

# Help

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# Introduction

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## BUSMASTER Overview

BUSMASTER is a user friendly and cost effective testing and development tool for CAN bus systems that runs on Windows 2000, Windows XP and Windows 7. It helps in monitoring, analyzing and simulation of CAN messages the bus. Using its powerful functions and user-programmability one can simulate CAN system of any complexity.

Additionally it provides options to analyze data bytes in raw data format or logical/physical data format and signals can be monitored separately. These two functionality is achieved using a message database. An in-built database editor is provided to create message databases.

The user can simulate a CAN node's behavior or enhance the functionality of BUSMASTER. This is done by means of 32 bit windows Dynamic Link Library (DLL). A DLL containing BUSMASTER interface can be loaded dynamically to simulate the node's behavior. An in-built Function editor is provided to write program in ANSI C and build a DLL. Once DLL is generated, it can be loaded and used dynamically.

There are many others features that can be used without any programming. The key such features are

- Display of messages,
- Message information and Interpretation,
- Filters,
- Logging,
- Replaying logged messages,
- Network statistics,
- Different time stamping,
- Interactive transmission of message blocks,
- Signal watch etc.

To facilitate the user programming a comprehensive set of APIs and event handlers are provided.

## Key Features

- Using USB port multiple USB CAN hardware can be connected and monitored with multiple instances of BUSMASTER application.
- It operates in Active mode. In active mode the tool influences the bus. In passive mode the tool does not have any influence on the bus.
- It supports CAN 2.0A and 2.0B protocol.
- The messages can be displayed in decimal or hexadecimal format.
- There are three different time stampings namely system time, relative time and absolute time mode. The absolute time is the time from when tool is connected to CAN bus. The relative time is time between two consecutive messages if the display is configured in scroll mode. In overwrite mode it is the time difference between two messages of same ID. Time stamping is done at CAN driver level. The system time is PCs real time value.
- User can log messages to a file and replay the logged file. The time stamping mode can be also be configured in System, Relative and Absolute mode during logging. The replay can be selectively done for transmitted, received and all messages. More then one logging session with same time stamping can be combined in a single replay session. The replay can also be configured in a cyclic manner with different time delay.
- The message filtering can be done through Software, hardware or both. Software filter works at application level while hardware filter works at CAN controller level.
- It supports transmission of message blocks in single shot or periodic mode with time/key trigger.
- It can display messages and error frames on CAN bus.
- User can configure acceptance filter, baud rate and warning limit. Warning limit is not supported currently by BUSMASTER with USB interface.
- Message display can be configured in different colours. Different colours can be assigned to different message IDs. Message display entries and the display update rate can be configured.
- It provides a message database editor for creating & editing of messages and its signals.

- The signals of message can be interpreted. It can be interpreted in a separate window or on message display window.
- Signals alone can be monitored separately with time stamping.
- It provides programming facility through Function editor. The event-based programming is done using ANSI C language. The user can use all windows provided APIs and any third party LIB/DLL/API files.
- It supports all bit rates up to 1 MBPS.
- User can analyse of bus statistics.
- User preferences can be saved or loaded. The last saved user preferences are loaded automatically at the start of application.



# What is new?

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## 2.3.0

Following features are added:

- LIN Statistics window
- LIN Signal watch
- LIN Filters
- LIN Message window configuration
- LIN Diagnostic ID support (3C and 3D)
- FlexRay ETAS BOA support for BOA 2.0 AND BOA 1.4
- Bug Fixes

## 2.2.0

Following features are added:

- Support for LIN ETAS BOA
- Support for LIN logging
- Support for BOA 2.0 for CAN and CANFD
- Bug Fixes

## 2.1.0

LIN support added for slave node functionality. The tool can be used to respond back to master requests. It supports the following features :

- Support for LIN v1.3 and v2.0
- Added LIN support for Vector XL library
- LDF importing for cluster configuration and message interpretation
- Modified Tx Window for DB and Non-DB frame configuration and data updation
- Message Window with Error information and interpretation
- Node Simulation for slave mode with message, timer, key and error handlers

## 2.0.0

Added Support For Following CAN Controllers:

- ETAS ISOLAR EVE CAN

Added FlexRay Support For Following Controllers:

- ETAS BOA

Added following FlexRay Modules:

- FIBEX Import support for 2.0,3.0
- Message Window
- Transmit Window

Added LIN Support for Following Controllers

- ETAS ISOLAR EVE LIN

Added Following LIN Modules:

- Message window
- Transmit Window

## 1.9.0

Support to following hardware interfaces are added:

- NSI interface
- i-View Interface
- Development Environment IDE is migrated to Visual Studio 2012
- Visual Studio Redistributable Package is expected by the installer script. Please refer development environment for more information

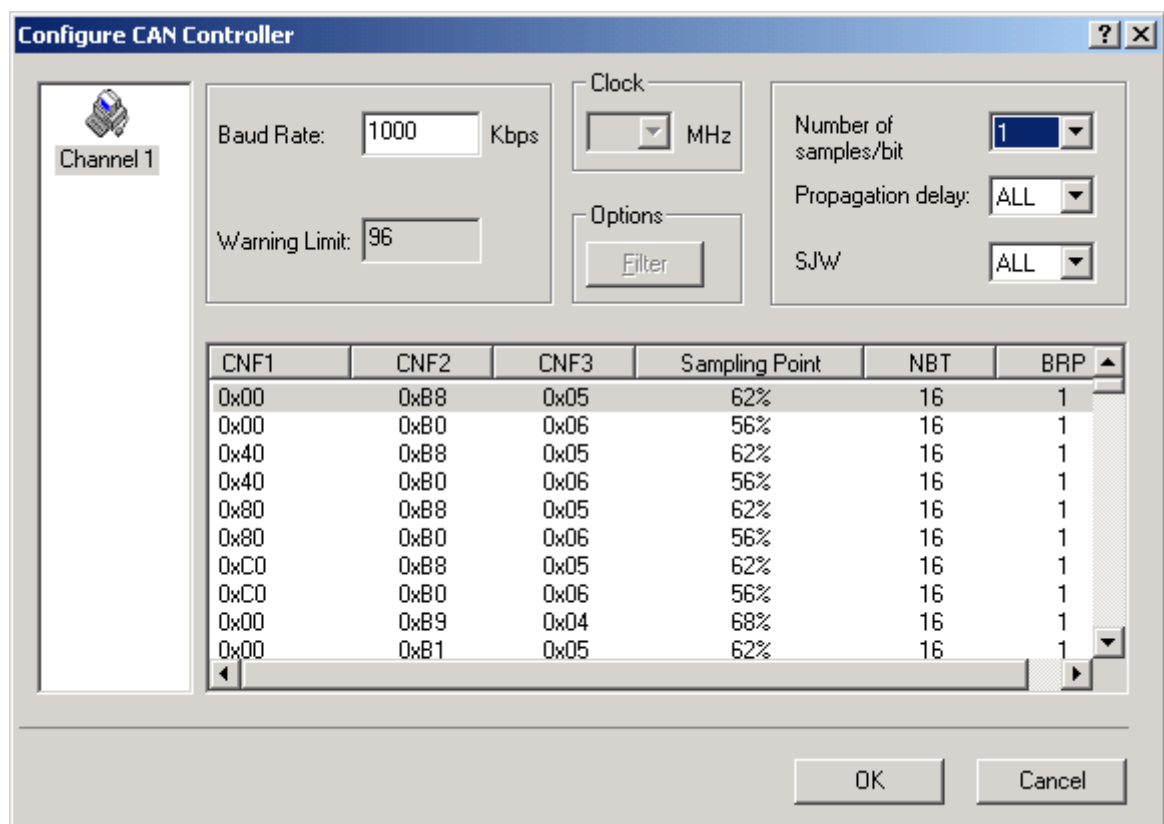
## Getting Started

If you are using BUSMASTER application for the first time then the following section will help you to get familiarized with the features of this tool. For this we will operate the BUSMASTER in self-reception mode i.e. the BUSMASTER tool will be the sender and receiver of CAN messages.

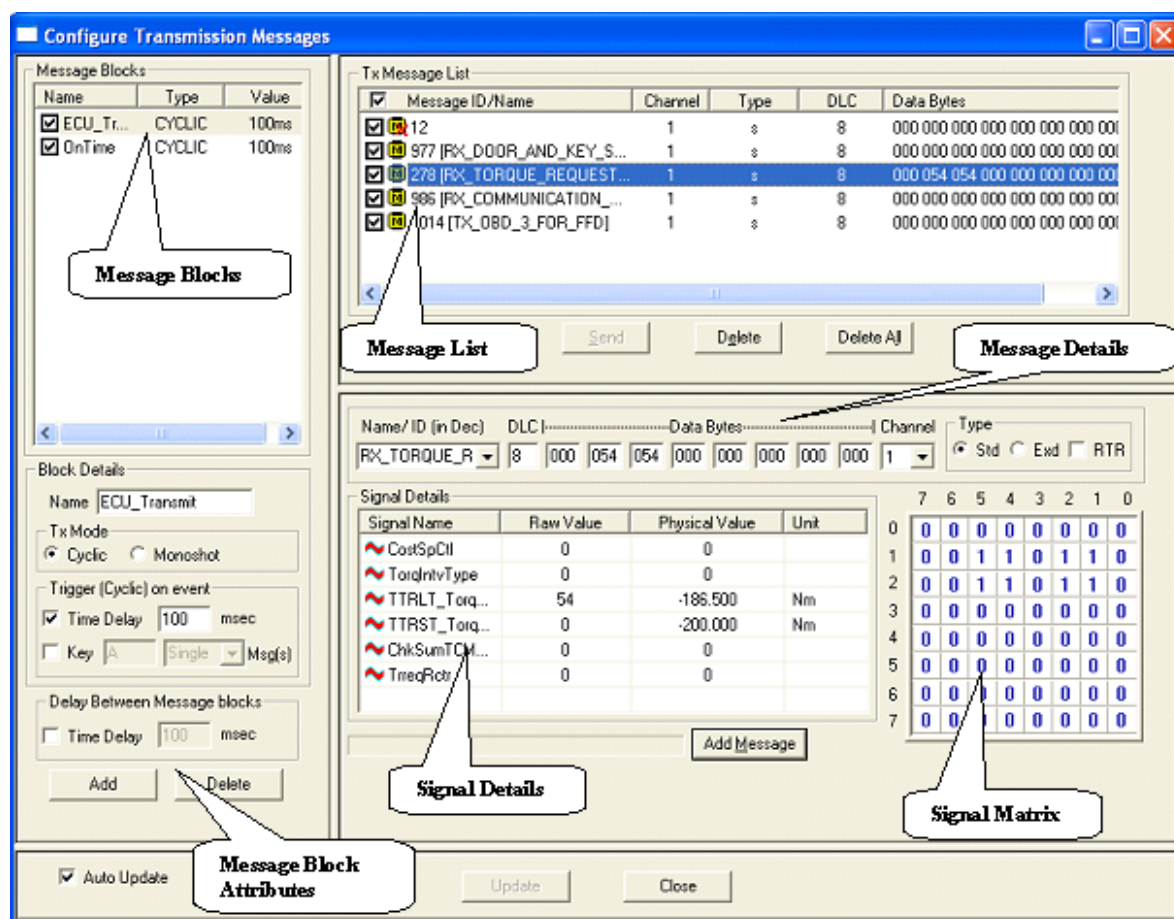
### Initial Setup

- Call BUSMASTER.exe by double clicking the appropriate icon in the BUSMASTER program group.
- The tool will only work with Active mode. Make sure that the USB hardware is connected to the PC and CAN bus.
- For setting the Baud Rate (a.k.a. Bit rate), go to Hardware menu and select Channel Configuration. This brings up a dialog box as shown in figure 1. Enter the required baud rate in the Baud Rate field.

Other than the baud rate values this dialog can be used to set other parameters like sampling point, Synchronization jump width, Hardware acceptance code, mask and warning limit.



- In USB interface, setting Warning limit is not supported. The default warning limit value 96 is set internally and user cannot change this value.
- Dual filtering is not supported in USB interface. Only single filtering is supported.
- To send CAN messages, the messages has to be defined first. For this select Transmit menu under CAN menu and select Configure menu. A dialog as shown below pops up.



- You can add a total of 32 Message Blocks having trigger condition either as “On Key” or “On Time” or both. Each block of message can have a total of 64 messages.
- You can activate any message block selectively for transmission by selecting a check box in Message Blocks list.

Message can be added that are not in the database as well as in the database. For details about this refer Transmit Message(s)

From the same dialog box one can select the time interval between two consecutive messages by entering the delay value in milliseconds in the Interval box. The Key box is used to enter key value for key trigger. The transmission can be configured as one shot or cyclic by selecting or deselecting the item Monoshot.

Close the dialog by clicking on OK button. You can use Apply button to save the changes without closing the dialog.

User can also select the message from the list and transmit over the CAN bus by using Send button or by right click in the list and selecting the Send menu. Message blocks and messages in blocks can be added/deleted by selecting the menus. The pop up menu is displayed when user right clicks the corresponding list.

The message details can be modified even the transmission is in progress. Message data can be directly modified by changing the data byte values or the signal values. Signal values can be given as raw value or physical value. In all these cases all other values will be updated accordingly. You can modify the message details and select Apply or OK button to reflect the changes for transmission. During transmission you can't modify the details of message block which is active. But you can add a new block or change the message block details for block, which is not active.

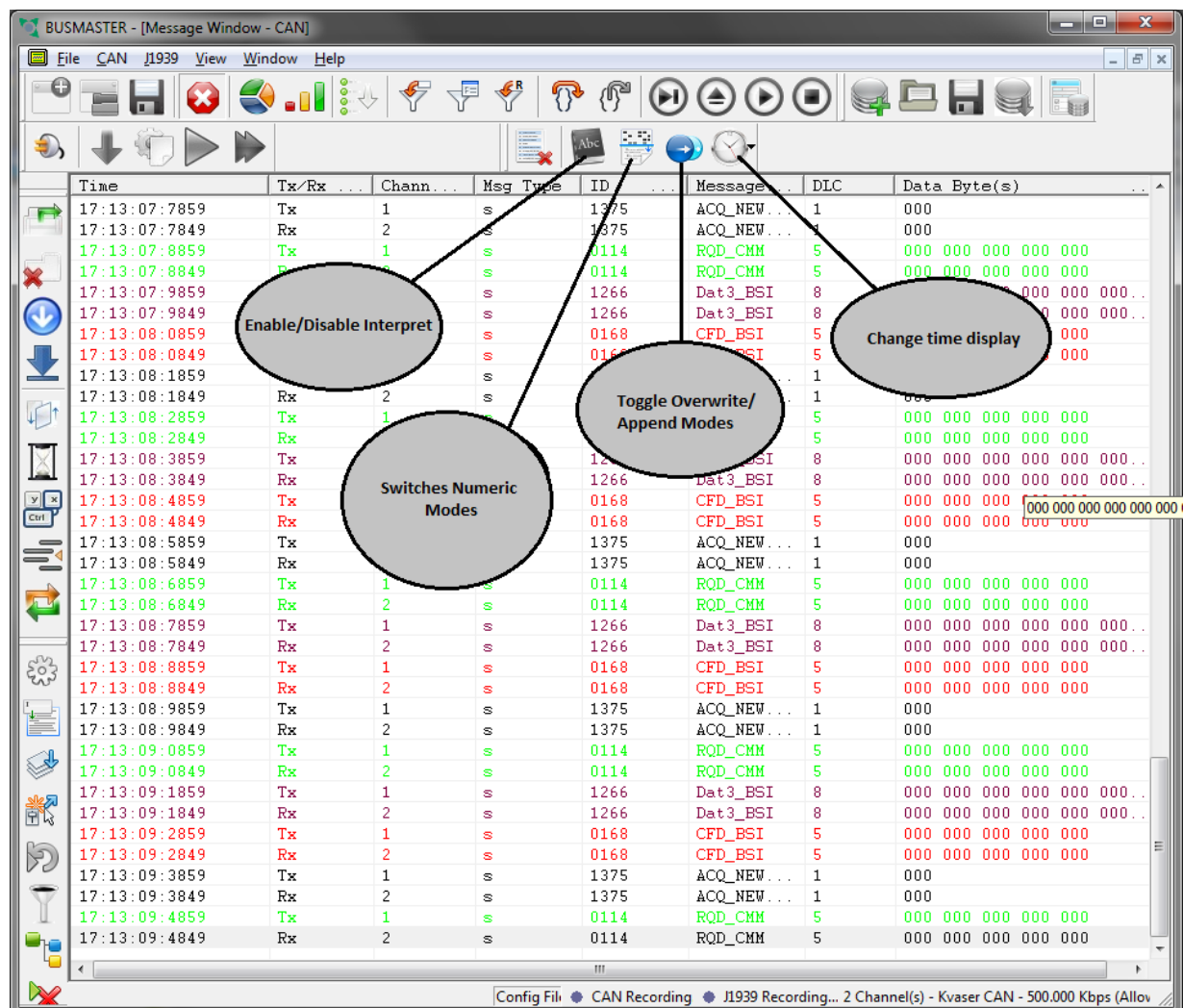
On selection of start transmission only those blocks which is active having at least one message frame will be transmitted. Also if the trigger is selected as On Key then the transmission will start when the corresponding key is pressed.

Now the messages to be transmitted have been configured and it's ready to be transmitted.

- Select the Connect menu from the CAN menu option. This initializes the CAN controller.
- To initiate the transmission of the messages go to the menu **CAN --> Transmit --> Enable**.

A cross mark on the message icon in the Tx Message list indicates that the message is not available in the database.

If the installation is proper and working then you should be able to see the configured messages being transmitted and receive simultaneously in the Message display window as shown in below



## Operating Modes

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The BUSMASTER can be operated in Active mode

- Active: In this mode the controller will participate in the bus activity i.e. it will generate acknowledgement signal, error signals etc on reception of message and also will be able to transmit messages.
- Passive - Currently this mode is disabled.

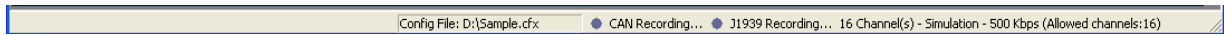
Any one of the above mentioned modes can be selected from the menu **Hardware --> Driver Mode**.

By default BUSMASTER will be in Active mode.

## Status Bar

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The status bar gives the following information



- The first pane shows the loaded configuration file path.
- The second pane displays the data logging status for CAN and J1939
- The extreme right pane indicates the hardware selected, baud rate and the number of channels supported by the application.



**Note:**

- Error Counters values and controller status are displayed in Network Statics window.

# CAN

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## Introduction

## Configuration

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BUSMASTER has provision for configuring the following properties

- **Baudrate:** By default the tool is configured to operate at 100kbps. This can be changed to any valid value between 5 kbps and 1000 kbps.
- **Acceptance Filter:** To increase the response of the tool at very high messages rate one can set the acceptance filter. The controller filters the messages based on the values set for acceptance code and mask. This filtering is faster than the software filter (App filters).
- **Warning Limit:** One can monitor the condition of the network by setting a warning limit value. The user will be notified when either one of the error counter (Tx & Rx) exceeds the warning limit. By default this value is set to 96. The valid range is from 1 to 127. In USB interface setting warning limit is not supported and it is internally set to 96.
- **Message Display:** Every Message can be assigned a user defined color and text. The text associated with the message will be displayed in the selected color along with its data in the message display window whenever that message is transmitted or received. By default all the messages received are displayed in black color. Display entries can be configured. This is the number of entries that the display will show. When the messages received exceeds this count Display will scroll to show the latest entries. The display update rate can also be configured. This will be used to refresh the display periodically.
- **App Filters:** You can opt to view and log messages of your choice. Message filters provide this facility. Filters can be applied to message display window, filters and / or message log. The filter list is configurable from **CAN --> Filter Configuration** menu.
- **Message Logging:** You can select a file to log all the transmitted & received messages. The start of logging can also be triggered on reception of specific message name or message ID. You can configure a logging session for different time stamping mode as well as Hex/Decimal format. You can also select to append or overwrite an existing log file.
- **Message Replay:** The messages that are logged to a file can be replayed. The replay can be configured by choosing replay type, time delay and replay file name. You can explicitly specify the delay required between messages or between cycles wherever applicable.
- **Transmit Message:** You can configure/define messages that are to be sent on CAN bus. The configured messages can be database messages or undefined messages (Undefined messages are those messages that are not available in the database). Further the messages to be sent can be define as standard, extended messages or as a RTR message.
- **Simulated Systems:** Simulated systems can be configured under CAN Bus consisting of multiple nodes, each representing a dll. Multiple user programs can be built as dlls and loaded. The configured simulated systems can be saved and used across sessions.

The entire above-mentioned configuration except message replay is saved across sessions.

Refer the respective sections for more details

## Baudrate

While defining a baud rate the number of samples/bit value can also be defined. For a selected baud rate a set of all possible combinations of CNF0, CNF1 and CNF2 values will be listed. From this you can select any one set. The selected combination of CNF0, CNF1 and CNF2 values will be used to initialize the CAN controller. The baud rate can be changed by the method mentioned below.

- Select **Hardware --> Channel Configuration**.
- Configure CAN Controller dialog box will be displayed as shown below.
- Enter the required Baud rate.
- If required select the Number of Sample/Bit.
- Specific values for propagation delay and SJW can be selected too. Default selection for them is ALL.



- If the default value is not appropriate for the application then the required CNF0, CNF1 and CNF2 value can be selected by selecting an entry from in the list.

CNF1	CNF2	CNF3	Sampling Point	NBT	BRP
0x00	0xB8	0x05	62%	16	1
0x00	0xB0	0x06	56%	16	1
0x40	0xB8	0x05	62%	16	1
0x40	0xB0	0x06	56%	16	1
0x80	0xB8	0x05	62%	16	1
0x80	0xB0	0x06	56%	16	1
0xC0	0xB8	0x05	62%	16	1
0xC0	0xB0	0x06	56%	16	1
0x00	0xB9	0x04	68%	16	1
0x00	0xB1	0x05	62%	16	1

Other fields like BRP, Sampling Point, SJW and NBT are dependent on CNF0, CNF1 and CNF2 values. On clicking the "OK" button the controller will be initialized with the selected baud rate.

For more details on bit values of CNF0, CNF1 and CNF2 and the calculation of baud rate refer the section Bit Time Calculation.

 **Note:** For MH Tiny CAN, either Bit Rate or BTR will be considered. If Bit Rate value is available BTR will be discarded.

## Bit Timing Calculation

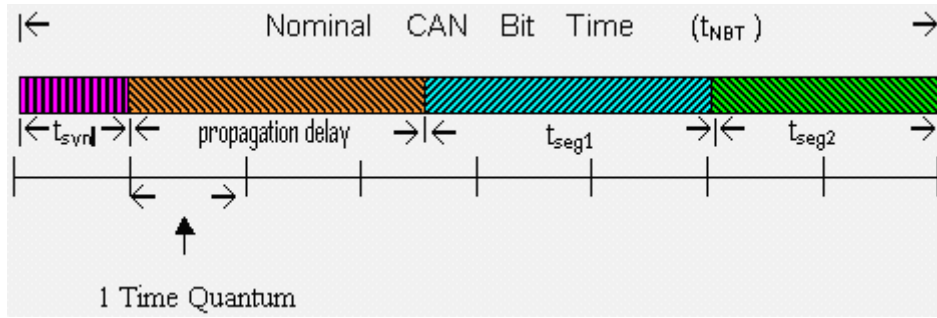
Abbreviations used:

- tNBT - Nominal CAN Bit time
- tsyn - Synchronization segment
- PD - Propagation delay
- tseg1 - Time segment 1
- tseg2 - Time segment 2
- tq - Time quantum
- BRP - Baud rate prescaler
- fsys - Controller system clock
- fclk - Clock Frequency
- NBT - Number of tq in tNBT
- tPD - Propagation Delay time

The CAN protocol supports bit rates in the range of 1Kbps and 1000Kbps. Each node has its own clock generator and oscillator.

Configuring the bit timing parameters for each node can facilitate a common bit rate on the bus.

The Nominal CAN Bit Time (NBT) divided into four segments as shown below.



Hence,  $t_{NBT} = t_{syn} + t_{PD} + t_{seg1} + t_{seg2}$

The Nominal Bit Rate is the number of bits per second.

Nominal Bit Rate =  $1 / \text{Nominal Bit Time}$

Each segment consists of a specific programmable number of time quantum, which is basic unit of bit time. The synchronization segment is that part of the bit time where the edges of the CAN bus level.

Mapping between  $f_{sys}$  and  $tq$ : The controller needs to regulate its system clock period ( $1 / f_{sys}$ ) in order to realise the time quantum ( $tq$ ) desired. The coefficient of regulation is defined as Baud Rate Prescaler (BRP). Hence,

$$tq = 2 * (BRP / f_{sys}) \quad (I)$$

$$f_{sys} = f_{clk} / 2 \quad (II), \text{ where } f_{clk} \text{ is Clock Frequency}$$

$$t_{NBT} = 1 / \text{baud rate} \quad (III)$$

$$NBT = t_{NBT} / tq \quad (IV)$$

Hence from equation (I), (II) and (III)

$$NBT = (1 / \text{baud rate}) / (4 * BRP / f_{clk})$$

$$\Rightarrow NBT * BRP = f_{clk} / (4 * \text{Baud Rate})$$

The product value  $NBT * BRP$  will be an integer value. Appropriate baud rate will be calculated to get an integer value for the above product. This will ensure that Clock Frequency remains same for a particular CAN controller.

