plugged into the PC there is usually no need to click SETUP but if the BitScope is not locally connected (via USB or a local LAN) or if more than one BitScope is available, SETUP is required tell Logic which BitScope to connect with and use.

When connection is successfully established the CONNECT button reports the device version string of the BitScope to which Logic has connected. Logic configures itself for that BitScope (e.g. it may change the number of channels displayed or protocols supported).
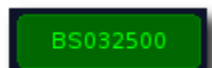
If connection was unsuccessful, the CONNECT button turns red.

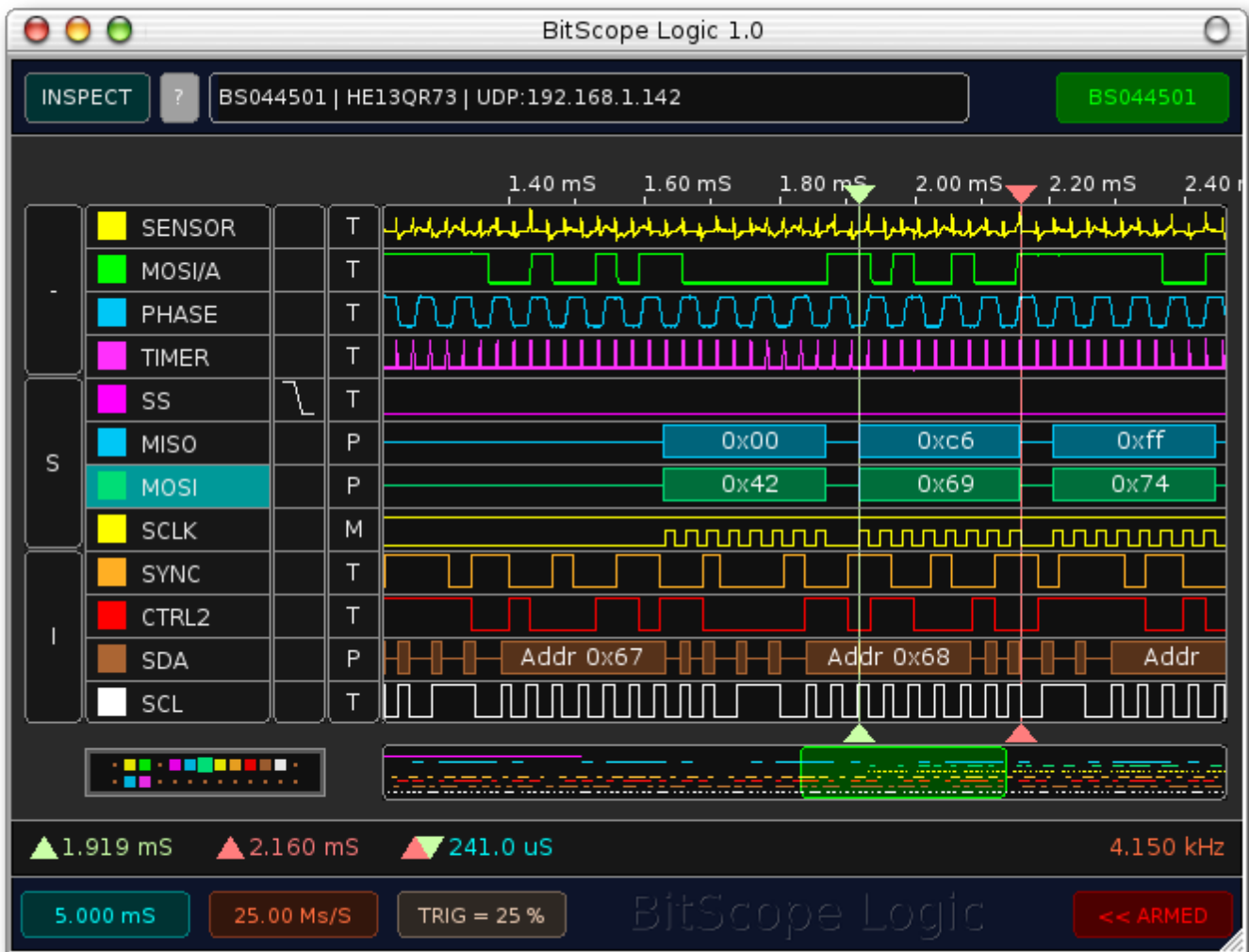In this case click the SETUP button to reveal the setup dialog:
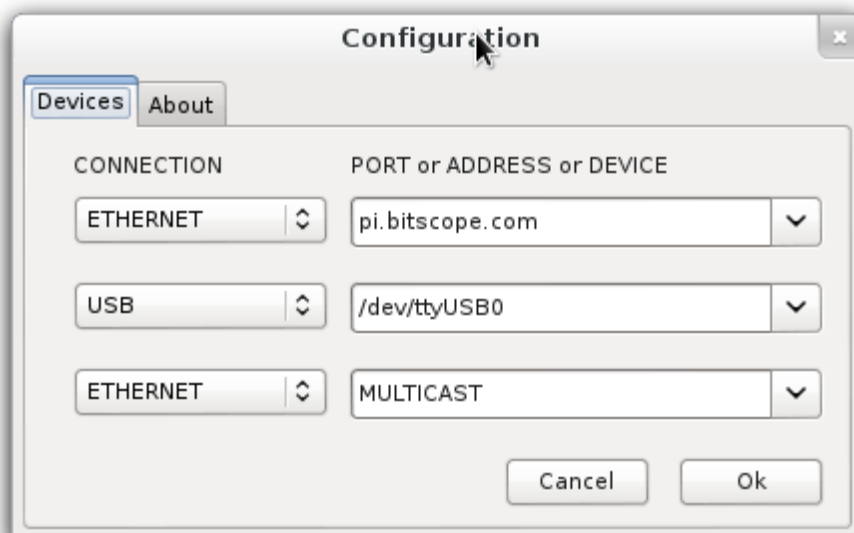
and update at least one link specification as appropriate for the connection to your BitScope.

