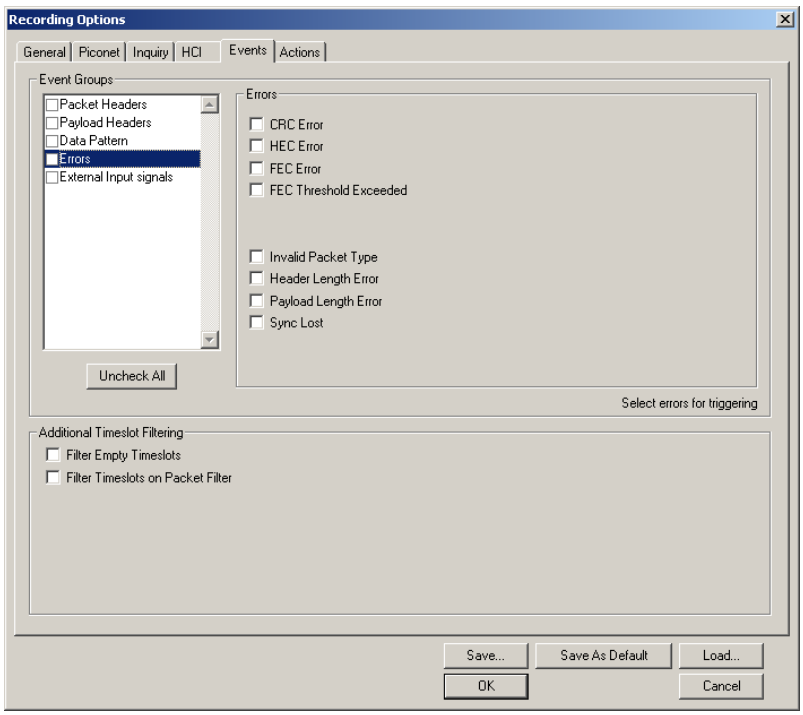
You see the **Errors** window:



Use any combination of the listed packet/signaling/protocol errors as a Trigger.

CRC Error

A CRC error in the packet data payload of the previous data packet.

HEC Error

An HEC (header error check) error in the packet header for the previous Bluetooth data packet.

FEC Error

An uncorrectable FEC (Forward Error Correction) error in the packet header for the previous Bluetooth data packet.

Threshold Exceeded

Indicates that the number of single-bit FEC errors detected since the current recording started has exceeded the specified value.

Invalid Packet Type

An invalid value was detected in the 'packet type' field of the packet header for the previous Bluetooth data packet.

Header Length Error

Indicates that a received Bluetooth data packet was terminated before all bits of the packet header were received.

Payload Length Error

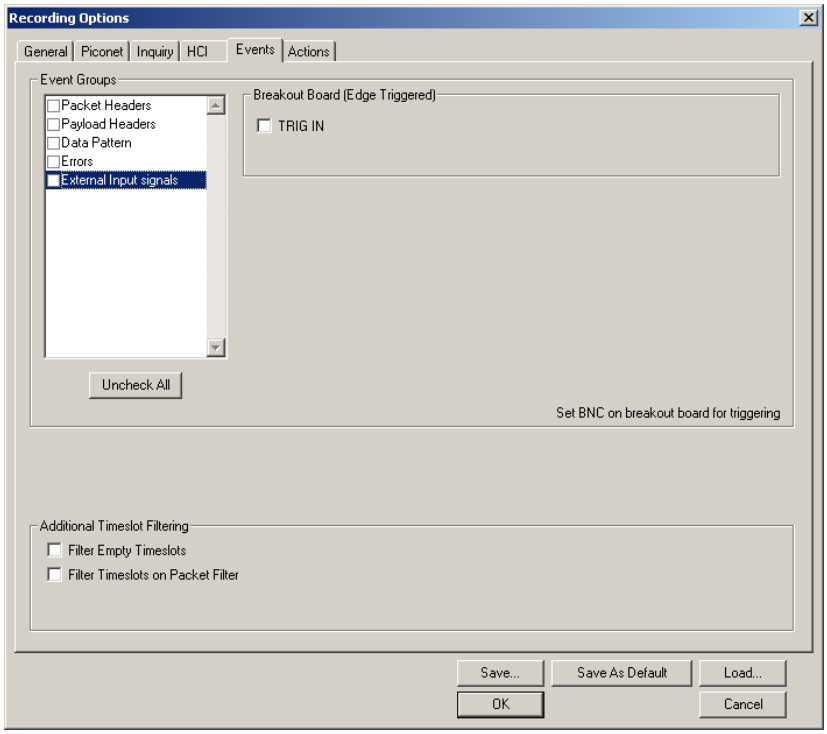
Indicates that the payload of a received Bluetooth data packet was either longer than expected, or that a Bluetooth data packet terminated before the expected end of the payload data.

Sync Loss

When set, indicates that a loss of piconet synchronization occurred during the frequency slot prior to this slot.

External Input Signals

Selecting "External Input Signals" causes the analyzer to trigger on an external signal received from the breakoutboard.



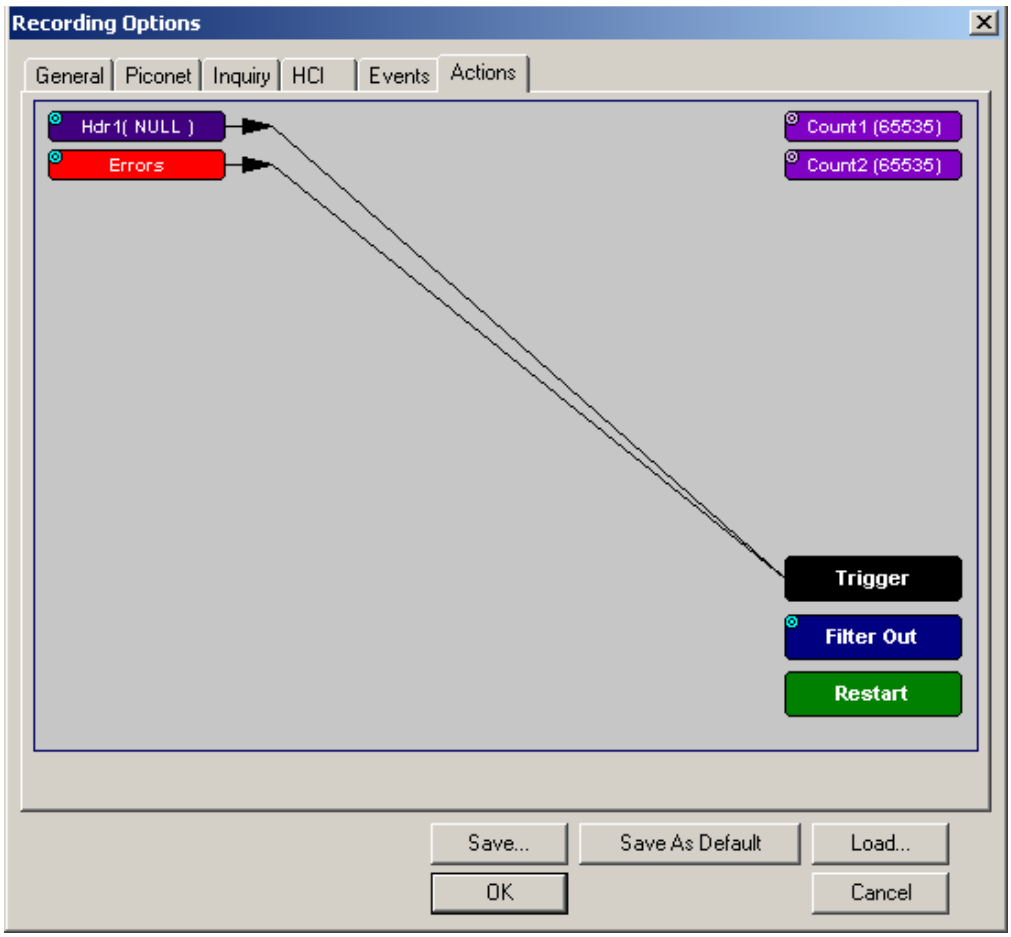
Breakout Board (Edge Triggered)

The following names are derived from pins on the CATC-provided breakout board.

- *TRIG IN* - Selectable Edge triggered inputs. Will trigger on any edge it detects.

6.7 Recording Options - Actions

The **Actions** screen allows you to specify the type of action that Merlin II should perform when it encounters the events specified in the **Events** window.



Action Buttons - Their Functions

The **Action** buttons in the right side of the window provide the means of setting triggers, filters, and restarts. To set an action, you simply drag your mouse from an Event to an Action. As described further on, this movement will link the two via an arrow.

Trigger

The **Trigger** button enables event triggering.

Filter In/Out

The **Filter In/Out** button allows events to be filtered in or out of the recording. Filtering provides a useful method of excluding data from the trace so you can conserve recording memory.

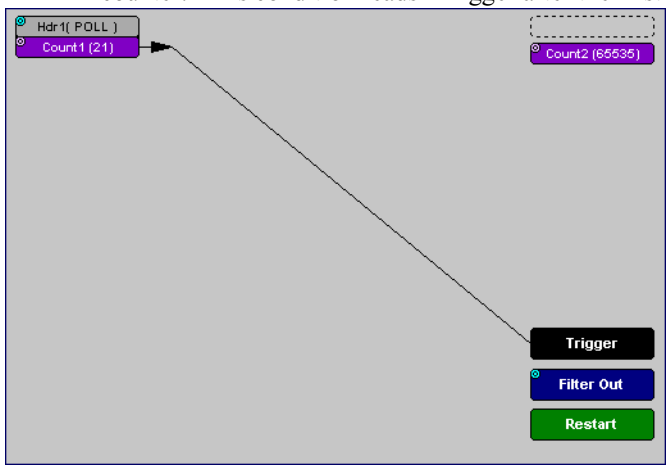
Restart

The **Restart** button causes the two counters Count1 and Count2 to be reset to zero. It also causes the search for *event sequences* to restart. Event sequences are sequences of events that trigger the end of the recording. Restart buttons provide you with a way of saying "If you see a sequence of A, B, C, and D, then trigger. However, if you see *X* anywhere during the sequence, restart your search."

Count1, Count2

Count1 and Count2 are counters for specifying how many events must occur before an event can cause a trigger. Counters allow conditions to be made such as "Trigger after the 21st Poll packet" (see screenshot below).

The Actions window showing a condition based on a Poll packet and a counter. This condition reads "Trigger after the 21st Poll packet."



Connecting Events to Counters

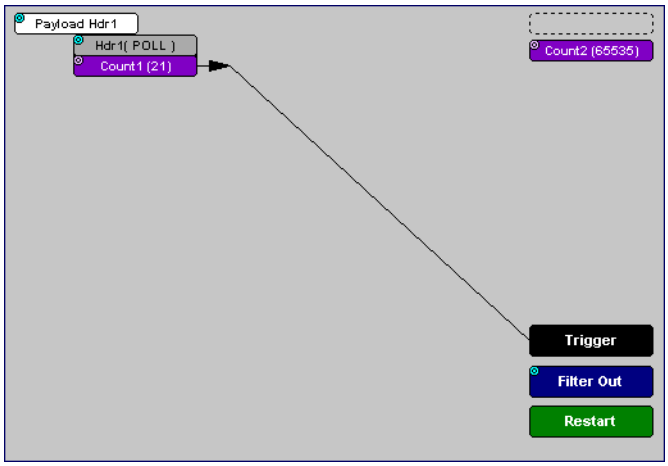
To connect an event to a counter, click an Event button, then click one of the two counter buttons. The Counter will reposition itself immediately below the event. A line will the connect the counter to the Trigger button.

This latter connection between the Counter button and the Trigger button occurs because counters always work in association with triggers. Counters act as assistants to triggers.

Setting Multiple Conditions with Counters

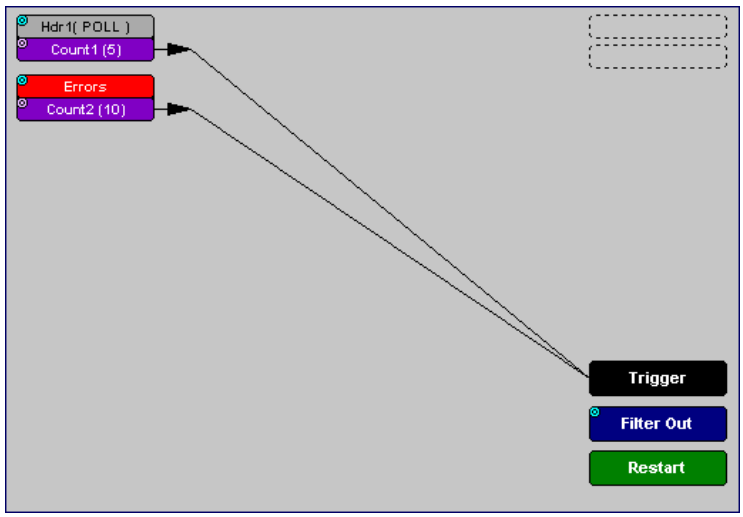
You can create multiple event conditions by linking a counter to multiple events or by linking two counters to two or more events.

Linking Multiple Events to One Counter - When two or more Events are strung together and then connected to a counter, the event button that is touching the counter gets counted. The example below reads "Trigger after you see a sequence of a packet with the specified payload followed by a 21 null packets."



Linking Two Events to Two or More Counters - If an Event is linked to **Count1** and a second event is linked to **Count2**, it creates an "or" statement. This statement reads "Trigger when Count1 OR Count2 has reached their specified values."

This example reads "Trigger when Count1 has counted 5 Poll packets or Count2 has counted 10 errors."



Blue Dot Menus

Count1, **Count2** and a few other buttons in the **Actions** window have blue dots in their top left-hand corners that indicate the presence of context-sensitive menus. These menus let you set the button's values and/or operations. Click the left mouse button on a dot to open the menu.

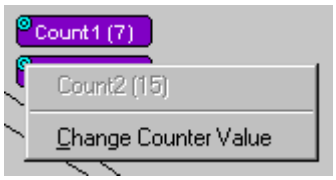
Counters Blue Dot Menu

The **Count1** and **Count2** blue dot menus allow the value of their counters to be changed. The value you specify here tells Merlin II how many instances of an event must take place before a trigger occurs. The counter can be set between 1 and 65,535.

To set a Counter,

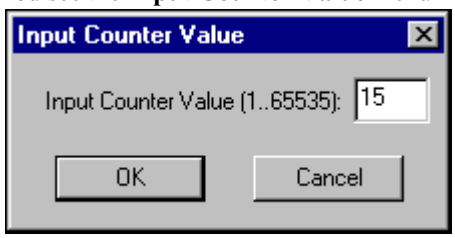
Step 1 Click on the blue dot in the upper left corner of the **Count** button.

You see the **Change Counter Value** menu:



Step 2 Click **Change Counter Value**

You see the **Input Counter Value** menu



Step 3 Enter an input value to tell the Analyzer how many times this event must occur before triggering the end of a recording

Step 4 Click **OK**.

Filter Out/In Blue Dot Menu

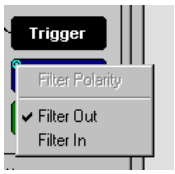
The **Filter Out/In** button toggles between "**Filter Out**" and "**Filter In**".

- **Filter In** records ONLY those packets related to the specified event.
- **Filter Out** records all packets EXCEPT those related to the specified event.

To filter an event in or out of a recording,

Step 1 Click the blue dot on **Filter Out**. (Note: the button may say **Filter In** depending on the last action specified.)

You see the **Filter Out/In** menu:



Use this menu to toggle the selection between **Filter Out** and **Filter In**.

Step 2 Select "**Filter In**".

The button changes to read "Filter In".

Enabling High Pulse, Low Pulse or Pulse Toggle Signal Outputs

Once External Trigger Output has been enabled, you can configure the output signal to one of three formats:

Pulse High - This is the default format. The Pulse High setting causes the Analyzer to transmit a 5 volt, 16.66 nanosecond signal.

Pulse Low - This format causes the Analyzer to transmit a -5 volt, 16.66 nanosecond signal.

Toggle - This format causes the Analyzer to transmit a signal that will toggle with each trigger event between a continuous 5 volt signal and a continuous -5 volt signal.

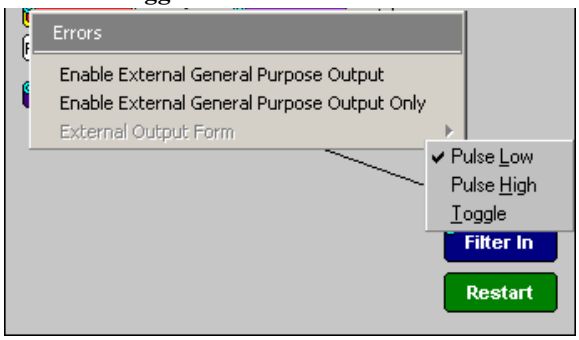
To configure the output signal,

Step 1 Click the blue dot on an Event button that has a small arrow attached to it like the one shown above.

A Blue Dot Menu will open. "**External Trigger Form**" should be a choice available. If it is not, you will need to choose "**Enable External Trigger**" and then reopen the menu.

Step 2 Choose "**External Trigger Form**"

A menu will appear with choices for "**Pulse Low**", "**Pulse High**", and "**Toggle**".



Step 3 Choose an option not currently selected.

The menu closes.

Step 4 Reopen the menu.

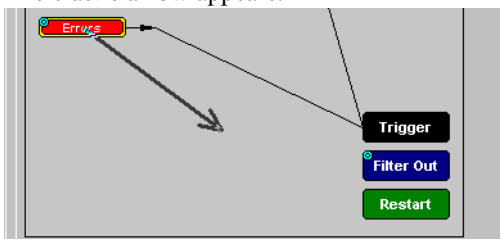
Note that your new selection is now checked.

Elastic Arrow

Elastic arrows allow you to associate Events, Counters, and Actions. To make an association,

Step 1 Click the left mouse button on an Event button such as **Hdr1** or **Errors**.

The elastic arrow appears.



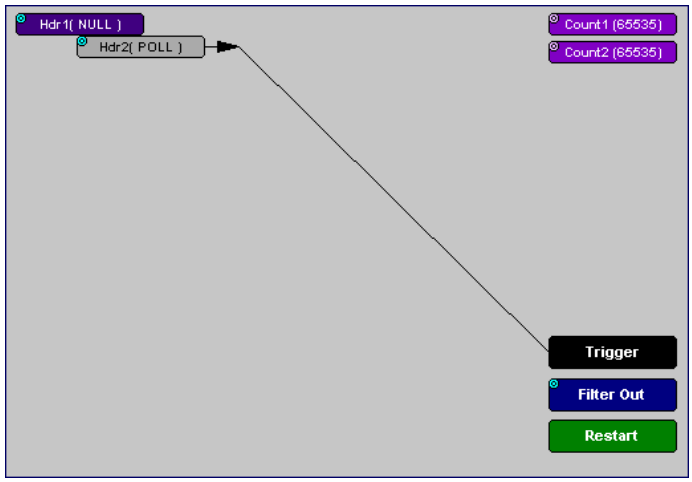
Step 2 Drag the arrow to the desired Action button.

Step 3 With the pointer over an Actions button, click again the left mouse button again.

The arrow is replaced with a black line connecting the Event button to the Action button.

Event Sequencing

If you drag your mouse from one event button to another, you will create a compound condition known as an *Event Sequence*. An event sequence is a condition that says "Trigger when you see the following sequence of packets." The example below may help to clarify.