Additionally,

$$NBT * tq = t_{NBT} = t_{syn} + t_{PD} + t_{seg1} + t_{seg2} \quad (V)$$

Clearly,

$$t_{syn} = tq \quad (VI)$$

$$t_{seg1} = TSEG1 * tq \quad (VII)$$

$$t_{seg2} = TSEG2 * tq \quad (VIII)$$

$$t_{PD} = PD * tq \quad (IX)$$

Therefore from equation (VI), (VII) and (VIII).

$$NBT = TSEG1 + TSEG2 + PD + 1.$$

$$\text{Sampling Point} = ((NBT - TSEG2) / NBT) * 100 \%$$

The neoVI hardware consist of three registers namely CNF1, CNF2, CNF3 the details of which are given below:

**CNF1 Register**

CNF1.7	CNF1.6	CNF1.5	CNF1.4	CNF1.3	CNF1.2	CNF1.1	CNF1.0
SJW1	SJW0	BRP5	BRP4	BRP3	BRP2	BRP1	BRP0

**CNF2 Register**

CNF2.7	CNF2.6	CNF2.5	CNF2.4	CNF2.3	CNF2.2	CNF2.1	CNF2.0
FLAG	SAM	TSEG1.2	TSEG1.1	TSEG1.0	PD2	PD1	PD0

**CNF3 Register**

CNF3.7	CNF3.6	CNF3.5	CNF3.4	CNF3.3	CNF3.2	CNF3.1	CNF3.0
-	WAKEFIL	-	-	-	TSEG2.2	TSEG2.1	TSEG2.0

$SAM (Sampling) = 0 \text{ or } 1 \text{ (1 or 3)}$

$SJW = 2 \times SJW1 + SJW0 + 1$

$BRP = 32 \times BRP5 + 16 \times BRP4 + 8 \times BRP3 + 4 \times BRP2 + 2 \times BRP1 + BRP0 + 1$

$TSEG1 = 4 \times TSEG1.2 + 2 \times TSEG1.1 + TSEG1.0 + 1$

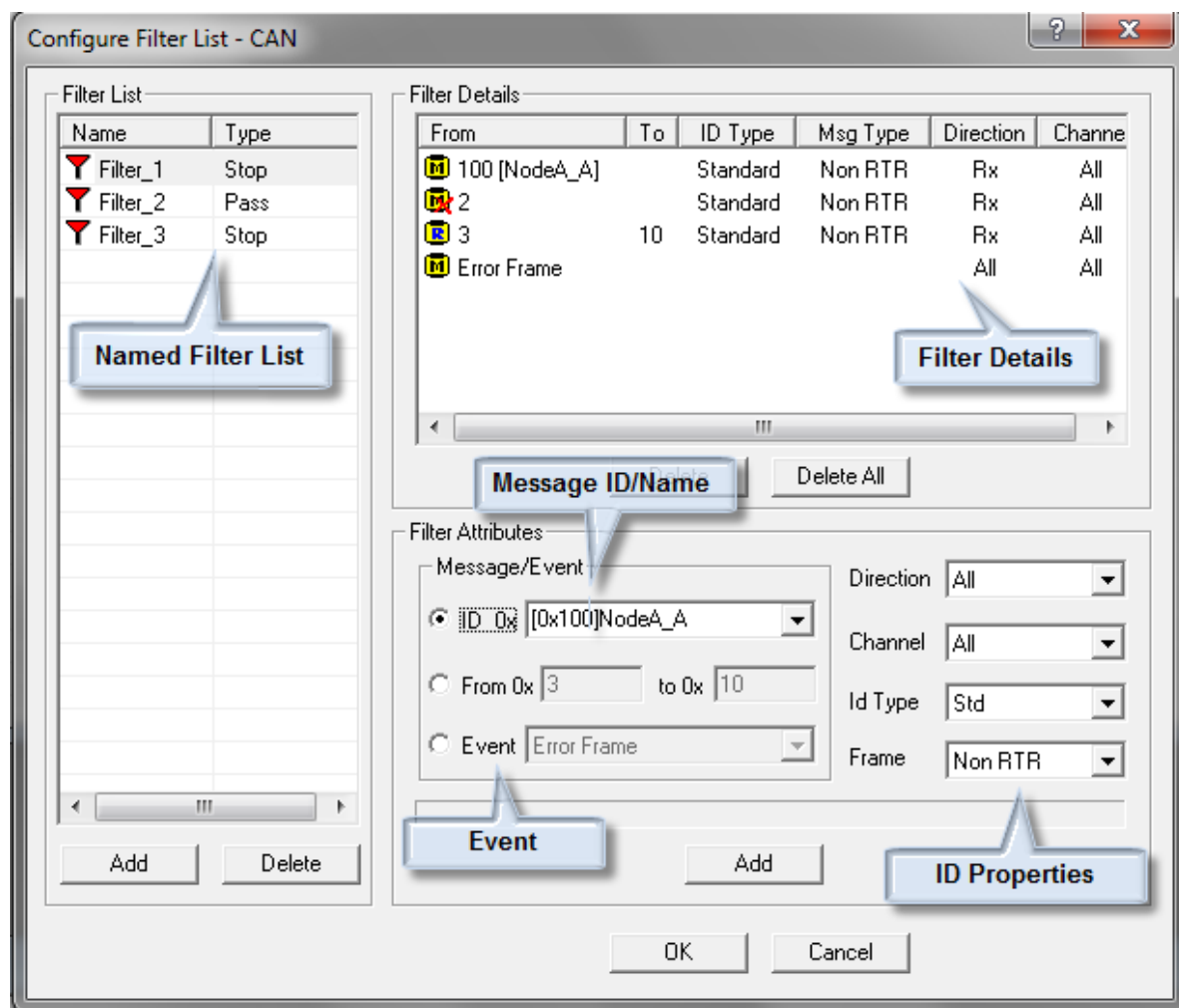
$TSEG2 = 4 \times TSEG2.2 + 2 \times TSEG2.1 + TSEG2.0 + 1$

$FLAG = 0 \text{ or } 1 \text{ ( "TSEG2 Ignored" or "TSEG2 Considered" )}$

**App Filter**

User can configure filter list by choosing messages to be filtered. To configure the filter list, follow the steps given below

- Select **CAN --> Filter Configuration**.
- The dialog box specified below will be displayed.



### Filter List

It is a list of filters that are identified by the name. The name of the filter should be unique and can have any kind of special characters also. The second parameter tells about the type of the filter, pass or stop. Pass filter allows only the configured message or range of message to pass. On the other side stop filter blocks the configured messages. These filters shall be used in display, logging and replay filters.

### Filter Details

This section shows list of message names, ID and range along with ID type, message frame type, direction and channel number. Type is denoted by different icons. Selecting an entry from the list updates the details of the filter in Filter Attributes section.

### Filter Attributes

Filter attributes gives more details of selected filter entry. Message Name or ID in case of single id filtering and message ID range in case of range filter will be updated. ID type will give whether the ID is standard or extended type. If ID type is "All" then ID type will be ignored. Frame type will show whether the message is of remote transmit request or not. If this field shows all then frame type will be ignored. Direction field will show whether the message is transmitted or received. If it is all then direction will be ignored. Channel field associates the message with particular channel. Channel all makes the message independent of channels.

Database message names shall be selected from the Message ID combo box. Message ID shall be directly typed in this combo box. If the filter is for a range of messages then the Range radio button shall be selected. This will enable range edit boxes. Message ID type gives information about the ID or message name. For database message this field will be automatically updated. But user can change the type to override the database definition. To make the filter to work for both standard and extended type user shall select the ID type as All. Other attributes shall be selected based on the filter requirements.

Event radio button shall be selected for Event filter. This will enable Event combo box, from which event type can be selected. Channel combo box will be enabled.

The Add button in the Filter Attributes section will add configured filter in to the selected named filter list. This button will be disabled in case of invalid parameter entered by the user and appropriate error message will be displayed in the status bar.

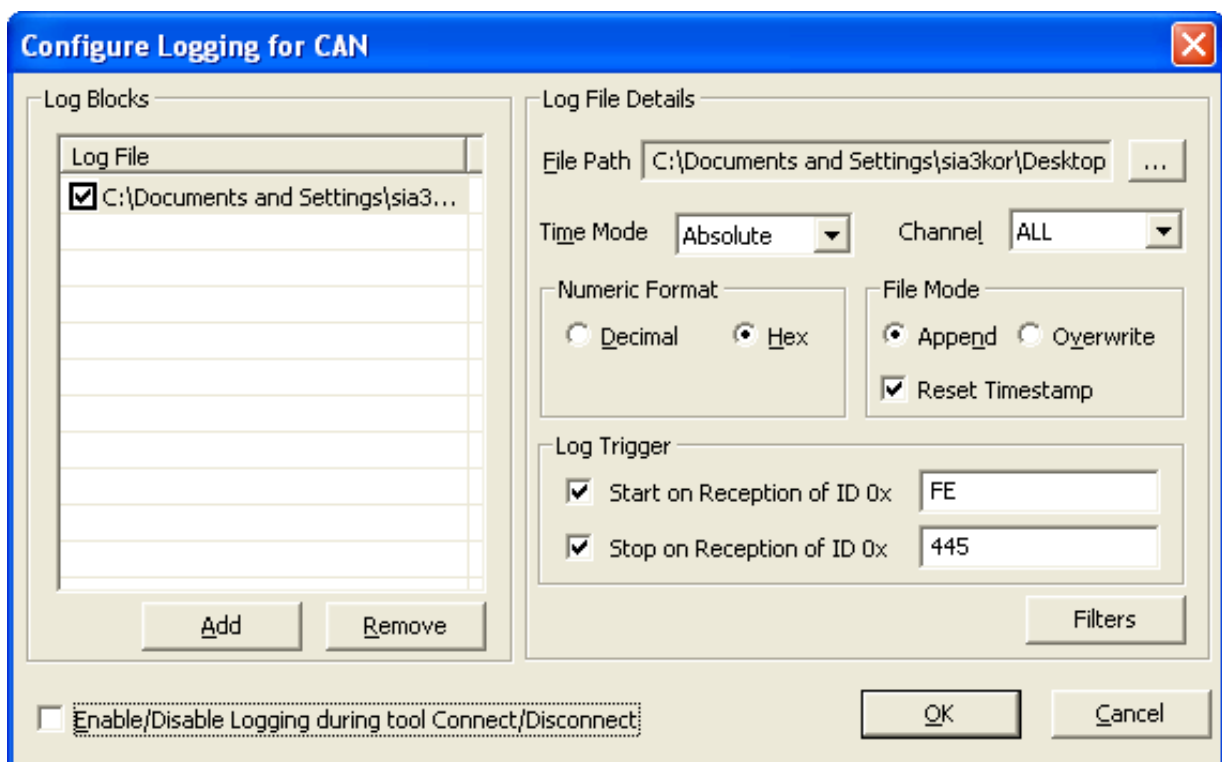
Once the filter is added in to the Filter List then the name of the filter will appear in the Filter Configuration List to select. Any modification on these filter will immediately reflect in the all modules that are using these filters.

Filter list will be saved in configuration file and will be updated while loading a configuration file. While loading a configuration file created with BUSMASTER 3.06.02.X.XXX version one filter entry will be created with the previous filter information.

## Log and Replay

### Logging

User can configure log file setting using **CAN --> Logging --> Configure** menu. This will show log file configuration dialog as shown below.



### Log Files

User can add as many as log files in to the list of Log Files. This list will show the log files that are already configured. To add a new Log file select Add button. This will add a log file with default file name. User can change the file name using "..." button in the Log File Details section. The check box associated with the log file will make the log file eligible for logging. If the check box is not checked logging will not happen to that particular file.

### Log File Details

Log file details will give configuration of the selected log file. This will give info of log file path, time mode, numeric mode, file mode, log triggers and log filter.

## Log File Path

The file path text box will give the selected log file path. To change the path select "..." button. This will show file selection dialog. On selection of a log file, the file path text box will be updated with selected file path.

## Log File Size

Log file size is fixed to a limit of 50 MB. This limit is set as most of the editors will take lot of time to open if the file size is large.

## Time Mode

Logging of messages can be done in three different time modes. System time, Absolute time and Relative time mode. In system time mode time stamping of message is done using real time clock of the system. In absolute time mode the time stamping is done with respect to the absolute timer that will be stated during connect. In relative time mode the time stamping of a message is with respect to previously received message.

Reset Timestamp for every enable logging is provided. If this option is selected then the absolute time will be reset whenever the logging is enabled.

## Numeric Mode

This tells the numeric format of log file entries. It has two options Hex and Decimal. Message ID and data bytes of a CAN message will use this as a base while format for logging.

## File Mode

In Append file mode, log sessions will be appended at the end of the file. Each logging session will have its own session header and footer. In Overwrite file mode the file will be overwritten for the first session. For consecutive sessions the file name will be suffixed with an incrementing number and each session will be logged in new files. The log file name will be incremented every-time when you stop the logging process.

If already log files are created in the previous session and if a new session is started, then the log files created already will be overwritten in both overwrite and append mode. In this case, the successive files already created in the previous session will contain old session data.

## Logging Indication

Recording or logging is indicated in the status bar for both CAN and J1939. When the logging is enabled and data is logged in to the file, an icon will be shown in the status bar with glowing on and glowing off continuously till the logging is stopped. When the logging is stopped then icon will be disabled.

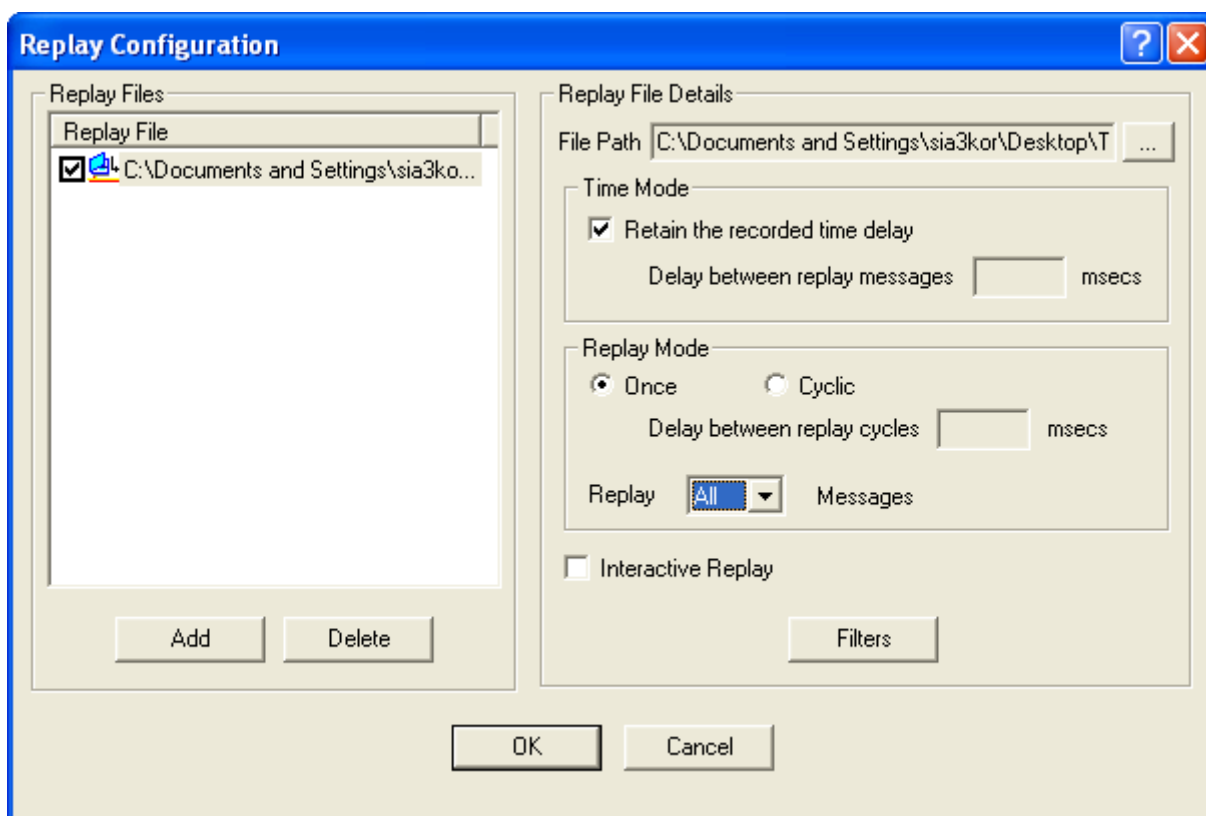
### Example

If the log file name is xyz.log for the first time, then for the next time the log file name will be xyz0.log.

Similarly, if the log file name is xyzn.log for the first time, where n – is any number, then for the next time the log file name will be xyzm.log, where  $m = n + 1$ .

## Replay

User can configure replay file setting using **CAN --> Replay --> Configure** menu. This will show replay file configuration dialog as shown below.



### Replay Files

User can add as many as replay files in to the replay list. This list will show the replay files that are already configured. To add a new Replay file select Add button. This will show replay file selection dialog. User can select log files that are created using BUSMASTER. Once the user has selected a replay file, the file will be added to the replay list. User can change the file "..." button in the Replay File Details section. The check box associated with replay file will make the replay file eligible to run. If the check box is not checked then that replay will not be used for replay.

### Replay File Details

Replay file details will give configuration of the selected replay file. This will give info of replay file path, time mode, replay mode, filters and Replay type.

### Replay File Path

The file path text box will give the selected replay file path. To change the path select "..." button. This will show file selection dialog. On selection of a log file, the file path text box will be updated with selected file path.

### Replay Time Mode

Time mode or replay tells whether to use logged time for replay or to use user specified value. If user selects Retain Delay option then the delay between messages will be calculated from the log file time stamping. If this option is not checked then user can specify the delay between messages.

### Replay Mode

Replay mode instructs whether the replay file has to be transmitted only once or cyclically. In cyclic mode, messages will be transmitted periodically. User can specify the cycle delay which will be used in between cycles. Where as in monoshot or once, the replay of messages will happen only once.

Replay messages option is provided to select the messages to be replayed. Tx, Rx and All messages options are listed. All the messages in the log file will be replayed if All is selected. If Tx is selected then only the messages

logged with Tx flag in the log file will be replayed. If Rx is selected then only the messages logged with Rx flag in the log file will be replayed.

### Interactive Replay

In interactive replay mode, the log file content will be display as list of messages and user can navigate this list and can transmit interested messages. User can step through replay messages, can skip messages, can start message transmission continuously and can insert break points.

### Non Interactive Replay

In non interactive mode, reply will start during tool connect and will be stopped during tool disconnect. In case of cyclic mode the replay will continue till tool disconnect and in monoshot or once, all messages will be transmitted only once and replay will start.

## Configure Replay

Replay can be configured using the three parameters mentioned below

- File Name
- Mode
- Time Delay

There are two modes of Replay

- Single Run - The messages in the file will be replayed only once.
- Cyclic - The messages in the file will be replayed cyclically.

The time delay can be set to control the delay between two consecutive messages and between two consecutive replay of the same file.

The following field controls delays

- Recorded time delay in the log file
- Time delay between messages.
- Time delay between cycles – Applicable for only cyclic mode.

Time delay 1 and 2 are mutually exclusive irrespective of replay mode. This time delay is the time duration between transmission of two consecutive messages. The minimum time delay (in milliseconds) is one millisecond.

On clicking the OK button a Message Replay Window will be displayed. This will contain all messages in the replay file. By default first message in the replay window will be selected. Please see section Replay a File for further details.

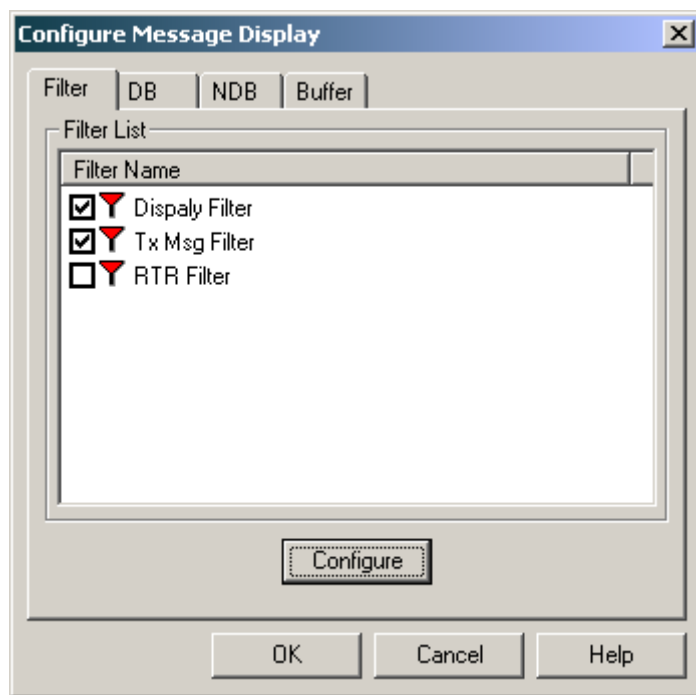
User can configure to replay all message logged or only transmitted message or only received message by selecting the option from Replay Message Type. It can be done during configuration of replay.

## Message Display

### Message Filter

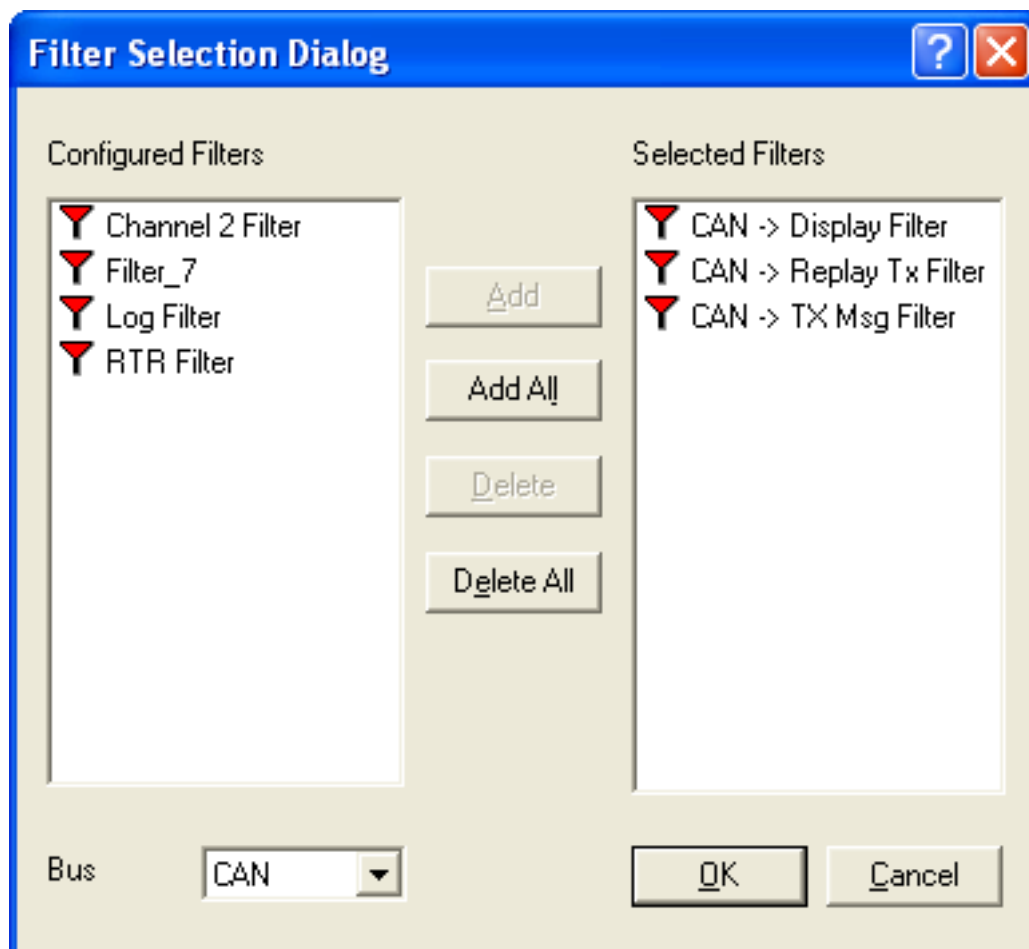
Filters for message display can be configured by selecting **CAN --> Message Window --> Configure** and by selecting Filter tab. This will show list of filters configured for Message Display.





### Display Filter

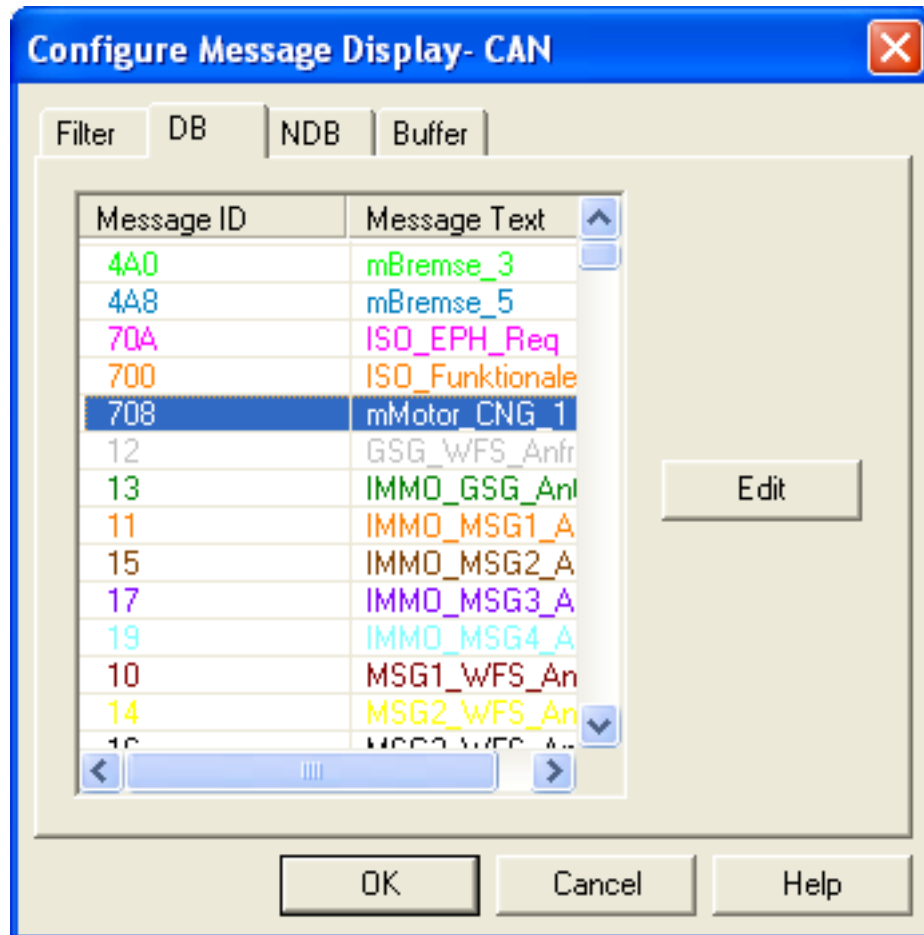
To configure display filter list select Configure button which will list available filters and selected filters.