Refer to the **probe file guide** for full details.

3. Main Display and User Interface

The **Main Display** provides access to most of the user interface elements of BitScope Logic:

Shown here is Logic connected with [BS445](#) which supports 12 channels (4 analog plus 8 logic). The most important element of the main display is the timing diagram which shows logic traces and packet data. To their left are the display mode selectors (T,M,P), trigger controls (/,\,_,-) and protocol selectors (-,S,I etc).

Below the timing diagram is the navigator and to it's left is the signal connection key.

3.1 Display Modes

The Display Mode determines how logic data should be displayed.

There are three options: **Timing** (T), **Packets** (P) or **Mixed** (M).

To select a Display Mode, right-click a box in the 'Mode' column of the application.

A pop-up menu with the options will appear. Left-clicking a Mode box will toggle between the last selected value. More details on each mode are shown on the following page.

3.1.1 Timing Display Mode

When **Timing Mode** (T) is selected only the logic timing information is shown. The channel is shown as a trace of high or low levels with transitions appearing whenever the signal switches.
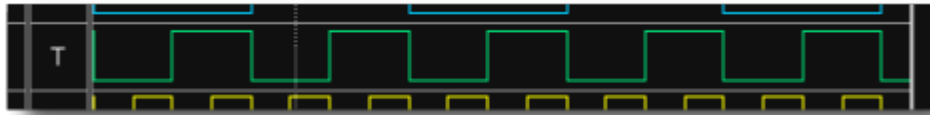
The analog channels are similar but the waveform shown is continuous instead of discrete. In the case of analog channels timing mode is the only display mode supported because it does not make sense to display packet data for analog signals. Note that some BitScope models (BS10) allow the analog channels to be routed via a comparator to produce an equivalent logic signal (switching at the user specified trigger level) which can be decoded and displayed as protocol packets.

3.1.2 Packet Display Mode

When **Packet Mode** (P) is selected the protocol packet decoded from the logic timing data is shown instead of the data itself if the protocol is successfully detected and decoded.

The packets that are displayed depends on the protocol selected for channel or channels concerned. Within each displayed packet the decoded payload data or packet type can be displayed (see below).

3.1.3 Mixed Display Mode

When **Mixed Mode** (M) is selected both packet data and the timing data are displayed together:

In this way both the packets and the timing data from which they have been decoded can be seen together.