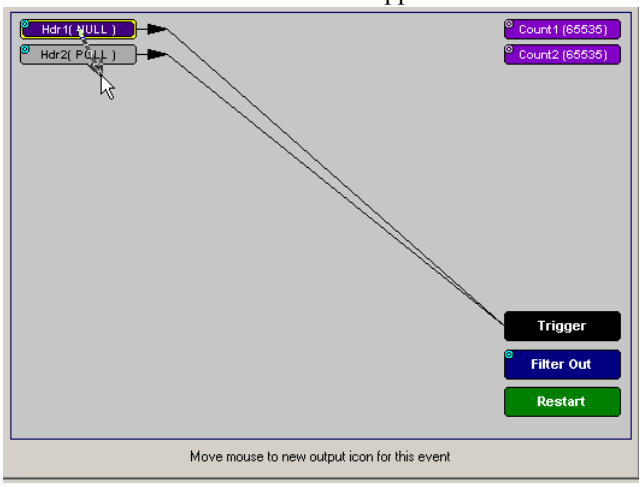
This example means "Trigger when you see a packet with an Null Header followed by a packet with a Poll Header."

To create an event sequence, perform the following steps:

Step 1 Select two events from the Events window

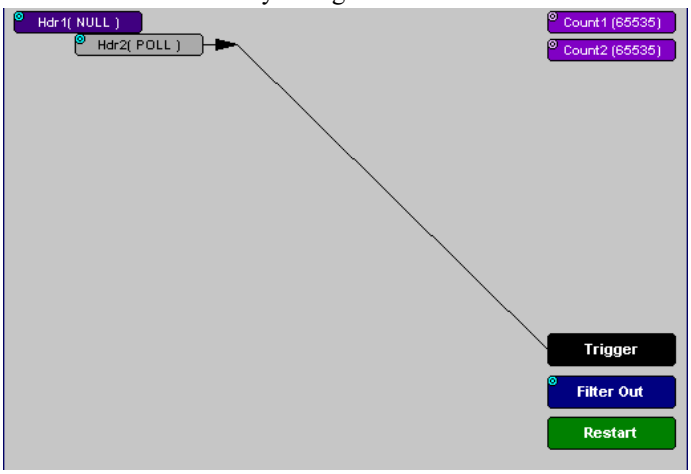
Step 2 Open the Actions window and click on one of the two Event buttons.

An elastic arrow should appear.



Step 3 Click on the other event.

The arrow should connect to the second button and the second button should instantly change locations to the center section of the window.



6.8 Saving Recording Options

To complete your Recording Options settings, use the features at the bottom of the **Recording Options** screen. These features remain the same no matter which of the three Recording Options screens you are working in.

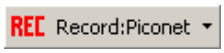
- Click **Save** to save the currently specified Recording Options for use in future recording sessions. Any file name can be specified, though use of the **.rec** is recommended; if no extension is specified, **.rec** is added by default.
- Click **Load** to load a previously saved ***.rec** file, thus restoring a previous set of Recording Options. You can also load the recording options from trace files.
- The **Save as Default** function is equivalent to the **Save** function, specifying the file name **default.rec.** Whenever you start up the Analyzer, it automatically loads the **default.rec** file if one exists.
- Click **OK** to apply any changes and close this dialog box.
- Click **Cancel** to cancel any immediate changes you have made and exit the Recording Options menu.

6.9 Recording Bluetooth Traffic

To start a recording once the appropriate Recording Options have been set,

Step 1 Select **Start** under **Record** on the Menu Bar

OR

Click  on the Tool Bar.

Your recording session can continue until it has finished naturally or you may need to stop manually by clicking on the Tool Bar, depending on how you set the Recording Options.

To manually stop recording,

Step 2 Select **Stop** under **Record** on the Menu Bar

OR

Click on the Tool Bar.

Note The manual Stop Recording feature is primarily of use when recording low-volume traffic, which can take a long time to fill the recording buffer.

When the recording is finished, the bus traffic is saved to the hard drive as a file named **data.tfb** or whatever name you assign as the default filename.

If you have enabled the recording is serial HCI traffic from IUT, then a second trace file is created called data_hci.tfb.

To save a current recording for future reference,

Step 3 Select **Save As** under **File** on the Menu Bar.

OR

Click on the Tool Bar.

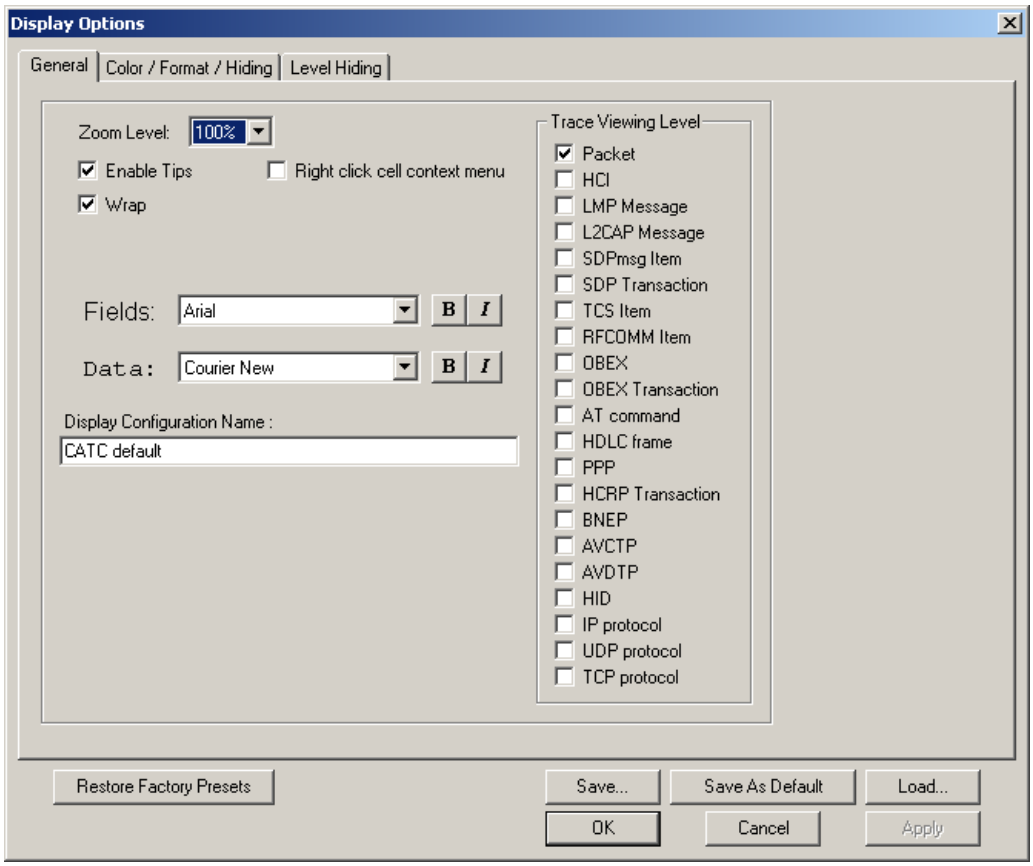
You see the standard **Save As** screen.

Step 4 Give the recording a unique name and save it to the appropriate directory.

7. Display Options

Use the **Display Options** menu to specify the way CATC Trace information is displayed.

From the **Setup** menu, select **Display Options**.



7.1 General Display Options

Use the General Display Options to specify the basic appearance of a Trace view.

- **Zoom Level**: Adjustable in discrete increments from 10% to 200% percent.
- **Enable Tips**: Select to enable Tool Tips with explanation text to pop up when you position your cursor over various fields in the Trace View.
- **Wrap**: Causes packets to wrap within the window if their length exceeds the width of the window.
- **Right click cell context menu**: Activates the right mouse button for opening cell context menus.
- **Trace Viewing Level**: Allows you to select the hierarchical level at which traffic is displayed.
- **Fields**: Configures the appearance of field text within the trace.
- **Data**: Configures the appearance of data within the trace.
- **Display Configuration Name**: Comment field associated with the ***.opt** file containing the current Display Options values. You can also create and store your unique Display Options for future use.

To create a new Display Options file, follow these steps:

Step 1 Enter a comment for the new file in the **Display Configuration Name** field.

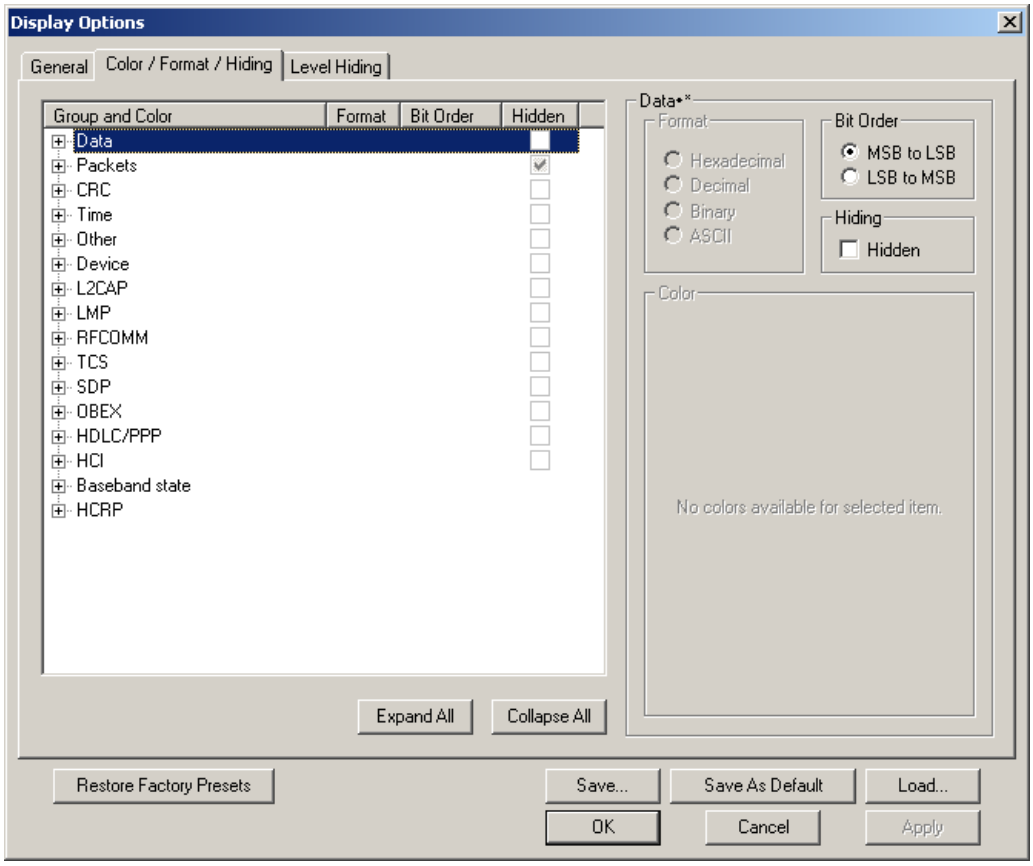
Step 2 Click **Save**...

Step 3 Specify a filename (***.opt**).

Step 4 Click **Save**.

7.2 Setting Color, Formatting, and Hiding Options

Click the **Color/Format/Hiding** tab on the Display Options screen.



Use this window to customize the colors and formats associated with each field in the Trace view. You can also use this window to hide fields within the trace.

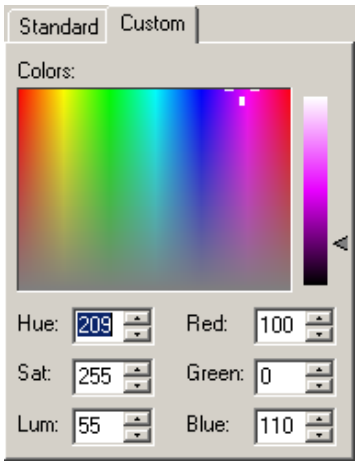
Setting Color Display Options

To change the colors of elements in the trace, select an item in the Group and Color column and use the color pallet screen on the right to make the desired changes.

Note The color of an Invalid Data (packet error) field cannot be changed; it is permanently set to red.

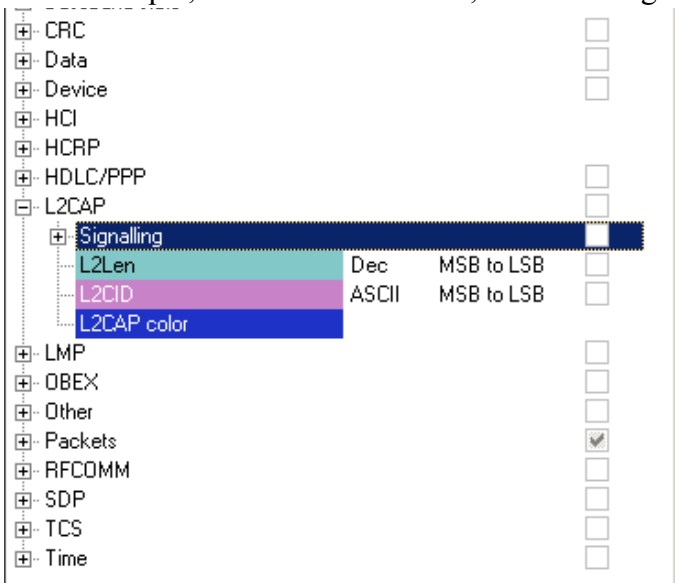
Use this window to customize the colors associated with each field in the trace. You can experiment with these options to achieve the color combination best suited to a particular graphic system.

You can also customize the colors by using the options in the Custom tab.

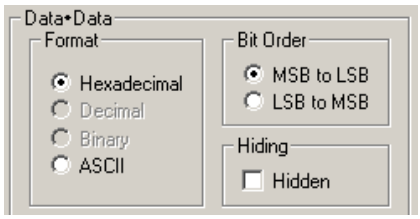


Changing Field Formats

To change field formats, select an item under the Group and Color column. This action will enable the formats radio buttons on the right. The format types change with respect to the item selected under the Group and Color column. For example, if L2CAP is selected, the following displays:



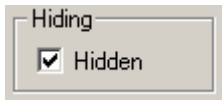
The following formats are available:



Note Not every format is available for every item.

Hiding Display Options

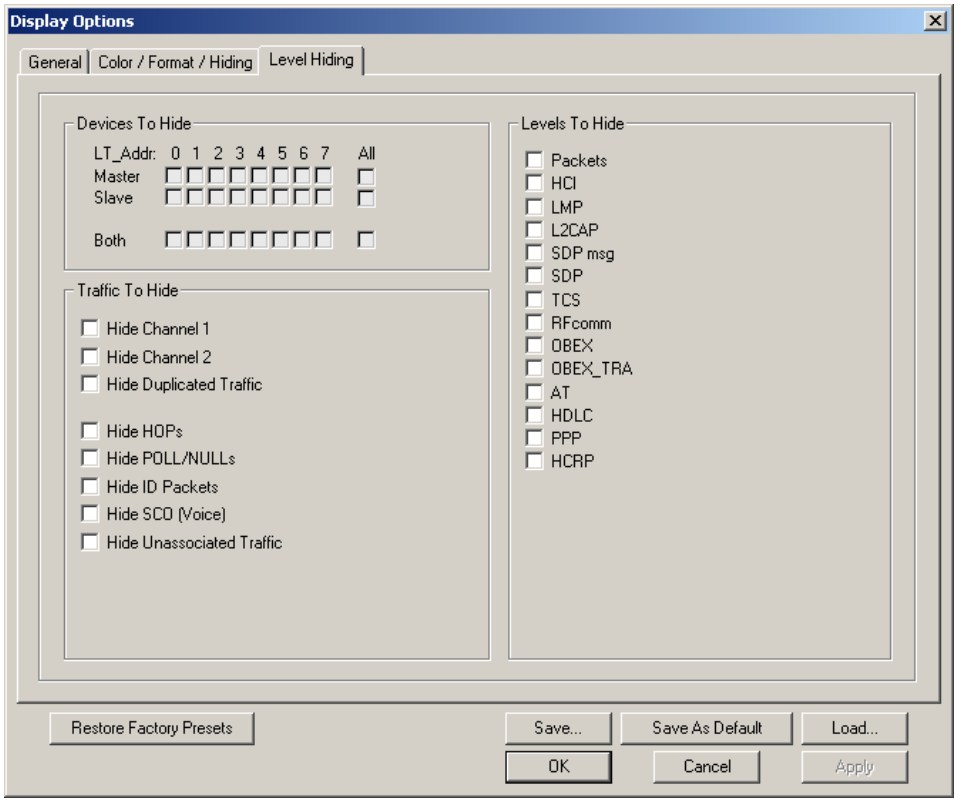
To hide one or more fields in the trace, select the appropriate item from the Group and color column, click the checkbox marked **Hidden**, and click the **Save** button.



You can also hide Sequences from a trace by selecting the desired options from the checkboxes.

7.3 Level Hiding Options

The Level Hiding tab allows you to hide various types of traffic. To hide traffic, select one or more items, then click **Save**.



Level Hiding Parameters

Use the Hiding window to hide various fields, packets, messages, and protocols from the Trace View screen. You can modify these settings at will to display a specific area of a Trace.

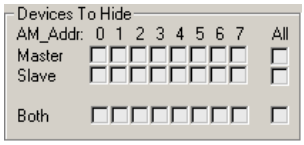
Hiding Fields

The "Hide Fields" checkboxes allow individual fields to be hidden within a trace. Click the checkbox(es) of your choice to hide one or more fields.

Hiding Packets, Messages, and Protocols

The "Hide Packets and Transactions" box contains two grids of checkboxes for hiding whole packets, messages, protocols, and traffic from individual devices. The grids are labeled "Devices to Hide" and "Levels to Hide".

Devices to Hide



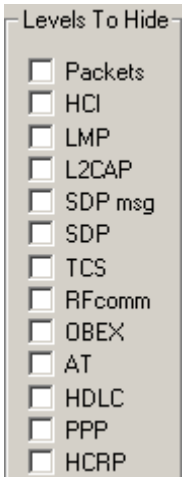
The "Devices to Hide" grid lets you hide traffic according to device address. The grid divides into columns which represent different devices.

Columns labeled "**0**" through "**7**" and "**All**" represent the **Active Member Address** of a device. By checking one of the boxes in a column, you hide the traffic of the selected device (or traffic from all devices if you have selected **All**.)

The row in which you place your checkmark determines whether you are hiding traffic going to or from a device.

- Master - Hide traffic from a Master to selected Slaves
- Slave - Hide traffic from selected Slaves to the Master
- Both - Hide all traffic between the Master and selected Slave

Example: to hide all traffic from a Master *to* a Slave device with an address of six, click the checkbox under column **6** on the row marked **Master**.

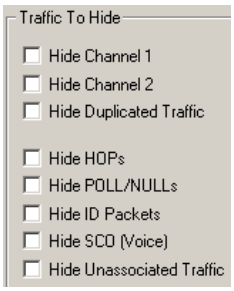


Levels to Hide

The "Levels to Hide" grid divides into rows which represent the different packet, message, and protocol levels. Clicking a checkbox will cause Merlin II to hide all traffic of a selected level.

Traffic To Hide

At the bottom of the Hiding tab of the Display Options window are check boxes for hiding HOPs, POLLs, NULLs, and other kinds of traffic.

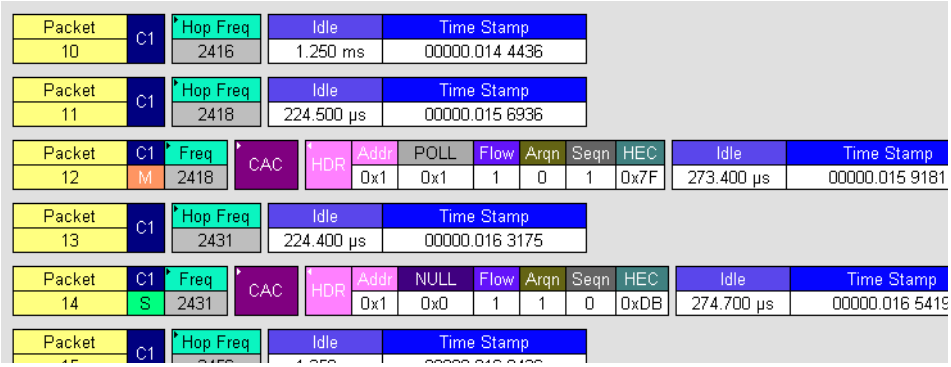


7.4 Saving Display Options

To complete your display options settings, use the features at the bottom of the **Display Options** window. These features remain the same no matter which of the four **Display Options** windows you are working in.