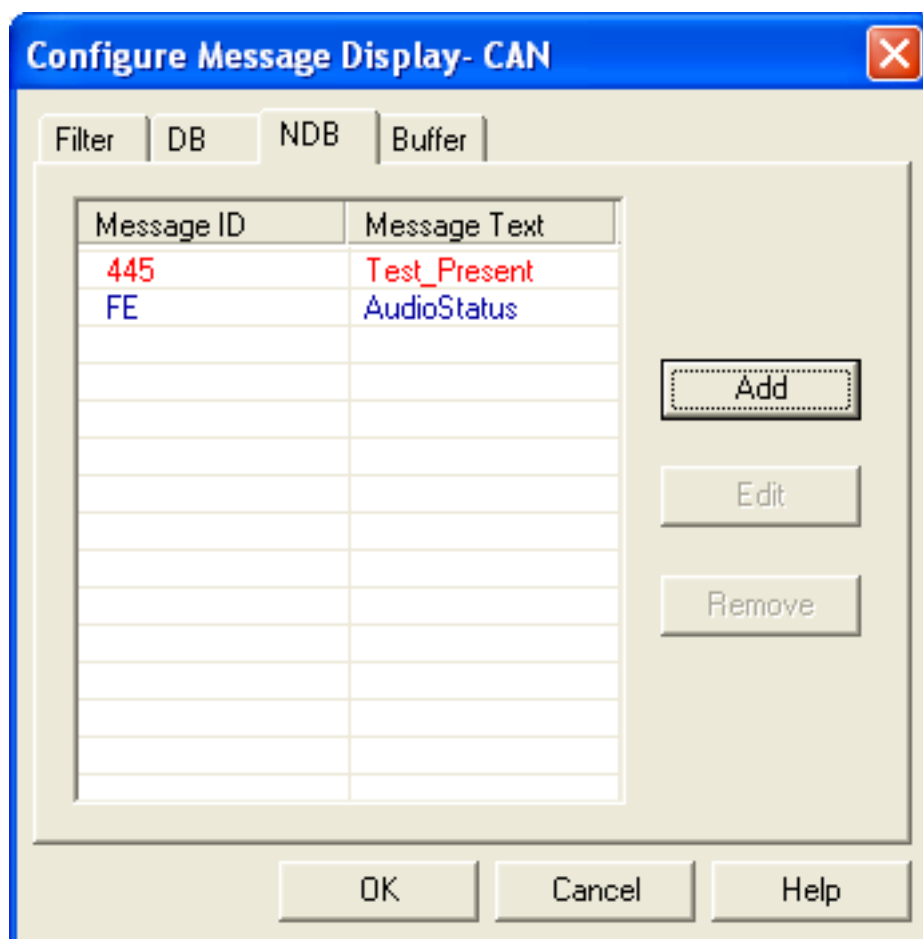


### Message Coloring

User can configure the color with which the message will be displayed and associate a textual description to message.

By default all messages are displayed in black color and the message ID itself as the associated text. For the database message user can only edit the color.

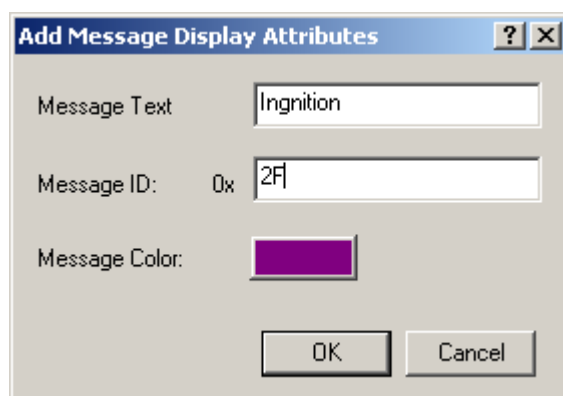




### Adding message attribute

To configure a message display option, please follow the steps given below

1. Select **CAN --> Message Window --> Configure**
2. Dialog box **Configure Message Display** as in above figure will be displayed
3. Click on **Add** button
4. One more dialog box **Add Message Display Attributes** as shown below will pop up.



5. Enter the message ID and Message text
6. Click on the colored button to select a color, This click pops up a color palette as shown above.
7. Select a suitable color
8. Select **OK** button to confirm

Subsequent reception / transmission of the message that has been configured will be displayed with associated text & color.

### **Editing a message attribute**

To edit the message attributes please follow the steps given below

1. Select **CAN --> Message Window --> Configure**.
2. Dialog box Configure Message Display will be displayed.
3. Select the message entry to be edited from the message list.
4. Either click on Edit button or double click on the selected entry.
5. One more dialog box Edit Message Attributes will pop up.
6. Change the required Message attributes.
7. Select OK buttons to confirm.

Subsequent reception/transmission of the message that has been configured will be displayed with associated text & color.

### **Deleting message display attribute**

To delete an entry from the Message List follow the steps given below

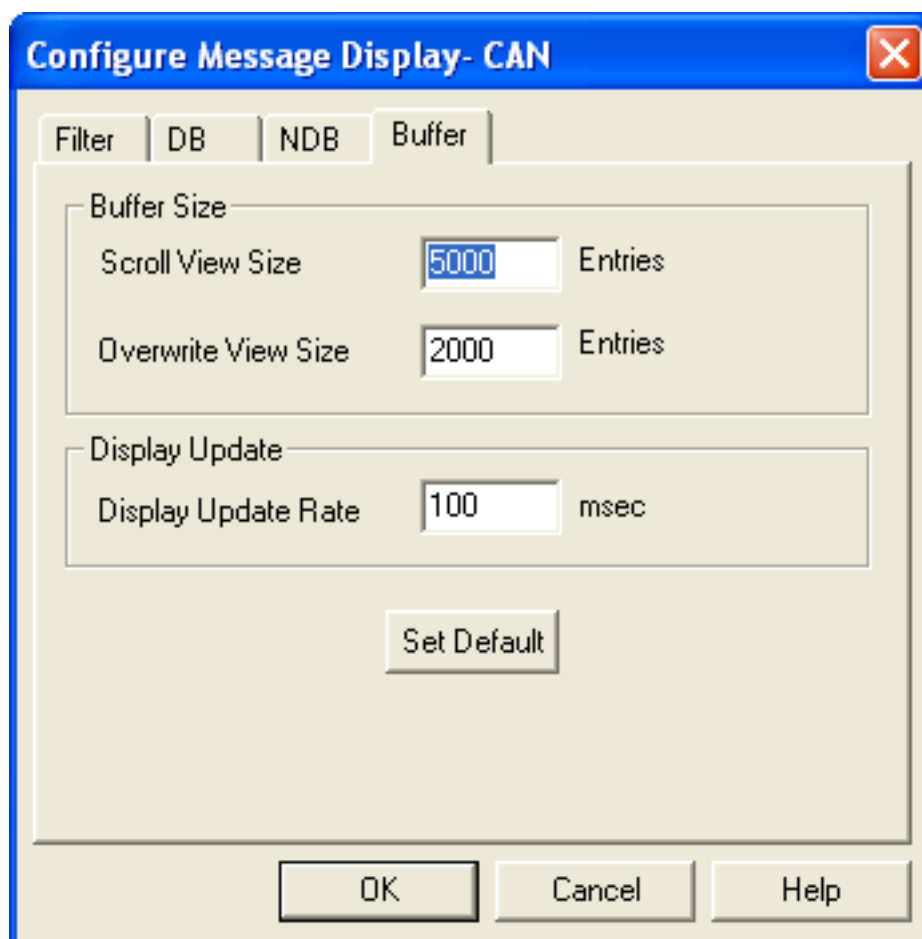
1. Select **CAN --> Message Window --> Configure**.
2. A dialog box will pop up. Select the message entry to be deleted from the message entry list.
3. Click on Remove button. A delete confirmation message box will be displayed.
4. Select Yes to confirm deletion.
5. Select OK button to confirm the modification of entries.

On subsequent reception/transmission, the message will be displayed in black color.

### **Display Buffer size & Update Rate configuration**

To configure Append and overwrite buffer size, follow the steps given below

1. Select **CAN --> Message Window --> Configure**.
2. A dialog box will pop up. Select the Buffer page.



3. The buffer size can be from 200 to 32500 display entries. The display update rate can be from 50 to 20000 milliseconds.
4. Set entries for Append buffer and overwrite buffer. Set display update rate.
5. Select OK button to confirm the modification of entries.
6. Select Set Default button to set the default values.

### Show Last Option

This option can be used to set the focus of the list item to the latest item in Scroll mode. In append mode latest message entries will be added at the end. To make the latest entries visible always select **CAN --> Message Window --> Show Last**.



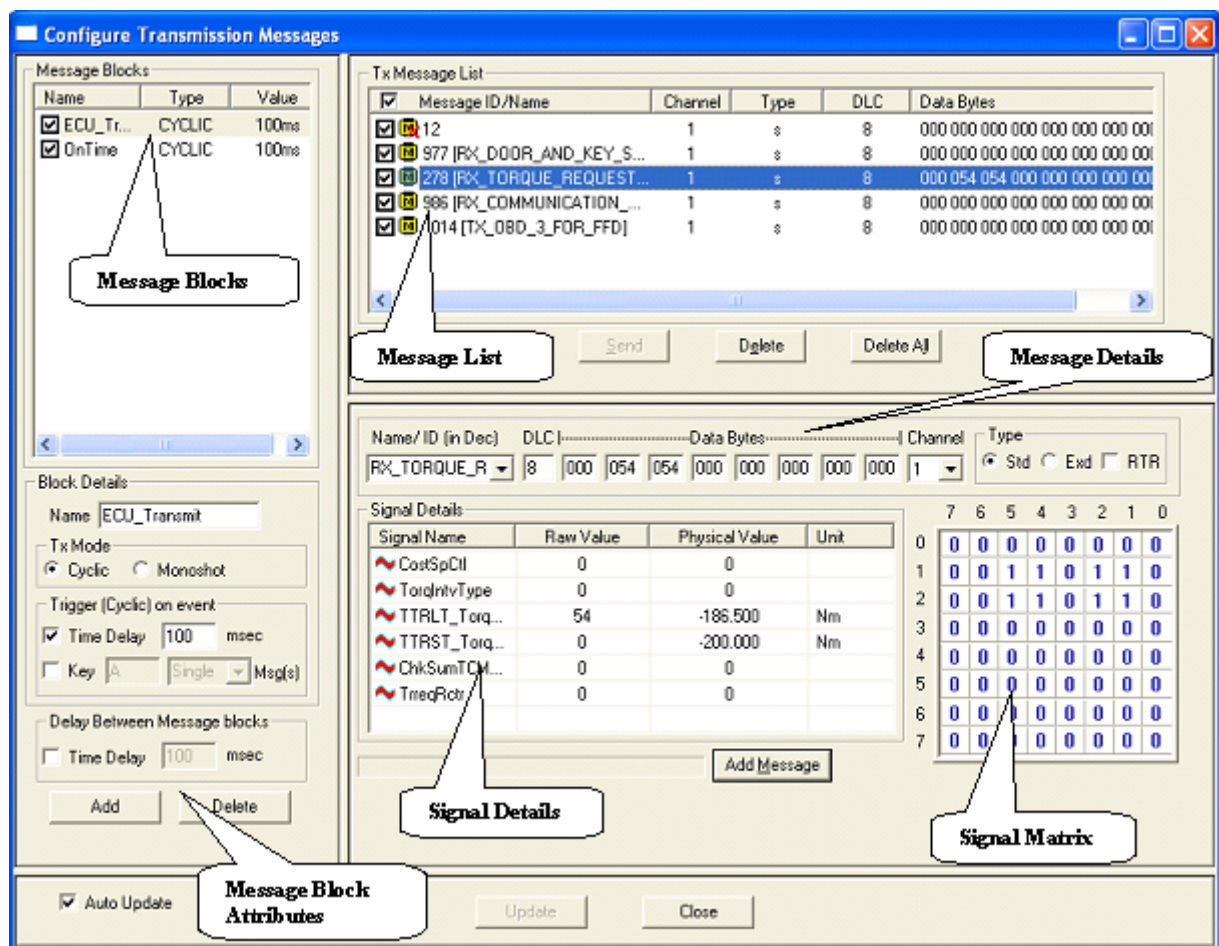
#### Note:

- In overwrite mode this option will be disabled to avoid rolling of selection.
- Selection will be update only during display update.

## Transmit Messages

Messages can be send over CAN-bus by following the steps given below. Select **CAN --> Transmit --> Configure** menu option. This will display the dialog as shown is figure below.

### Getting Started



- Add a message block and select the trigger as “On Key” or “On Time” or both. Select a name of message block and then enter appropriate message details in “Configure Message”.
- If the field for Message ID/Name has a database message then DLC and frame type will be updated with database information. The Signal List will be enabled with signals defined in the database. Signal Raw or Physical values can be directly entered in this list. After validation the data will be updated.
- Signal descriptor can be used to enter physical value. Double clicking the physical value cell of a signal that got descriptor will show a list of signal descriptors.
- If the message ID is not a database message enter DLC, Message bytes. In this case signal list will be disabled.
- RTR message can be added to by selecting RTR checkbox
- If there is selection in the message list, changes will update the selected message.
- Selecting Add Message button will add a new message entry.
- Database messages can be directly entered by name or ID in the Message ID/ Name combo box or can be selected from the combo box list items.
- Signal Matrix will show the bit pattern of the data bytes.
- Instead of using Update button, Auto Update option can be selected to dynamically save the data.
- Select Update button to save the changes and press the toolbar button shown in the figure below.
-

**Note:**

- Start/Stop Transmission toolbar button will be enabled only if the tool is connected.
- Message transmission shall be stopped with out tool disconnect.

The messages added in to the Tx message list can also be modified. Follow the steps given below.

- Select an entry in the message list. The selected detail will be unpacked and will be displayed in the edit controls below. If it is a database message then the signal details will be listed in the signal list with both physical and raw values.
- Any modification in Message Name/ID, DLC, Data bytes, signal raw and physical values will directly reflect in the selected message entry in the message list. The signal matrix will also get updated to reflect the changes.
- Selecting Apply or OK button will reflect message details change in transmission immediately if message transmission is on.

User can delete a message frame entry from the list by following the steps given below.

- Select **CAN --> Transmit --> Configure** menu option. This will display the dialog box as shown below in figure (a).
- Select an entry in the message frame list.
- Select Delete button. A delete confirmation will be displayed. Select Yes to confirm deletion. The selected item will be deleted from the list. Multiple items can be selected to delete multiple items in one shot.
- Select Delete All button to delete all entries in the message block. A delete all confirmation will be displayed. Select Yes to confirm deletion. This will clear message block entries.
- The other way of doing delete is Right click mouse button. This will display a pop-up menu Delete and Delete All. Select Delete pop-up menu. A delete confirmation will be displayed. Select Yes to confirm deletion. The selected message frame will be removed from the message frame list.

The added messages can be directly transmitted instantaneously. The steps to do this is listed below

- Select a message entry or message entries from the message list.
- Select Send button to transmit these messages.
- The other way of doing this is right click on selected message entries. This will show a popup menu with Send option. Select Send to transmit selected messages once.

**Note:**

- To send a message tool should be in connected state.
- If more then one message are selected to send, all messages will be transmitted one after another without any delay.

**Transmission Blocks - In Detail**

The transmission blocks are segregated in to Message Blocks and Message frames that belong to a block. Message blocks will have logical name and triggering attributes and list of messages. Message block name is logical representation of the block. Message block attributes are triggering type and trigger value.

## Triggering Type

Two types of triggering are supported by BUSMASTER. These are timer and key triggering. In timer triggering messages will be transferred periodically with the time delay mentioned in the trigger value. In case of key triggering the message will be transmitted on press of the trigger character. These options will go along with the repetition mode called Monoshot or Cyclic. In monoshot mode messages belong to a block will be transmitted only once. After completing the cycle of transmission nothing will be transmitted. In cyclic mode message transmission will happen cyclically. After completing one cycle of transmission, first message in the block will be transmitted and so on.

In case of key triggering, if the mode is monoshot, messages in the block will be transmitted one after another for each trigger key press. Once all messages are transmitted nothing will be transmitted. If the mode is cyclic after completing one cycle the first message will be transmitted on press on the key again and this cycle will continue. The special attribute All Message is used to generate heavy load condition. This is attribute is applicable only for key triggering. If All Message is checked and the mode is monoshot, on press of the key all messages will be transmitted once without any delay in between. If the mode is cyclic then all messages will be transmitted continuously with out any delay in between. This can be stopped only by stopping the Tx message transmission.

### Triggering Value

For timer triggering the triggering value is in milliseconds. The minimum supported timer value is 1 millisecond. For key triggering the value can be A-Z, a-z, 0-9.



#### Note:

- Key trigger character is case sensitive.
- Same key character shall be used for multiple message blocks.
- One block shall be configured as both key and time triggering.

## Time Delay Between blocks

Time delay between blocks is used to transmit one block of data at a time. This supersedes time delay between messages. When "Time Delay" for Delay Between Message Blocks is checked the "Time Delay" for Trigger will be disabled and the time will not be considered for message transmission. When the "Transmit Messages" is selected, the messages in the block will be sent immediately. After the given time delay between blocks is elapsed, messages of the second block will be sent and will be continued till all the blocks are sent.

When the "Time Delay" for Delay Between Blocks is unchecked the "Time Delay" for Trigger will be enabled and the previous check status will be maintained.

If the Tx Mode selected is monoshot then the messages will be transmitted only once. For cyclic mode, messages will be transmitted continuously based on the delay given.

If key trigger is selected as Trigger event then messages will be sent on the key press event

## Adding a Message Block

To create a new message block select Add from Message Blocks frame. This will create a new message block with default values and with empty message list. User shall modify attributes of the message block to customize the message block. User shall be able to add maximum of 32 message blocks.

## Deleting a message Block

To delete a message block select the message block from the list and select Delete button. This will prompt delete confirmation dialog. Selecting Ok to this dialog will delete message block from message blocks list. Deleting a message block will remove all messages belong to that message block.

Addition and Deletion of message block shall be done by using context sensitive popup menus. This will be displayed if the user right clicks on message block list.

## Message List

Message list will show the list of messages belong to a message block. A message block shall be selected from Message Block to see the list of messages it has. Message list will show message frame with its ID, Name if it is a database message, frame type, DLC and data bytes. The icon used for each entry will denote whether it is a database message or non database message. The data bytes will be listed in hex or decimal format as per the tool



bar numeric mode. By default messages will be displayed in hexadecimal mode. The frame type will show the message is using standard frame type or extended frame type. The RTR messages will be denoted by 'r'. With message in the list the following operations shall be performed.

### Send

This will send the selected message(s) immediately. To perform this action the tool must be in connected state. The selected messages will be transmitted on CAN bus without having any delay in between the messages.

### Delete

This will delete the selected message entry from the message block. Multiple selections shall be done to delete more than one messages. A delete confirmation message will be popped up before deletion. On selection of Yes to this confirmation the selected messages will be deleted.

### Delete All

This is to clear the message list. This will show a confirmation message. Selecting Yes to this confirmation will clear all messages in the message block.

### Configuring Message Details

A message details shall be configured in different ways. Message details like ID/Name shall be directly typed in the Message Name/ID combo box. Database message names shall be either directly typed or selected from the drop down list. This list will be populated with the imported database messages. Similarly message ID shall be directly entered here. If corresponding database message found, this will be replaced with the message name.

Message length shall be entered or modified using the field DLC. The allowed DLC values are 1-8. If a database message is entered or selected from the drop down list, the length of that message will be automatically taken from the database and will be filled in this field.

Data bytes values shall be directly entered using Data Bytes fields. The message data shall be meaningfully entered using signal values of the message. Only for a database message signal values shall be given. For non database messages the value can be entered only through data bytes fields.

Message Type can be configured using Standard/Extended radio button and RTR check box. Message will be validated on change of frame type.

Any message can be converted to RTR by checking the checkbox RTR. Signal details of a message will be removed if the message is of type RTR.

### Signal Details

For a database message, all signals belonging to the message will be displayed in the signal list with its physical value with unit and raw value. User shall enter value in terms of physical value of the signal or raw value of the signal. If signal descriptor is defined for a signal then physical value will show list of signal descriptors while entering the signal value. This makes entering value of a signal. Message data bytes, physical and raw values will be updated if there is any modification in these fields. Any modification in physical value of a signal will be updated appropriately the raw value and data bytes packing and same for raw value and data bytes modification.



#### Note:

- Changing data bytes may violate signal boundary validation. If the data bytes of a database message are modified directly, the message will be made as dirty. This will be denoted by a \* in message list.

### Signal Matrix

Signal matrix will show the packing of the signal values in to the data bytes visually. This matrix has 64 cells and each represents one bit of the message data byte. If message length is lesser than 8 bytes then the invalid bytes will be disabled. While selecting a signal from the signal list, it will be highlighted in the signal matrix. This matrix will be handy to visualize the signal packing in to the data bytes. For a RTR message this matrix will be disabled.

## Signal Definition

To get the definition of a signal just double click the signal name from the signal list. This will pop up the signal definition dialog from data base. The signal Type, Length, Start Bit, Minimum and Maximum value, Offset, Factor and unit information will be displayed.

## Add Message

This button will create new message entry in the selected message block. This will take the valued of message details field and will create a new message frame. This message will be put in to the message list of selected message block.

## Status

A status text will be update for any invalid data entry. This will be cleared of the invalid data got modified to a valid one. This will show appropriate error messages for an invalid data entry. Once valid data got this text will be cleared and consequently the Add Message button will be enabled.



### Note:

- If a message is selected from the message list then all modifications will update the selected message.
- If none of the message is selected then modifications are local and only Add Message will add this data in to the message list as a new message.
- A new message shall be added any time by selecting the Add Message button. This button will be enabled only if the data entered in message details field are valid.
- Maximum of 64 messages shall be added in to a signal message block. Maximum of 32 Message Blocks shall be added.

## Apply

To make changes to reflect the transmission, select Apply button. This will make changes permanent and the changes will reflect in the transmission if TX is on. The TX dialog will remain open to continue modifications.

## Ok

This will make changes permanent and will close the dialog. The changes will reflect in the transmission if TX is on.

## Cancel

To cancel the changes select Cancel. This will close the dialog with out saving the changes. All changes will be ignored and can not be recalled.



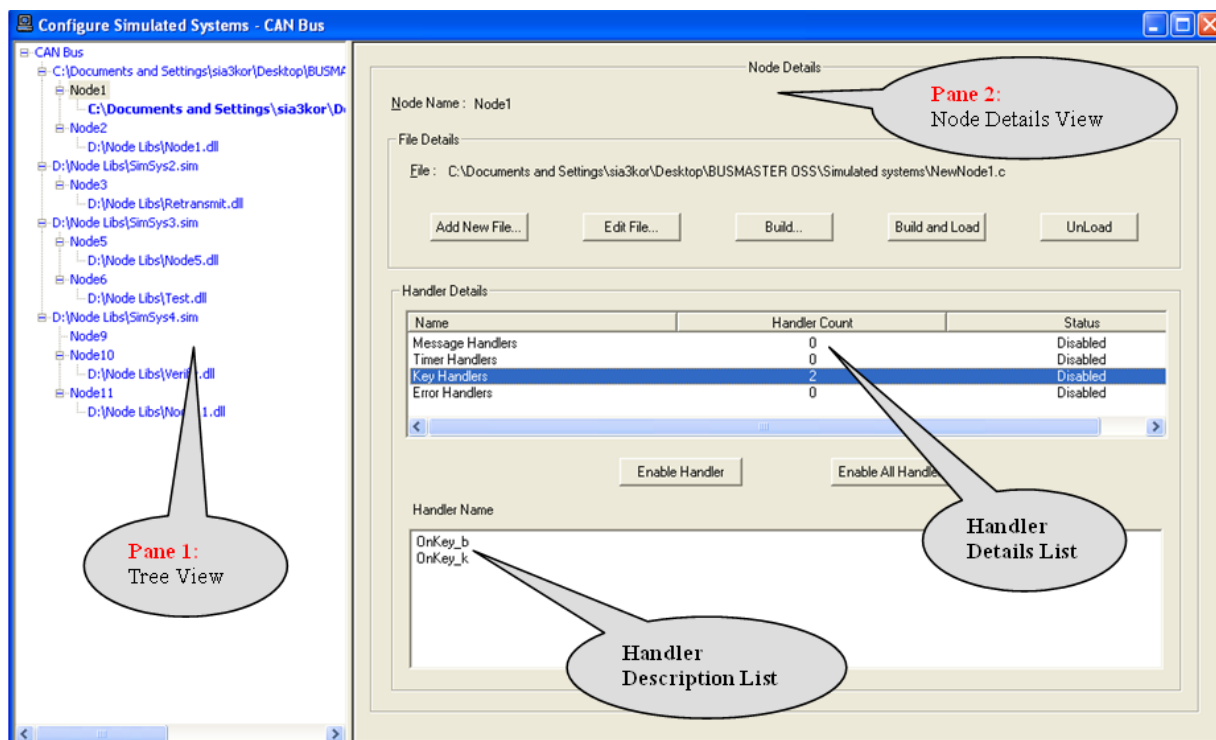
### Note:

- Signal Value shall be modified even if the transmission is on.
- New Messages shall be added in to the message block even if the transmission is on.
- If Message Transmission is on message from any block can not be deleted Any active message block (with check box is on in Message Block list) can not be switched off if Tx is on.

## Simulated Systems

Simulated systems can be configured under the CAN-bus by following the steps given below. Select **CAN --> Node Simulation --> Configure** menu option. This will display the window as shown is figure below.

There are two panes in the **Configure Simulated Systems** window as shown in figure below.



### Left Pane

This will have the details of all simulated systems listed in a tree fashion. Will be called Pane 1.

### Right Pane

This pane will display the details of each node that you select from the Pane1. Will be called Pane 2.

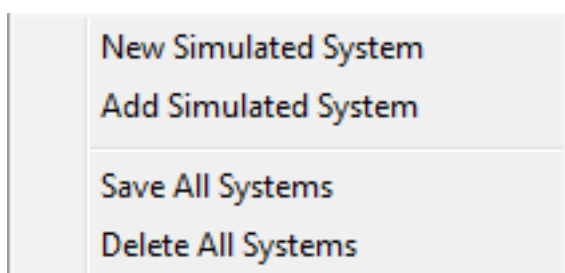
By default no simulated system is configured. Once the user adds or creates simulated systems under CAN Bus it will be stored across sessions.

### New Simulated System

To configure a new simulated system under CAN Bus, please follow the steps given below

1. Select root item in Pane 1 and right click.
2. A pop-up menu will be displayed as shown in figure below.
3. Select **New Simulated System** menu option.
4. A dialog box will be displayed.
5. Key in the new simulated system name and select **Save**.