3.2 Packet Display Formats

The packet display format shows information which depends on the chosen Protocol. It can be either:

- **Type** - the type of packet, for example ACK, Data, ERR, CRC etc. Type is indicated with a type code which differs between protocols or
- **Data** - the payload information read from the timing data for the selected protocol.

This information will be shown in each packet on the screen:

Note that there is not enough room in the packet itself, no text will be displayed on the screen. To view the data in this case, select (click on) the packet and view the information via the **Packet Log**.

3.3 Navigation Control

Often much more data will be captured than may be required for decoding or analysis, usually because it it not know ahead of time where the relevant information may be. BitScope Logic provides easy navigation controls to enable scrolling and relocating the position through the data frame to find regions of interest.

The most important tool is the **Navigator**.
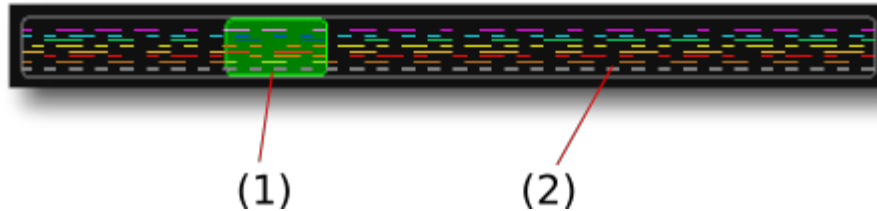
The Navigator appears below the main display and shows the full extent of the capture frame and the region within the frame currently shown on the main display. It comprises two parts:

ID	BUTTON	DESCRIPTION
(1)	VIEW PORT	Movable overlay that shows the extent of data shown on the main display.
(2)	NAVIGATOR	Channel logic rendered in channel colour when the level is high.

As the View Port is moved the main display updates to show the viewed region in more detail. The Navigator shows itself shows all channels in overview. When the signal is high it is rendered in channel colour. When the signal is low the channel is shown blank producing the dashed appearance. It can be very convenient to see the entire capture in this way as patterns in the logic data are usually clearly visible.

3.3.1 Waveform Scrolling

The View Port provides a convenient way to adjust the waveform (time) offset to locate a region of interest to any position on the display. Simply drag the View Port with the mouse pointer (or finger on a touch screen).

As the View Port moves the main display is updated dynamically to match the new location.

There are also keyboard and mouse wheel short-cuts to do this as follows:

Move Left	Left Arrow Key	Mouse Wheel Down
Move Right	Right Arrow Key	Mouse Wheel Up

Note that the mouse wheel can be used this way only when the mouse pointer is located over the Navigator.

3.3.2 Time Scale Zoom

In addition to relocating the View Port it's possible to change its size, that is, change the time scale used for the main display. The range of time scale zoom available depends on the BitScope model used and the size of the capture frame used but typically is at least a factor or 10. There are also keyboard and mouse wheel short-cuts to do this as follows:

Zoom In	Up Arrow Key	Ctrl + Mouse Wheel Up
Zoom Out	Down Arrow Key	Ctrl + Mouse Wheel Down

The mouse wheel can be used this way only when the mouse pointer is located over the Navigator.

3.3.3 Out of Bounds

When zooming out, it is possible to zoom out too far. In this case, the zoom will keep the correct center, but will display the View Port in orange:


Orange indicates that the View Port has a region out of bounds and that there is blank data on the screen.

3.4 The Channel Key

The Channel Key is a graphical representation of the logic POD pins on the BitScope.

Valid channels are shown in a colored square. Use this key to find the relevant pin on the BitScope.

1. **Analog Pins** - The pins in columns 1 and 2 are reserved for the Analog POD inputs on BitScope. They are used for the Analog Nybble.

2. **Logic Pins** - The colored pins shown here are reserved for the digital logic channels. The ground pin is beneath each logic pin. These pins correspond to the High and Low Nybble.

3. **Selected Channel** - When a channel is selected, the light on the Channel Key will expand. To select a channel, you must left-click on the Channel Name.
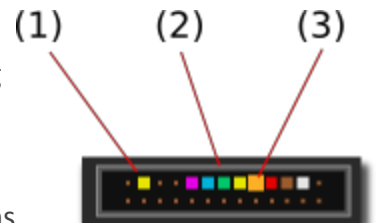
3.5 Measurement Cursors

There are two cursors on the main display: **POINT** (2) and **MARK** (1).