- Click **Save** to save the currently specified display options for use in future sessions. Any file name can be specified, but you must use the **.opt** extension. If no extension is specified, **.opt** is added by default.
- Click **Load** to load a previously saved ***.opt** file, thus restoring a previous set of display options.
- The **Save as Default** function is equivalent to the **Save** function, specifying the file name **default.opt.** Whenever you start up the Analyzer, it automatically loads the **default.opt** file if one exists.
- Click **OK** to apply any changes you have made to **Display Options** and close this dialog box.
- Click **Cancel** to cancel any immediate changes you have made and exit the **Display Options** menu.
- Click **Apply** to apply your changes while keeping the **Display Options** window open.

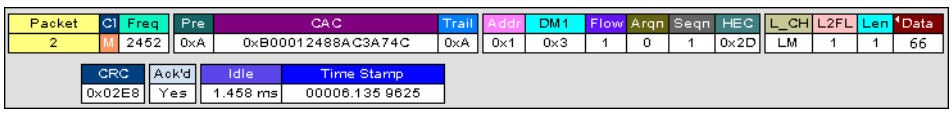
8. Reading a CATC Trace



8.1 Trace View Features

- The Merlin II packet view display makes extensive use of color and graphics to fully document the captured traffic.
- Packets are shown on separate rows, with their individual fields both labeled and color coded.
- Packets are numbered (sequentially, as recorded), time-stamped, and highlighted to show the device status (master or slave).
- Display formats can be named and saved for later use.
- Pop-up Tool Tips annotate packet fields with detailed information about their contents.
- Data fields can be collapsed to occupy minimal space in the display (which can in turn be zoomed in and out to optimize screen utilization).
- The display software can operate independent of the hardware and so can function as a stand-alone Trace Viewer that may be freely distributed.

8.2 Interpreting the Displayed Information



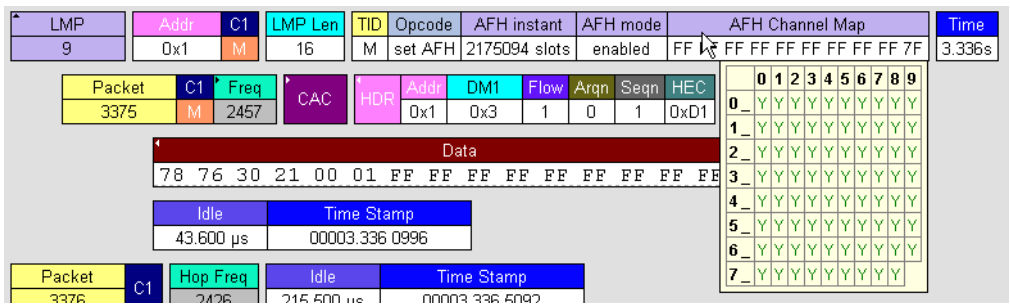
The following table describes some of the abbreviations used in the BTTracer display. Packet #0 is described from left to right:

Packet:#	**Packet/Event Number**
C1/M, C2/S	M =Master Device Transmitting; S = Slave Device Transmitting C1 = Channel 1; C2 = Channel 2
Freq	Current Hop Frequency (in MHz)
Pre	Preamble of the Sync word

Packet:#	Packet/Event Number
CAC	Channel Access Code
Trail	Access Code Trailer of the Sync word
Addr	Active Member Address
DM1	DM1 Packet Type
Flow	ACL Link Flow Control
Arqn	Acknowledgment Indication Flag
Seqn	Sequential Numbering
HEC	Header Error Correction Code
L_CH	LMP Message
L2FL	L2CAP Flow Control Flag
Len	Message Length in Bytes including Opcode
TID	LMP Transition initiated by Master
Opcode	LMP-host_connection_req
CRC	Cyclic Redundancy Check
Ack'd	Packet Acknowledgment based on subsequent packet's ARQN with same LT_ADDR
Idle	Idle Time in nanoseconds
Time Stamp	Decimal in Seconds.Milliseconds.Microseconds*10 This is the analyzer internal clock as a reference with resolution of 100 ns.

8.3 Tooltips

You can get additional information about each field in a trace by holding your mouse pointer over a field. A tooltip will appear with details about the field.



8.4 Set Marker

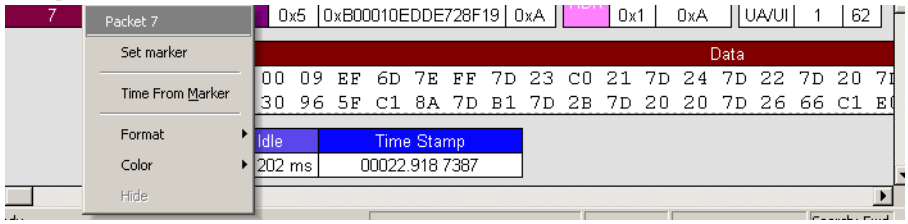
Note **Set Marker** works in conjunction with the **Go to Marker** feature.

You can define a unique Marker for each packet.

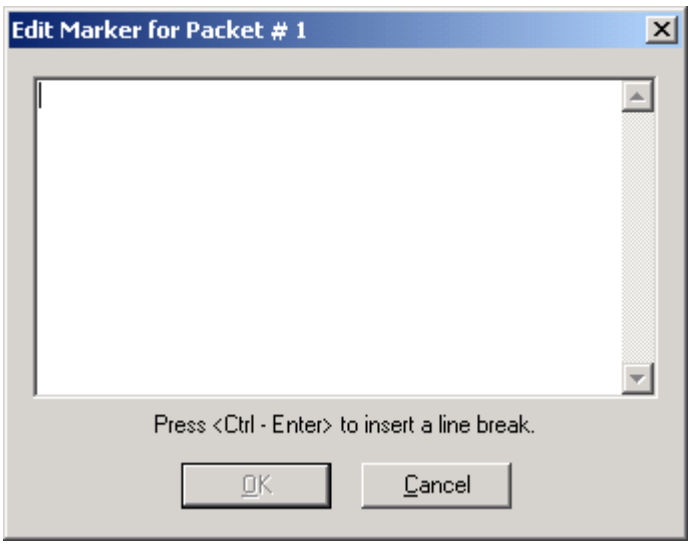
To place a marker on a packet,

Step 1 Left-click on **Packet #** for the packet you wish to mark.

Step 2 Select **Set Marker**.



You see the **Edit Marker Comment** window where you can enter a unique comment about this packet.:



Step 3 Enter your comment.

Step 4 Click **OK**.

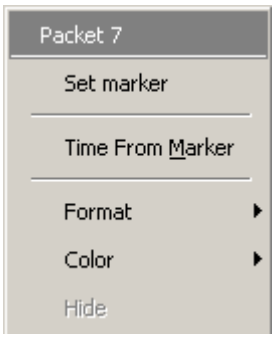
A marked packet is indicated by a vertical red bar along the left edge of the packet # block:

8.5 Edit or Clear Marker

To clear or edit the comments associated with a packet marker,

Step 1 Left-click on **Packet #** for the chosen packet.

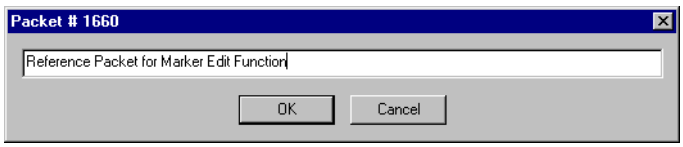
You see the **Packet** menu:



To edit the Marker Comment,

Step 2 Select **Edit marker**.

You see the **Edit marker comment** window:



Step 3 Edit the comment as desired.

Step 4 Click **OK**.

To clear a Marker,

Step 5 Click **Clear marker**.

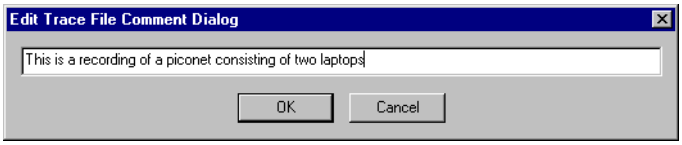
The vertical red Marker bar disappears.

8.6 Adding Comments to a Trace File

You can create, view, or edit the 100-character comment field associated with each Trace file.

Step 1 Select **Edit Comment** under **File** on the Menu Bar.

You see the **Edit comment for trace file** window:



Step 2 Create, view, or edit the comment.

Step 3 Click **OK**.

8.7 Expanded and Collapsed Data Formats

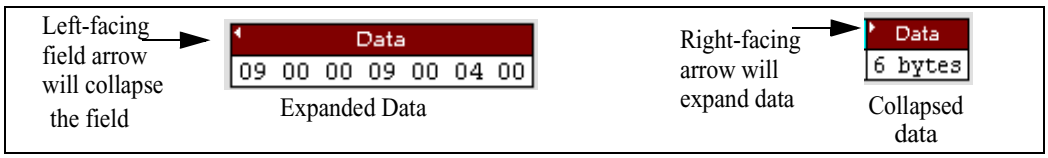
The data field can be expanded to display greater detail or collapsed to a compact view. The Expand/Collapse Data feature operates as a toggle. There are three ways to toggle between the two views.

Double-Clicking

You can expand or collapse a Data field by double-clicking anywhere in the Data field of a packet.

Left-clicking a Field Arrow

Many fields have small arrows in the top left corner. If you left-click this arrow, the field will toggle back and forth between collapsed and expanded views.



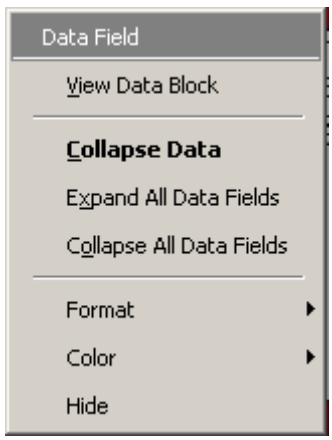
If you click and hold down the left mouse button on one of these arrows, you can collapse or expand the field for *ALL* packets, messages or protocols.

Using the Shortcut Menu

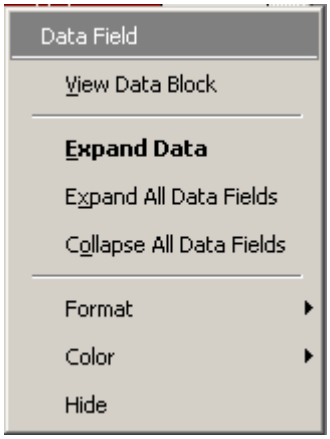
If you left-click on a **Data** field, a menu will open for expanding or collapsing data fields.

Step 1 Left-click on **Data** in the Data packet you want to expand or collapse.

If your Data Trace View is currently expanded, you see the **Collapse Data** menu:



If your Data Trace View is currently collapsed, you see the **Expand Data** menu:



Note that you can choose to expand or collapse

- **Only** the Data in the selected Data packet

  OR

- **All** Data Fields in the Trace View.

Step 2 Select the desired Expand Data or Collapse Data menu item.

The Trace View is repositioned with the selected packet(s) adjusted in the format you have specified.

8.8 Hide Frequency Hops

You can hide Frequency Hops (Hops) from a trace by pressing the **Hide Hops** button on the Tool Bar:

From the Tool Bar

- Click

to hide all Hop packets.

8.9 Hide Nulls and Polls

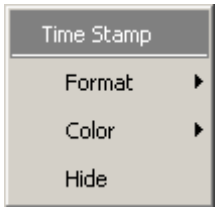
You can hide Nulls and Polls from a trace by pressing the **Hide Nulls and Polls** button on the Tool Bar.

From the Tool Bar

- Click to hide all Nulls and Polls.

8.10 Menus in Clicked Fields

You can display the following menu when you click in a field in a trace.



8.11 Hide Unassociated Traffic

You can hide all traffic that is not associated with the current decode level by pressing the **Hide Unassociated Traffic** button on the Tool Bar.

From the Tool Bar

- First, click one or more decode buttons such as the **View L2CAP Messages** . This button will cause Merlin II to decode the trace and display selected level of decode.
- Next, click to hide all unassociated traffic.

The **Hide Unassociated Traffic** button will cause Merlin II to hide all traffic except for the selected decode messages or protocols. In the example above, all packets would be hidden and only L2CAP messages would display.

8.12 Hide Channel

You can hide all traffic recorded by the channel by pressing . on the toolbar.

8.13 Hide Duplicated Traffic

On two-channel recordings some packets may be recorded by both channels. You can hide duplicated packets by pressing on the toolbar.

9. Searching Traces

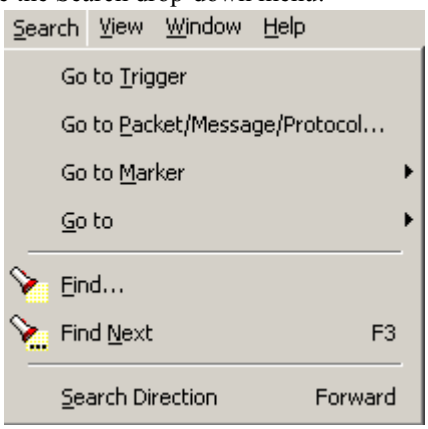
Merlin II has several search commands that enable you to navigate a trace in search of key events such as errors and triggers. These commands are launched from the search menu.

9.1 Search Menu

The Search menu provides several options for searching through recorded traffic, allowing you to find specific packets based on triggering status, packet number, marking, or content.

- Click **Search** in the Menu bar.

  You see the Search drop-down menu:



Go to Trigger

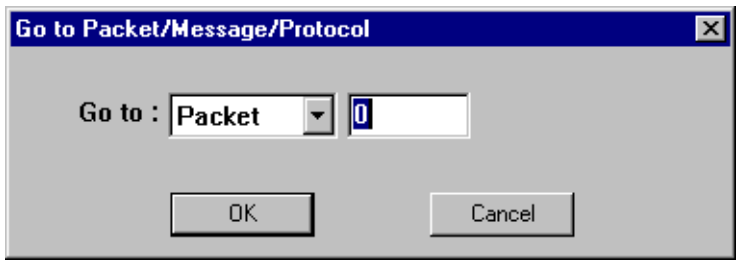
To display a triggering event, select **Go to Trigger** under **Search** on the Menu bar. The **Trace Viewer** display will reposition the trace to show the triggering event at the top of the screen.

Go to Packet/Message/Protocol

To display a specific packet, Message or Protocol

Step 1 Select **Go to Packet/Message/Protocol** under **Search** on the Menu Bar.

You see the **Go to Packet/Message/Protocol** window:



Step 2 Enter the number of the packet, message or protocol you want to display.

Step 3 Click **OK.**

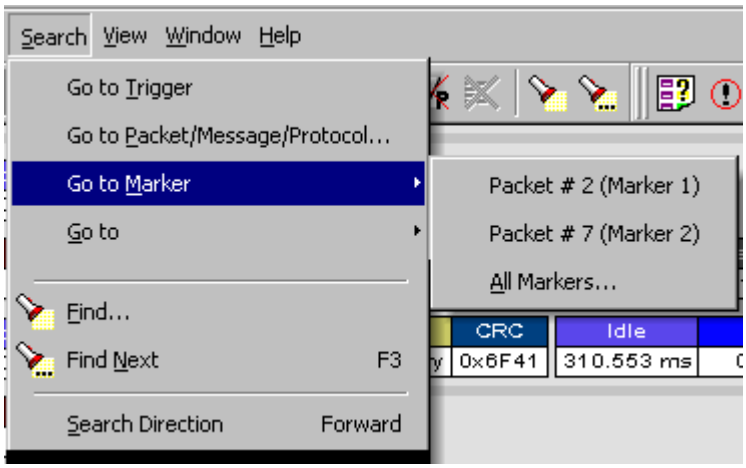
The Trace View repositions to show the packet at the top of your screen.

Go to Marker

To instruct the analyzer to display a marked packet,

Step 1 Select **Go to Marker** under **Search** on the Menu Bar.

You see a drop-down menu listing the marked packets in that Trace View:



Step 2 Select the desired packet from the displayed list.

The Trace View repositions to show the packet at the top of your screen.

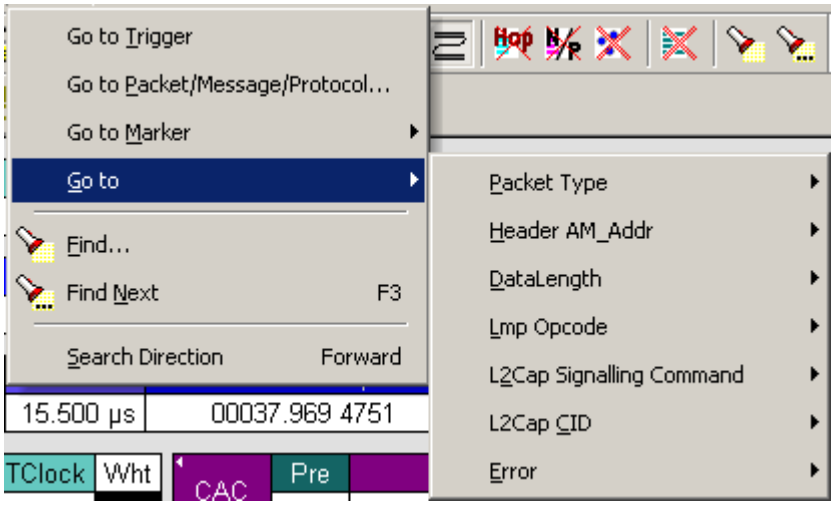
Note The **Go to Marker** feature functions in conjunction with the **Set Marker** feature. The comments within the parentheses following each marked packet are added or edited with the **Set Marker** feature.

Go to

The **Go To** feature takes you directly to an event in a Trace.

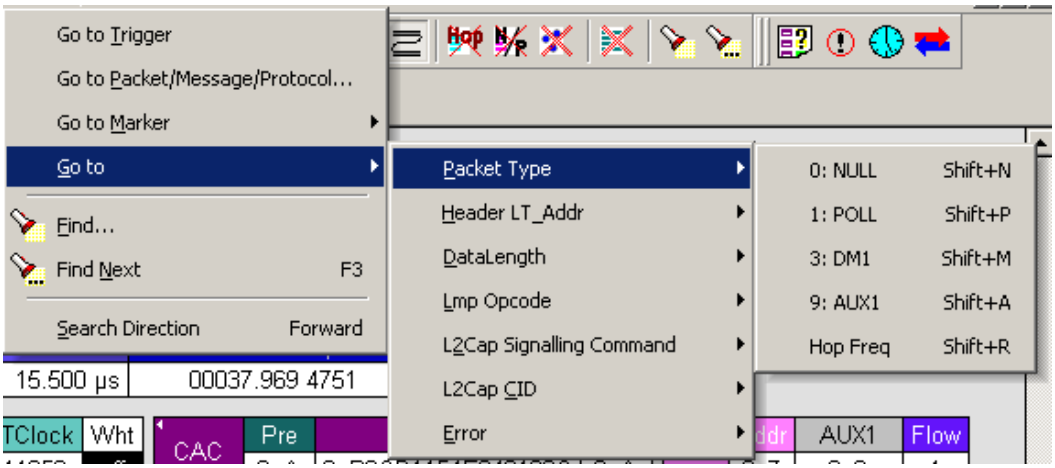
Step 1 Select **Go To** under **Search** on the Menu Bar.