The new simulated system path is added as last item in the Pane 1.



### Add Simulated System

To add an existing simulated system under CAN Bus, please follow the steps given below

1. Select root item in Pane 1 and right click.
2. A pop-up menu will be displayed as shown in figure above.
3. Select **Add Simulated System** menu option.
4. A dialog box will be displayed.
5. Select a simulated system and say **Add**.

The simulated system path and its details are added as last item in the Pane 1.



**Note:**

- The node name and the DLL should be unique under the CAN bus across all the simulated systems.
- Only when the simulated system which is to be added has the node name or the DLL which is not present under the CAN Bus, it can be added.

### Save All Systems

To save all the simulated system configuration files under CAN Bus, please follow the steps given below

- Select root item in Pane 1 and right click.
- A pop-up menu will be displayed as shown in figure above.
- Select **Save All Systems** menu option.

The simulated system details are saved into its respective ".sim" files.

### Delete All Systems

To delete all the simulated systems under CAN Bus, please follow the steps given below

- Select root item in Pane 1 and right click.
- A pop-up menu will be displayed as shown in figure above.
- Select **Delete All Systems** menu option.
- A confirmation dialog box will be displayed.
- On selecting **Yes** all the simulated systems will be deleted from the Pane 1.

All the simulated systems are deleted from Pane 1 under the CAN Bus.



**Note:**

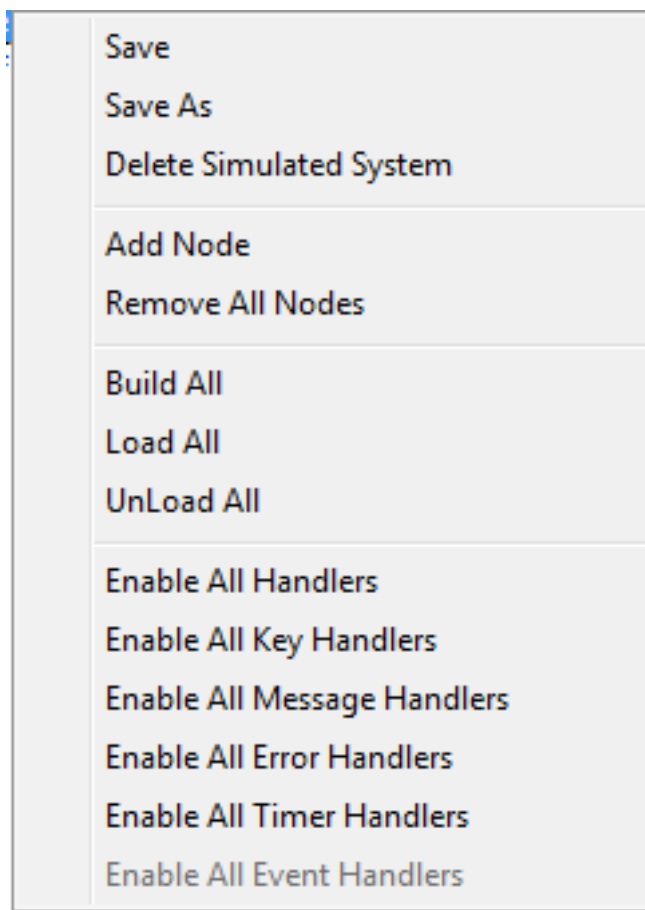
- **Delete All Systems** option is enabled only when there are any simulated systems under the CAN Bus.
- All the systems under the CAN Bus can be deleted only when all the DLLs under it are not loaded.
- The simulated systems under the CAN Bus can be saved by saving the tool's configuration by **File > Save** into its respective ".cfx" file.

### Save

To save the selected simulated system configuration file under CAN Bus, please follow the steps given below

- Select the simulated system in Pane 1 and right click.
- A pop-up menu will be displayed as shown in figure below.
- Select **Save** menu option.

The selected simulated system details are saved into its ".sim" files.



### Save As

To save the selected simulated system configuration file as a different file, please follow the steps given below

- Select the simulated system in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select **Save As** menu option.
- A dialog box will be displayed.
- Key in the new simulated system name and select **Save**.

### Delete Simulated System

To delete the simulated system under CAN Bus, please follow the steps given below

- Select the simulated system in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select **Delete Simulated System** menu option.
- A confirmation dialog box will be displayed.
- On selecting **Yes** the simulated system will be deleted from the Pane 1.



#### Note:

- Simulated System can be deleted only when the DLLs under it are not loaded.
- The simulated systems under the CAN Bus can be saved by saving the tool's configuration by **File > Save** into its respective ".cfx" file.

### Add Node

To configure a node under a simulated system, please follow the steps given below

- Select the simulated system in Pane 1 and right click.

- A pop-up menu will be displayed.
- Select **Add Node** menu option.
- Dialog box Node Details as in the figure below will be displayed.
- Enter the Node name and select the DLL which is unique under the CAN Bus.
- **Clear** button can be used to remove the selected DLL from the node.
- Select **OK** button to confirm.

The node details will be shown under the selected simulated system in Pane 1.

### Remove All Nodes

To remove all the nodes under a simulated system, please follow the steps given below

- Select the simulated system in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select **Remove All Nodes** menu option.
- A confirmation dialog box will be displayed.
- On selecting **Yes** all the nodes will be removed from the Pane 1 under the selected simulated system.



#### Note:

- **Remove All Nodes** option is enabled only when there are any nodes under the simulated system.
- All the nodes from any simulated system can be removed only when the DLLs under it are not loaded.
- The configuration of the simulated system under the CAN Bus can be saved into the ".sim" file.

### Edit Node

To edit a node under a simulated system, please follow the steps given below

- Select the node which is to be edited in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select **Edit Node** menu option.
- Dialog box Node Details as in the figure below will be displayed.
- Enter the Node name and select the DLL which is unique under the CAN Bus.
- **Clear** button can be used to remove the selected DLL from the node.
- Select **OK** button to confirm.

The edited node details will be shown in Pane 1.



#### Note:

- Any node can be edited only when the DLL under it is not loaded.
- The configuration of the simulated system under the CAN Bus can be saved into the ".sim" file.

### Remove Node

To remove a node under a simulated system , please follow the steps given below

- Select the node which is to be removed in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select Remove Node menu option. The node will be removed from the simulated system in Pane 1.



#### Note:

- Any node can be removed only when the DLL under it is not loaded.
- The configuration of the simulated system under the CAN Bus can be saved into the ".sim" file.

### Open File

To change the associated C file with a node and open it, please follow the steps given below

- Select the node for which you want to change the associated C file in Pane 1. The details will be displayed in the Pane 2.
- Click on **Open File** button in Pane 2.

- Select **Edit Node** menu option.
- A confirmation dialog box will be displayed. Select **Yes** in it.
- A dialog box will be displayed which allows you to browse through the directories to select the C file.
- Select a C file and click **Open**.
- The selected C file will be opened in Function editor.

The edited node details will be shown in Pane 1 and also in Pane 2.



**Note:**

- The C file associated with any node can be changed only when the DLL under it is not loaded.
- The configuration of the simulated system under the CAN Bus can be saved into the ".sim" file.

## Edit File

To edit the C file associated with a node, please follow the steps given below

- Select the node for which you want to edit the C file in Pane 1. The details will be displayed in the Pane 2.
- Click on **Edit File** button in Pane 2.
- The C file associated with the node will be opened with the Function editor for the user to edit.

## Execute Handlers

### Function Editor

BUSMASTER can work as a programmable node over a CAN bus. User can program different event handlers using function editor. The programming language is C.

Five types of event handlers are supported.

- Message Handlers
- Timer Handlers
- Key Handlers
- Error Handlers
- DLL Handlers

These function handlers when built and loaded are executed on

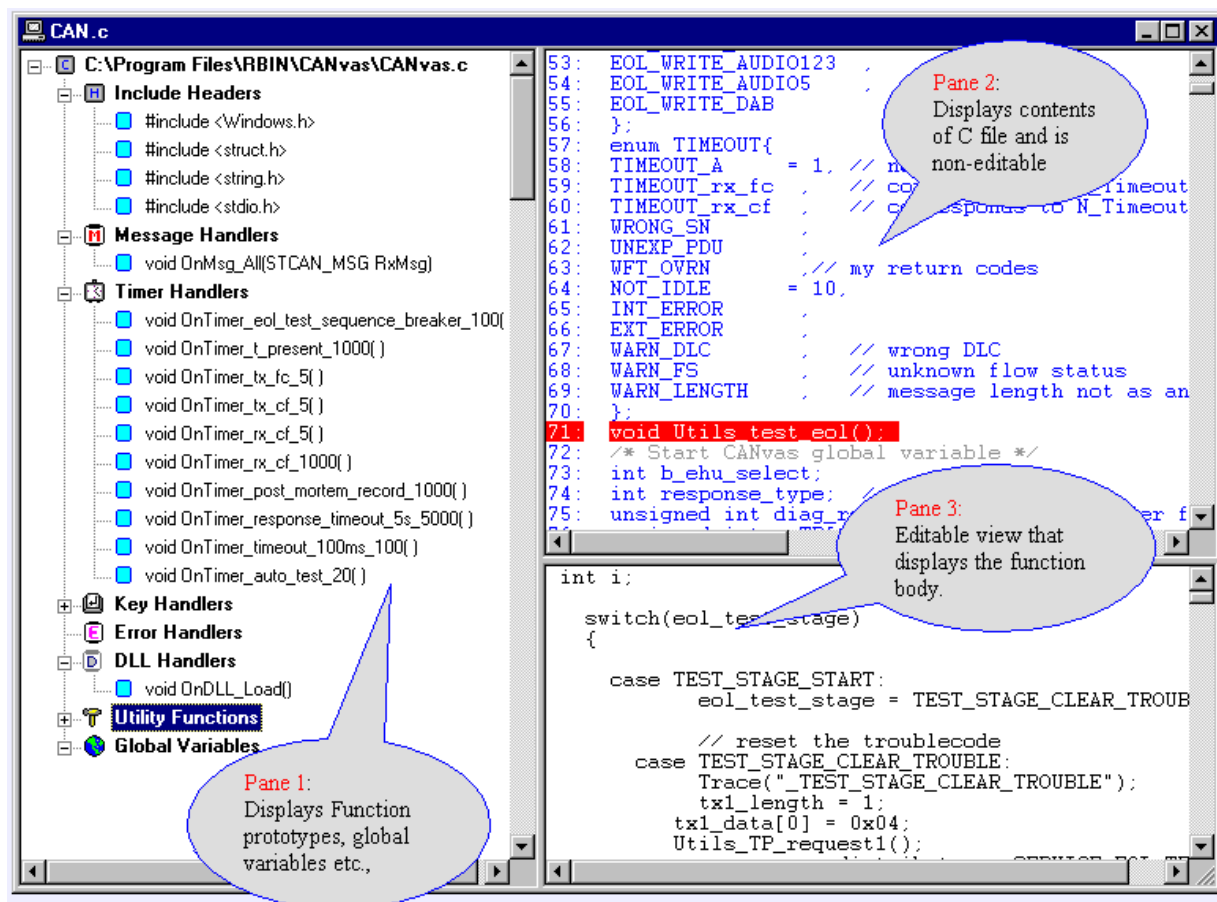
- Receipt of a Message.
- Elapse of a time interval.
- Press of a Key
- Detection of error or change in error state
- Loading / unloading of DLL.

User can also include Header File names, add Global Variables and Utility Functions while programming the event handlers. All these functions can be edited and saved in a file with extension ".c". The source file can be built to a DLL. This DLL can be loaded dynamically.

There are three panes in function editor as shown below

- Left Pane : Will be called Pane 1.
- Right Top Pane : Will be called Pane 2.
- Right Bottom Pane : Will be called Pane 3.

Pane 1 displays the list of functions, included header files and global variables defined. Pane 2 displays the contents of the source file. Through Pane 3 User can edit the body of function selected.



### General access to the function editor

Go to **CAN --> Node Simulation --> Configure** to open the window **Configure Simulated Systems**. Right click on **CAN Bus** in the left pane and select **New Simulated System** or **Add Simulated System**. Select then the "sim" file.

Right click on the new simulated system and select **Add Node**. The name will also be used as basename for the generated DLL. The **Node Details** will become visible in the right pane.

### Create a new function

Follow the description in the previous chapter "General access to the function editor".

Select **Add New File...** in the right pane under **File Details** to add new functions to the node. The function editor will open automatically.

### Edit an existing function

Follow the description in the previous chapter "General access to the function editor".

Select **Edit File...** in the right pane under **File Details** to edit an existing function of the node.

### Include Header file

User can include a header filename while programming event handlers. To do so please follow the steps given below:

1. Select **Include Headers** category in the Pane 1 and right click.
2. A pop-up menu comes up. Select **Add**. A dialog box appears.
3. Click on **Browse** button to select the required header file name and click on **OK** button.
4. The selected header filename will be added to the source file in the Pane 2 and also under **Include Headers** category in Pane 1.



### Edit Include Header File Name

User can edit the name of the header file, to do so please follow the steps given below

1. Select the **Include Header** filename under **Include Header** category to be edited in the Pane 1 and Right click.
2. A pop-up menu will be displayed.
3. Select **Edit**.
4. A dialog box will be displayed.
5. Click on **Browse** button to select the required header file and click on **OK** button.

The selected header file will be replaced with the previous header file in the source file in the Pane 2 and also under **Include Headers** category in Pane 1.

### Delete Handlers

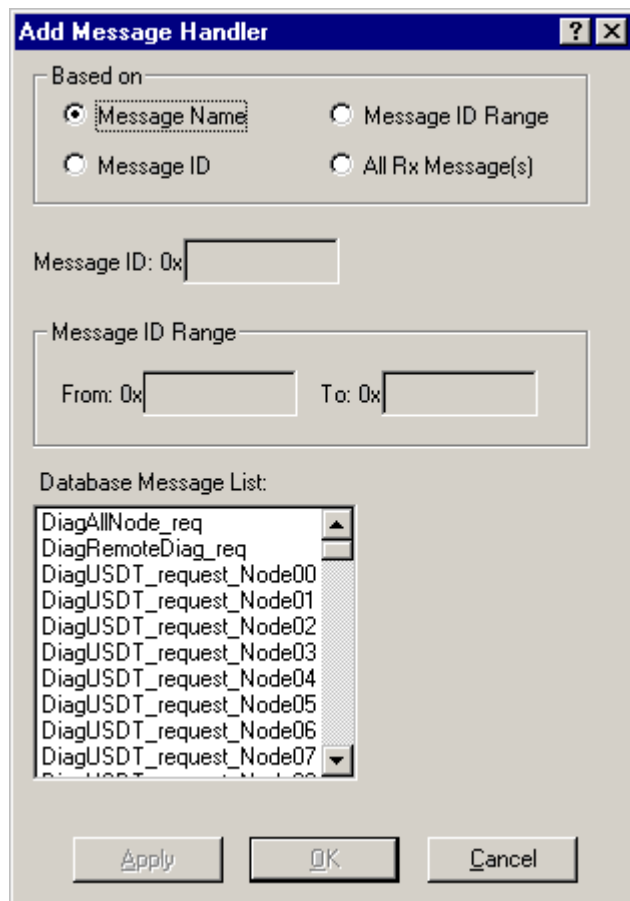
User can delete Header files, Message Handlers, Timer Handlers, Key Handlers, Error handlers, DLL handlers and Utility Functions in source file opened for editing, to do so follow the steps given below:

1. Select the item to be deleted in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select **Delete**.
4. A confirmation message is displayed.
5. Select **Yes**.

The selected item's definition will be deleted from the source file in the Pane 2 and also in Pane 1.

### Add Message Handler

1. Select **Message Handlers** category in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. On selecting **Add** menu. A dialog as shown below pops up.



The image shows a Windows-style dialog box titled "Add Message Handler". It has a standard title bar with a question mark icon and a close button. The dialog is divided into several sections:

- Based on:** A group box containing four radio buttons: "Message Name" (selected), "Message ID Range", "Message ID", and "All Rx Message(s)".
- Message ID:** A text field with the label "Message ID: 0x" followed by an empty input box.
- Message ID Range:** A group box containing two text fields: "From: 0x" followed by an empty input box, and "To: 0x" followed by an empty input box.
- Database Message List:** A list box containing the following items: "DiagAllNode\_req", "DiagRemoteDiag\_req", "DiagUSDT\_request\_Node00", "DiagUSDT\_request\_Node01", "DiagUSDT\_request\_Node02", "DiagUSDT\_request\_Node03", "DiagUSDT\_request\_Node04", "DiagUSDT\_request\_Node05", "DiagUSDT\_request\_Node06", and "DiagUSDT\_request\_Node07". The list box has a scroll bar on the right.
- Buttons:** At the bottom of the dialog are three buttons: "Apply", "OK", and "Cancel".

4. From this dialog message handlers of different type can be selected. The different types of message handlers supported are

- Message handler based on the message name.
- Message handler based on message ID.
- Message handler based on range of message ID.
- Message handler for all received messages.

The type of message handler can be selected using the radio buttons. To add handler based on the message name the corresponding message should be available in the imported database. Multiple messages can be added from this dialog box by clicking on **Apply** button after selecting a message handler.

Function definition will be added to the source file in the Pane 2 and the prototype under Message Handlers category in Pane 1.

### Add Timer Handler

1. Select **Timer Handlers** category in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select **Add**. A dialog box appears.
4. Enter Timer Handler Name like e.g., "Time\_One" and the Timer Value in milliseconds.
5. Select **OK** button.
6. Function definition will be added to the source file automatically in the Pane 2 and the prototype under Timer Handlers category in Pane 1.



#### Note:

- Adding a Sleep function inside a Timer handler might have an adverse effect on the application.
- Maximum of 16 timers can run simultaneously in cyclic mode. Anything above 16 will fail to start.

### Add Key Handler

1. Select **Key Handlers** category in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select **Add**. A dialog box appears asking the user to press a key.
4. Press a key for which User want to write the handler. The same will be displayed in the dialog box.
5. Select **OK** button or **Apply** button if more key handlers are to be added from the same dialog.

Function definition will be added to the source file automatically in the Pane 2 and the prototype under Key Handlers category in Pane 1.

### Add Error Handler

1. Select **Error Handlers** category in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select **Add**. A dialog as shown below pops up from this dialog select the type of error handlers to be handled by your program and click on **OK** button.



Function definition will be added to the source file automatically in the Pane 2 and the prototype under Error Handlers category in Pane 1.

### Add DLL Handler

DLL handlers are invoked at the time of loading the DLL or while unloading the DLL. The procedure for adding DLL handlers is similar to that of adding error handlers.

### Add Utility Function

1. Select **Utility Functions** category in the Pane 1 and right click.
2. A pop-up menu comes up.
3. Select **Add**. A dialog box appears.
4. Return Type of the utility function can be selected from the combo box or directly typed. The combo box will have primitive data types and database message structure names.
5. Enter the Function Prototype in the Edit control like e.g., "Func\_One( int a, int b )".
6. Select **OK** button.

Function definition will be added to the source file automatically in the Pane 2 and the prototype under Utility Functions category in Pane 1.

### Global Variables

To add/delete/modify global variables follow the steps given below.

1. Select **Global Variables** category in the Pane 1 and double click.
2. The Pane 3 will become editable and will show global variable block.
3. Change this block to Add/Delete/Modify the global variables.

Variable declaration will be added to the source file automatically in the Pane 2.



#### Note:

- Use global variable block to use macros, structure or union definitions. The scope of variables and definitions given in this block is throughout the program.

### Edit Function Body

User can edit any function body by double clicking the prototype of the function displayed in Pane 1. On double click of the function prototype, the function body will be displayed in the Pane 3 and will be ready for editing.

### Variable of Message Type

BUSMASTER defines structures for messages define in the database. User can use these structures while programming. Please follow the steps below to add variable of the message type

1. Edit the function for which database message name is to be added. (Refer: section Edit Function Body)

2. Right click in the Pane 3.
3. A pop-up menu is displayed.
4. Select **Insert Message**. A dialog box is displayed with all the database messages under Message list.
5. Choose a message from the list.
6. Select the check box option in the dialog box.
7. Click on **Select** button.

The selected message variable will be displayed in the Pane 3 and the same is updated in the Pane 2.

### Insert Message name

User can add a tag of message structure and this could be used for defining variables. Please follow the steps below to insert a message structure tag into the function.

1. Edit the function for which database message name is to be added. (Refer: section Edit Function Body)
2. Right click in the Pane 3.
3. A pop-up menu is displayed.
4. Select **Insert Message**. A dialog box is displayed with all the database messages under Message list.
5. Choose a message from the list and click on **Select** button.
6. The selected message will be displayed in the Pane 3 and the same is updated in the Pane 2.

### Insert Signal name

User can use signal names while programming. The signal names have to be used in conjunction with the corresponding message variable. It is member of message structure. Please follow the steps below to insert a signal name into the function.

1. Edit the function in which signal name is to be added. (Refer: section Edit Function Bodyedit\_function\_body)
2. Right click in the Pane 3. A pop-up menu is displayed.
3. Select **Insert Signal**. A dialog box is displayed with all the database messages under Message list.
4. Choose a message from the list. A list of signals will be displayed under Signals list.
5. Select a signal and click on **Select** button.
6. The selected signal will be displayed in the Pane 3 and the same is updated in the Pane 2.

### Insert a Function

BUSMASTER provides API functions, which can be used while programming. These functions can be used to interact with BUSMASTER application. Please follow the steps below to insert a function

1. Edit the function for which prototype is to be added. (Refer: Editing Function Body)
2. Right click in the Pane 3. A pop-up menu is displayed.
3. Select **Insert Function**. A dialog box is displayed with a set of function prototypes. (API Listing)
4. Choose required function prototype from the list and click on **OK** button.
5. The selected function prototype will be displayed in the Pane 3 and the same is updated in the Pane 2.

## Message Log

---

CAN messages can be logged to a file for analysis and replay. Log file name shall be selected as described in section Log and Replay.

To start message logging select Log Start or press the Tool Bar Button shown in the figure below. The tool bar is toggle button. Clicking on the button or selecting the menu again will stop logging. Once the logging has started, the messages received and transmitted will be logged in to the file with time of message reception.



## Enabling/Disabling Logging



### Note:

- Logging will fail if the log file is not present in the specified location.
- Logging status is stored in configuration file and logging will be started automatically during application startup if it is enabled and saved in the configuration file.

## Replay

User can replay messages from a BUSMASTER log file. User can choose multiple log files for replay in different modes. Please find more details to configure replay in section Log and Replay.

The log file content can be filtered to choose interested messages alone. To add filters, select Filter option from Replay Configuration Window. Before starting replay, active filters will be applied on log file and resulting messages will be taken for replay.

Replaying a log file shall be done in two methods. That is

- Interactive and
- Non-Interactive

In interactive replay mode, the log file content will be display as list of messages and user can navigate this list and can transmit interested messages. User can step through replay messages, can skip messages, can start message transmission continuously and can insert break points.

In non interactive mode, replay will start during tool connect and will be stopped during tool disconnect. In case of cyclic mode the replay will continue till tool disconnect and in monoshot or once, all messages will be transmitted only once and replay will start.

Based on replay mode, user can configure replays in two different modes.

- Single Run Mode and
- Cyclic Mode

Please find more information on these modes on respective sections

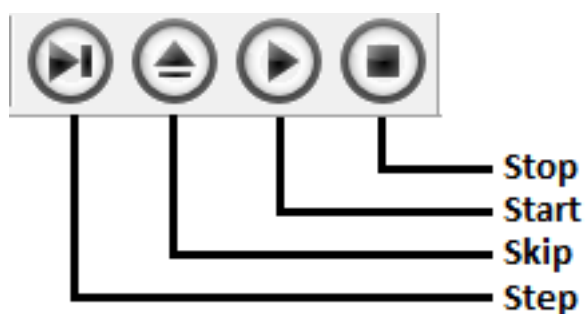
## Cyclic Mode

Find more details to configure replay in cyclic mode in section Log and Replay.

### Interactive Replay

In interactive replay mode, replay window will be displayed during connect. Follow the steps given below to start replay.

- Select a block of messages from Message Replay Window
- Select **CAN --> Replay --> Go** or tool bar button Go (shown in figure below ) to start sending message cyclically one by one starting with first one in message block. Message replay window will be freezed. If mode is **Cyclic** then the selected messages from **Replay window** will be sent. By default only the first message will be selected. After sending all the selected messages it waits for the delay mentioned in **Delay between replay cycles**. Then the cycle will be repeated.
- Select **CAN --> Replay --> Stop** or Stop tool bar button (shown in figure below) to stop replay. Once the replay is stopped, Replay Message Window will be activated again.



Replay window will be closed during tool disconnect.

### Non-Interactive Replay

In non-interactive replay mode, replay will start during tool connect. First filters will be applied on the messages from the log file. Then replay will start with the filtered set and will continue transmitting messages continuously. If a cycle of transmission is complete, next cycle of transmission will start after cyclic delay.

To stop all non-interactive replays, disconnect the tool.

## Single Run Mode

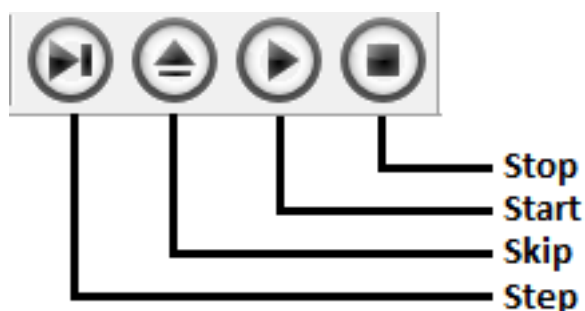
Find more details to configure replay in cyclic mode in section Log and Replay.

### Interactive Replay

In interactive replay mode, replay window will be displayed during connect. Follow the steps given below to start replay.

- Select a message from Message Replay Window.
- There are four options to select
  - **CAN > Replay > Go**
  - **CAN > Replay > Step**
  - **CAN > Replay > Skip**
  - **CAN > Replay > Stop**

User can use tool bar button shown in figure below for this purpose.



### Step

If User selects Step the current highlighted message will be sent over CAN bus and next message will be highlighted. If the current highlighted message is the last message in message replay window, then first message in the replay window will be highlighted.

## Skip

If User selects Skip the highlighted message will not be sent and next message will be highlighted. the current highlighted message is the last message in message replay window, then first message in the replay window will highlighted.