The time values of the cursors (relative to the trigger) are shown in the bar at the base of the screen and the time difference between cursors is also available in the same location.

To move the cursors, simply hold left-click and drag the cursor to the appropriate position. The cursors also support a **snap-to-edge feature**, which can be used by *holding the Ctrl key while moving a cursor*.

The cursors will snap to the logic timing edge nearest to the location of the mouse pointer (not any associated packets if these are also displayed). It is therefore easy to locate either cursor in any edge with precision to make quick timing measurements between them.
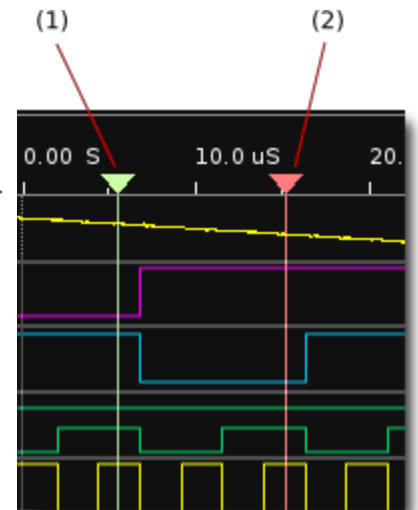
4. Waveform Capture

After connection has been made with BitScope the waveforms and logic data must be captured.

This requires choices to me made about what sample rate, capture duration and trigger conditions to use.

4.1 Capture Parameters

At the bottom left of the main display is the capture control panel where these parameters are assigned:

1. **Capture Time**

2. **Sample Rate**

3. **PreTrigger**

(1)   (2)   (3)

500.0 uS   40.00 Ms/S   TRIG = 25 %
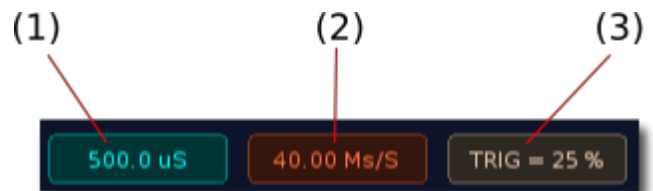
To change any of these parameters, right-click to open the pop-up menu of options. The selected value will be used for the next capture.

For long duration captures and/or very high speed sample rates, the number of samples required may exceed the available internal buffer. If this occurs, the parameters must be reduced (i.e. a lower sample rate or shorter duration) to fit within the available buffer. This happens automatically. If you choose a sample rate that is too fast, then the capture time will be reduced. Conversely, if you choose a capture time that is too long, then the sample rate will be reduced.

Please note that some protocols require a sample rate several times higher than the protocol clock rate. If sampled at a rate that is too low the data may not be able to be decoded correctly.

4.2 Trigger Condition

If no trigger condition is established, waveform capture proceeds immediately the RUN button is clicked. Often this is not what is required. Instead a trigger condition is first established which ensures that capture proceeds only when the trigger condition is met.

The capture can be programmed to acquire data before or after the trigger, or both before and after it. By default all capture occurs after the trigger but the **PreTrigger** (3) parameter allows you to choose whether to capture pre-trigger as well.

The trigger condition can then be set for on any combination of logic channels.

The settings for a trigger channel is chosen from the trigger column on the main display.

/	**RISE**	Transition from low level to high level.
\	**FALL**	Transition from high to low level.
-	**HIGH**	Level high (any time).
_	**LOW**	Level low (any time).
	NONE	Don't care (does not participate in the trigger condition)

When a capture has commended and condition is seen on the logic inputs, the trigger fires.

The condition applying to each channel is selected by right-clicking on a channel trigger cell to show the pop-up options for each option.

Left-clicking the trigger cell toggles between the last two selected values.
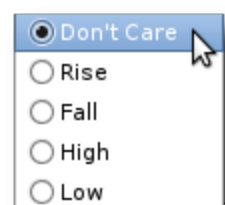
Assigned trigger condition is be used for the next Capture.