You see the **Go To** drop-down menu:



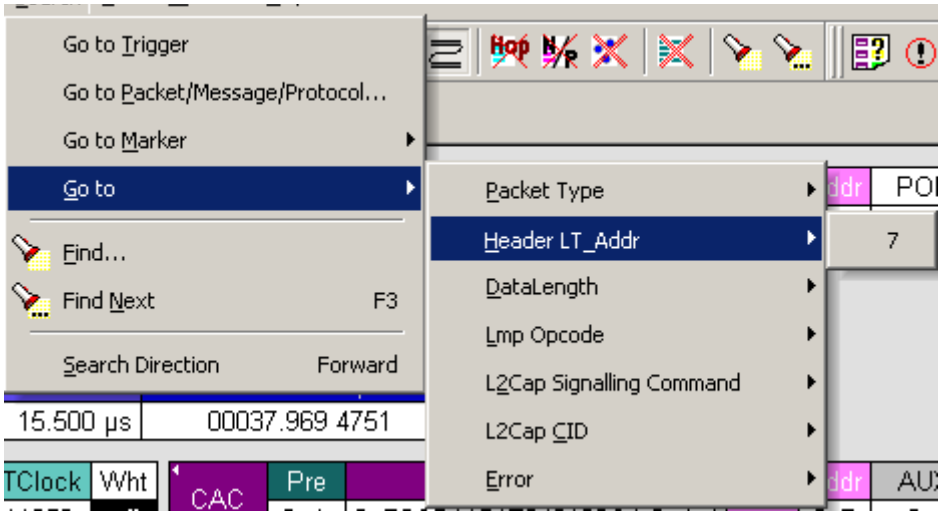
Step 2 Select the event you want to go to and enter the necessary information.

Packet Types



Select the type of packet you want to go to.

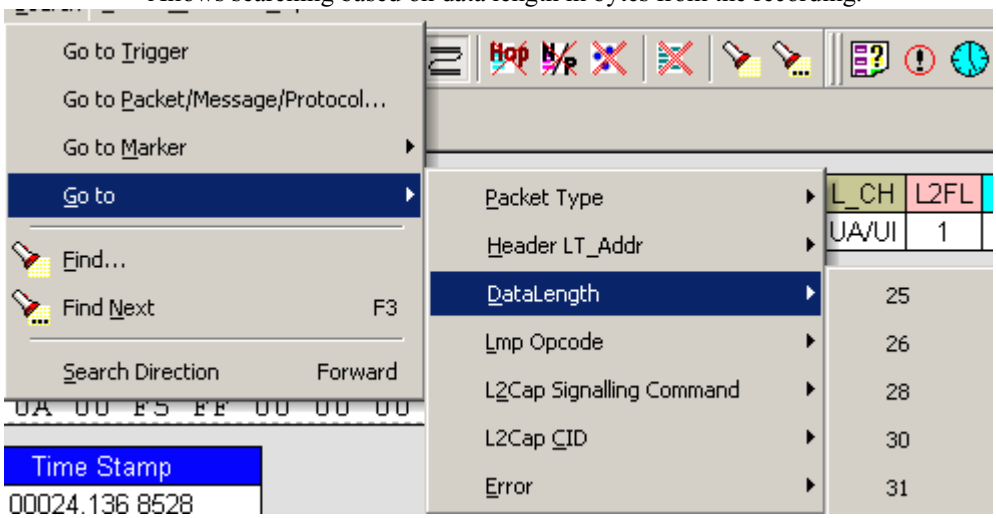
Header LT_Addr



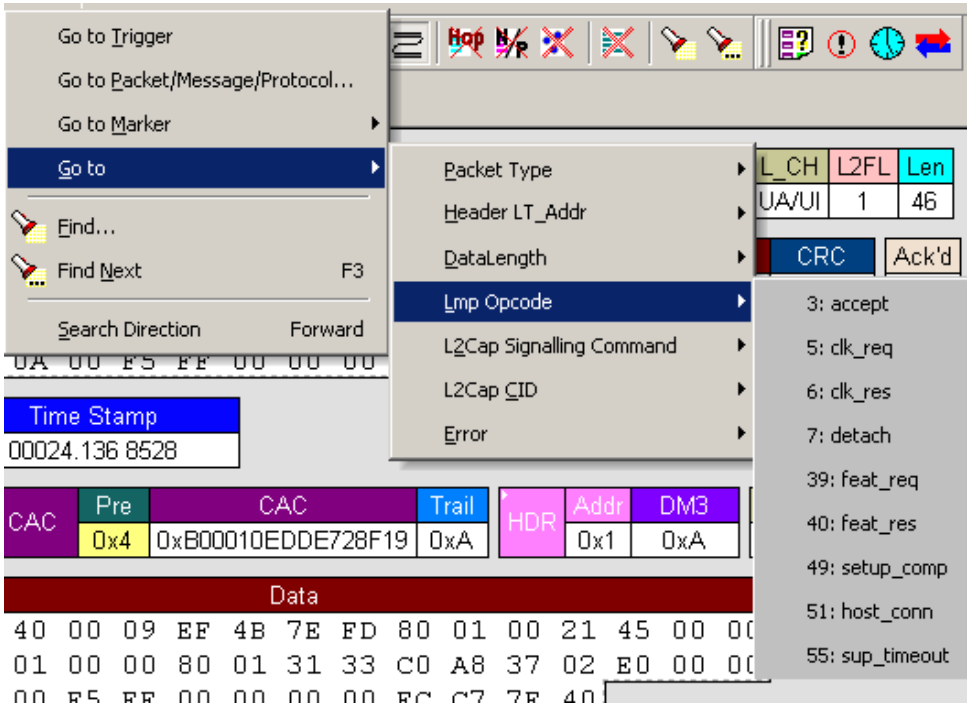
Select an Logical Transport Address from the list.

DataLength

Allows searching based on data length in bytes from the recording.

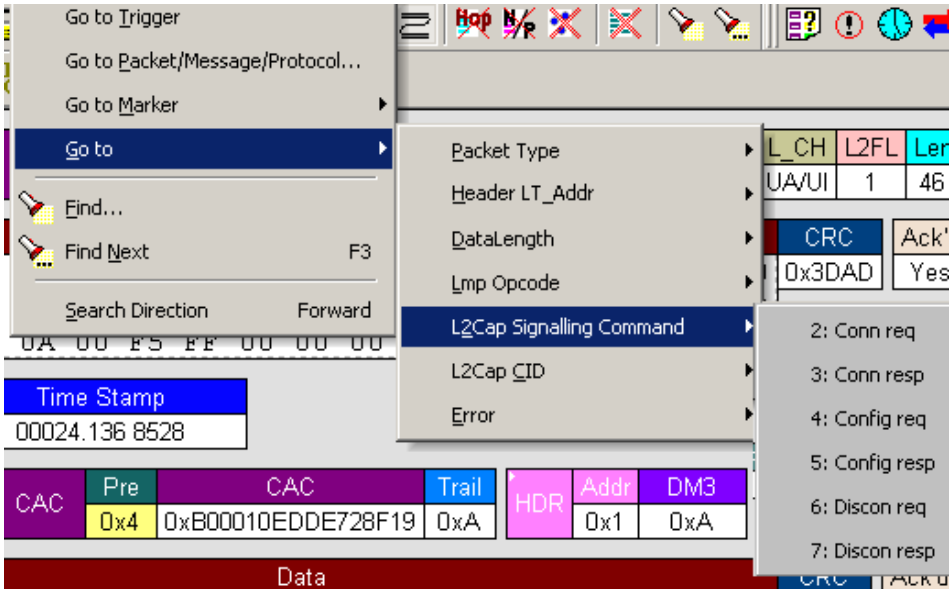


Lmp Opcode



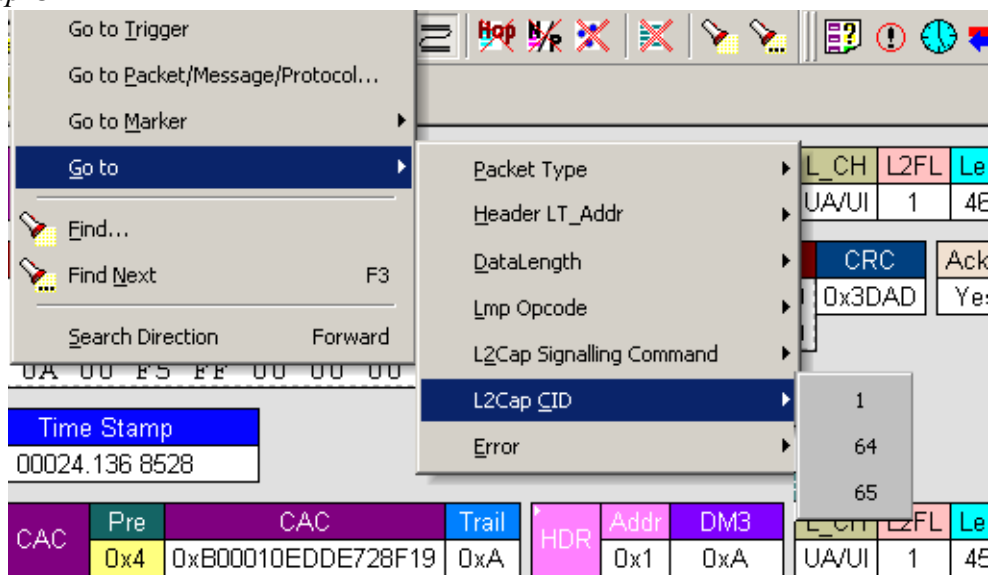
Select the Link Management Protocol Operational Code (Lmp Opcode) that you want to go to.

L2Cap Signalling Command



Select the type of L2Cap Signalling Command that you want to go to.

L2Cap CID



Select the L2Cap Channel ID (L2 Cap CID) that you want to go to.

Error

Moves trace view to next uncorrected error.

Soft Bit Error

Moves trace view to next soft (corrected) error.

Loss of Sync

Moves trace viewer to the next loss of sync.

Find

Find is a utility that allows you to conduct searches of one or more events within a trace. Find allows you to search different hierarchical levels within the trace - packets, LMP Messages, L2CAP messages etc.

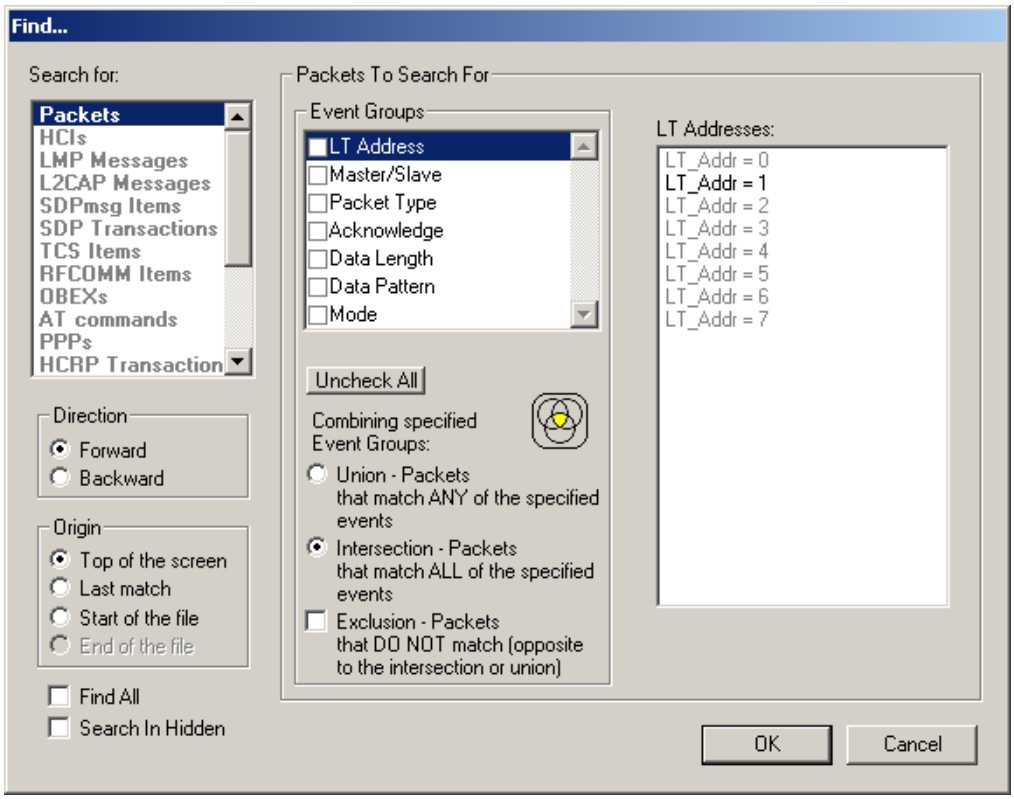
To start find,

- Select **Find...** under **Search** on the Menu Bar

OR

Click in the Tool Bar.

You see the **User-Defined Find Events** screen:



The **Find** window divides into three areas:

Left area -- Controls the search level, search direction and search origin.

Find All - Extracts the results and place them in a separate trace.

Search In Hidden - Searches all packets including packets that have been hidden.

Center area -- Controls the event groups to be searched. The selection you make will display further choices on the right side of the Find window. At the bottom are three options called Union, Intersection, and Exclusion that are used with multi-criteria searches. These options are explained below.

Right area -- Controls the specific events to be searched within the trace. The box in this right section displays events from the selected Event Group.

The right area is context sensitive -- the Event Group selected in the Center area will determine what events will display on the right. For example, if you select **Packet Type**, the Right area will show you a list of packet types. Bold entries in the list represent items that actually occurred in the trace.

In the screenshot shown above, for example, LT Address is selected. On the right, you see that only Address 1 is in bold. This indicates that only a single device was transmitting traffic in the displayed trace.

Event Groups

Event Groups are categories of events that can occur in a trace. Clicking on an Event Group will display a list of Event types on the right side of the Find window that occur within each Event Group.

LT Address

Contains a list of seven Logical Transport addresses. Bold entries represent devices that occur in the trace.

Master/Slave

Contains two options labeled **Master** and **Slave**. Selecting an option will cause Merlin II to search for traffic based on the selected role.

Packet Type

Contains a list of all Bluetooth packet types. If a packet type occurs in the trace, it will appear in bold.

Acknowledge

Contains a list of three Acknowledge types: **Explicit NACK**, **Implicit NACK**, and **ACK.** The three Acknowledge types are responses a device can issue to attempts to transmit packets to it.

A device can send an Acknowledgment in two ways: through setting the ARQN field to 0 (= explicitly not acknowledged), to 1 (explicitly acknowledged) or by sending an empty packet that does not have an ARQN field (= implicitly not acknowledged).

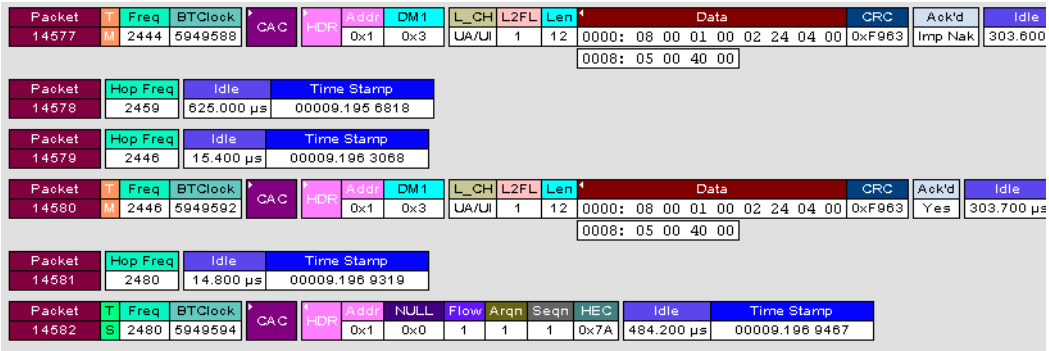
Explicit NACK - Explicitly not acknowledged. An Explicit NACK is an explicit response by a device that it did not receive a data packet. The Explicit NACK is transmitted in the ARQN field (=Acknowledgment Request Negotiation field). ARQN=0 means 'Explicit NACK.'

Implicit NACK - Implicitly not acknowledged. An Implicit NACK is a NACK that is implied rather than explicitly stated. If a device responds to a data packet by sending an empty packet, the NACK is implied.

ACK - Acknowledged. If a data packet is successfully transmitted to a target device, the target device acknowledges the received packet by setting the ARQN field to 1.

Acknowledgments are easily seen in Merlin II traces because Merlin II adds an **Ack'd** field on data packets of the transmitting device. This means that you do not have to hunt through the trace to see if the packet was acknowledged.

The following screenshot shows two examples of Acknowledgments.

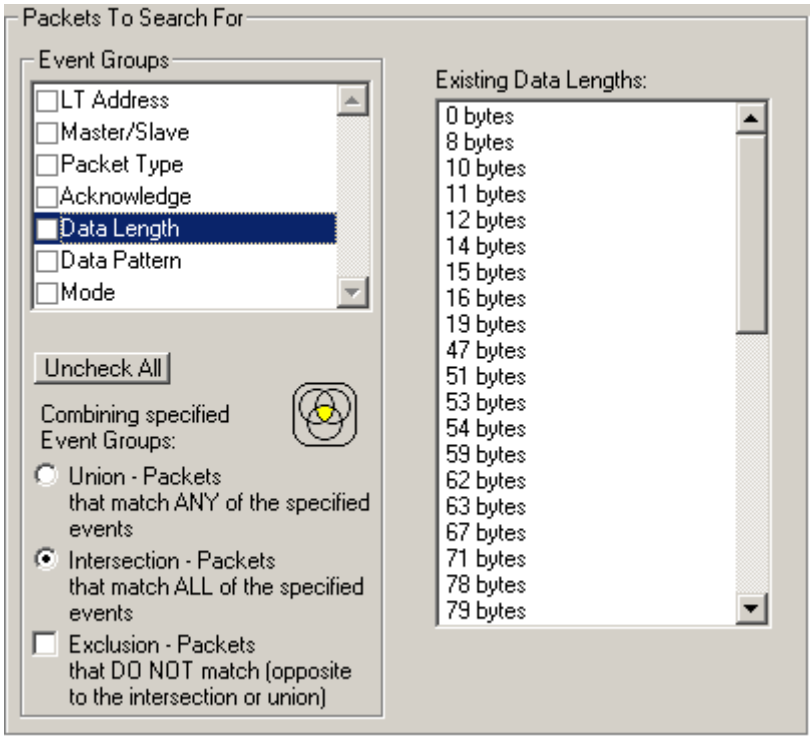


Implicit NACK - Packet 14577 is a data packet sent by the piconet Master device. Packet 14579 should have been a data packet with an acknowledgment. Instead, it is an empty packet. This Master interprets this empty packet as an **Implicit NACK** (i.e., implicitly not acknowledged). Merlin II summarizes this packet exchange by adding an **Ack'd** field to the Master's data packet and setting the **Ack'd** field to **Imp Nak**.

ACK - Packet 14580 is the Master's retransmission of the data sent in packet 14577. Packet 14582 is the reply by the Slave device. This reply contains an ARQN field with a value of (= Acknowledge). Merlin II summarizes this packet exchange by setting the **Ack'd** field on packet 14580 to **Ack**.