## Go

If User selects Go then replay will start and message transmission will happen continuously with configured message delay. Replay message window will be freezed. Once replay finds break point or the last message is already transmitted, replay will stop. In case of break point, that line will be highlighted. If it is due to the last message transmission, then first message will be highlighted. Once the replay is stopped, replay message window will be activated again.

## Stop

If user selects Stop, the replay of messages will be stopped. If replay is in the middle of message transmission, that message will be completely transmitted and then replay will stop. Once the replay is stopped, replay window will be activated again and next message of last transmitted message will be highlighted.

## Break Points

Inserting break points in the replay messages enables user to transmit a section of messages and then go in to the step mode. Break points shall be inserted by just double clicking the message entry in the replay window. This is a toggling functionality. Double clicking again on the same message entry will disable break point.

Replay with Go option will stop at break point. This makes user to analyze the CAN communication better.

Note

- Break points are available only in interactive single run mode and will be considered in Go option only
- In case of Step, break points are ignored

## Non-Interactive Replay

In non-interactive replay, message transmission will start from the beginning during tool connect. Message transmission will be stopped during tool disconnect.

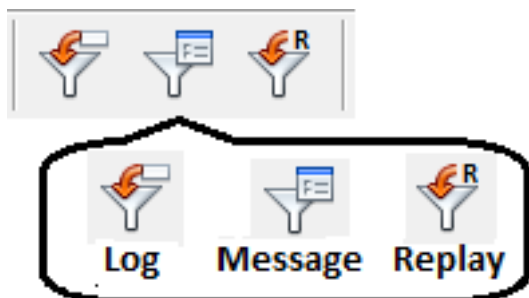
## Enable/Disable Filter

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Filter (App Filter) can be enabled/disabled-using tool bar buttons or menu. Filters must have been configured prior to this. (Refer section Configure - App Filter and Display Filter).

### Display Filter

To enable message window filtering select **CAN --> Message Window --> Enable Filters** or press **Display Filter** toolbar button shown in figure below.



To disable filtering select the toolbar button again. Filtering will toggle on each press.

## Log Filter

To enabling filter for logging select **CAN --> Logging --> Enable Filters** or press **Log Filter** toolbar button shown in the fig. The filter will be applied on messages that are received after enabling the filter. To disable select the same menu item or toolbar button again. Filtering will toggle on each press.

## Replay Filter

To enabling filter for replay select **CAN --> Replay --> Enable Filters** or press **Replay Filter** toolbar button shown in the fig. To disable select the same menu item or toolbar button again. Filtering will toggle on each press.



**Note:** Note

- Message filter and Log filter will be applied only for the incoming messages after enabling the filter.
- Filters can be Enabled/Disabled irrespective of tool connection status.

## Node Simulation

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Once the program is written it can be built as a DLL and loaded. The GCC compiler is used for this purpose. You can either build or build and load on the fly. You can also unload any loaded DLL. Once the DLL is loaded, all the handler function can be invoked/revoked selectively. Once the user program is loaded in to the BUSMASTER application handlers are exposed to the application.

### Build

To make a build the program file should be associated with a node under a simulated system. (Refer section Simulated Systems) Selecting Build All from toolbar or **CAN --> Node Simulation --> Build All** will start building all the C files under all the simulated systems configured in that session. The building status will be displayed in the Output Window. If any errors found in the program, it will be listed with the line number. Clicking the error line in the output window will open that particular file in Function editor and highlights the code in source window and will select the corresponding line in the Pane 2 (Refer section Function Editor) and makes the same editable in Pane 3. (Refer section Function Editor) If there is no error in the program, the DLLs will be generated and user will be notified of successful creation of DLLs. User can load these DLLs using **CAN --> Node Simulation --> Load All** menu.

All the program files under the simulated system(s) can also be built by right clicking on any simulated system and selecting **Build All** in simulated system window Pane 1. The program file under the node can be built by selecting **Build** in the simulated system window Pane 2.

### Build and Load

User can build and load a DLL in one step. After associating the program file(s) to the node(s) , select **CAN --> Node Simulation --> Build & Load All** . It will first build the DLLs. Once the DLLs are built successfully, they will be loaded automatically. The loaded DLLs will be unloaded before loading the selected DLLs. Once DLLs are loaded all handler functions written in the corresponding source files can be invoked.

The program file under the node can be built and loaded by selecting **Build and Load** in the **Configure Simulated Systems** window Pane 2.

### Load

User can load BUSMASTER DLLs built earlier. Select **CAN --> Node Simulation --> Load All** to load the DLLs associated with the nodes under the simulated systems. Once DLLs are loaded successfully you will be notified with message. The already loaded DLLs will be unloaded before loading all the DLL(s). There will be no warning before unloading the DLLs. Once DLLs are loaded all the handler function(s) written in the corresponding source files can be executed.

All the DLLs under the simulated system(s) can also be loaded by right clicking on any simulated system and selecting **Load All** in simulated system window Pane 1. The DLL under the node can be loaded by selecting **Load** in the **Configure Simulated Systems** window Pane 2.



## Unload

User can unload the DLLs from BUSMASTER. To unload the DLL select **CAN --> Node Simulation -->**

**Unload All**. Once the DLLs are unloaded all the handlers defined in those DLLs are no more available. If any handlers are executed that time, those will be informed about unload. If all handlers are completed its execution then the DLLs will be unloaded. If any timer handlers are heavily loaded and didn't complete its execution, unload will show a warning message and unload will be suspended. In this case user shall initiate unload again to forcibly unload the DLLs.

All the DLLs under the simulated system(s) can also be unloaded by right clicking on any simulated system and selecting **UnLoad All in Configure Simulated Systems** window Pane 1. The DLL under the node can be unloaded by selecting **UnLoad** in the **Configure Simulated Systems** window Pane 2.

## Node Simulation Examples

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Node simulation supports both C and C++ compilation. Below are the examples in C++ for CAN and J1939.

### J1939

```
/* This file is generated by BUSMASTER */
/* VERSION [1.1] */
/* BUSMASTER VERSION [1.7.0] */
/* PROTOCOL [J1939] */

/* Start J1939 include header */
#include <Windows.h>
#include <J1939Includes.h>

/* End J1939 include header */

/* Start J1939 global variable */

/* End J1939 global variable */

/* Start J1939 Function Prototype */
GCC_EXTERN void GCC_EXPORT OnTimer_Timer_1000( );
GCC_EXTERN void GCC_EXPORT OnKey_q(unsigned char KeyValue);
GCC_EXTERN void GCC_EXPORT OnPGN_All(STJ1939_MSG* RxMsg);
GCC_EXTERN void GCC_EXPORT OnEvent_DataConf(UINT32 unPGN, BYTE bySrc, BYTE
byDest, BOOL bSuccess);
GCC_EXTERN void GCC_EXPORT OnEvent_AddressClaim(BYTE byAddress);
int Utils_(int x,int y);
GCC_EXTERN void GCC_EXPORT OnDLL_Load();
GCC_EXTERN void GCC_EXPORT OnDLL_Unload();
GCC_EXTERN void GCC_EXPORT OnTimer_dew_10( );
GCC_EXTERN void GCC_EXPORT OnBus_Connect();
GCC_EXTERN void GCC_EXPORT OnBus_Disconnect();
GCC_EXTERN void GCC_EXPORT OnPGNID_100(STJ1939_MSG* RxMsg);
/* End J1939 Function Prototype */

/* Start J1939 generated function - OnTimer_Timer_1000 */
void OnTimer_Timer_1000( )
{
STJ1939_MSG msg;

msg.m_sMsgProperties.m_byChannel = 1;
msg.m_sMsgProperties.m_eType = MSG_TYPE_DATA;
msg.m_sMsgProperties.m_eDirection = DIR_TX;

msg.m_sMsgProperties.m_uExtendedID.m_s29BitId.m_bySrcAddress = 5;

msg.m_unDLC = 5;
msg.m_pbyData = new BYTE[15];
BYTE tmp[] = {12, 34, 45, 56, 78};
```

```

memcpy(msg.m_pbyData, tmp, 5);
Trace("J1939 Time Handler");
SendMsg (&msg);
}/* End J1939 generated function - OnTimer_Timer_1000 */
/* Start J1939 generated function - OnKey_q */
void OnKey_q(unsigned char KeyValue)
{
    STJ1939_MSG msg;

    msg.m_sMsgProperties.m_byChannel = 1;
    msg.m_sMsgProperties.m_eType = MSG_TYPE_DATA;
    msg.m_sMsgProperties.m_eDirection = DIR_TX;

    msg.m_sMsgProperties.m_uExtendedID.m_s29BitId.m_bySrcAddress = 5;

    msg.m_unDLC = 5;
    msg.m_pbyData = new BYTE[15];
    BYTE tmp[] = {11, 22, 33, 44, 55};
    memcpy(msg.m_pbyData, tmp, 5);

    SendMsg (&msg);
}/* End J1939 generated function - OnKey_q */
/* Start J1939 generated function - OnPGN_All */
void OnPGN_All(STJ1939_MSG* RxMsg)
{
    /* TODO */
    Trace("MSG ALL");

    STJ1939_MSG msg;

    msg.m_sMsgProperties.m_byChannel = 1;
    msg.m_sMsgProperties.m_eType = MSG_TYPE_DATA;
    msg.m_sMsgProperties.m_eDirection = DIR_TX;

    msg.m_sMsgProperties.m_uExtendedID.m_s29BitId.m_bySrcAddress = 5;

    msg.m_unDLC = 8;
    msg.m_pbyData = new BYTE[15];
    BYTE tmp[] = {12, 34, 45, 56, 78};
    memcpy(msg.m_pbyData, tmp, 5);
    SendMsg (&msg);
}/* End J1939 generated function - OnPGN_All */
/* Start J1939 generated function - OnEvent_DataConf */
void OnEvent_DataConf(UINT32 unPGN, BYTE bySrc, BYTE byDest, BOOL bSuccess)
{
    /* TODO */
    Trace("Data Handler");
}/* End J1939 generated function - OnEvent_DataConf */
/* Start J1939 generated function - OnEvent_AddressClaim */
void OnEvent_AddressClaim(BYTE byAddress)
{
    /* TODO */
    Trace("Address Claim Event");
}/* End J1939 generated function - OnEvent_AddressClaim */
/* Start J1939 generated function - Utils_ */
int Utils_(int x,int y)
{
    /* TODO */
}/* End J1939 generated function - Utils_ */
/* Start J1939 generated function - OnDLL_Load */
void OnDLL_Load()
{
    Trace("Dll has been loaded");
    /* TODO: Define and Initialise the following variables*/
    UINT ReturnValue ;
    ReturnValue = EnableLogging();

}/* End J1939 generated function - OnDLL_Load */

```

```

/* Start J1939 generated function - OnDLL_Unload */
void OnDLL_Unload()
{
Trace("Dll is unloaded");
/* TODO: Define and Initialise the following variables*/
  UINT ReturnValue ;
ReturnValue = DisableLogging();

}/* End J1939 generated function - OnDLL_Unload */
/* Start J1939 generated function - OnTimer_dew_10 */
void OnTimer_dew_10( )
{
STJ1939_MSG msg;

msg.m_sMsgProperties.m_byChannel = 1;
msg.m_sMsgProperties.m_eType = MSG_TYPE_DATA;
msg.m_sMsgProperties.m_eDirection = DIR_TX;

msg.m_sMsgProperties.m_uExtendedID.m_s29BitId.m_bySrcAddress = 5;

msg.m_unDLC = 5;
msg.m_pbyData = new BYTE[15];
BYTE tmp[] = {12, 34, 45, 56, 78};
memcpy(msg.m_pbyData, tmp, 5);
Trace("J1939 Time Handler");
SendMsg (&msg);
}/* End J1939 generated function - OnTimer_dew_10 */
/* Start J1939 generated function - OnBus_Connect */
void OnBus_Connect()
{
Trace("Bus Disconnected");
}/* End J1939 generated function - OnBus_Connect */
/* Start J1939 generated function - OnBus_Disconnect */
void OnBus_Disconnect()
{
Trace("Bus Disconnected");
}/* End J1939 generated function - OnBus_Disconnect */
/* Start J1939 generated function - OnPGNID_100 */
void OnPGNID_100(STJ1939_MSG* RxMsg)
{
Trace("MSG ALL");

STJ1939_MSG msg;

msg.m_sMsgProperties.m_byChannel = 2;
msg.m_sMsgProperties.m_eType = MSG_TYPE_DATA;
msg.m_sMsgProperties.m_eDirection = DIR_TX;

msg.m_sMsgProperties.m_uExtendedID.m_s29BitId.m_bySrcAddress = 5;

msg.m_unDLC = 8;
msg.m_pbyData = new BYTE[15];
BYTE tmp[] = {18, 58, 45, 56, 11};
memcpy(msg.m_pbyData, tmp, 5);
SendMsg (&msg);
}/* End J1939 generated function - OnPGNID_100 */

```

## CAN

```

/* This file is generated by BUSMASTER */
/* VERSION [1.1] */
/* BUSMASTER VERSION [1.7.0] */
/* PROTOCOL [CAN] */

/* Start BUSMASTER include header */
#include <Windows.h>
#include <CANIncludes.h>

```

```

/* End BUSMASTER include header */

/* Start BUSMASTER global variable */

/* End BUSMASTER global variable */

/* Start BUSMASTER Function Prototype */
GCC_EXTERN void GCC_EXPORT OnMsg_All(STCAN_MSG RxMsg);
GCC_EXTERN void GCC_EXPORT OnKey_d(unsigned char KeyValue);
GCC_EXTERN void GCC_EXPORT OnError_Warning_Limit(SCAN_ERR ErrorMsg);
GCC_EXTERN void GCC_EXPORT OnDLL_Load();
GCC_EXTERN void GCC_EXPORT OnDLL_Unload();
GCC_EXTERN void GCC_EXPORT OnTimer_new_100( );
GCC_EXTERN void GCC_EXPORT OnBus_Connect();
GCC_EXTERN void GCC_EXPORT OnBus_Disconnect();
/* End BUSMASTER Function Prototype */

/* Start BUSMASTER generated function - OnMsg_All */
void OnMsg_All(STCAN_MSG RxMsg)
{
    // Initialise message structure
    RxMsg.m_unMsgID = 0x100;                // Message ID
    RxMsg.m_ucEXTENDED = FALSE;            // Standard Message type
    RxMsg.m_ucRTR = FALSE;                 // Not RTR type
    RxMsg.m_ucDLC = 8;                     // Length is 8 Bytes
    RxMsg.m_sWhichBit.m_auData[0] = 10;    // Lower 4 Bytes
    RxMsg.m_sWhichBit.m_auData[1] = 20;    // Upper 4 Bytes
    RxMsg.m_ucChannel = 1;
    SendMsg(RxMsg);

}/* End BUSMASTER generated function - OnMsg_All */
/* Start BUSMASTER generated function - OnKey_d */
void OnKey_d(unsigned char KeyValue)
{
    Connect();
}/* End BUSMASTER generated function - OnKey_d */
/* Start BUSMASTER generated function - OnError_Warning_Limit */
void OnError_Warning_Limit(SCAN_ERR ErrorMsg)
{
    Trace("Warning Limit reached");
}/* End BUSMASTER generated function - OnError_Warning_Limit */
/* Start BUSMASTER generated function - OnDLL_Load */
void OnDLL_Load()
{
    /* TODO: Define and Initialise the following variables*/

    EnableLogging();
}/* End BUSMASTER generated function - OnDLL_Load */
/* Start BUSMASTER generated function - OnDLL_Unload */
void OnDLL_Unload()
{
    /* TODO: Define and Initialise the following variables*/
    DisableLogging();
}/* End BUSMASTER generated function - OnDLL_Unload */
/* Start BUSMASTER generated function - OnTimer_new_100 */
void OnTimer_new_100( )
{
    // Initialise message structure
    STCAN_MSG sMsg;

    sMsg.m_unMsgID = 0x20;                // Message ID
    sMsg.m_ucEXTENDED = FALSE;            // Standard Message type
    sMsg.m_ucRTR = FALSE;                 // Not RTR type
    sMsg.m_ucDLC = 8;                     // Length is 8 Bytes

```

```

sMsg.m_sWhichBit.m_auData[0] = 10; // Lower 4 Bytes
sMsg.m_sWhichBit.m_auData[1] = 20; // Upper 4 Bytes
sMsg.m_sWhichBit.m_auData[2] = 30; // Upper 4 Bytes
sMsg.m_ucChannel = 1;
SendMsg(sMsg);
}/* End BUSMASTER generated function - OnTimer_new_100 */
/* Start BUSMASTER generated function - OnBus_Connect */
void OnBus_Connect()
{
Trace("Bus connected");
}/* End BUSMASTER generated function - OnBus_Connect */
/* Start BUSMASTER generated function - OnBus_Disconnect */
void OnBus_Disconnect()
{
Trace("Bus Disconnected");
}/* End BUSMASTER generated function - OnBus_Disconnect */

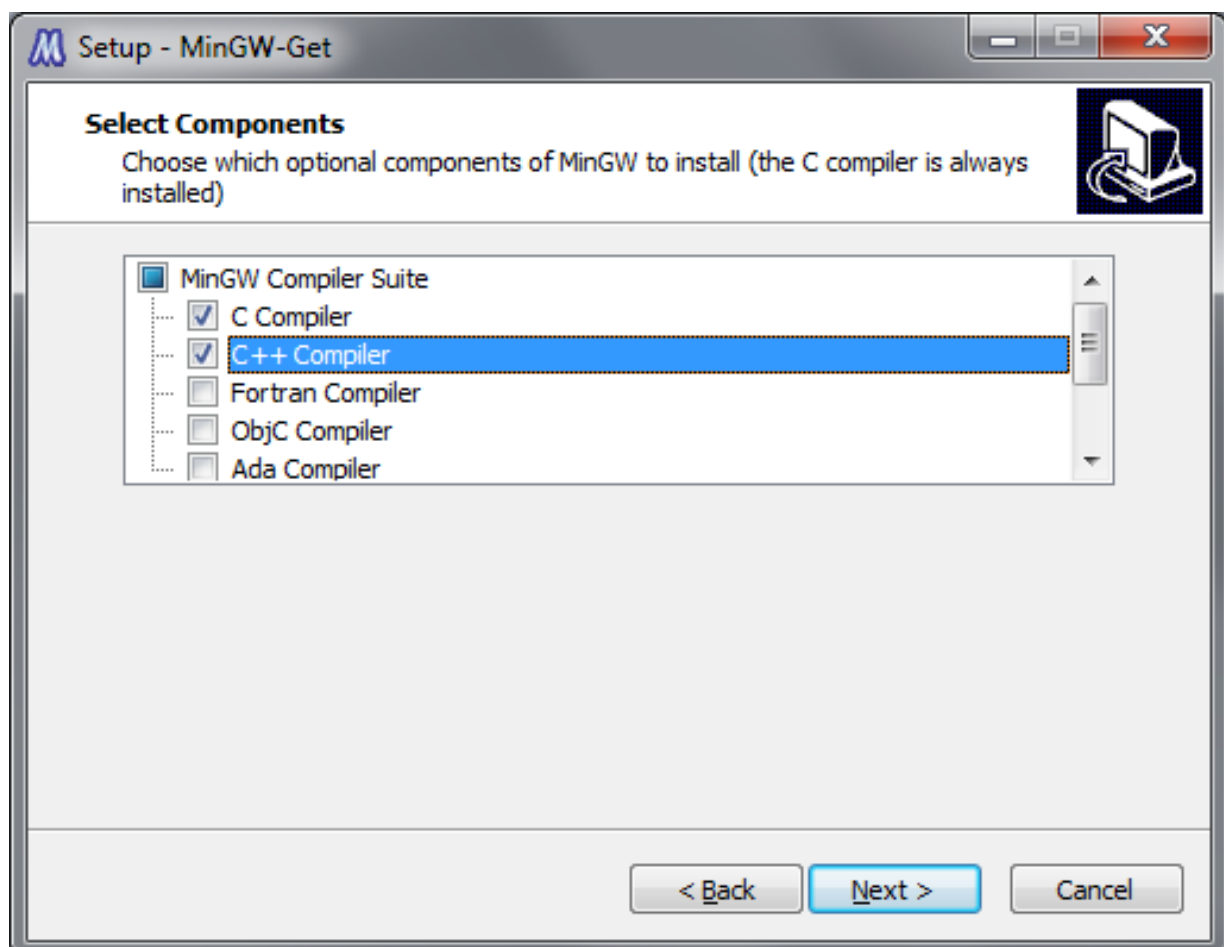
```

## MinGW Installation

### MinGW Installation

The following steps should be followed to install MinGW folder and use it to successfully compile CPP files in Node Simulation using BUSMASTER.

- Download latest mingw executable from the following link <http://sourceforge.net/projects/mingw/files/Installer/mingw-get-inst/> and then use it to download the actual MinGW and copy the MinGW folder to C: drive
- During MinGW installation, please choose the C++ compiler in component list as shown in the screen below as it is not selected by default:



- Set the environment variable 'path' as 'C:\MinGW\bin'.

## Execute Handlers

There are five types of function handlers, which are executed on reception of corresponding event

- Message Handlers
- Timer Handlers
- Key Handlers
- Error Handlers
- DLL Handlers

### Message Handlers

Message Handlers are functions written by you to be executed on reception of a specific message, range of messages or all received messages. You can write message handlers using message names defined in active database, the message ID, for a range of messages based on message ID or for all received messages. See section Function Editor for further details. Before enabling message handler, the corresponding DLL should be loaded. Select **CAN --> Node Simulation --> All Message Handler(s)** to enable all the message handler(s) of all the DLLs under the simulated system(s). On reception of a message corresponding message handler will be invoked. You can also execute all the message handlers of all the DLLs under the simulated system(s) using tool bar button shown in figure below.



**Enable/Disable Message Handlers**

All the message handler(s) under the simulated system(s) can also be executed by right clicking on any simulated system and selecting **Enable All Handlers** in **Configure Simulated Systems** window Pane 1. The message handler(s) under the node can be executed by selecting the Message handlers in Handler Details List and clicking **Enable Handler** in the **Configure Simulated Systems** window Pane 2.

### Timer Handlers

The timer handler functions are those function which will be executed on elapse of selected time interval. Please see section Function Editor for further details. After the DLLs are loaded, timer handlers can be invoked using **CAN --> Node Simulation --> All Timer Handler(s)**. You can also press tool bar button shown in figure below.



**Enable/Disable Timer Handlers**

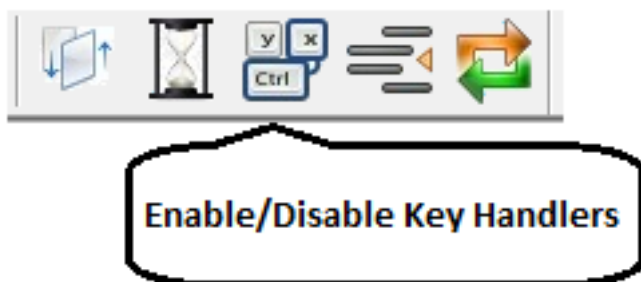
All the timer handler(s) under the simulated system(s) can also be executed by right clicking on any simulated system and selecting **Enable All Timer Handlers** in simulated system window Pane 1. The timer handler(s)

under the node can be executed by selecting the Timer handlers in Handler Details List and clicking **Enable Handler** in the **Configure Simulated Systems** window Pane 2.

## Key Handlers

BUSMASTER supports a maximum of 62 key handlers (Alphanumeric keys – A to Z, a to z, 0 to 9). Additionally a single key handler for handling all the 62 key handlers is supported, for this '\*' has to be selected.

The key handler function can be executed by pressing the corresponding key for which the key handler is written. Pressing the toolbar button shown in the figure below will enable Key handlers. Pressing the same tool bar again will disable key handlers. Please see section Function Editor for further details.



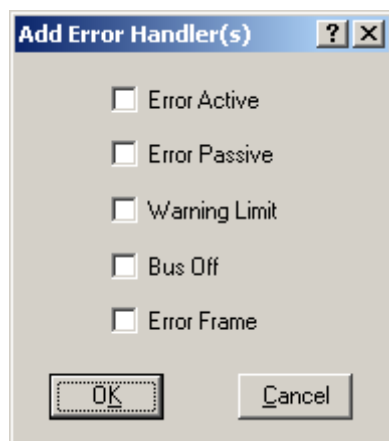
All the key handler(s) under the simulated system(s) can also be executed by right clicking on any simulated system and selecting **Enable All Key Handlers** in simulated system window Pane 1. The key handler(s) under the node can be executed by selecting the Key handlers in Handler Details List and clicking **Enable Handler** in the **Configure Simulated Systems** window Pane 2.

## Error Handlers

User can write functions to handle following types of error or error state of the controller

- Error frame Handler – This function gets activated when a error frame is received
- Bus Off Handler – gets activated when the controller enters the bus off state
- Active Error Handler – gets activated when the controller enters the error active state.
- Passive Error Handler – gets activated when the controller enters error passive state.
- Warning Limit Handler – gets activated when the controller enters crosses the warning limit that has been set.

These handlers can be added in the code by right clicking on the item **Error Handlers** and selecting **Add** from the pop up menu. This brings up a dialog box as shown below, listing the all the supported error handlers, one can select the required handlers and on clicking **OK** button the framework for the function handler gets added in the .c file.



To delete error handlers select **Error Handlers** and right click. Select **Delete** from popup menu. Select handlers that are to be deleted. Selecting **Ok** will delete checked handlers.

All the error handler(s) under the simulated system(s) can also be executed by right clicking on any simulated system and selecting **Enable All Error Handlers in Configure Simulated Systems** window Pane 1. The error handler(s) under the node can be executed by selecting the Error handlers in Handler Details List and clicking **Enable Handler** in the **Configure Simulated Systems** window Pane 2.

## DLL Handlers

User can write functions to handle initialization and de-initialization at the time of loading and unloading the user program. The two events supported are

- Load - When the DLL is loaded
- UnLoad - When the DLL is unloaded.

Adding & deleting the Dll handlers is same as that of error handlers.