Note: conditions can be applied to the analog channels as well but they may not be be used at the same time as the logic triggers on most BitScope models. That is, if you assign a trigger to an analog channel any logic trigger condition will be overridden and vice vera.

4.3 Capture Control

The capture button commences waveform acquisition, subject to the prevailing trigger condition,and shows the current status of capture as it proceeds. Left-click the capture button to start a capture cycle. Capture sequences throught the following steps:

```
Armed -> Capture -> Acquire -> Decode -> Idle
```

The steps are as follows:

STEP	DESCRIPTION
ARMED	When clicked capture reports 'ARMED' and wait for the trigger.
CAPTURE	The trigger condition has been is seen and data is being captured to the buffer.
ACQUIRE	Capture has completed and data is being uploaded to the host computer.
DECODE	The acquired data is being decoded for display.
IDLE	Capture has completed.

If the trigger condition is never seen, capture will never complete. To abort such a capture, left-click the capture button which will abort the current cycle.

It is also possible to capture continuously. Right click on the capture button to select repeat mode. In repeat mode, the repeat symbol will appear beside the button. In repeat mode, left-clicking the Capture Button will run the capture cycle repeatedly. Left-click the Capture Button again to stop the cycle.

Note that if you change settings in repeat mode, the parameters will update on the next capture cycle not the prevailing one.

5. Protocol Analysis

BitScope Logic can decode data according to various protocols.

A Protocol is selected by right-clicking a protocol cell, as show. Selecting a protocol automatically decodes the existing data according to that protocol.

To configure a particular protocol decoder, left-click the protocol cell which will open the protocol options.
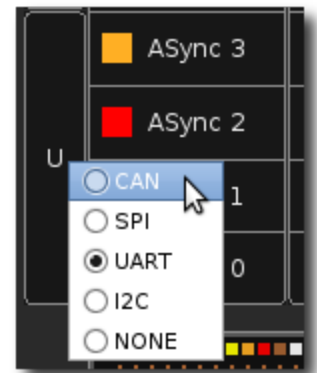
5.1 Protocol Nybbles

Logic has two protocol decoders.

Each decoder applies to a a 4 logic channel block called a Protocol Nybble (D7..D4 and D3..D0).

Each channel within the nybble forms part of the protocol group being decoded. For single channel protocols such as UART or CANBus this means up to 4 independent signals may be decoded. For others, such as SPI which require up to 4 signals it means one (bi-directional) SPI channel may be decoded per nybble.

There is a third nybble for the analog channels. The Analog Nybble differs between BitScopes, but all have at least one analog channel. The High and Low Nybbles can be assigned a Protocol by right-clicking on the protocol box. For example, a (single channel) analog nybble may look like:

The high logic nybbles selected for SPI decoding may look like:
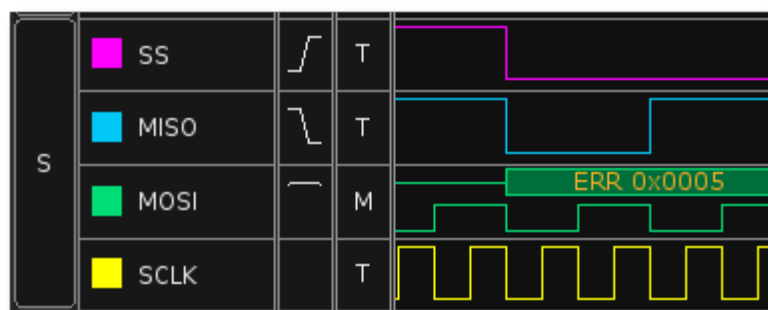
And the low nybble with no decoders applied like this:
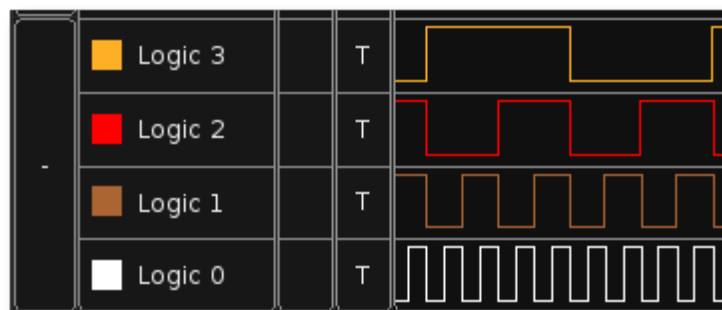
Note that for each protocol, a different number of channels lines may be required.