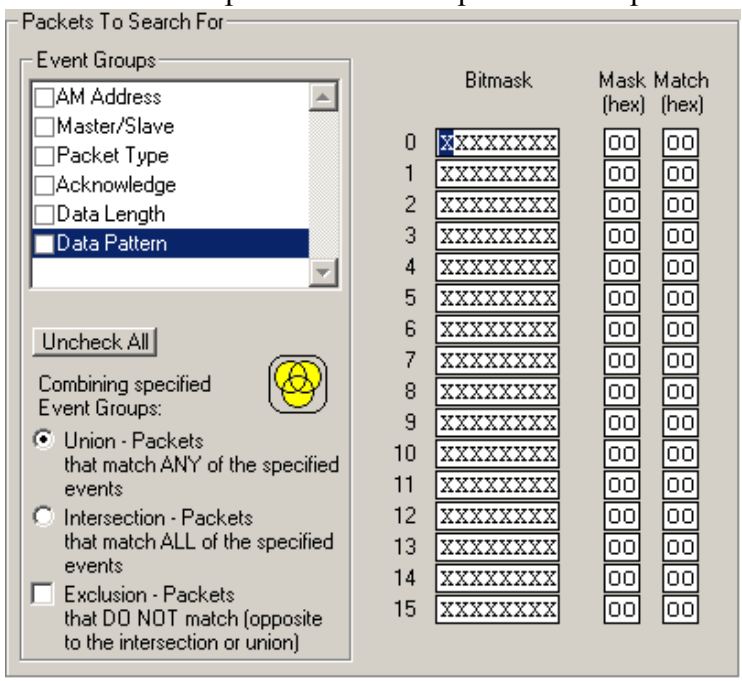
Data Length

Contains a list of all data lengths that occur in the trace.



Data Pattern

Searches for the next packet that has a specified data pattern.



Searching for Bit Patterns

You search for a bit pattern by using the box labeled **Bitmask**. Enter one of the three following values:

- X = 'Don't care,'
- 0 = 'Match a 0',
- 1 = 'Match a 1.'

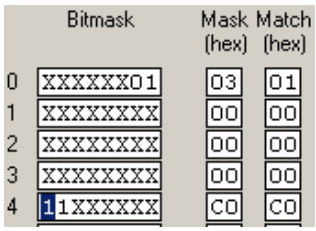
Example -- xxxxxx01 means 'Look for a data pattern where the first 6 bits can be any value but the last two bits must be 01.'

Searching for Long Patterns

You can search for long pattern sequences by entering patterns into multiple rows within the editor. Entering a pattern on one row and skipping several rows before entering the second pattern tells Merlin II to search for the entire pattern between the two specified rows.

Example - Enter xxxxxx01 in row 1 and 11xxxxxx in row 2. This pattern means 'Look for the pattern xxxxxx0111xxxxxx.'

Example - If you enter xxxxxx01 into row 0 and 11xxxxxx into row 4, it means 'Look for the pattern xxxxxx01 xxxxxxxx xxxxxxxx xxxxxxxx 11xxxxxx.'



Searching for Hexadecimal Patterns

The columns marked Match and Mask allow you to specify a pattern in hex. You enter the pattern you want to match in the column marked Match, and enter the mask in the column marked Mask. The Mask column allows you to specify which bits you are searching for.

Example - A Match of 03 and a Mask of '0F' tells Merlin II that you are looking for the hex pattern of 03 occurring in the last four bits of the pattern. If you enter these values in the Match and Mask columns, the Bitmask section will automatically display the equivalent bit values: XXXX0011.

Union, Intersection, and Exclusion

If you select multiple events, you will need to use the options Union or Intersection to conduct the search.

Union is used to search for any selected event: "Find x or y." Union lets you tell the analyzer to search the trace for any of any of the selected items.

Intersection is used to search for all selected events: "Find x and y." Intersection lets you tell the analyzer to search the trace for any packet having all of the selected events.

Exclusion is used to exclude selected traffic from the trace. Exclusion is used with Union and Intersection --i.e., you select Exclusion with Union or Intersection.

- **Exclusion + Union** -- tells Merlin II to exclude packets with any of the specified events.
- **Exclusion + Intersection** -- tells Merlin II to exclude packets with all of the specified events.

Using Find

Step 1 Select the display level to be searched from the **Search For** box on the left side of the window.

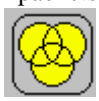
For example, to search through L2CAP messages, select L2CAP. The display level that you select will affect options presented in the Events Group box.

Step 2 Select a search direction and origin.

Step 3 Select one or more events from the **Events Group** box.

Your choices will affect options presented in the box on the right side of the screen.

Step 4 If you have selected two or more criteria, then select either :

- **Union:** Find all packets that match ANY of the specified events. An  example would be to find packets with either X or Y.
- **Intersection:** Find all packets that match ALL of the specified events. An example would be to find all packets with X and Y.

If you want to selected events from the trace, then select:

- **Exclusion:** Exclude all packets that match any of the specified events. This option works in conjunction with Union and Intersection. Select an exclusion plus one of the other two options. If you select Exclusion and Union, it means Exclude packets in any of the following events. An example would be to exclude packets with either X or Y.

Step 5 Click **OK**.

The search will then occur. Afterwards, the packets meeting the search criteria will display.

Some Find Examples

Search for all DM1 and Poll packets with an Active Member Address of 7.

Step 1 From the Event Group, select **Packet Types**.

Step 2 From the box on the right, select **DM1** and **Poll**.

Step 3 From the Event Group, select **Header LT_Addr**.

Step 4 From the box on the right, select **LT_Addr=7**.

Step 5 From the Center area, select **Intersection**.

Selecting Intersection tells Merlin II to find packets with ALL of the selected traits.

Step 6 Press **OK**.

The trace should reposition to the first DM1 or Poll packet that has an Active Member address of 7.

Exclude all DM1 and Poll Packets with Logical Transport Addresses of 7.

Step 1 Select **Packet Types** from the From the Event Group

Step 2 Select **DM1** and **Poll** from the box on the right.

Step 3 Select **Header LT_Addr** from the Event Group.

Step 4 Select **LT_Addr=7** from the box on the right.

Step 5 From the Center area, select **Intersection and Exclusion**

Step 6 Press **OK**.

The trace will re-display so that it excludes *DM1 packets with LT_Addr=7* and *Poll packets with LT_Addr=7*.

Exclude all packets with ANY of the following attributes: DM1, Poll, or LT_Addr=7.

Step 1 Select **Packet Types** from the Event Groups.

Step 2 Select DM1 and Poll from the box on the right.

Step 3 Select **Header LT_Addr** from Event Group.

Step 4 Select **LT_Addr=7** from the box on the right

Step 5 Select **Union** and **Exclusion**.

Selecting Union causes the analyzer to search for any of the selected events.

Step 6 Press **OK**.

The trace will re-display so that it excludes *DM1s, Polls, or any packet with LT_Addr=7*.

Find Next

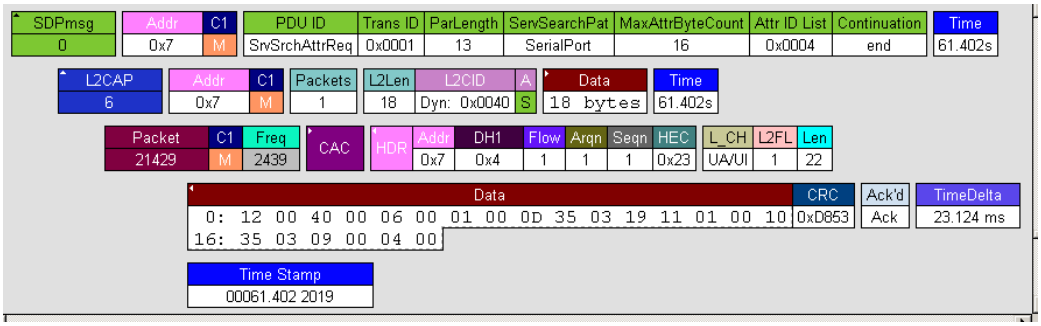
To apply the previous **Find** parameters to the next search,

- Select **Find Next** under **Search** on the Menu Bar

  OR

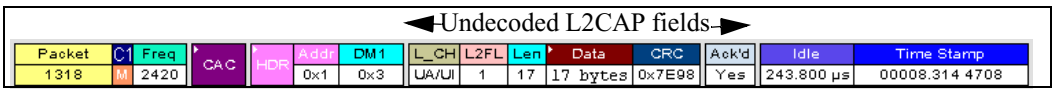
  Click on the Tool Bar.

10. Decoding Protocols



10.1 Introduction

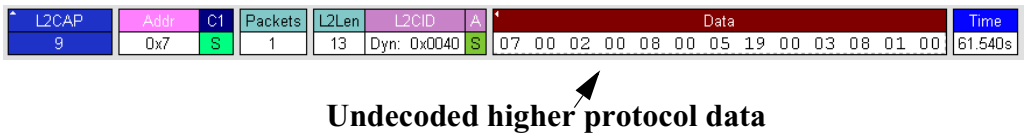
Merlin II can decode HCI, LMP and L2CAP messages, and RFCOMM, SDP, TCS, HDLC, PPP, OBEX, HCRP, BNEP, HID, IP, TCP, and UDP protocols. The default is *packet level* decoding, which means that baseband packets will be displayed when you first view a trace. If these packets are carrying LMP, L2CAP or other protocols, the protocols will display as undecoded fields such as the L2CAP packet below.



By issuing a decode command, Merlin II can decode these LMP and higher fields and display the data in summary statements called *LMP/L2CAP Messages*, *Protocols Messages, and Protocol Transactions*.

10.2 LMP and L2CAP Messages

LMP and L2CAP Messages are lines in a trace that summarize LMP and L2CAP actions such as an *LMP connection request.* LMP and L2CAP Messages summarize the type of action, the number of packets involved in the action, and the device performing the action. If the message is carrying higher protocol data such as RFCOMM, TCS, OBEX or SDP data, the message displays this data in an undecoded format that can be decoded later.



10.3 Decoding and Viewing Higher Protocol Data

Higher protocol data can be decoded two ways: by clicking a decode button on the toolbar or by selecting a decode command from a pull down menu.

Decoding Via the Decoding Toolbar

The Decoding Toolbar has ten buttons for decoding packets, messages, and protocols:

- **Pkt** (Display Packets)
- **HCI** (Display HCI Protocol)
- **LMP** (Display LMP Messages)
- **L2CAP** (Display L2CAP **M**essages)
- **SDP Msg** (Display SDP Protocol Messages)
- **SDP** Tra (Display SDP Transactions)
- **TCS** (Display TCS Protocol messages)
- **RFCOMM** (Display RFCOMM Protocol)
- **OBEX** (Display OBEX Protocol)
- **OBEX Tra** (Display OBEX Protocol Transactions)
- **AT** (Display AT Commands Protocol)
- **HDLC** (Display HDLC Protocol)
- **PPP** (Display PPP)
- **HCRP** (Display HCRP)
- **AVCTP** (Display AVCTP)
- **AVDTP** (Display AVDTP)
- **BNEP** (Display Bluetooth Network Encapsulation Protocol)
- **HID** (Display HID Protocol)
- **IP** (Display IP)
- **TCP** (Display TCP)
- **UDP** (Display UDP)

For example, to display LMP messages, click

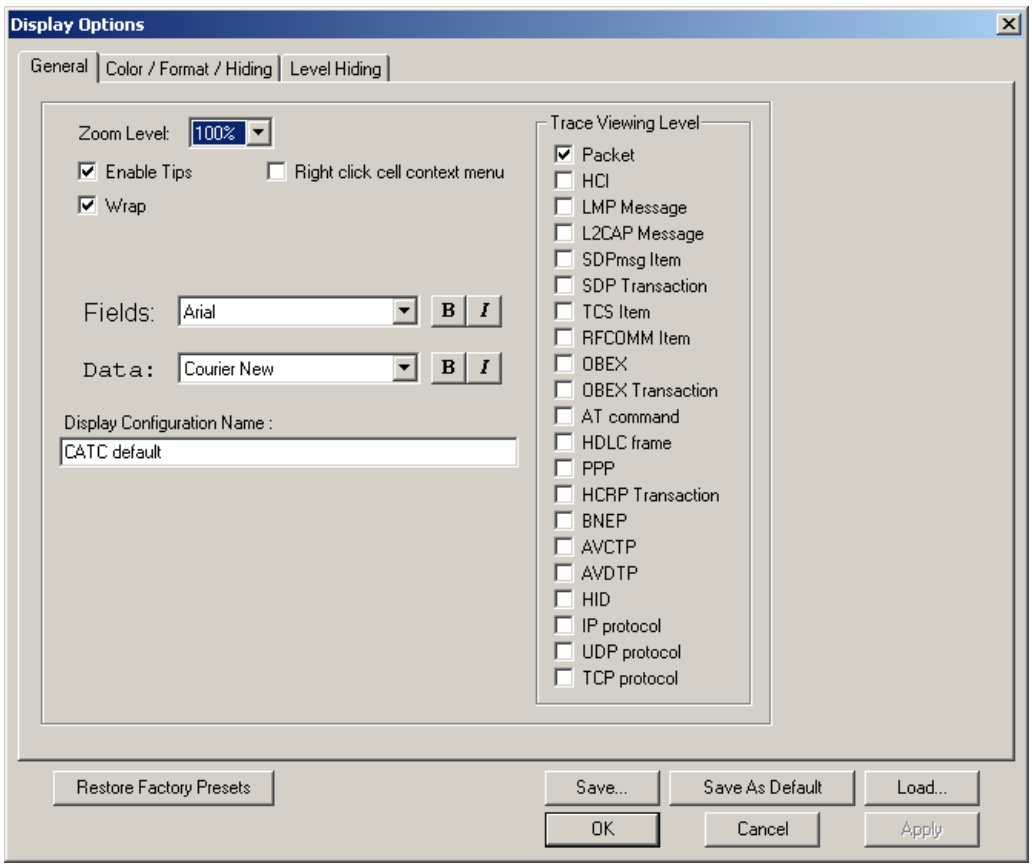
.

Note Once a decode has been performed, it will probably be necessary to scroll through the display to find the decoded messages or protocols. You can shorten your search by first clicking the Hide Unassociated Traffic button .

Decoding Via the Display Options Dialog Box

The Display Options dialog box has three options for issuing decode commands. To issue a command,

Step 1 From the menu bar, select **Setup>Decoding Options**

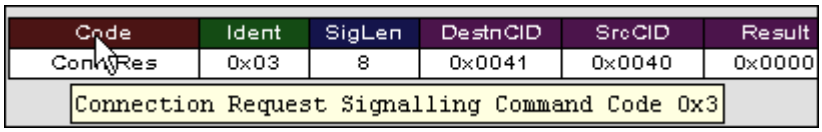


Step 2 Select the option for the desired level of decoding.

Step 3 Click **OK** or **Apply**.

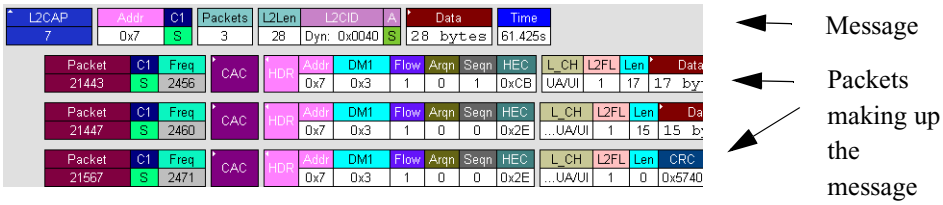
10.4 Tooltips

Additional information about fields can be attained by positioning your mouse pointer over a field of interest. A tooltip will appear that will provide details about the field. In some cases, there can be a considerable amount of information available.



10.5 Viewing Packets in LMP and L2CAP Messages

LMP and L2CAP Messages can be "opened" to reveal their constituent packets by double-clicking the first cell in of the message or clicking once on the small arrow on that same cell. The packets will then display below the message. The following screenshot shows an example of a message and its packets.



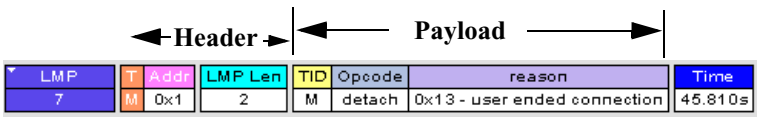
10.6 Types of LMP and L2CAP Messages

If you scroll through a trace, you will see three kinds of message:

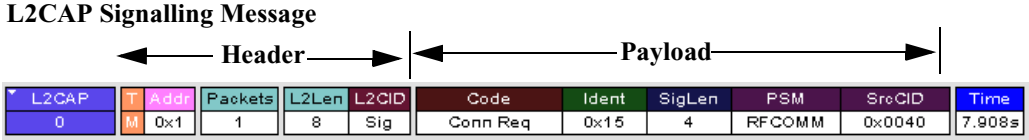
- LMP Signalling Message
- L2CAP signalling Message
- L2CAP Data Transfer Message

Each message has the same basic message header but differs in its payload.

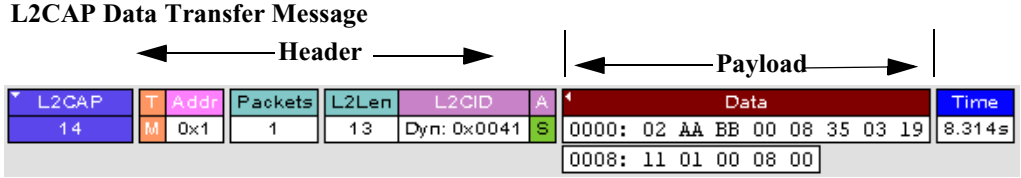
LMP Signalling Message



L2CAP Signalling Message



L2CAP Data Transfer Message



LMP and L2CAP Signalling messages have payloads of commands for establishing LMP and L2CAP channels. L2CAP Data-Transfer messages have a payload that may include RFCOMM, SDP, or TCS data. In order to

view higher protocol data, you will need to decode the messages (shown in the next section). The decoded data will appear as new lines in the trace called "Protocol Messages."

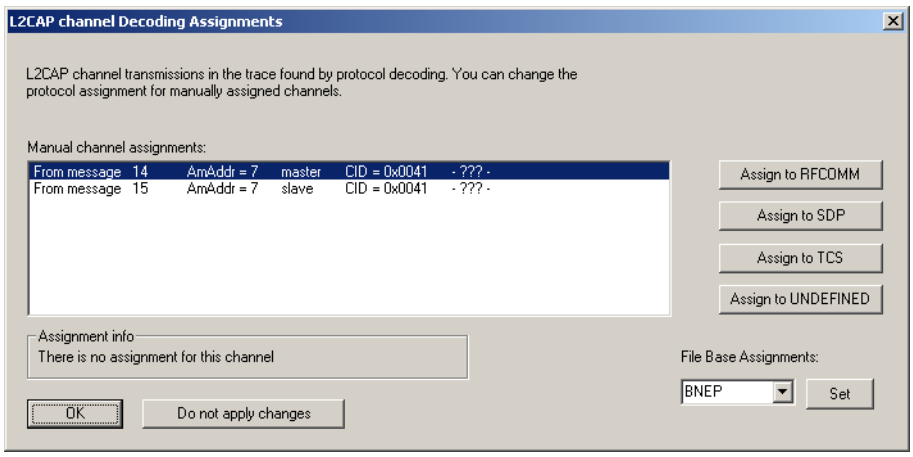
10.7 Viewing L2CAP Channel Connections

Once L2CAP messages have been decoded and displayed, you can check or change their L2CAP channel connections by opening the L2CAP Decoding Connections dialog box.

To view or change an L2CAP channel connection,

Step 1 Select from the menu bar
View>Decoding Assignments

The following dialog box will open.



Step 2 Click on a channel assignment and then look at the Connect and Disconnect buttons on the far right of the dialog box.

If the Connect and Disconnect buttons are grayed-out, it means that Merlin II made the channel assignments using data in the trace. You can verify that Merlin II performed the assignments by looking at the text in the "Slave Channel" box in the lower left corner of the dialog box. If you see "Connection Recorded" it means that Merlin II performed the channel assignments.