## Database Editor

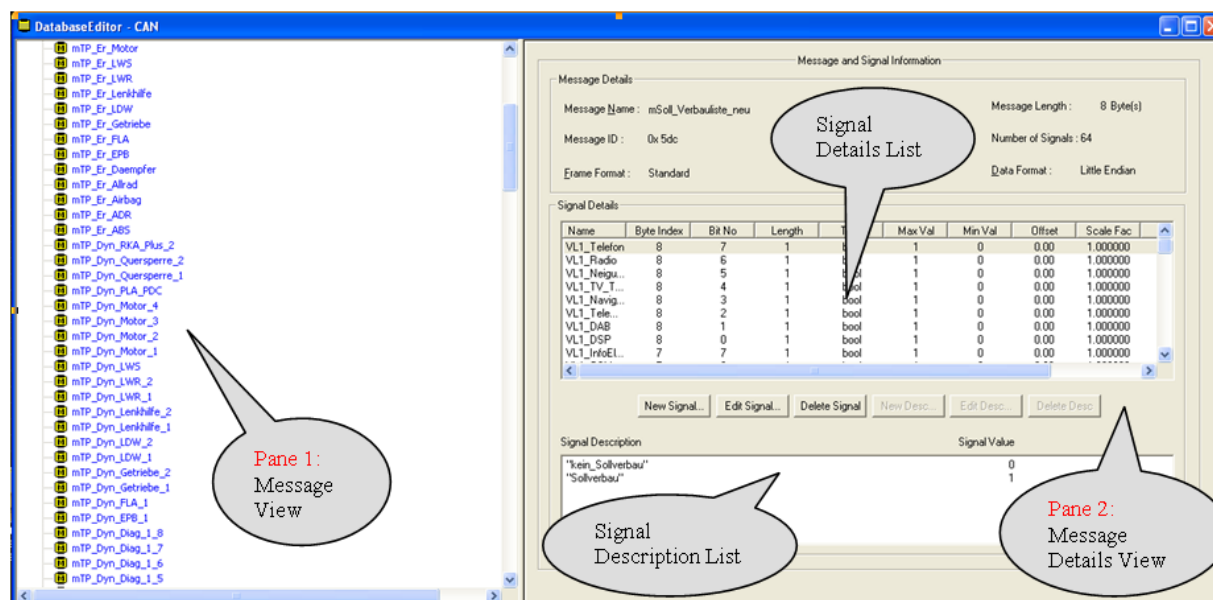
BUSMASTER database consists of information about expected message. You can create a database of messages to be transmitted or received over CAN bus. Each message has a unique ID and name. Each message has upto eight bytes of data. You can define the length of message in bytes. Each message can consist of one or more signals. In a message each signal has start bit and length, no two signals can overlap. Signal can have an offset, a multiplication factor and engineering units. These three information together are used to display signal value received in engineering units. The data received is multiplied by the factor, added to the offset to obtain the engineering value. Also a particular value of the signal can be given a meaningful name by using signal descriptor (e.g. ON = 1, OFF = 0). This information will be used while interpreting the messages.

User can create new BUSMASTER database by selecting **CAN --> Database --> New** menu option. This menu option will be enabled only when no database editor is open.

User can also open any BUSMASTER database by selecting **CAN --> Database --> Open** menu option.

This will allow you to specify the database name, which you want to open and edit.

There are two panes in the database editor as shown in figure below.



### Left Pane

This will have the names of all messages listed in a tree fashion. Will be called Pane 1.



## Right Pane

This pane will display the details of each message that you select from the Pane1. Will be called Pane 2.

By default no database is loaded. Once the user imports a database it will be stored across sessions. This is called the active database, which will be used for interpretation and by the function editor.

## Import Database

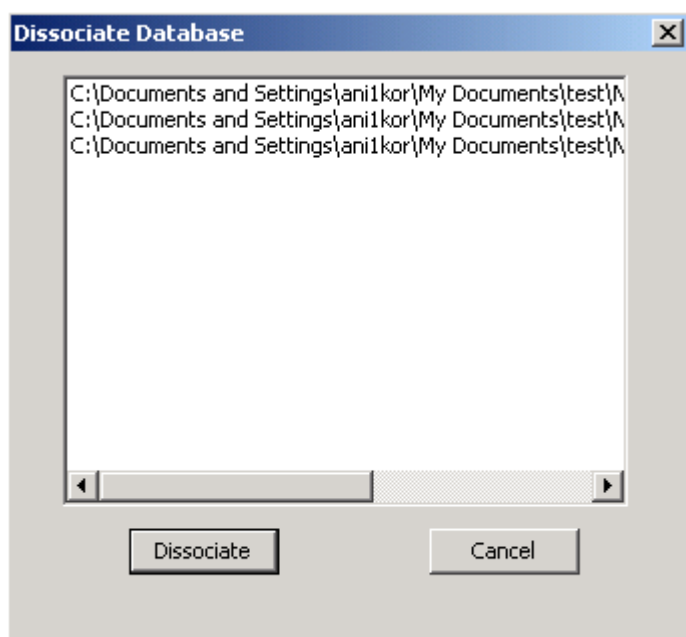
User can select any number of BUSMASTER generated database and make them as active databases.

1. Select **CAN --> Database --> Associate** menu option. An open file dialog will be displayed.
2. Select the databases and click on Open button.

## Dissociate Database

User can Dissociate any number of active database from the application.

1. Select **CAN --> Database --> Dissociate** menu option. Following dialog box will be displayed:



2. Select the databases and click on Dissociate button.

## Add Message

User can add new messages to the database following the steps given below

1. Select root item in Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select New Message menu option.
4. A dialog box will be displayed.
5. Key in all the details and select OK button.

The new message name is added as last item in the Pane 1 and the details are displayed in the Pane 2.

## Edit Message

User can edit messages in database by following the steps given below

1. Select message name to be edited in Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select Edit Message menu option.
4. A dialog box will be displayed with all the message attributes displayed.

5. Key in all the details and select OK button.

The new message name will be added as last item in the Pane 1 and the details are displayed in the Pane 2.

### Delete Message

User can delete messages in database by following the steps given below

1. Select message name to be deleted in Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select Delete menu option.
4. A delete confirmation message will be displayed.
5. Select Yes.

The message name is deleted from Pane 1 and the details are displayed in the Pane 2.

### Add Signal

Message consists of signals. To define a signal in message follow steps given below

1. Click the message name for which you want to add the signal from the Pane 1.
2. The details of the message will be displayed in the Pane 2.
3. Right click in the signal details list in Pane 2.
4. A pop-up menu will be displayed.
5. Select New Signal menu option.
6. A signal details dialog box will be displayed.
7. Key in the signal details and click on OK button.

The new signal and its attributes are displayed in the signal details list. Selecting New Signal button will do the same.

### Edit signal attributes

User can edit the attribute of a signal define earlier, please follow the steps below to do so

1. Click the message name for which you want to edit the signal attributes from the Pane 1. The details will be displayed in the Pane 2.
2. Select the signal in the signal details list in Pane 2.
3. Right click. A pop-up menu will be displayed.
4. Select Edit Signal menu option.
5. A signal details dialog box will be displayed.
6. Key in the signal details and click on OK button.

The changes are displayed in the signal details list for the selected signal. Selecting the signal details from the list and clicking on Edit Signal button will do the same.

### Deleting a signal

User can edit the attribute of a signal define earlier, please follow the steps below to do so

1. Click the message name for which you want to delete the signal from the Pane 1.
2. The details will be displayed in the Pane 2.
3. Select the signal in the signal details list in Pane 2.
4. Right click. A pop-up menu will be displayed.
5. Select Delete menu option. A delete confirmation message will be displayed.
6. Select Yes.

The signal and its attributes are deleted from signal details list in Pane 2. Selecting the signal details from the list and clicking on Delete Signal button will do the same.

### Add Signal description

User can add the give description for a value of a signal , please follow the steps below to do so

1. Click the message name for which you want to add description for the signal from the Pane 1. The details will be displayed in the Pane 2.
2. Select the signal in the signal details list in Pane 2.
3. Right click. A pop-up menu will be displayed.
4. Select Add Description menu option. A dialog box will be displayed.
5. Enter description and the signal value and click on OK button.

The new signal description and value are displayed in the signal description list. Selecting the signal details from the list and clicking on New Desc button can do the same.

### Edit Signal Description and Signal value

User can edit the give description for the value of a signal, please follow the steps below to do so

1. Click the message name for which you want to edit description for the signal from the Pane 1.
2. The details will be displayed in the Pane 2.
3. Select the signal description and value from the signal description list in Pane 2.
4. Right click. A pop-up menu will be displayed.
5. Select Edit Description menu option. A dialog box will be displayed.
6. Enter description and the signal value and click on OK button.

The changes in signal description and value are displayed in the signal description list. The same can be done by selecting the signal details from the list and the description to be edited and by clicking on Edit Desc button.

### Delete

User can delete Signal description and Signal value by following the steps given below

1. Click the message name for which you want to delete description for the signal from the Pane 1. The details will be displayed in the Pane 2.
2. Select the signal description and value from the signal description list in Pane 2.
3. Right click. A pop-up menu will be displayed.
4. Select Delete Description menu option.
5. A delete confirmation message will be displayed.
6. Click on Yes button.

The selected signal description and value are deleted from the signal description list. The same can be done by selecting the signal details from the list and the description to be deleted and by clicking on Delete Desc button.

### Save database

User can save the database to a file by selecting **CAN --> Database --> Save** or by clicking on the tool bar button shown below.



User also have an option to save the file at different folder location with different name. You can do this by following the steps given below.

1. Select **CAN > Database > Save As** menu option.
2. A save as file dialog box will be displayed. Enter the file name. Click on Save button.

### Closing database editor

Select **CAN > Database > Close** menu option to close any opened database file. Or click on [X] button at the right upper corner of the database window.

## Message Window

---

BUSMASTER reports all kinds of messages through this window. A message can arise from any one of the two categories as mentioned below

- Message transmitted across the CAN bus, including the one generated by BUSMASTER.
- Error messages

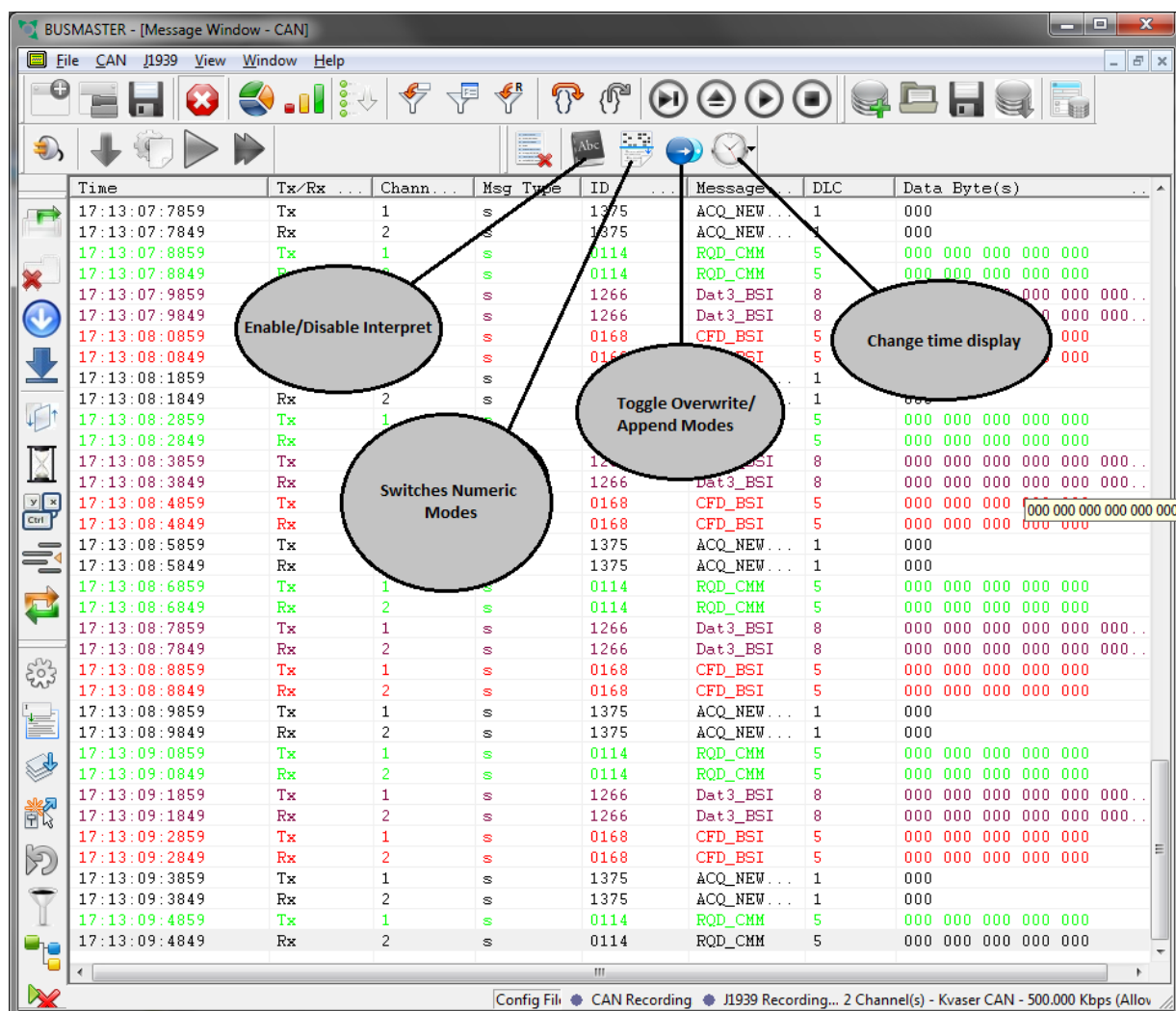
Each message is displayed in a separate line, which consists of the following five fields listed below respectively

- Time – Time can be viewed in three different modes, namely
  - System – In this mode, message will be displayed with PC/System time.
  - Relative – In this mode, message will be displayed with time since the reception of the message with same identifier previously.
  - Absolute – In this mode, the reference is the time of connection. Messages will be displayed with time since the logical connection with the device(ES581) is established.

In all cases time format is maintained as HH: MM: SS: MS where MS stands for millisecond, and the display will be in 24-hour scale.

- Tx/Rx - A message transmitted from BUSMASTER is tagged as Tx whereas for a received one the tag is Rx.
- Type – The indicates if the message is of standard, extended or RTR type, the convention followed is
  - S – Standard frame
  - X – Extended frame
  - Sr – Standard RTR frame
  - Xr – Extended RTR frame
- Message - This section contains the message ID. However, BUSMASTER enables to attribute a message with a specified name and color. If a particular message code is attributed with a name and a color, message name will appear in place of message ID and the message will be displayed in the specified color.
- DLC – It is abbreviation for data length count. It shows number of data bytes in the message body.
- Data Byte(s) – The data bytes are displayed either in hexadecimal or in decimal mode. Please refer to section Toggle numeric mode to know how to toggle numeric modes. On occurrence of an error a suitable error message will be displayed in red color

The following subsections describe various toolbar buttons used to change display of message entry.



## Change Time Display

This is a tool bar button which pops out a menu with three options System, absolute and relative time mode display.

## Toggle Message Overwrite

This is a toggle tool bar button. This button is used to switch between message overwrite mode and append mode. In message overwrite mode there will be only one instance of a message ID in the message window. Subsequent messages received with the same ID will overwrite the message entry. In append mode a newly added message entry will be appended instead. Please refer to description B of the figure shown in section Message Window.

## Toggle Numeric Mode

This is a toggle tool bar button. This button is used to switch between decimal mode and hexadecimal mode. In decimal mode data bytes will be displayed in decimal format. In hexadecimal mode data bytes will be displayed in hexadecimal format. By default messages will be displayed in hexadecimal mode. Please refer to description C of the figure shown in section Message Window.

## Toggle Message Interpretation

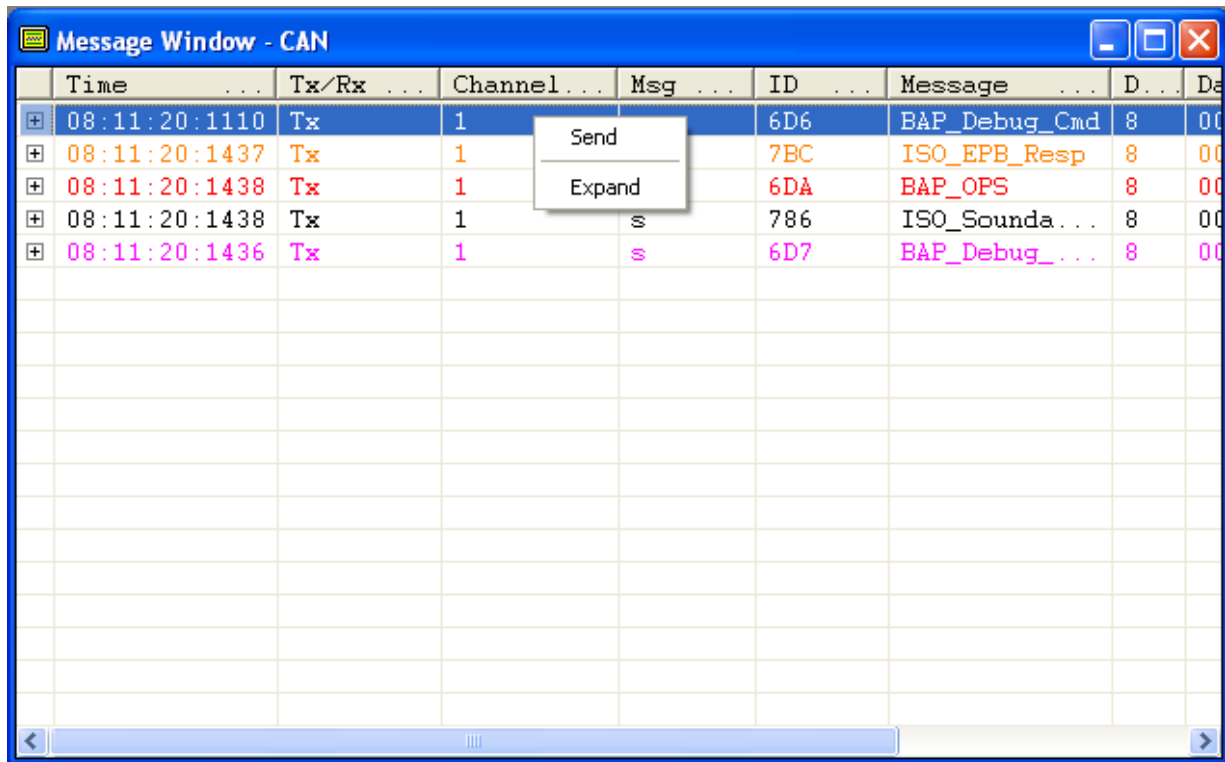
This is a toggle tool bar button. This button is used either to enable or disable message on-line interpretation. This button is enabled only in message overwrite mode. If on-line interpretation of message is enabled, a message entry will be followed by a textual description of the received message. Please refer to description D of the figure shown in section Message Window

The aforementioned will be done only if the message ID is found in the database. Else the message will be followed by a notification message stating “message not found in the database”.

Message interpretation can be obtained by double clicking on the message.

### Selective Message Interpretation

Messages can be selectively interpreted in overwrite display mode. Select a database message entry and right click. BUSMASTER will popup this menu.



Select Expand to expand the message entry with its signal value. Signal values will be displayed in terms Raw and Physical values. The expanded entries can be closed by right clicking on that entry and selecting Collapse. The expanded entries can be closed by right clicking on that entry and selecting Collapse. Alternatively we can click on the '+' sign shown against each interpretable message to expand the message entry And clicking on the '-' sign will collapse the expanded entries as shown in figure below.

Time	Direction	Channel	Msg Type	ID	Message	DLC	D
11:34:13:5023	Rx	2	s	588	mMotor_7	8	0
11:34:14:5023	Tx	2	s	5F7	mKlimaEKomp_1	4	0
KE1_Comp_rev_rq 0x2 100.000 Unit_MinutInver KE1_Luftstellung 0x0 0.000 Unit_PerCent KE1_Comp_rev_rq "Enable"							
11:34:13:5023	Rx	2	s	393	mGate_Komf_3	8	0
11:34:14:0019	Tx	2	s	5C0	mEPB_1	8	0
11:34:14:0537	Tx	1	s	520	mKombi_3	8	0
11:34:14:0995	Tx	1	s	5E0	mClima_1	8	0
11:34:13:5741	Tx	1	s	570	mBSG_Last	5	0
11:34:13:6174	Tx	1	s	393	mGate_Komf_3	8	0
11:34:13:6623	Tx	2	s	5A0	mBremse_2	8	0
11:34:13:7047	Tx	2	s	5B7	mBremse_11	8	0
11:34:13:7893	Tx	1	s	366	mAWV	8	0

### Interpretation Dialog

A message can be interpreted separately in a popup window using Interpretation dialog. Double clicking a message entry will show interpretation dialog with the message details. This will have a list of signals and its Raw and Physical Values.

Message Interpretation		
Message		
Name	mMotor_7	ID 588
Signal(s)		
Name	Physical Value	Raw Value
MO7_Oeltemp	-34.000	0x1A
MO7_StaGluehk	8.000	0x1
MO7_Lastabw_Heiz	"Hochleistun...	0x0
MO7_Gen_ein	"Generator_ein"	0x1
MO7_Lastabwurf	"Stufe_2"	0x2
MO7_RueckLLDz	"keine_Anf_e...	0x0
MO7_SleepInd	"CAN_wird_be...	0x0
MO7_Zus_Kuehl	"nein"	0x0
MO7_Mot_weckf...	"kein_Wecken...	0x0
MO7_PTC_bereit	1.000	0x1
MO7_GenLdResp	3.000	0x1
MO7_Ladedruckneu	0.080	0x4
MO7_GradientVorz	"positives_V...	0x0
MO7_Gradient_Dz	6.000	0x6
MO7_Hoeheninfo	0.055	0x7
MO7_DFM	3.200	0x8
MO7_Sta_PTC	"PTC_100_Pro...	0x0
MO7_StaOeltemp	"iO"	0x0
MO7_Fehlereintr	"Fehlerspeic...	0x1
MO7_Sta_VBegr	"inaktiv"	0x0
MO7_Fehler_VBegr	"V_Begrenzun...	0x0
MO7_LL_Solldz	"LLDZ_hat_We...	0x1

Left clicking on the message entry will change the message selection.

### Sending a Message From Message Display

Messages can be directly send from Message Display entry. Select a message entry and right click. This will popup message operation menu (Refer Fig.1). Select Send to transmit the selected message entry on the CAN bus.

### Clear Message Window

On pressing the tool bar button shown below the message window will be cleared.

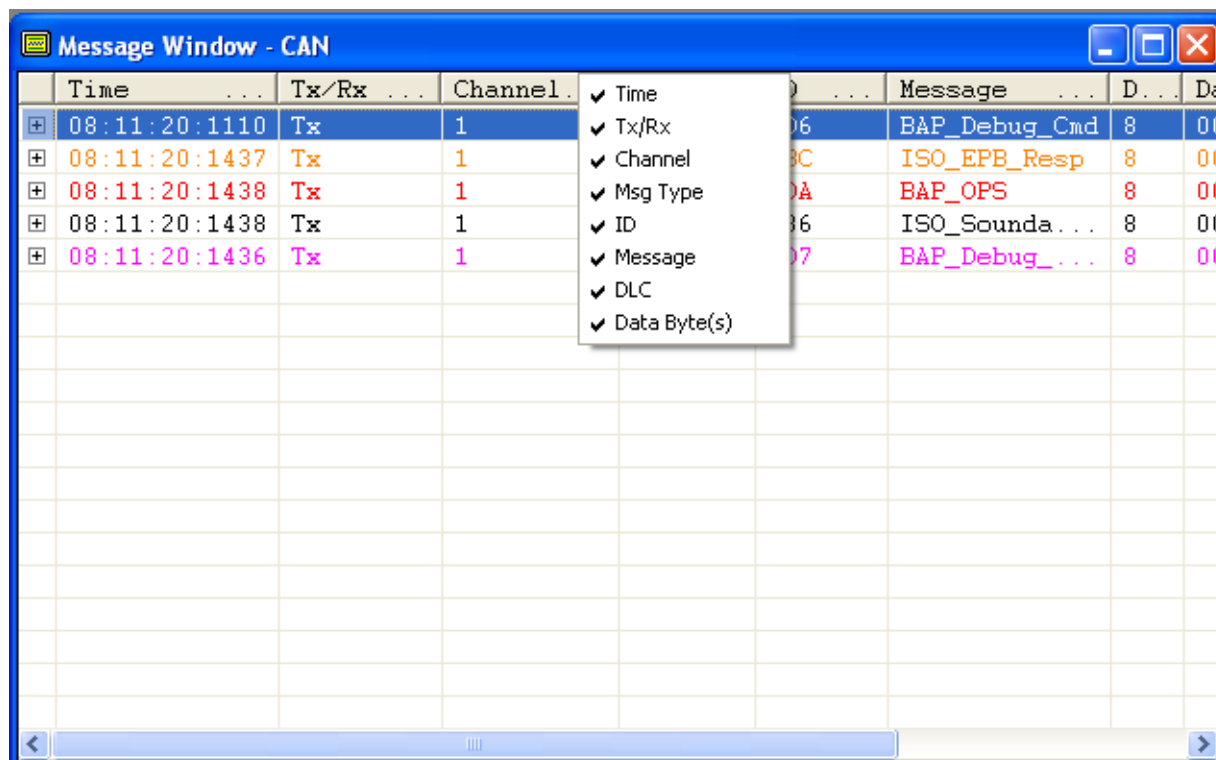




## Message Columns Ordering and visibility

Message columns can be dragged and dropped to any column position in the message window according to user's preference. The columns can also be shown or hidden. To show/ hide a column, right click on the columns header, a popup menu with all the column header names will be shown as shown in fig. 6 below. The columns which are currently shown are marked with a check mark against them in this menu. If user wishes to hide a column, just uncheck that column from the menu and the column will be hidden.

These column ordering and visibility are saved along with configuration.