For example, for the high-nybble SPI protocol above, 4 data lines are needed, and each line is assigned a function SS, MOSI, MISO or CLK. On the other hand, with a CANBus protocol selected, only one data line is needed. This means that a CAN nybble will contain 4 separate CAN lines:
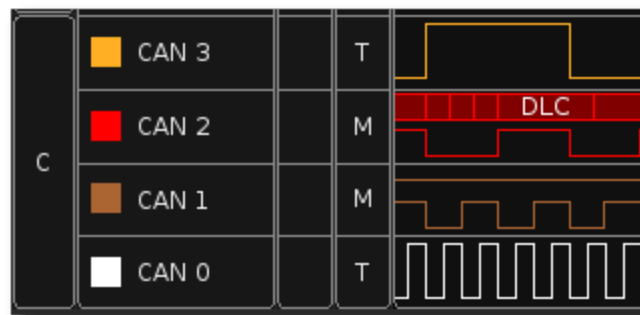
If you do not need the other CAN lines, then they can be disabled with the Protocol Options.

5.2 Protocol Options

The Protocol Options provide control over settings used for the selected protocol.
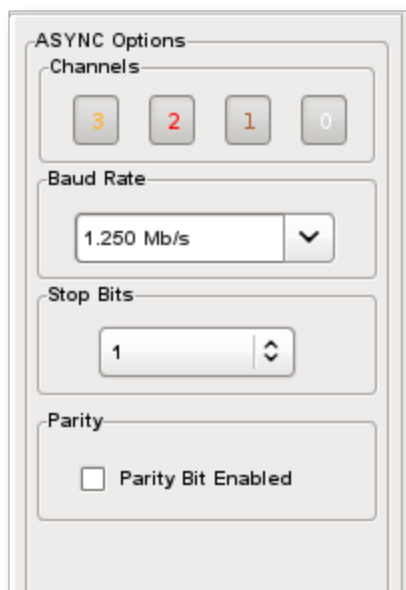
To view the Protocol Options, simply left-click on the protocol nybble. When a protocol is selected, it will be highlighted in blue, and the options will appear in the right panel.

Protocol Options will be different, depending on the Protocol selected but for all protocols, the Channel enable and disable buttons will always be present.

The enable buttons determine whether data is decoded or not.

If decoding large data sets, and do not need all 4 channels to be decoded, you can switch off the unused channels.

Most protocols allow and effective data rate or baud rate to be set. This tells the decoder at what speed the logic protocol is encoded. If set incorrectly the decoder will not decode the data correctly. It is also important to set the capture sample rate to sufficiently high value to ensure the decoder has enough data to work with. A rule of thumb is that the sample rate needs to be about 4 times higher than the baud rate.
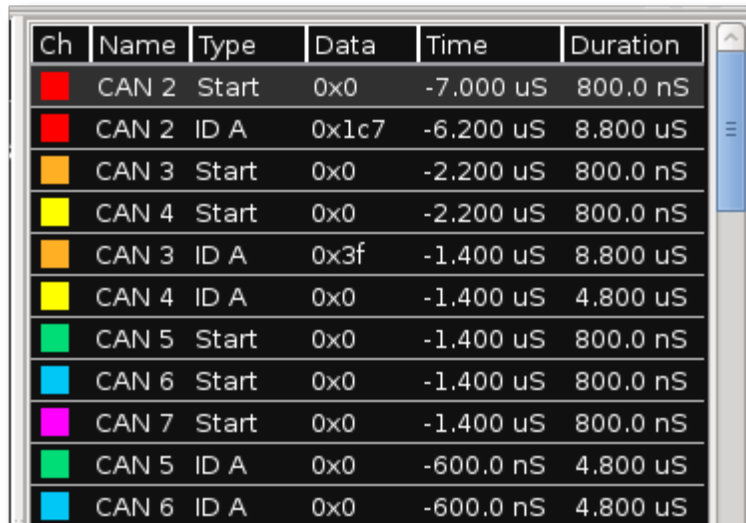
5.3 Packet Log

The Packet Log lists all the packets in the current capture in order of start time.