If Merlin II was not able to make these channel assignments, then the Connect and Disconnect buttons on the right side of the dialog box will be active. You can then assign and edit channel connections.

Step 3 Open the drop-down menu labeled LT_Addr (Active Member Address). If possible, select an address other than the currently displayed address.

The connections for the 'new' device should now display.

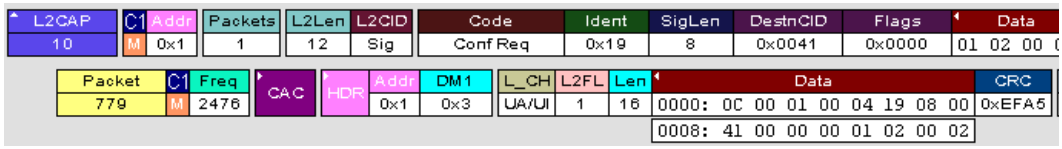
10.8 Viewing Protocol Messages and Transactions

By pressing a button such as SDP Msg or OB EX, you can cause Merlin II to decode the higher level protocol data contained within L2CAP messages and display them as packet-like rows called *Protocol Messages*. Protocol Messages have headers marked "protocol" and fields that vary in appearance and content depending on the type of protocol.

Some Protocol Messages can be grouped into a higher level entity called a *Protocol Transaction*. A Protocol Transaction is a row in a trace that summarizes the higher level protocol data that is transmitted between a Master and Slave device when one sends a request and the other sends back a response. For example, if you press SDP Tra, Merlin II will locate SDP requests and responses between a Master and Slave device summarize their data.

Viewing L2CAP Messages in Protocol Messages

If the protocol heading is double-clicked, the L2CAP data-transfer messages that make up the protocol will display below the protocol. You can also expand the protocol by left-clicking the small downward pointing arrow on the protocol header.



How to Decode

Decoding Protocol messages is the same process as decoding LMP and L2CAP messages.

Using the Toolbar - To decode using the Toolbar, press one of the protocol decode buttons such as: TCS . PPP OB EX .

Using the Menu - To decode using the menu, select:
Setup>Display Options

Then select one of the decode checkboxes.

Once a decode command has been issued, Merlin II will create Protocol Messages in the trace. You will probably have to hide hops, polls, and null packets and then scroll through the trace in order to find Protocol messages.

Expanding Protocol Messages

Protocol messages can be expanded to reveal their constituent packets using any of the following methods:

- Left-click the small downward pointing arrow in the message/protocol header

- Double-click a message/protocol header
- Left-click the message/protocol header and choose "Expand Transaction" from the short-cut menu

10.9 Decoding via the Profiles Toolbar

The Profiles toolbar presents buttons that represent profiles. The Profiles buttons do not represent an additional set of decodes; rather, they represent shortcuts for the existing decodes. By clicking a Profiles button, the analyzer software will automatically depress the protocol buttons needed to decode all of the protocols associated with the selected Profile - for example, RFCOMM, PPP, or IP.

To display the Profiles toolbar, select **View** > **Toolbars** > **Profiles**.

10.10 Changing Protocol Assignments

If a sequence of messages is assigned the wrong protocol, errors will display. To change or remove a protocol assignment, you will need to access the **Assignment** menu and issue an Add Assignment command.

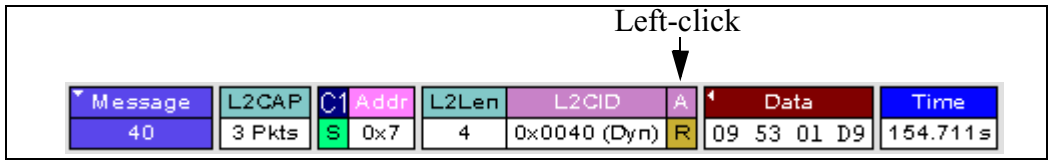
Step 1 Click

to display L2CAP messages.

Note You need to view L2CAP Messages in order to have access to the "**A**" field that permits reassigning protocols.

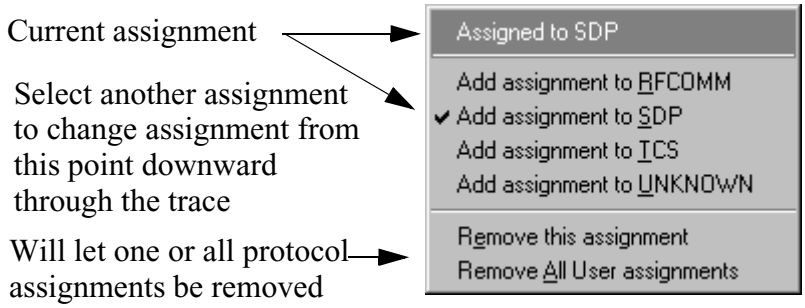
Step 2 Scroll through the trace until you have located an L2CAP message with a field marked "**A**."

Step 3 Left-click the field marked "**A.**"



An **Assignment** menu will open for assigning, re-assigning, or un-assigning protocols to messages. This menu is context-sensitive and will vary in content depending on the protocols in the trace.

The Assignment Menu



Step 4 From the menu, select one of the "Add Assignment" options not already selected.

At this point, the protocol assignment will change to your selection.

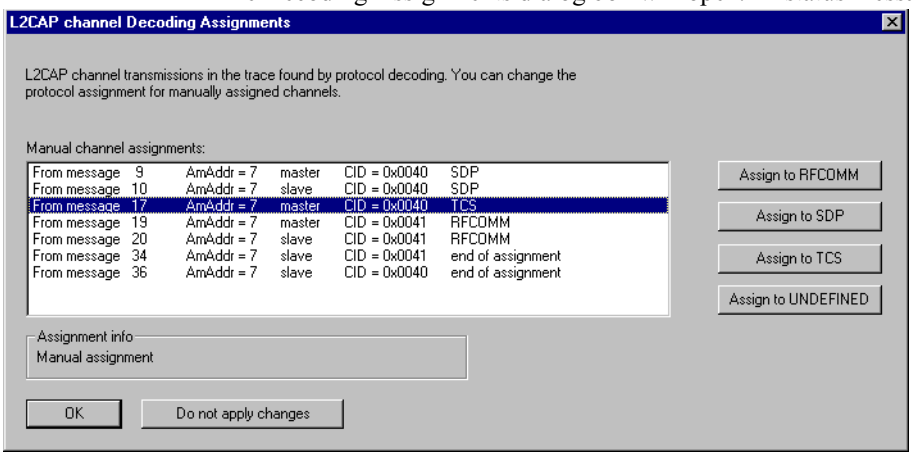
Using the Decoding Assignments Dialog Box

You can get a complete list of all protocol assignments by opening the Decoding Assignments dialog box. This dialog box will tell you which protocol assignments were made by Merlin II and which are user-assigned. User-assigned protocols can be reassigned if need be using this dialog box.

To open the Decoding Assignments dialog box and reassign a protocol,

Step 1 Select from the menu
View>Decoding assignments

The Decoding Assignments dialog box will open. A status message in



the bottom left corner of the dialog box will indicate who assigned the protocol.

Step 2 Click on one of the displayed assignments.

If the protocol was assigned by Merlin II, the Assign buttons on the right will be grayed out and unavailable. If you want to change these assignments, you will have to use the pop-up menus described in the previous section. If a protocol has been manually assigned by a user, the Assign buttons will become active and allow you to make a change in assignment.

Step 3 If possible, click the appropriate Assign button.

Removing User-Assigned Protocol Assignments

As you practice assigning and reassigning protocols, you will find that one of the more useful commands is "Remove All User Assignments." This command allows you to undo all of your assignments.

To remove some or all user-assigned protocol assignments,

Step 1 Double-click any Protocol Message header to open view L2CAP messages.

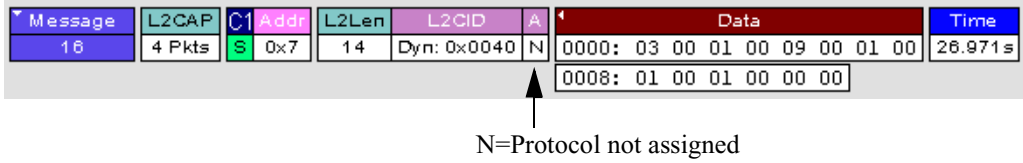
Step 2 Locate a message with a field marked "**A**."

Step 3 Left-click on the "A" field to open the Assignment menu.

Step 4 Select "Remove All User assignments" or "Remove this assignment."

Manually Assigning Protocols

If a recording does not capture the beginning of a dialog between a Master and Slave devices, Merlin II may not have the L2CAP messages it needs to determine the correct protocol assignments. In this case, L2CAP messages will display an "N" in the Assignment field that means "Not Assigned."



An L2CAP message without a protocol assignment for the higher protocol data.

If you know what the protocol assignment should be for the missing assignments, you can manually add them by right-clicking your mouse over the A field shown above and selecting from the pop-up Assignment menu shown on the previous page.

Other Assignments: OBEX Client/Server Status

OBEX messages carry a status that indicates whether the transmitting device is an OBEX client or OBEX server.

To view an OBEX message's client/server status,

Step 1 Open an OBEX trace file such as the sample file "OBEXsample.tfb" in C:\Program files\CATC\Merlin II.

Step 2 Press . , and to hide Hops, NAKs, and unassociated traffic.

Step 3 Press to decode OBEX.

Step 4 Left-click your mouse over the field marked Type.

A pop-up menu will appear indicating whether the message was produced by an OBEX client or server. If the menu items appear

Left-click over the Type field to open the OBEX Client/Server Assign menu.

grayed-out (as they do in this example) it means that Merlin II assigned the client or server status based on data it found in the trace. If the menu items appear in black, it means that the user assigned the status and is therefore free to change the assignment.

Changing an OBEX Client or Server Status

If the beginning sequence of traffic is not recorded in a trace, the client/server status of the transmitting devices will not be preserved in the trace. In this case, the OBEX Client/Server pop-up menu will become active and you will be able to change the assignment.

Decoding BNEP

BNEP (Bluetooth Network Encapsulation Protocol) is a protocol that allows devices to encapsulate network protocols such as IP. Since BNEP can carry different types of network protocols, you need to tell Merlin II what protocol the BNEP is going to be carrying. You do this via a script file called *bnep.dec* that is read during the initialization of the Merlin II software. This file tells Merlin II how to decode BNEP fields. Once read, BNEP can be correctly decoded by pressing the BN EP button on the toolbar. If the decode file is not read at initialization, Merlin II will display the data in an undecoded format.

For more information on BNEP decoding, see a supplemental document on BNEP in the support directory on the CATC web site:

http://www.catc.com/products/support/sup_Merlin II/bluetooth.html

Decoding HID

HID (Human Interface Device) is a profile associated with traffic from devices such as a mouse or a keyboard. To decode HID traffic, you will need to tell Merlin II what types of HID traffic it will be recording. You do this by editing a script file called *hid.dec*. Merlin II reads this file during the initialization of the Merlin II software. This file tells Merlin II how to decode the HID fields. Once read, HID can be correctly decoded by pressing the HID button. If the decode file is not read at initialization, Merlin II will display the data in an undecoded format.

Other Decoding Options

Other decoding options include the following:

- IP
- TCP
- UDP
- AVCTP
- AVDTP
- HCRP

10.11 Encryption

Bluetooth encryption is a multi-staged process that provides devices with secure, encrypted communications. The process begins with a device prompting the user for a Personal Identification Number (PIN). When the right PIN is entered, the Slave begins an encryption setup dialogue with the Master. At the beginning of this dialogue, the Slave and the Master agree on a *Link Key*. A Link Key is a 128-bit value that the two devices use for authentication. When the Slave and Master agree on a Link Key, the Slave then negotiates for the transfer of the *Encryption Key* from the Master device. The Encryption Key is used to encrypt and decrypt messages. Once the Encryption Key is transferred, both devices use it to encrypt all subsequent communications.

In order for Merlin II to decode encrypted traffic, it needs the *Link Key* for each Master-Slave connection for which encryption will be used. If you know the Link Key, you can enter the Key into the Encryption Options dialog box. If you do not know it, you give Merlin II the PIN for a device and allow Merlin II to discover the Link Key on its own. Once Merlin II has the Link Key, it can capture the rest of what it needs by listening to the Master and Slave devices as they negotiate for the Encryption Key.

Note - The encryption settings here are for the Merlin II only. The BTTrainer has its own encryption settings.

Note - There is no need to configure Encryption settings if Merlin II is used to record BT*Trainer* traffic.

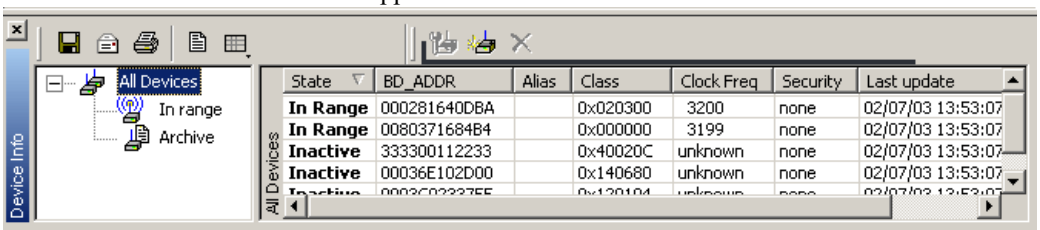
Configuring Merlin II for Encryption

For Merlin II to successfully decrypt traffic, two steps need to be performed: 1) Merlin II needs to be given the PIN or Link Key for each Master-Slave connection; and 2) Recording needs to be begun *before* the Slave connects to the Master. If recording is begun prior to the creating the Master-Slave connection, Merlin II will be able to obtain the encryption key and decode encrypted traffic.

The following steps show how to configure Merlin II for encrypted traffic.

Step 1 Select **View >Device List**

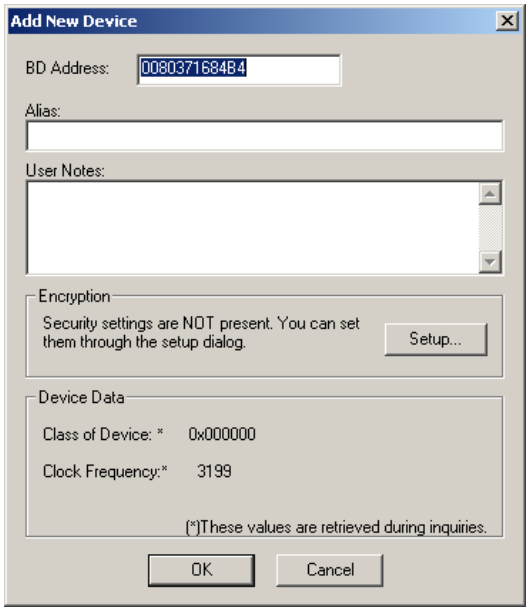
The Device List appears.



Step 2 Click in the row for the device of interest.

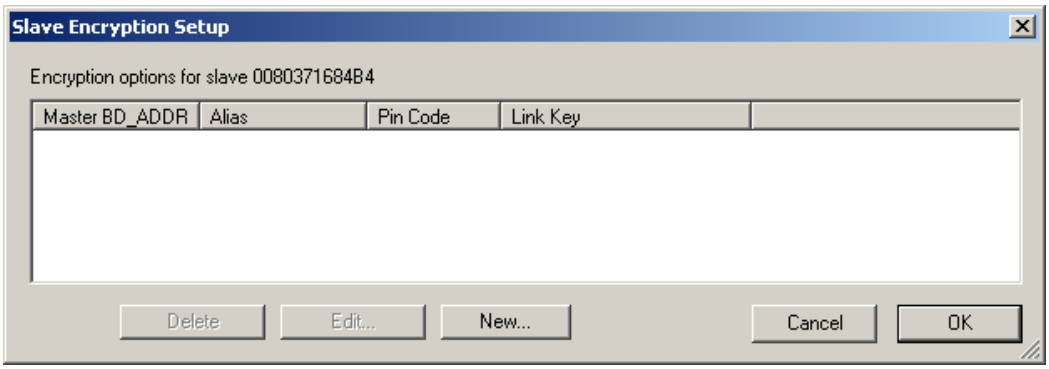
Step 3 Click the Edit Devices button

The following dialog box opens.



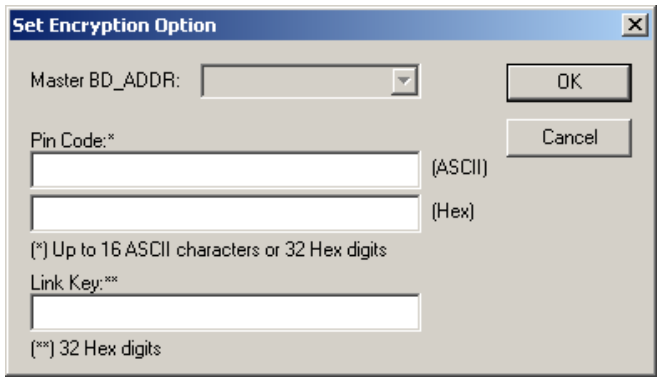
Step 4 Click the **Setup ...** button.

The following dialog box opens:



Step 5 Click the button marked **New**.

The following dialog box appears.



Step 6 Enter the appropriate Personal Identification Number (PIN) for the selected device to the box marked **PIN Code**. This PIN allows Merlin II to learn the Link Key. If you do not have the PIN, skip to Step 5.

Note The PIN you provide should be the same used by the Slave. For example, if your Slave device requires a PIN of "1234", then enter the same PIN in the dialog box shown above.

Step 7 If you do not have the PIN, or if the Master and Slave have already agreed upon the Link Key, manually enter a Link Key as a 128 bit (sixteen byte) hex value into the box marked **Current Link Key**. If you have the PIN, you can skip this step.

Step 1 If the Master and Slave were previously connected, they may already agree on the Link Key. In this case, you will need to provide Merlin II with the Link Key and not simply the PIN.

Step 2 Click **OK**

The changes you have made are applied and the information is displayed in the **Slave Encryption Setup** dialog box as shown previously.

Step 3 Click **OK**.

The **Slave Encryption Setup** dialog box closes. Within the Device List, you should see a "Yes" in the Security field for the selected device.

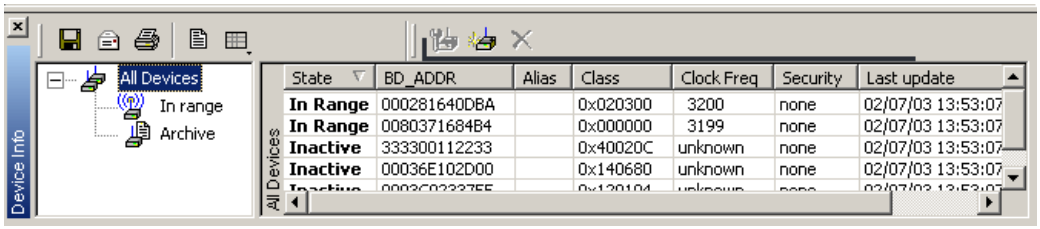
10.12 Re-applying Encryption Settings

If you record a trace with the wrong encryption settings, the trace will not decrypt properly. Merlin II lets you correct the problem by re-applying encryption settings after a recording is finished.

To correct an improperly decrypted trace file, perform the following steps.

Step 1 With the trace open, open the Device List by selecting **View > Device List** from the menu.