## Signal Generation

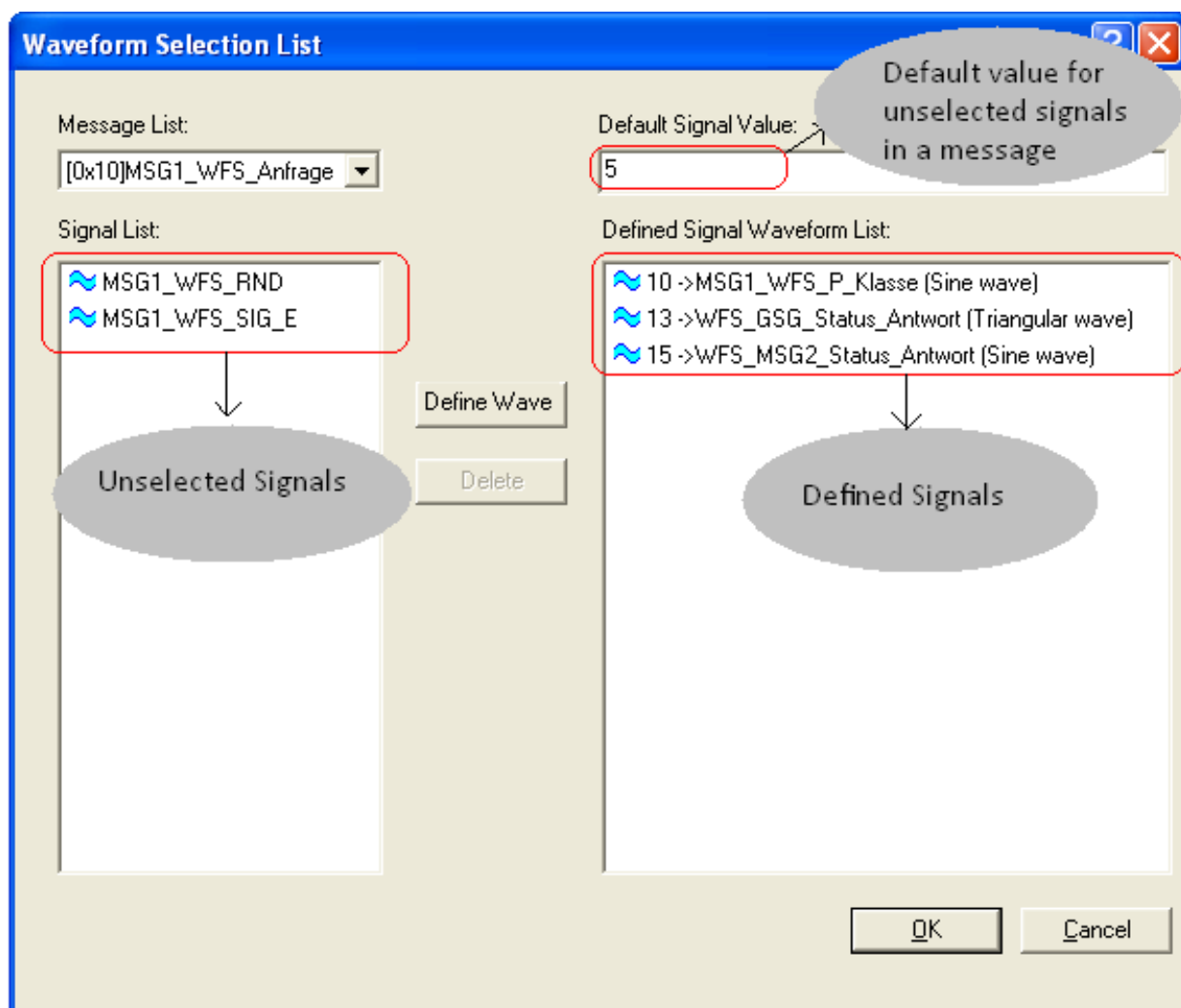
Signal Generation allows the user to configure each signal in database messages with particular waveform and send the messages with these signal values at a particular sampling time period..

Each Signal can have different waveform settings allotted like Signal type, Amplitude, Frequency.

All the signals will be having a standard sampling time at which their amplitude will be calculated depending on the wave type and they will be sent out.

Currently only two waveforms are supported, Sine Wave and Triangular Wave.

To configure signals, go to menu option, **CAN --> Signal Graph --> Configure** and user will be shown with the following dialog box.



The above shown figure contains the list of all the messages in a combo box, “Message list:” which are present in currently selected database file.

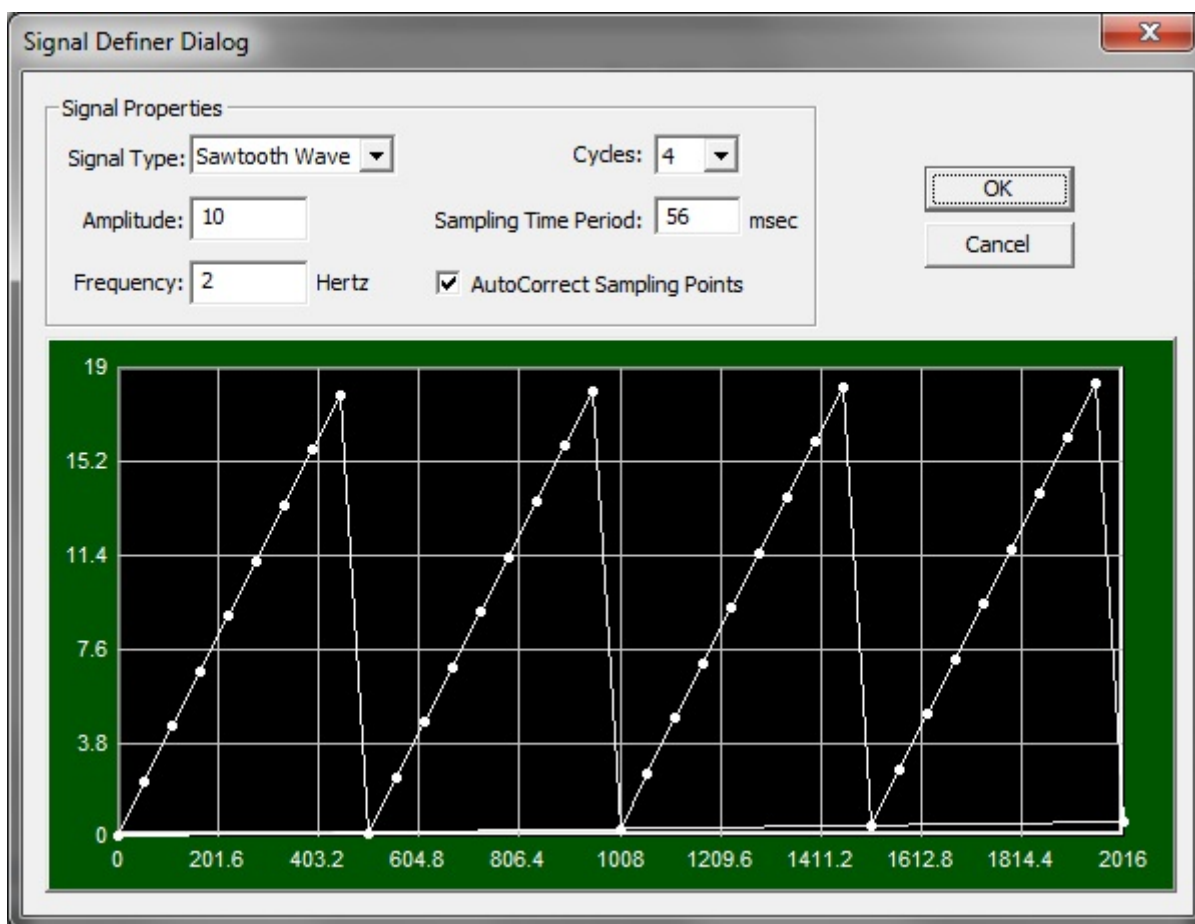
“Signal List” List control shows the signals in currently selected message in combo box which are not defined with any waveform.

“Defined Signal Waveform List” List control shows all the signals in different messages for which the waveforms are defined.

Use the “Define Wave” button to define a waveform for a particular signal. Alternatively double click on the unselected signals can be used to do the same. When user triggers this event, the following dialog pops out.

Currently there are 4 types of waves supported:

1. Sine Wave
2. Cos Wave
3. Triangular Wave
4. Sawtooth Wave



The dialog will be loaded with default waveform settings i.e. a sine wave with amplitude 10, frequency 1 and sampling time period 125. User can make appropriate changes to the wave by choosing signal type, desired amplitude and frequency. “Ok” button click will add the signal to Defined signals list.

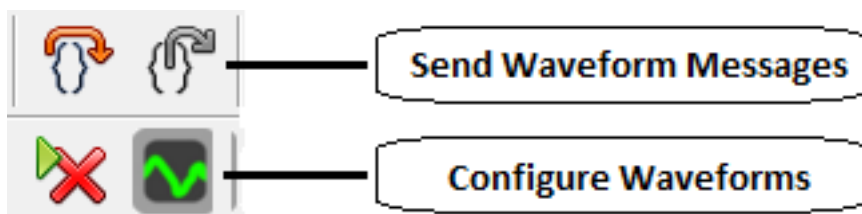
The sampling Time Period which is last modified will be applicable to all the signals. For example, if for first signals you choose the sampling time period as 125 and for the second signal, you choose the sampling time period as 100. Then the sampling time period applicable is 100 for first and second signals.

“AutoCorrect Sampling Points” checkbox when checked, will calculate the sampling time period for a given frequency such that there will be at least 8 points in the a cycle and the graph does not distort.

Maximum frequency that can be set is 125 and Sampling Time Period is 32767

Now, if user wants to transmit the defined signals, make sure the application is in connected state and use the menu option **CAN --> Waveform Messages --> Enable**.

Alternatively user can use the toolbar items shown below for configuring and sending waveform signals.



Use the “Delete” button in Fig. 1 to delete previously configured signals defined signals list.

The Waveform Signals defined are saved along with configuration.

## Signal Watch

---

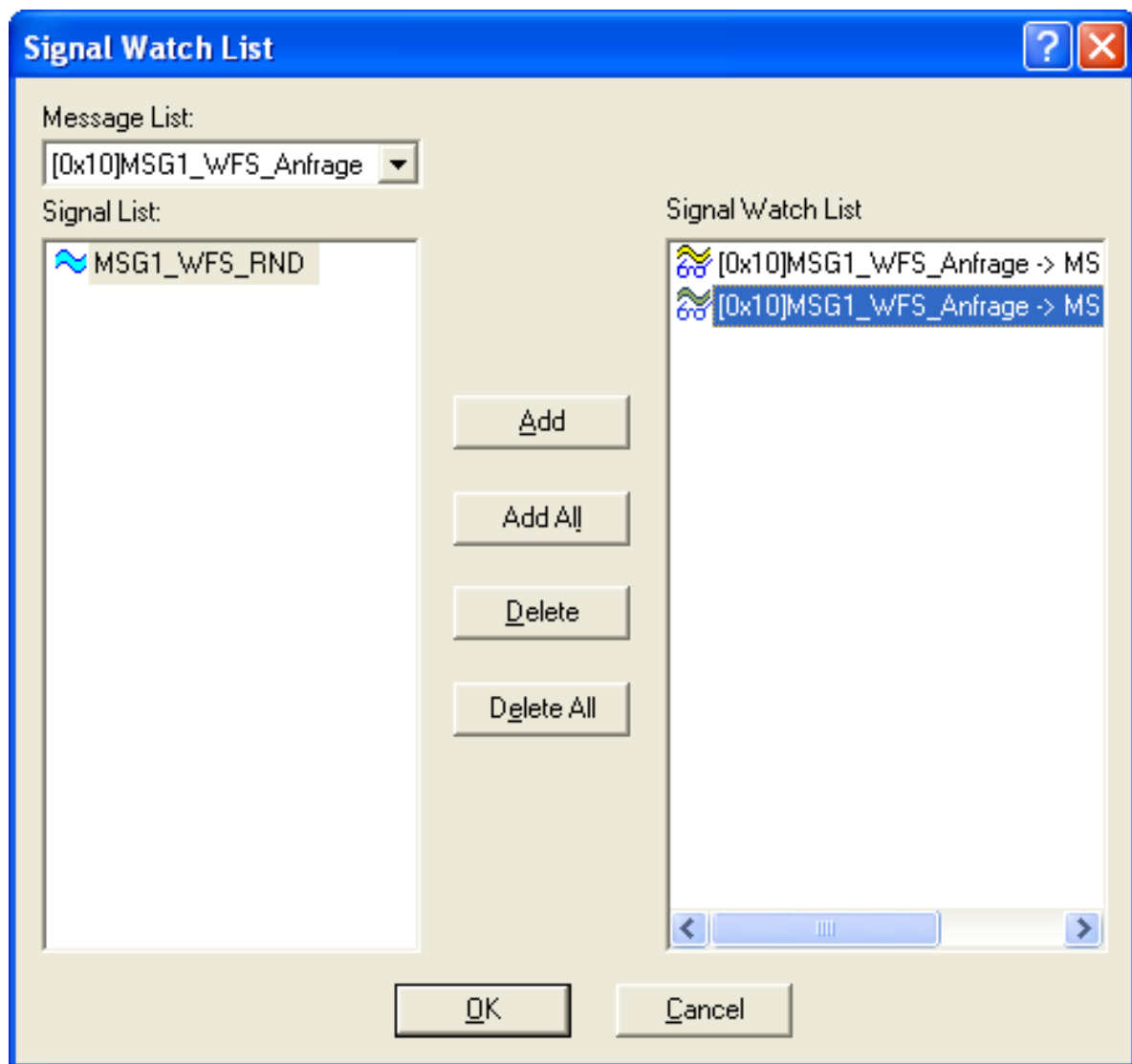
User can watch the value of a signal using the signal watch window as and when a message having that signal is received. The Physical and Raw values will be listed and updated as and when the message arrives. Click on the tool bar button shown below to display the signal watch window.



### Add/ Delete Signals

Signal watch list can be interactively populated. The following list describes the steps to Add/Delete signals from Signal Watch List.

- Click on **CAN --> Signal Watch --> Configure**.
- A dialog box will be displayed with all the database messages listed under the Message list and the list of signals defined in the selected message. The Signal Watch List will show the Watch List.



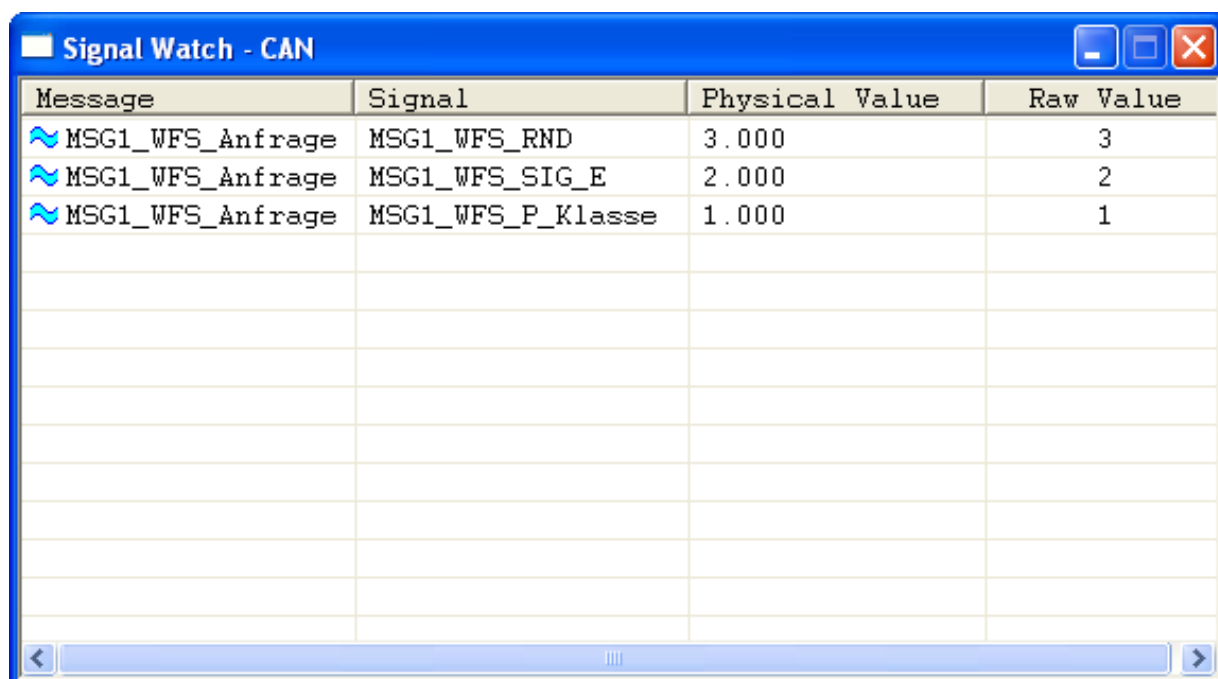
- Select a message and select associated signal from the Signal list. Select Add to move the selected signal in to Watch List. Multiple signals can be added by multiple selection and selecting Add button. All signals belonging to a message can be added in to the watch list by selecting Add All button.
- Double clicking the signal name in Signal List will add the signal in to the Watch List.
- Signal from the Watch List can be deleted by selecting the entry and by selecting Delete button. Multiple signals can be deleted by multiple selection.
- Signal Watch List can be cleared by selecting Delete All button.
- Changes will be saved and applied on selection of Ok. Cancel will ignore the changes.
- The Signal Watch List will be saved in the configuration file and will be reloaded during the load of that configuration file.



**Note:** To get details of a signal right click the signal and select Signal Details menu item. This will show signal details like start bit, length, type etc. in a dialog.

### Show Signal Watch Window

To popup signal watch window, select the toolbar button explained in the previous section and select Show. This will show the Signal Watch Window.



After receiving a message BUSMASTER will update the signal watch window if the signals of received message are included in the signal watch list. The signal watch list will show Raw and Physical value of the signal with the Unit along with Message and Signal name.

### Close signal watch window

User can directly close the window by clicking on Close [X] button.

OR

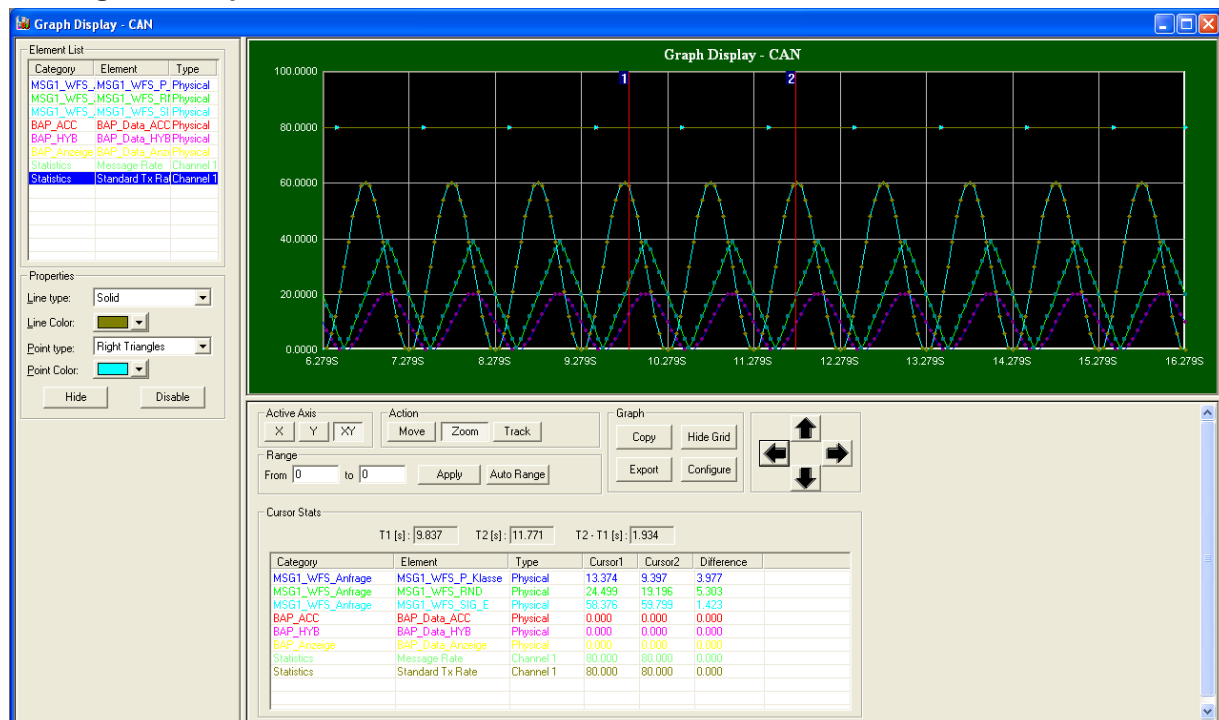
1. Click on the drop-down button associated with the tool bar button shown above. This will pop-up a menu.
2. Click on Close menu option to close the signal watch window.

## Signal Graph

## Graph Support for Signal and Statistics

BUSMASTER Graph supports plotting graph for signal values and statistics parameters. This includes raw and physical values of a signal. Network statistics parameters can be added to plot graph. The number of graphs plotted is limited to 10. Various types of graph are supported by BUSMASTER. This includes types, color and sample points highlight with symbols. For analysis of the plotted graph various graph manipulation options are provided. The graph data can be exported in various formats ranging from image to report.

## Starting With Graph



To Start with BUSMASTER graph select **CAN --> Signal Graph --> Activate** menu item. This will show Graph Display with configuration setting option. The left side view will show list of elements added for plotting the graph. Below the element list properties of the selected element will be listed. This includes line type and color, sample point symbol type and color. An element can be hidden from the display and an element can be disabled so that it will not get currently receiving data. To configure element list Configure button is provided. This will show a dialog with database messages and statistics parameters.

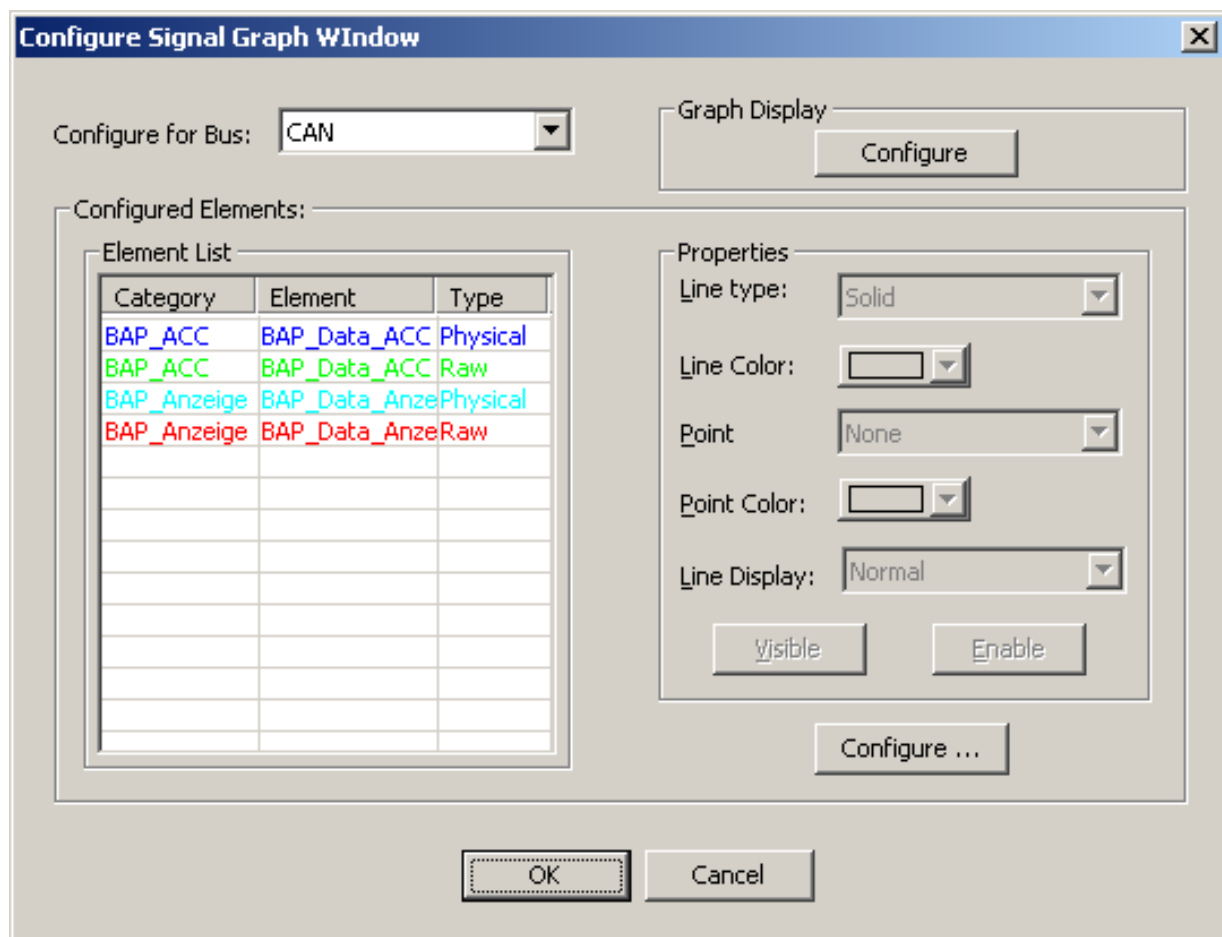
The right side view shows graph window. Below that controls are provided that will manipulate plotted graph. These ranges from basic manipulation of graph like moving, zooming and tracking the value. Advanced features like setting scale values automatically, setting all graph elements one below another and setting manual range. For easy navigation directional navigation keys are provided which will move the graph in the selected direction by one grid position.

Graph control shall be configured in terms of performance and view style. Graph buffer size and update rate can be configured by the user to optimize the performance. Graph window view style shall be fully configured by the user including colors of various graph window components. User shall configure the graph window to his known style like oscilloscope or Excel graph.

Data from graph buffer shall be exported in various formats. This includes exporting data as image, CSV used in excel and detailed HTML report. HTML report shall be printed after creation by BUSMASTER. This report shall be modified by the user after create using any HTML editor externally. This report will include graph elements detail like range, unit, color and min-max values.