To view the Packet Log, click the INSPECT button at the top left of the application.

The Packet Log and Packet Inspector will appear in the right hand panel of the application.

The Packet Log shows all decoded packets from all enabled channels in chronological order. Packets are colour coded and show key packet statistics including the channel, protocol, packet or fragment type, data payload, start time and duration:

ID	FEATURE	DESCRIPTION
(1)	Channel Colour	The colour assigned to the channel
(2)	Channel Name	The nam assigned to this channel (user definable)
(3)	Packet Type	The packet or fragment type (Data, ACK, ERR). Depends on protocol.
(4)	Data Payload	The data decoded from the packet. Depends on protocol.
(5)	Packet Start	The sample time of the first logic edge of the packet.
(6)	Packet Duration	The total duration of the packet.

Left-clicking a packet on the main display will highlight the packet in the Packet Log. Use the up and down arrows to navigate through the Packet Log. If a packet is selected it will be shown in the Packet Inspector.
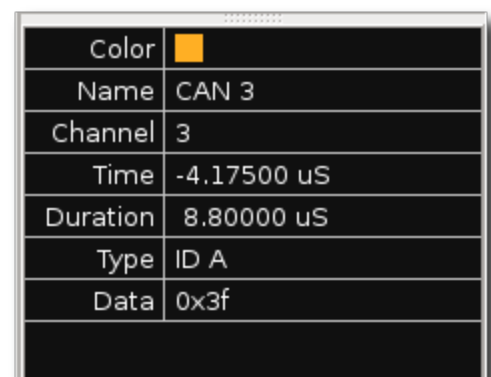
Disabling a channel in the Protocol Options will hide that channel's data from the Packet Log.

5.4 Packet Inspector

Below the Packet Log is the packet inspector.

The Packet Inspector shows details of the selected packet. If no packet is selected, then the Inspector will be empty.

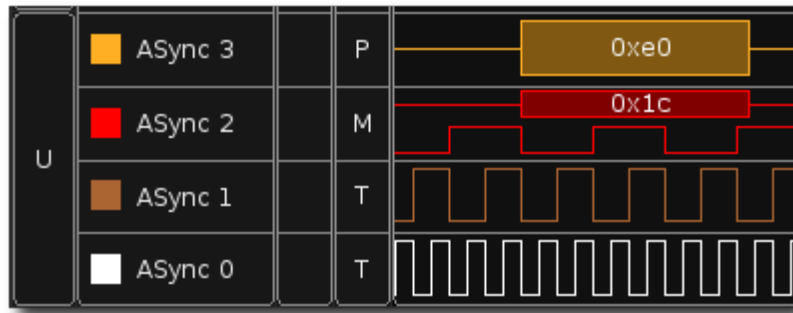The data shown will depend on the protocol selected.

6. Supported Protocols

Supported protocols include CANBus, SPI, I2C, and ASync Serial.

6.1 Asynchronous Serial (UART)

One of the oldest and simplest protocols is simple asynchronous serial; RS232, RS422 etc.

BitScope Logic can decode up to serial channels per protocol nybble.

To select the ASync Serial (UART) protocol, select ASync from the Protocol Nybble pop-up menu. The Protocol Nybble will indicate a 'U' when the UART protocol is selected.
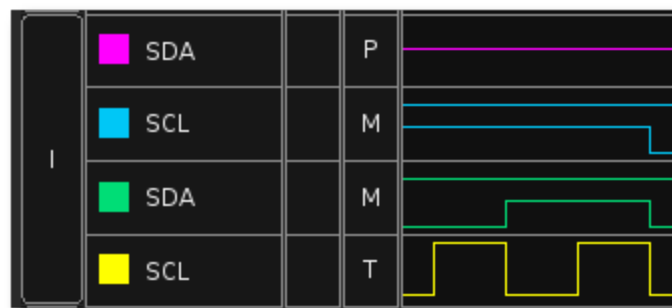
To set ASync options, left click on the Protocol Nybble to open the Protocol Options.

Note that ASync only requires one logic line. When ASync is selected on a Protocol Nybble, all 4 lines will be assigned the ASync protocol. Each line will be independent, and can be disabled from the Protocol Options.