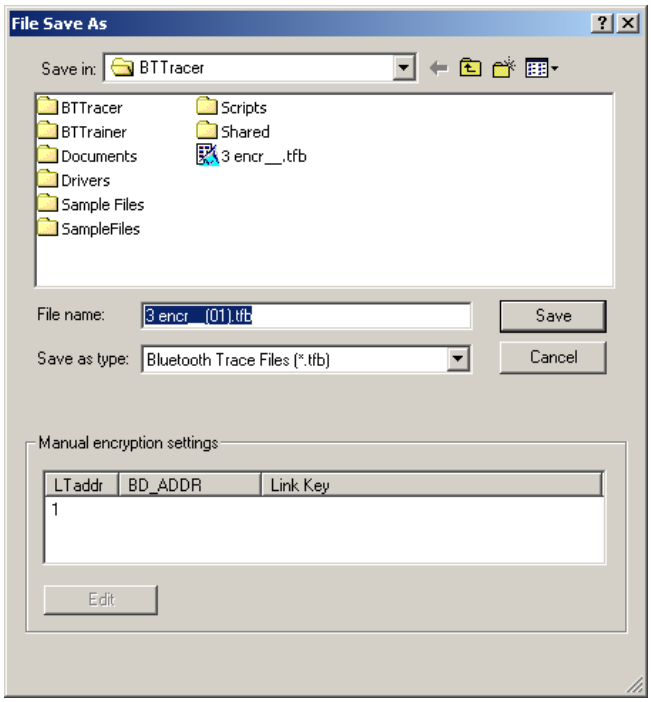
The Device List opens.



Step 2 Follow the directions outlined above in Section 10.11, "Encryption" on page 136 for adding/editing encryption settings.

Step 3 Once the new encryption settings have been applied, run the command **File > Re-apply Encryption Settings ...**

A Save As dialog box opens.



Step 4 Enter a file name (or use the default) and click **OK**.

The file is saved and the new settings are automatically applied. The new file opens automatically.

The file should now be decrypted properly.

Re-applying Encryption On Incomplete Traces

If your trace does not capture the authentication procedure, there will be no way for the analyzer to determine the BD Address of the Slave device. Accordingly, the software will not be able to decrypt the trace file.

If you are using a development kit and already know the BD Address of the Slave device and the Link Key, you can enter it manually in the Save As dialog box shown above.

Note LMP_start_encryption_req still has to be present in the trace in order to manually correct the settings.

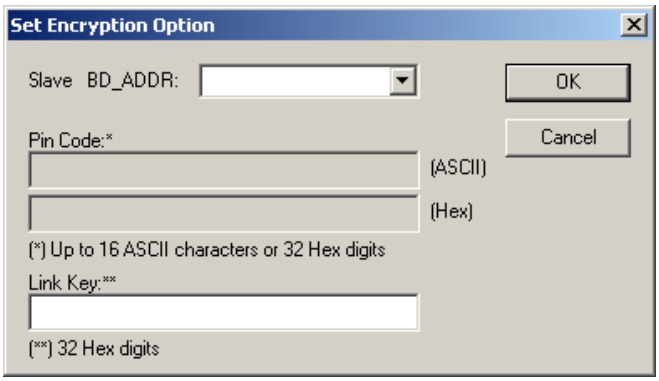
Step 1 Select **File** > **Re-apply Encryption Settings**.

The Save As dialog opens (shown on preceding page.)

Step 2 Select the LT Address for the device whose traffic you are trying to decrypt.

Step 3 Click the **Edit** button.

Step 4 The **Set Encryption Options** dialog box opens.



Step 5 Enter the BD Address and Link Key.

Step 6 Click **OK**.

The dialog box closes.

Step 7 Click **Save**.

The dialog box closes and the traffic is decrypted according to your settings.

11. Reports & Exporting Data

Merlin II has several utilities for producing statistics and graphs and for exporting data to files.

Reports include Device List, File Information, Error Summary, Bus Utilization, Timing and Bus Usage Calculation, Traffic Summary and Real Time Statistics.

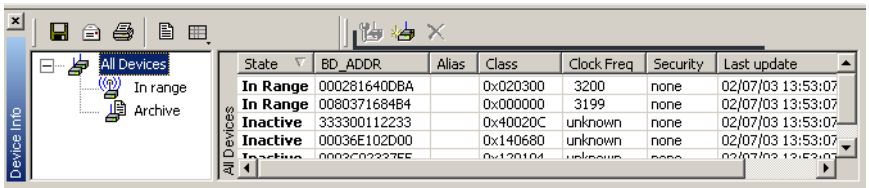
Trace data can be exported to three formats: text, .csv (a format suitable for spreadsheets and database applications), and, if audio data is present, various audio formats.

11.1 Device List

Device List describes devices discovered in a previous inquiry or devices entered by the user.

You open Device List by selecting **View > Device List**.

The list is stored in a file that is updated from one session to the next.



By default, Device List appears at the bottom of the Merlin II window.

Fields in the Device List

- **State** -- Device State
- **BD_ADDR** -- Bluetooth Device Address
- **Alias** -- Whatever alias you entered for the device in the Add New Device dialog
- **Class** -- The device class for each listed device
- **Clock Freq** -- Shows the device's Clock Frequency
- **Security** -- If Encryption is enabled, then this field will be marked with a "Yes." You enter Encryption by clicking the Add Devices button, and then clicking Options
- **Last Update** -- Shows when device information was last updated
- **User Notes** -- User comments. You add notes by clicking Add Devices and entering text into the dialog box

Buttons

Edit Device -- Opens a dialog box for editing the device settings in the Device List.

Add New Device -- Opens a dialog box for adding new devices to the list. (You can also enter devices by performing an Inquiry.) This dialog box lets you enter information that will appear in the device list: device names, addresses, aliases, and comments.

Remove Device -- Removes the selected device from the Device List.

11.2 File Information

The File Information report provides valuable information about how the recording was made, what the buffer settings were, what the trigger options were, and what version of all the analyzer hardware was used to make the recording.

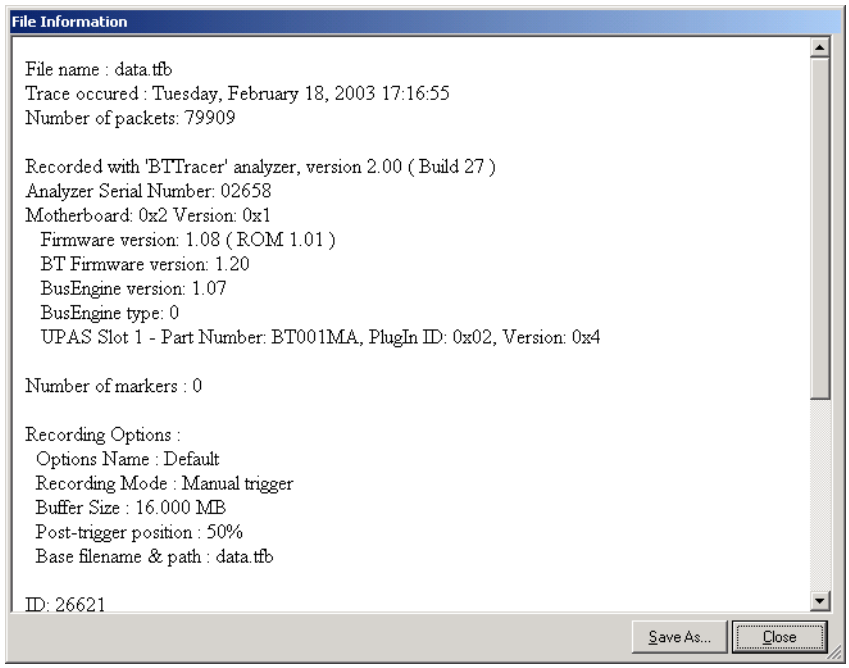
To display a File Information report,

- Select **File Information** under **Report** in the Menu Bar

  OR

  Click in the Tool Bar.

  You see the File Information screen:



11.3 Error Summary

The Error Summary command opens the **Traffic Summary** dialog box and displays an error summary of the current trace file. The dialog box allows you to go to a specific packet, and save the error file to a uniquely named file. See the discussion below on **Traffic Summary** for more information.

11.4 Timing Calculations

Starts the modeless calculator dialog for calculating various timing and bandwidth parameters in the recording file.

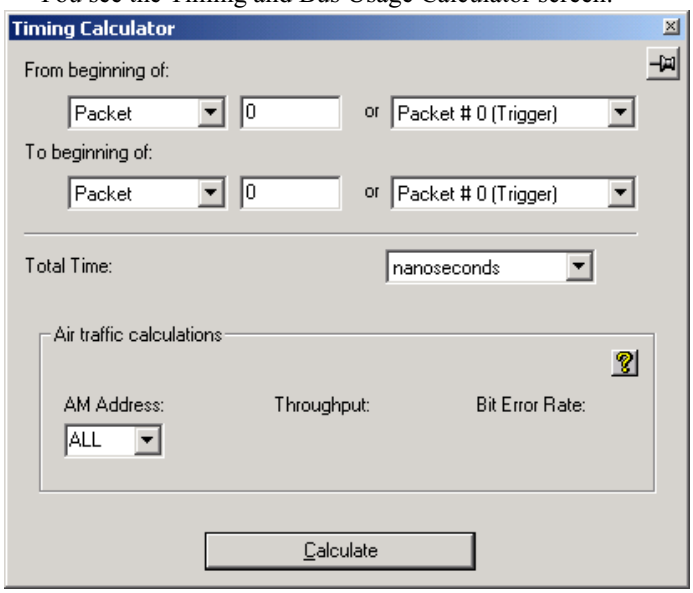
To display a File Information report,

- Select **Timing Calculations** under **Report** in the Menu Bar

  OR

  Click in the Tool Bar.

  You see the Timing and Bus Usage Calculator screen:



To calculate bus usage and bit rate errors,

Step 1 Enter the range of packets to be examined in the text boxes marked "From packet" and "To packet."

Step 2 If you wish to limit your calculations to a single device, select the device's address from the LT Address drop-down menu.

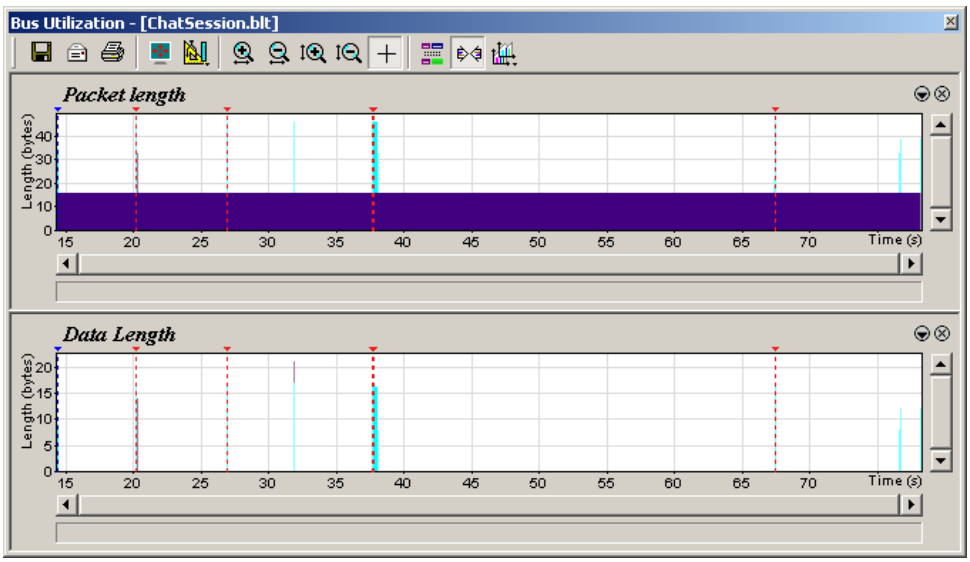
Step 3 Click the "Calculate" button.

At this point, bus usage will be calculated.

11.5 Bus Utilization

The **Bus Utilization** window displays a graph of bandwidth use within a displayed trace.

To open the Bus Utilization window, select **Report >Bus Utilization** or click the button marked . A window will open with graphs of Link Utilization, Data Throughput, and Packet Counts:



Bus Utilization Buttons

The Bus Utilization window has a row of buttons for changing the format of the displayed data and for exporting data:

The buttons have the following functions:

Save As - Saves the graphs as a bitmap file (*.bmp)

Email - Creates an email with a *.bmp file attachment of the graphs

Print

Full Screen

View Settings - opens a sub-menu with options for formatting the display. See "View Settings Menu" below.

Vertical zoom in

Vertical zoom out

Click and Drag zoom - Click diagonally to select and zoom in on part of the graph

Select Range

Sync and Graph areas - If two or more graphs are displayed, this button will synchronize the graphs to one another. Once synchronized, the positioning slider of one graph will move the other graphs

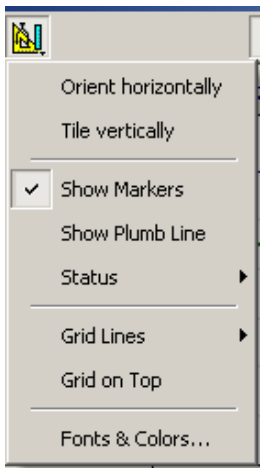
Horizontal zoom in

Horizontal zoom out

Graph Areas - Presents options for displaying additional graphs of data lengths, packet lengths, and percentage of bus utilized.

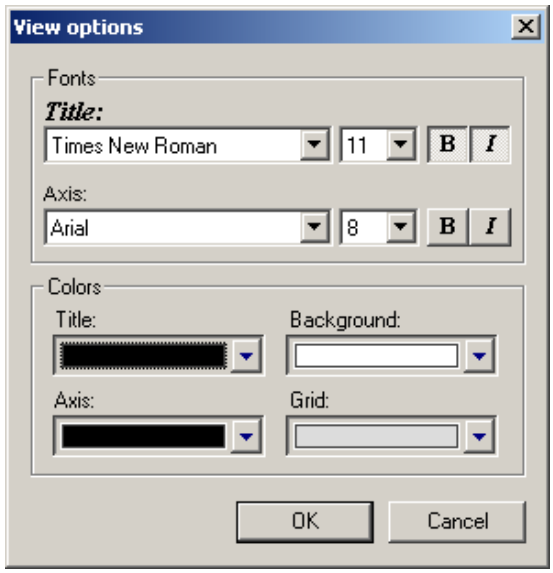
View Settings Menu

Clicking the View settings button causes a menu to open with options for formatting the display.



- **Orient Horizontally** - changes the orientation of bus usage to horizontal. After selecting this option, the menu will say "Orient Vertically."
- **Tile Vertically** - tiles the two graphs vertically (i.e., side by side).
- **Show Markers** - Places "tick" marks along the x axis of each graph.
- **Show Plumb Line** - Displays a vertical line that connects your cursor to the horizontal axis. As the mouse is moved, the status bar will show the packet and time frame to which the cursor is pointing.
- **Status** - Opens a sub-menu with the following options:
  - Bar - Displays a status bar at bottom of graph.
  - Tooltip - Causes a tooltip to appear if you position your mouse pointer over part of the graph and leave it there for a couple of seconds.
  - None - Turns off tooltips and the status bar.
- **Grid Lines** - Opens a sub-menu with the following options:
  - Both - Displays both X and Y axis gridlines.
  - X Axis - Displays X axis gridlines.
  - Y Axis - Display Y axis gridlines.
  - None - Turns off gridlines.
- **Grid on Top** - Moves the grid lines above the graph.

- **Fonts and Colors** - Opens a dialog box for setting the colors and fonts used in the graphs:

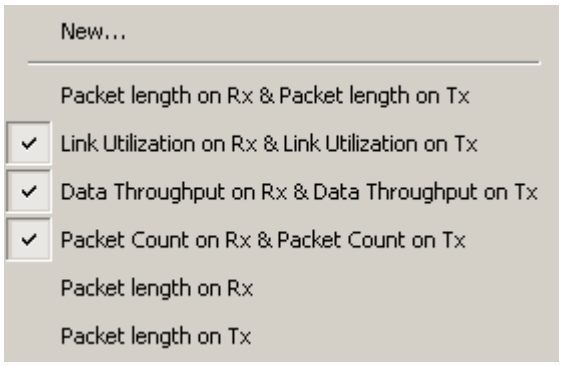


Graph Areas Menu

The Graph Areas menu allows you to view different information in the Bus Utilization window.

Step 1 Click the button.

The Graph Areas menu opens.



Step 2 Select the data you want to appear in the Graph Areas window.

To change the properties in the Bus Utilizations graph, follow these steps:

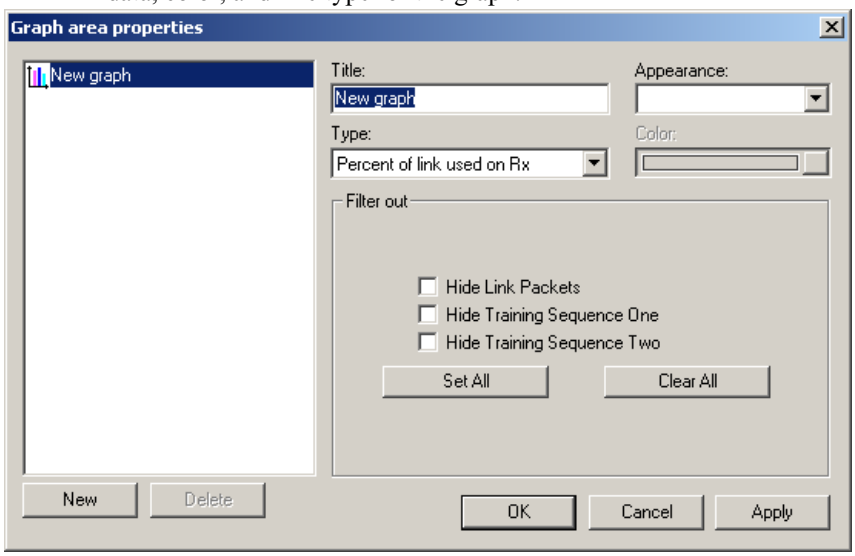
Step 1 In the **Graph Area**s menu, select the type of data to be displayed.

Step 2 Click **OK**.

Or

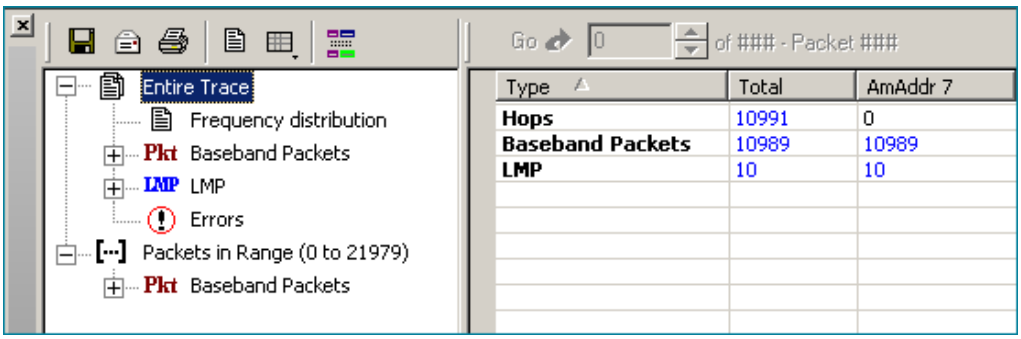
To make a new graph, click **New**.

The following dialog box will open. It will display options for setting the title, data, color, and line type for the graph.



11.6 Traffic Summary

The Traffic Summary dialog box displays a text summary of traffic captured in the current trace.



To open the Traffic Summary window, press .

The left pane displays a tree of the different protocol levels. Click the plus symbol (+) to expand the tree. The example above is fully expanded. The right pane displays a summary of the traffic for the selected level.