More information on the ASync protocol can be found here.

6.2 Inter-Integrated Circuit Bus (I2C)

The I2C protocol is widely used for attaching low-speed peripherals to a motherboard, embedded system, cellphone, or other digital electronic devices.

To select an I2C protocol, select I2C from the Protocol Nybble pop-up menu.

To set I2C options, left click on the Protocol Nybble to open the Protocol Options.

Note that I2C only requires two logic lines, a data line (SDA) and a clock (SCL). When I2C is selected on a Protocol Nybble, the nybble will be grouped into 2 independent I2Cprotocol decoders. The first will use lines 0 and 1, and the second will use lines 2 and 3. Each 'decoder' will work independently, and can be disabled from the Protocol Options. These line configurations are pre-determined on the Protocol Nybble. It is possible to change the name of each channel, but the functionality will always be fixed in this original order.

More information on the I2C protocol can be found here.

6.3 Serial Peripheral Interface (SPI)

The Serial Peripheral Interface bus is a in full duplex 4 signal master/slave communications protocol.

SPI devices communicate as master and slave pairs where the master initiates the data frame. Multiple slave devices are allowed with individual slave select lines. SPI implementations are highly varied and do not always use all the specified signals.

To select a SPI protocol, select SPI from the Protocol Nybble pop-up menu. When SPI is selected, an 'S' is displayed in the Protocol Nybble.
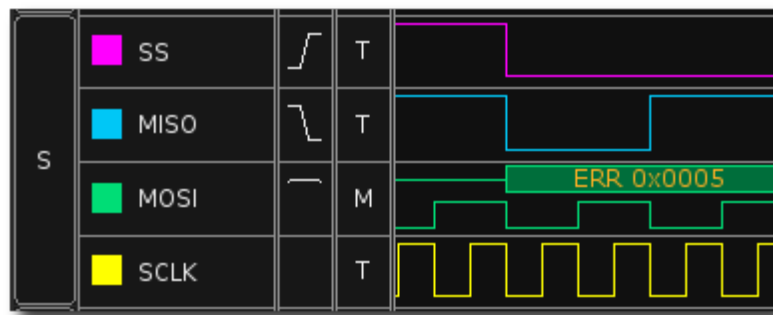
To set SPI options, left click on the Protocol Nybble to open the Protocol Options.

Note that SPI requires four logic lines:

- SS - Slave Select

- MOSI - Master Out, Slave In

- MISO - Master In, Slave Out

- CLK - Clock

These lines are pre-determined on the Protocol Nybble. It is possible to change the name of each channel, but the functionality will always be fixed in this original order. If more than one slave device is connected, more than one Slave Select line may be required. In this case it may be necessary to use logic channels from the other Protocol Nybble to view and optionally trigger on them.

More information on the SPI protocol can be found here.

6.4 Controller Area Network (CAN)

CAN bus implements is a message-based protocol, designed for automotive applications but now also used in many other applications. A CAN bus channel required only one signal so up to four may be decoded per protocol Nybble with BitScope Logic.
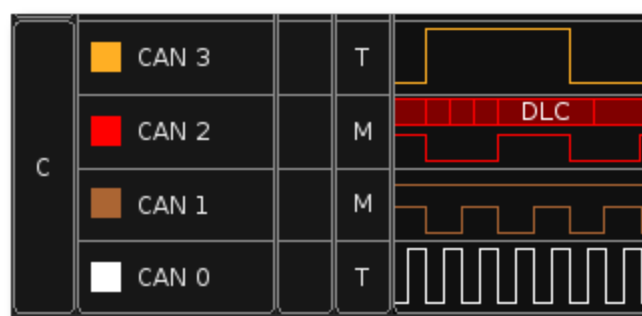
To select a CANBus protocol, select CAN from the Protocol Nybble pop-up menu. When CANBus is selected 'C' is displayed in the Protocol Nybble. To set CANBus options, left click on the Protocol Nybble to open the Protocol Options. Note that CANBus only requires one logic line. When CAN is selected on a Protocol Nybble, all 4 lines will be assigned the CAN protocol. Each line will be independent, and can be disabled from the Protocol Options. More information on the CANBus protocol can be found here.