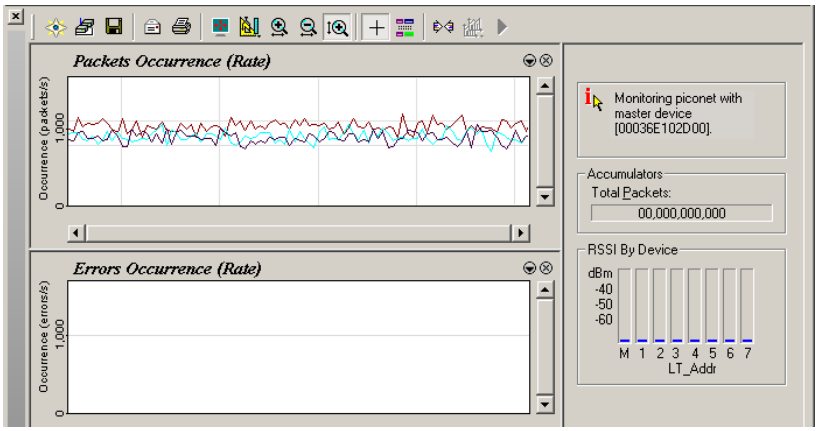
11.7 Real-Time Statistics

The Real-Time Statistics window displays a graph of real-time link activity.

Real Time Statistics displays a summary of the traffic currently being recorded by the analyzer.

To display the Real-Time Statistics window, click in the Tool Bar.

The Real Time Statistics window opens:



In order to see a graph of traffic, you will need to start recording. After starting piconet activity, press to start the Real-Time statistics monitor. Merlin II will then synchronize to the piconet and stream data in real time to this window and presented in a format of your choice.

To stop the monitor, press .

Real-Time Statistics Buttons

The Real-Time Statistics toolbar has buttons for changing the format of the displayed data and for exporting data:

The buttons have the following functions:

Save As - Saves Real-Time graphs as bitmap files (*.bmp)

Email - Creates an email with a *.bmp file attachment of the graphs

Print

Full Screen

View Settings - opens a sub-menu with options for formatting the display.

Vertical zoom in

Vertical zoom out

Click and Drag zoom - Click diagonally to select and zoom in on part of the graph

Select Range

Sync and Graph areas - If two or more graphs are displayed, this button will synchronize the graphs to one another. Once synchronized, the positioning slider of one graph will move the other graphs

Horizontal zoom in

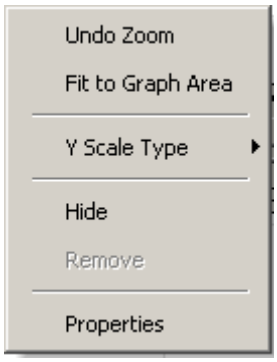
Horizontal zoom out

Graph Areas - Presents options for displaying additional graphs of data lengths, packet lengths, and percentage of bus utilized.

Start. Starts the Real-Time Monitor.

Stop Real-Time Monitoring.

Reset. Resets the graphs.



Real-Time Statistical Monitor Pop-up Menu

If you right-click a graph in the Real-Time window, a pop-up menu will appear with options for changing the format of the display.

Undo Zoom - If you have zoomed in, this command will undo the zoom.

Fit to Graph Area - Redisplays graph so that the entire trace fits inside graph area.

Y Scale Type -·

Linear - Converts display to linear format.

Logarithmic - Converts display to logarithmic format.

Hide - Hides the selected graph.

Properties - Opens a dialog box with options for changing the colors, titles and other features of the graphs.

Displaying Multiple Graphs

The Real Time Statistics window gives you the ability to create up to three separate graphing windows so that you can create separate graphs of traffic and tile them vertically. Within these windows, you can format the graphs in a number of ways.

To view two or three graphs simultaneously, click the **Graph Areas** button.

A menu opens with the following graph options:

- **General Statistics**
- **Packet Occurrence (rate)**
- **Errors Occurrence (rate)**
- **Retransmissions -** This graph shows the rate of retransmitted packets. In the Real-Time Statistics, a packet is evaluated as 'retransmitted' if at least one non-FHS seqn bit has already been received and if the previous sequence bit is the same as the current sequence bit. As the sequence bit toggles on data payloads carrying CRC, the Real-Time Statistics tracks the seqn bits in DM, DV, DH payload, and checks for correctness only if the payload was correctly decoded without errors.

11.8 Exporting Trace Data

Merlin II has export commands that enable you to extract trace data to CSV, text and other file formats. This chapter describes the export process.

Export commands are accessible through the menu: **File** > **Export**. The Export menu has five options:

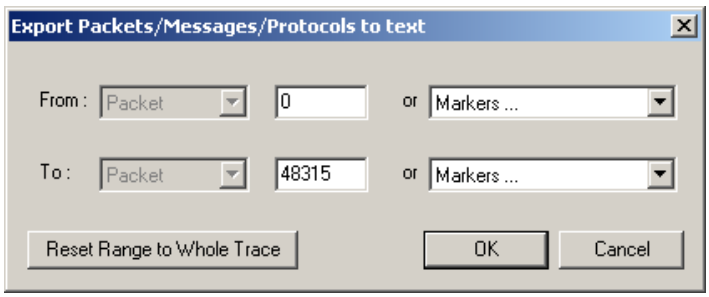
- Packets to Text (Packets View Format) ...
- Packets to CSV Text ...
- Audio Streams ...

11.9 Exporting To Text Format

To export trace data to a text file,

Step 1 Select **File** > **Export** > **Packets to Text (Packet View Format) ...**

The following dialog box opens.



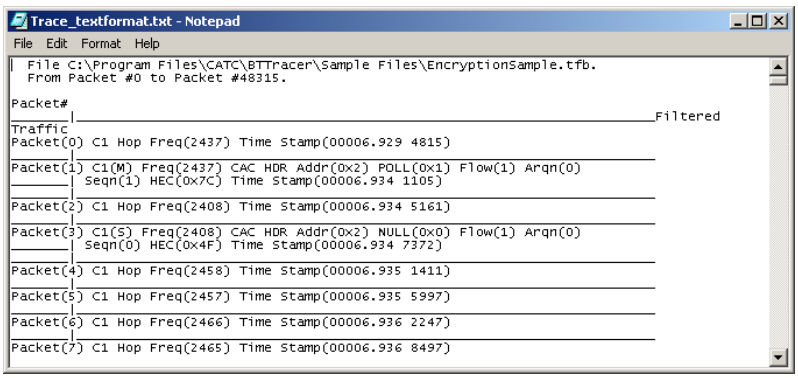
Step 2 Select the type and range of traffic to be searched from the From and To menus

Step 3 Click OK.

A **Save As** dialog box opens.

Step 4 Enter a name for the file and click **OK**.

The file is then saved. Exported text files look like this:



11.10 Exporting Trace Data to a .CSV Format

CATC's Merlin II generates over a dozen performance metrics automatically for every trace and measures them in the Traffic Summary, Bus Utilization, and Timing Calculations dialogs. Merlin II also has the ability, however, to extract a far wider range of performance data to a Comma Separated Value (**.csv)** format where it can be analyzed and measured with a spreadsheet, database or other application.

The command that extracts performance data to .csv format is called **Export to CSV Text** and is found under the File menu. This section describes the export process.

Step 1 In Merlin II, open a trace.

Step 2 From the SATracer menu, select F**ile > Export > CSV Text**. The CSV Export dialog box opens.

Step 3 Select a range using the **From** and **To** boxes.

Step 4 Select a folder where you want to export the file, and click **OK.** A **.csv** file will then be created. Below is an example

of a .csv file opened in Microsoft Excel.

Microsoft Excel - csvtext_example.csv

File Edit View Insert Format Tools Data Window Help

Arial 10 E11

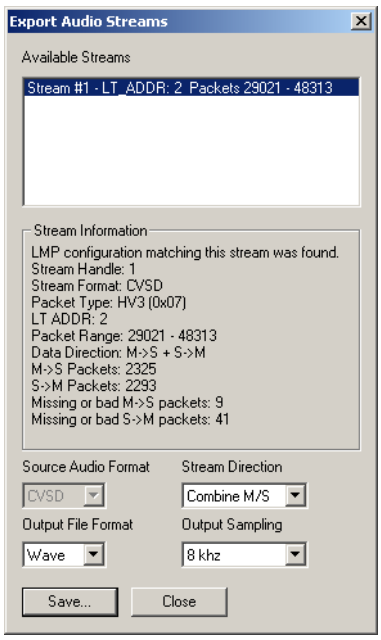
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Packet	M/S	Freq	BTClock	Preamble	SyncWord	Trailer	LT_ADDR	TYPE	FLOW	ARQN	SEQN	HEC
2	0												
3	1	M	2437					0x2	POLL	1	0	1	0x7C
4	2												
5	3	S	2408					0x2	NULL	1	0	0	0x4F
6	4												
7	5												
8	6												
9	7												
10	8												
11	9	M	2462					0x2	DM1	1	0	1	0x1B
12	10												
13	11	S	2410					0x2	NULL	1	1	0	0xD8
14	12												
15	13	M	2470					0x2	POLL	1	0	1	0x7C
16	14												
17	15	S	2418					0x2	NULL	1	1	0	0xD8

11.11 Exporting Audio Data

Merlin II has an **Export Audio Streams** command that allows you to extract audio data from a trace and export it into a file. The command lets you narrow your selection to a particular stream direction (master to slave or slave to master), and to set the output file format and output sampling.

Step 1 Select **File** > **Export** > **Audio Streams** from the menu.

The dialog box shown right opens.



Source Audio Format - Select the Source format.

Output File Format - Select an output format: WAVE or raw.

Stream Direction - Select stream direction that you wish to capture: Master to Slave, Slave to Master, or both ("Combine M/S").

Output Sampling - Select a sampling rate for the exported audio.

Step 2 Set the parameters, then click **Save**.

A Save As dialog opens.

Step 3 Select the name of the file to be created and its location, then click **OK**.

Appendix A: Merlin II Clock Calibration

The Merlin II system comes with a factory-tuned oscillator used to generated the internal clock. This clock is used for tracking the Bluetooth traffic and has to be kept calibrated.

The following is a detailed procedure for measuring and calibrating the oscillator.

Please do not try to do this calibration without the proper tools. Tempering with the clock calibration might void the warranty on Merlin II.

Tools needed for the calibration:

- The Merlin II system that you want to calibrate.
- Breakout board
- Mini DIN cable to connect the breakout board to the Merlin II
- Frequency counter
- BNC cable to connect the counter to the breakout board.

Steps prior to the procedure

Step 1 Make sure the breakout board is connected to the analyzer.

Step 2 Connect a frequency counter you want to use for the frequency measurement to the 'EXT OUT' BNC connector on the breakout board through a BNC cable. The frequency counter must be able to count frequencies up to 30MHz.

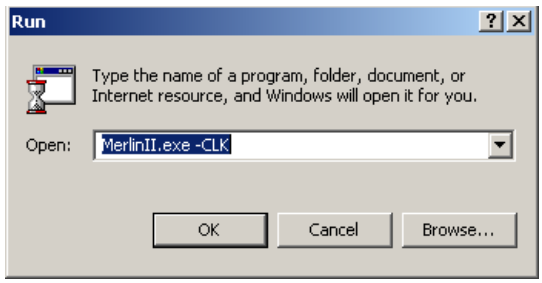
Step 3 Verify that the analyzer is powered and connected to the host machine.

1.1 Procedure:

To be able to access the clock calibration functionality in the application, you should run the Merlin II application from a command line with a -CLK argument:

Step 1 Select **Start** > **Run**.

Step 2 Enter *MerlinII.exe -CLK*



The application appears on the screen.

Step 3 Select **Setup** > **Recording Options** to open the Recording Options dialog box.

Step 4 Set Inquiry Timeout to **0**.

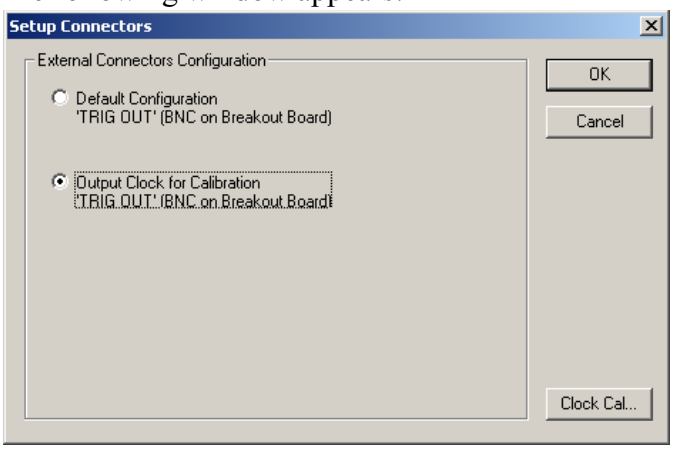
Step 5 Press the Start Recording button run inquiry for at least 5 minutes.

This will bring the analyzer to its operating temperature.

Step 6 Press Stop to stop the inquiry.

Step 7 Select **Setup** >**Connectors** from the menu.

The following window appears:

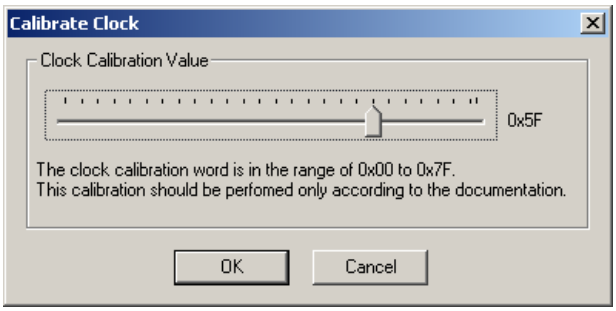


Step 8 Select the option **Output Clock for Calibration**.

At this point the clock signal should be directed to the 'TRIG OUT' BNC connector. The frequency counter should start showing a value around 26 MHz now.

Step 9 Click on the **Clock Cal...** button. Please note that this button is visible only when the Merlin II application is run with the -CLK argument.

The 'Calibrate Clock' window appears:



Step 10 Set frequency counter to use integration time of at least 1 second.

Step 11 Use the slider to adjust the clock only according to the following steps:

A.Adjust the frequency to 26 MHz (+/- 1ppm), i.e. to a value between 25.99998 MHz and 26.00002 MHz

B.Wait 5 minutes and verify that frequency is still within the range specified in step A.

Step 12 When finished, Click the **OK** button to confirm the setting.

If the calibration value has changed, a pop-up message appears.

Step 13 Select **OK** to cause the application to write the new calibration value to the Merlin II flash memory.

Step 14 In the **Setup Connectors** window select the 'Default Configuration' option and then click on the OK' button.

The **Setup Connectors** window closes.

At this point you can continue with normal operation.

How to Contact CATC

Type of Service	Contact
Call for technical support…	US and Canada: 1 (800) 909-2282 Worldwide: 1 (408) 727-6600
Fax your questions…	Worldwide: 1 (408) 727-6622
Write a letter…	Computer Access Technology Corp. Customer Support 3385 Scott Blvd Santa Clara, CA 95054-3115
Send e-mail…	support@CATC.com
Visit CATC's web site…	http://www.CATC.com/

Limited Hardware Warranty

So long as you or your authorized representative ("you" or "your"), fully complete and return the registration card provided with the applicable hardware product or peripheral hardware products (each a "Product") within fifteen days of the date of receipt from Computer Access Technology Corporation ("CATC") or one of its authorized representatives, CATC warrants that the Product will be free from defects in materials and workmanship for a period of three years (the "Warranty Period"). You may also complete your registration form via the internet by visiting http://www.catc.com/support/register/. The Warranty Period commences on the earlier of the date of delivery by CATC of a Product to a common carrier for shipment to you or to CATC's authorized representative from whom you purchase the Product.

What this Warranty Does Not Cover

This warranty does not cover damage due to external causes including accident, damage during shipment after delivery to a common carrier by CATC, abuse, misuse, problems with electrical power, including power surges and outages, servicing not authorized by CATC, usage or operation not in accordance with Product instructions, failure to perform required preventive maintenance, software related problems (whether or not provided by CATC), problems caused by use of accessories, parts or components not supplied by CATC, Products that have been modified or

altered by someone other than CATC, Products with missing or altered service tags or serial numbers, and Products for which CATC has not received payment in full.

Coverage During Warranty Period

During the Warranty Period, CATC or its authorized representatives will repair or replace Products, at CATC's sole discretion, covered under this limited warranty that are returned directly to CATC's facility or through CATC's authorized representatives.

How to Obtain Warranty Service

To request warranty service, you must complete and return the registration card or register via the internet within the fifteen day period described above and report your covered warranty claim by contacting CATC Technical Support or its authorized representative. CATC Technical Support can be reached at 800-909-7112 or via email at support@catc.com. You may also refer to CATC's website at http://www.catc.com for more information on how to contact an authorized representative in your region. If warranty service is required, CATC or its authorized representative will issue a Return Material Authorization Number. You must ship the Product back to CATC or its authorized representative, in its original or equivalent packaging, prepay shipping charges, and insure the shipment or accept the risk of loss or damage during shipment. CATC must receive the Product prior to expiration of the Warranty Period for the repair(s) to be covered. CATC or its authorized representative will thereafter ship the repaired or replacement Product to you freight prepaid by CATC if you are located in the continental United States. Shipments made outside the continental United States will be sent freight collect.

Please remove any peripheral accessories or parts before you ship the Product. CATC does not accept liability for lost or damaged peripheral accessories, data or software.

CATC owns all parts removed from Products it repairs. CATC may use new and/or reconditioned parts, at its sole discretion, made by various manufacturers in performing warranty repairs. If CATC repairs or replaces a Product, the Warranty Period for the Product is not extended.

If CATC evaluates and determines there is "no trouble found" in any Product returned or that the returned Product is not eligible for warranty coverage, CATC will inform you of its determination. If you thereafter request CATC to repair the Product, such labor and service shall be performed under the terms and conditions of CATC's then current repair

policy. If you chose not to have the Product repaired by CATC, you agree to pay CATC for the cost to return the Product to you and that CATC may require payment in advance of shipment.

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THIS LIMITED WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS. YOU MAY HAVE ADDITIONAL RIGHTS THAT VARY BY JURISDICTION. CATC'S RESPONSIBILITY FOR DEFECTS IN MATERIALS AND WORKMANSHIP IS LIMITED TO REPAIR AND REPLACEMENT AS SET FORTH IN THIS LIMITED WARRANTY STATEMENT. EXCEPT AS EXPRESSLY STATED IN THIS WARRANTY STATEMENT, CATC DISCLAIMS ALL EXPRESS AND IMPLIED WARRANTIES FOR ANY PRODUCT INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF AND CONDITIONS OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTIES THAT MAY ARISE FROM ANY COURSE OF DEALING, COURSE OF PERFORMANCE OR TRADE USAGE. SOME JURISDICTIONS MAY NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE PRECEDING LIMITATION MAY NOT APPLY TO YOU.

CATC DOES NOT ACCEPT LIABILITY BEYOND THE REMEDIES SET FORTH IN THIS LIMITED WARRANTY STATEMENT OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES INCLUDING, WITHOUT LIMITATION, ANY LIABILITY FOR THIRD PARTY CLAIMS AGAINST YOU FOR DAMAGES, PRODUCTS NOT BEING AVAILABLE FOR USE, OR FOR LOST DATA OR SOFTWARE. CATC'S LIABILITY TO YOU MAY NOT EXCEED THE AMOUNT YOU PAID FOR THE PRODUCT THAT IS THE SUBJECT OF A CLAIM. SOME JURISDICTIONS DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE PRECEDING EXCLUSION OR LIMITATION MAY NOT APPLY TO YOU.

The limited warranty on a Product may be transferred for the remaining term if the then current owner transfers ownership of the Product and notifies CATC of the transfer. You may notify CATC of the transfer by writing to:

Technical Support
Computer Access Technology Corporation
3385 Scott Blvd
Santa Clara, CA 95054-3115 USA

or by email at: support@catc.com.

Please include the transferring owner's name and address, the name and address of the new owner, the date of transfer, and the Product serial number.

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