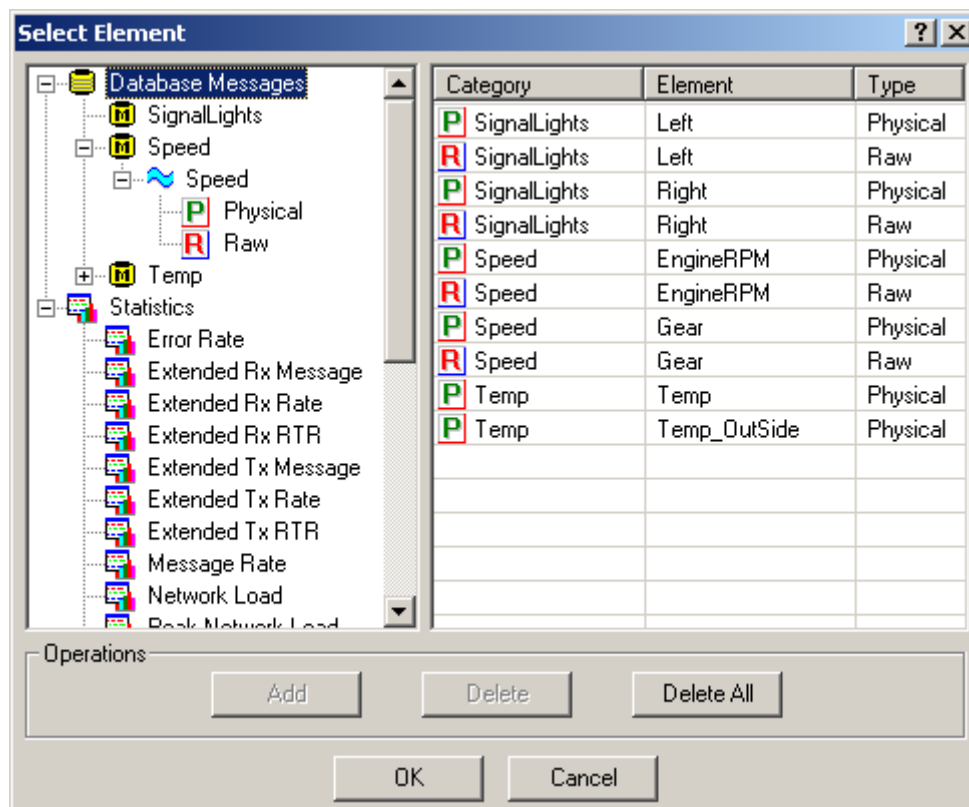
## Configuring Graph

To configure graph for a particular bus with graph elements or statistics elements select **CAN --> signal Graph --> Configure** menu item. This will show Configure Signal Graph Window dialog.



Select the bus name from the combo box for which you wish to configure graph elements data.

Click the 'Configure ...' button in the Configured Elements: group box shown in the above dialog. Element Selection dialog will be shown.





This dialog will show list of database message-signals and statistics parameters. Each signal will have physical and raw value entries. As soon as a signal value (physical or raw or both) is added in to the list that will be removed from the tree. To add an item, select the item (Physical or Raw value of signal or statistics parameters only) from tree and select Add button. This will add the item in to element list and will remove the item from tree.



**Note:**

- To add an item quickly, just double click the item.
- After an element addition element color and sample point type are automatically assigned.
- Only 10 elements are allowed to add. If elements count exceeds 10 the Add button will be disabled and double clicking the item will show error message.

To delete an item from the element list, select the item from the element list right side and select Delete button. This will remove the selected item from element list and will put the deleted item in to the tree at the appropriate place.

To delete all item from the element list select Delete All button. This will clear element list and will refresh tree to include all database messages and statistics parameters.

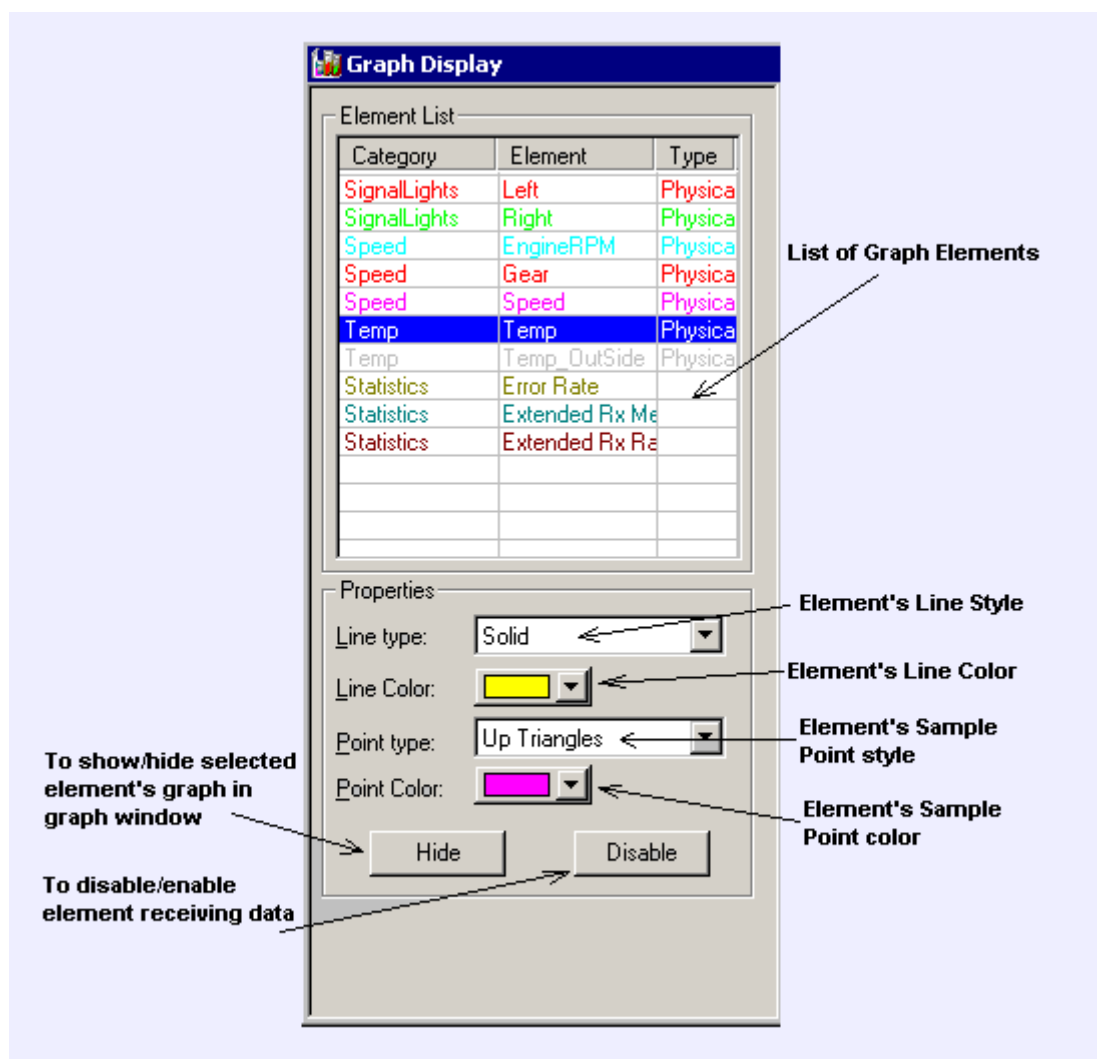


**Note:**

- To view details of a database signal just double click the item from element list. This will popup signal details dialog with signal definition.
- Selecting OK will save changes and will close element selection dialog .
- To undo changes done in element selection dialog just select Cancel button. This will ignore all changes done by the user.

## Graph Element List

The graph element list will be shown in left side view of graph window. This will show element name, category and value type. For a database signal this will show signal name, message name and value type. For statistics parameters this will show parameter name. Each element will be displayed in the color of that graph element. Selecting an element will update the element properties below the list.



Select a list item to see the element details and to modify the details. The selected item will be highlighted in the graph using bold solid line. Various line styles and point styles are supported by BUSMASTER. Sample points symbols will be drawn only if the tool is in disconnected state. When to tool is connected, the graph will go to tailored mode or run mode where cosmetic components of the graph will not be drawn.

### Line Type

BUSMASTER graph supports various types of lines ranging for different line styles to different line types. The following is the list of supported line types.

- Solid - Graph with solid line
- Dashed - Graph with Dashed lines
- Dotted - Graph with Dotted lines
- Dash-Dot - Graph with Dashed and Dotted lines
- Dash - Dot - Dotted - Graph with Dash followed by a Dot followed by a Dotted line.

### Line Color

Color of the graph line. User can select standard colors from the palette or user can define own color from the RGB and illumination space.

### Point Type

Type of the sample point element. User can select sample point symbols to highlight the points at which graph got samples. This will be disabled by selecting point type as NONE. BUSMASTER supports following symbol types.

- None ( To Disable Sample point Symbols )
- Dots
- Rectangles
- Diamonds
- Asterics
- Down Triangles
- Up Triangles
- Left Triangles
- Right Triangles

### Point Color

Color of the sample point symbol. User can select standard colors from the palette or user can define own color from the RGB and illumination space.

### Show/Hide

This is to show or hide a graph from graph window. The hidden graphs will not be plotted in graph window. But a hidden graph will receive samples if the tool is connected. User can be able to view the hidden graph at any point of time. This is to hide the graph from drawing.

### Enable/Disable

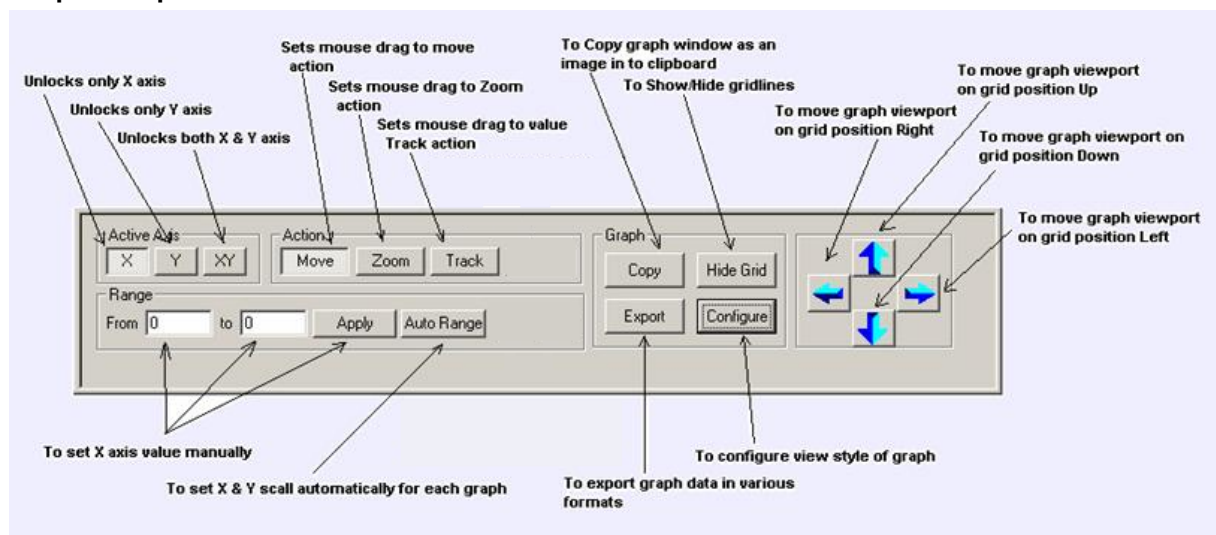
This is to enable or disable a graph element from receiving sample values. If a graph is disabled it will not receive any update for message/signals or statistics parameters. This is to avoid a graph getting samples from message/signals or statistics parameters. If the tool is connected and a graph element is disabled, it will not get latest values. If it is enabled again it will start getting latest values. Changing the enable property will reflect only if the tool is connected.



#### Note:

- Due to highlight, the line style modification will not be visible during selection. This will be visible if the selection moves to other element
- Disable is a run time option. This will be considered only if the tool is connected and message activity is on.

### Graph Manipulation Controls



### Active Axis

This unlocks mouse move only in the enabled axis. If X axis is selected only X axis value of mouse movement will be taken in to account. The behavior is same for Y axis too. If XY is selected then axis local will be removed and both X and Y will be considered for the action specified in the Action frame.

## Action

This setting will be taken during mouse drag. Action MOVE will move the graph while dragging the mouse in graph window. If ZOOM is selected the mouse drag will result in zooming the graph. TRACK will show the value at mouse cursor point in terms of selected element Y axis and X time axis values. The actions zoom and move are combined with active axis. If action is MOVE and active axis is X then mouse drag will move the graph only in X Axis. Similarly if action is ZOOM and active axis is X then mouse drag will zoom the graph only in X Axis (time scale zooming). Track will work independent of active axis. It will show both X and Y value of mouse point. This will freeze the graph from mouse drag actions and XY scale will remain same.

## Range

To set time axis value for all graphs this range option is given. This has inputs from and to. This will be the time axis min and max values. Valid time scale value shall be set by selecting the button Apply. Apply will validate time entered time scale value and will set the X axis time value. Decimal values could be entered to see the graph more closely.

## E.g.

- From 1 To 10 (Sec)
- From 2.23 To 2.24 (Sec)

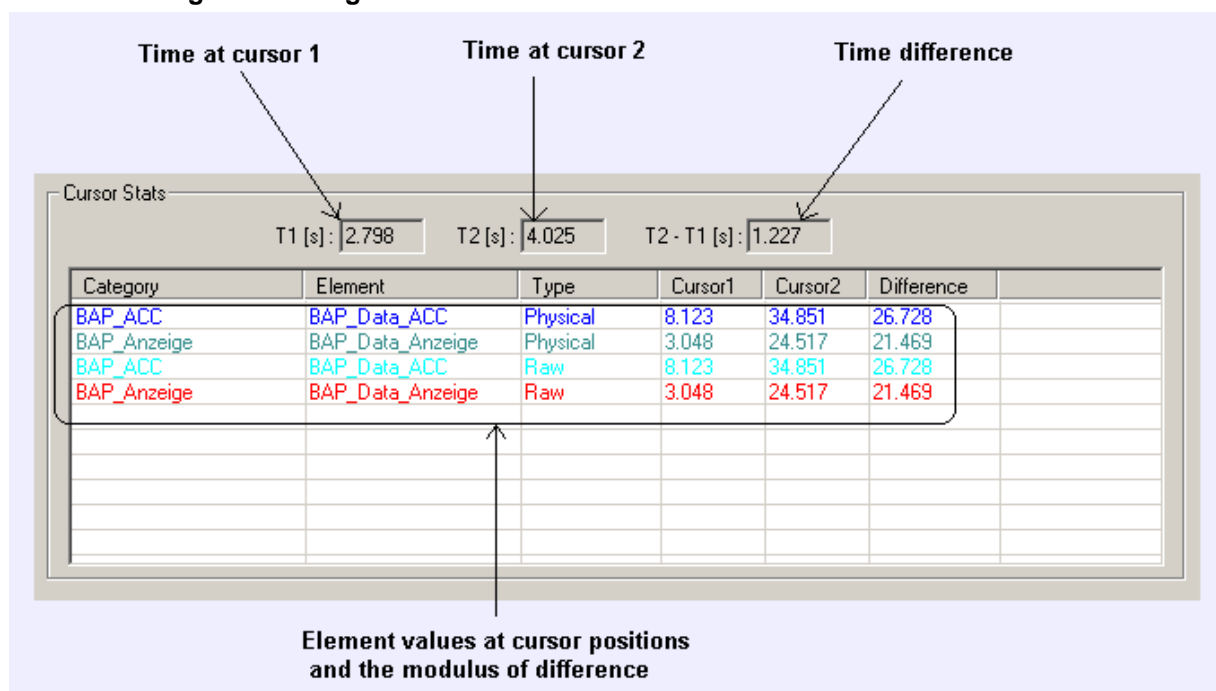
## Auto Range

To set optimal values for time axis and Y scale for all graphs auto range option is given. This will find the min and max time value to set optimal X Axis value. Each graph will set its own Y axis value such that the graph will occupy whole graph window. All graphs will overlap each other as each graph is utilizing whole graph window. This mode will be useful to find the overlapping between the signal values or to compare value of various signals and statistics parameters.

## Auto Fit

To set optimal values for time axis and Y scale will set to a value such that each graph will be displayed one by one. This will be useful to find all graphs with out any overlap. All graph elements will occupy portion of graph window so that its element value will not merge with other graph element. The whole graph area will be shared across all graph elements.

## Cursors for Signal Tracking



## Description

Cursors for Signal tracking is an offline feature available for viewing the element values at different time values.

Cursors can be activated by left mouse double clicks on the graph. When the two cursors are activated, user can view the time values at respective cursor positions and the element values in the bottom view of the graph as shown in the above figure.

User can deactivate the cursors by right mouse double click on the graph.

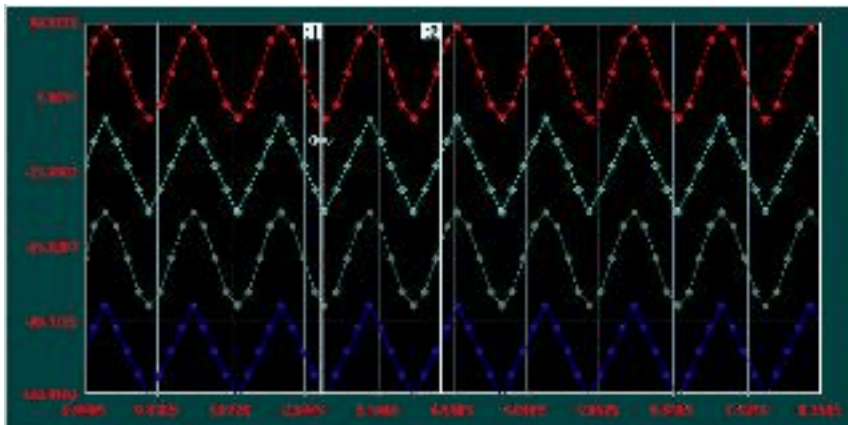
The time values at cursors are shown in a read only edit boxes. The list box shown in the above figure presents the interpolated element values at both the cursor positions and the modulus of difference between both the values.

## Track Mode

Track mode is activated by clicking the Track button in Actions group of Graph manipulations controls.

In this mode, user can drag the cursors to new time values. For this user has to position the mouse on the cursor which is to be dragged to a new position. Then keep holding the left mouse and drag the cursor to new position.

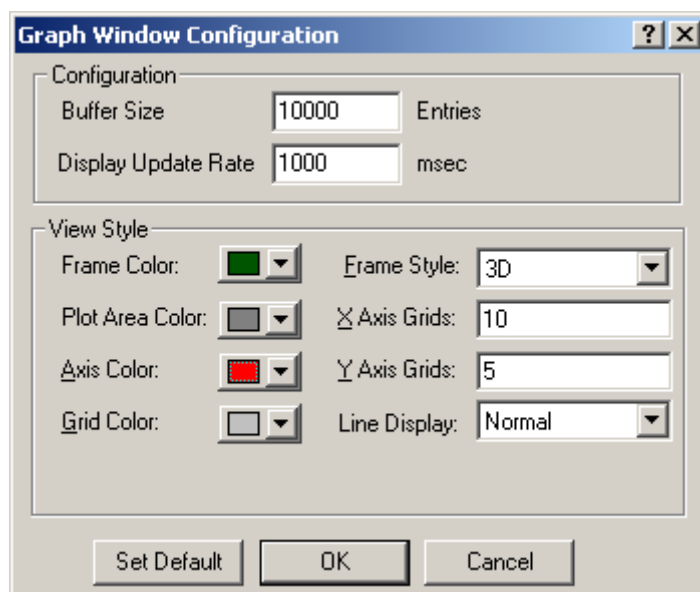
The image below shows the dragging of cursor to new time value.



If the user wants to clear the cursors on the graph at any point of time, right mouse double click will do the job.

## Graph Window Configuration

To change look and feel of graph select Configure button from right side view of graph window. This will popup graph configuration dialog. This dialog has various graph view style parameters.



### Buffer Size

User can configure graph buffer size in terms of number of entries in the graph. Buffer will be created with this size for each graph elements in the graph. If the graph has two message signals and two statistics signals and the buffer size is 10000 entries, each element can hold 10000 entries and individual buffers will be created to hold 10000 samples. Once the buffer will become full old data will be removed to make room for latest data. For optimal performance of the tool keep this buffer size minimum or with the default value. The supported value for this parameter is between 1000 - 50000 entries.

### Display Update Rate

This is the cyclic time delay after which the display will be updated. This refresh timer delay will be set to this value. The default value is 1000 msec or one second. The supported value for this parameter is between 1000 - 20000 millisecond.

### Frame Color

This is the color of the Frame. Frame is the rectangle area that covers the graph plotting area. This parameter depends on the frame style also. This color will be considered only for frame styles FLAT and SCOPE. Selecting this button will popup a dialog where standard colors will be displayed. There will be an option to give custom RGB values also.

### Plot Area Color

This is the color of graph elements plotting area. This forms the background of the graph area.

### Axis Color

This is the color of axis rectangle. Axis rectangle is visible only if the frame style is flat. Other wise this rectangle will be hidden by 3D border of the frame.

### Grid Color

This is the color of grid lines. This change will be visible only if grid lines are visible.

### Frame Style

Three types of frame styles are supported. FLAT, 3D and FRAME. In flat style axis rectangle will cover graph plotting area. This is a flat rectangle. In 3D style a 3D rectangle will cover graph plotting area. Axis rectangle will be in 3D format. In FRAME style a gradient picture will be used to cover plotting area.

### Grid Lines

This will configure number of grid lines displayed on X and Y axis. Supported range is 2 - 10. The grid line starts from left to right in case of X axis. The last grid line will merge with right side boundary. For Y axis grid lines will start from bottom to top. The last Y axis grid will merge with top boundary of the graph.

### Line Display

This will configure line display style of grid lines displayed on X and Y axis. Currently three styles of display are supported for graph drawing. They Normal , Step Mode XY (Graph will be advanced in X axis first and then in Y Axis.) and Step Mode YX (Graph will be advanced in Y axis first and then in X Axis.).

### Set Default

This will set all parameters to default values. View style parameters will be set to default color and style. Buffer size will be set to 10000 entries and display update rate will be set to 1000 msec.



#### Note:

- All graph window configuration parameters are saved in BUSMASTER configuration file. While loading a configuration file all are restored.

## Graph Export

BUSMASTER graph shall be exported in several types. These are Comma Separated Format or CSV, detailed HTML report and as a bitmap picture. In CSV export graph element details are exported with corresponding time values.

To make extensive test report HTML format will be handy. This will generate a report in HTML format with graph and elements details. The same shall be printed directly from BUSMASTER if Print option is enabled.

To save the graph window details as image, image export option is given. This will save the graph windows snapshot in to the specified bitmap file.

### Note:

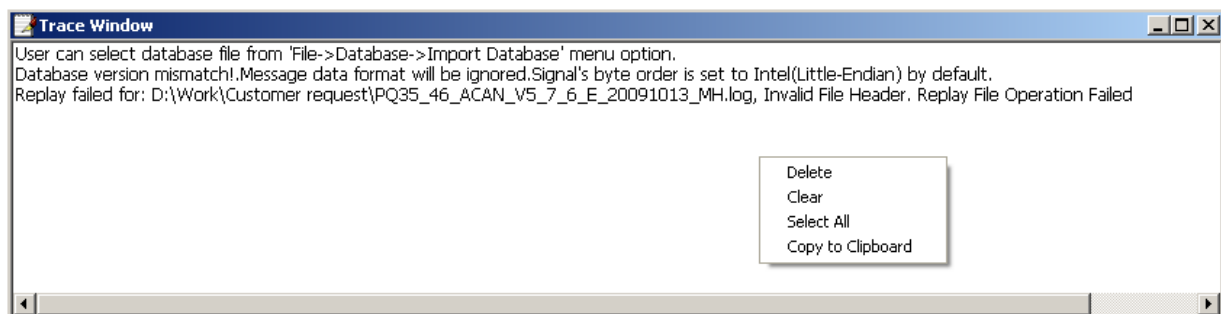


- CSV export will export only the data that is currently in element buffer of the graph.
- HTML report will take the snapshot of the graph window. This will not modify either time range or y axis appearance. User has freedom to set any time range and Y axis range. This should be done before exporting the report.
- To optimise printing, select light plot area color. This will make background of the graph lighter and elements can be easily identified.
- **Note:** Select Landscape as page format to fit whole report in one page.



## Trace Window

Trace window gives details about the result of the latest operation. Result can be information, warning or error. Below picture shows some text displayed in the trace window. This window basically contains a multiple selection list box where user can select, clear, delete the entries. It is possible to copy the text into clipboard also.



To display trace window Select the menu **Window --> Trace Window**.

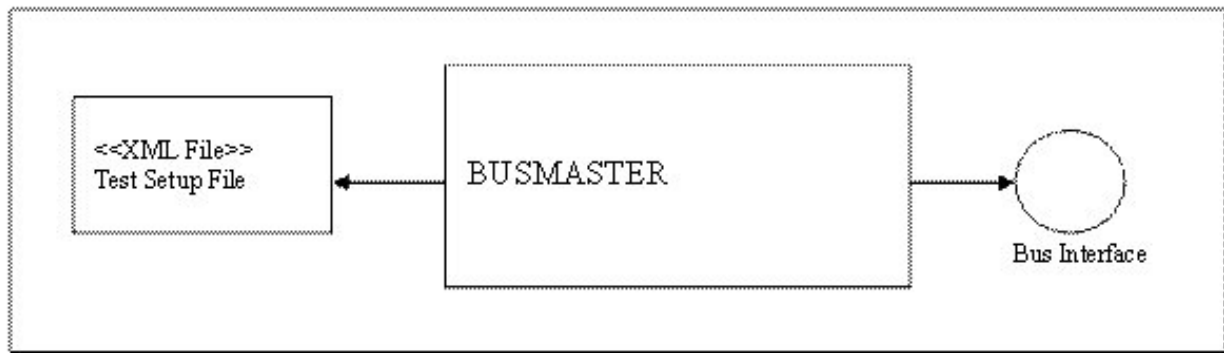
## Test Automation

### Introduction to Test Automation

Test Automation is a process of optimizing the effort in testing where the user only needs to define the test cases (rather than writing codes in Node programming). The test cases may be taken directly as input parameters for the execution of a testing session carried out by Test Automation module of BUSMASTER. This means user can expend more time for writing proper test cases rather than implementation issues of the same.

To be noted - this is neither a substitute nor a variant of node programming. In the former the actions are predetermined; it is only the parameter set (both in terms of signal value and time axis) that varies, whereas in the later the node behavior / logic are programmed. So the Test Automation is an extension of the tool to simplify the process of carrying out tests of a genre and generating the report.

A schematic diagram of Test Automation scenario is presented below:



Test Automation in BUSMASTER can be divided into three Modules:

- Test Setup File
- Test Setup Editor
- Test Executor

## Test Setup File

### Description

A test setup is a XML file which contains the instruction set of the various test cases. The contents test setup file can be divided as follows:

- Test setup := <Header> + <Test case list>
- Test case list := {test case 1, test case 2, ..., test case N}, where  $N \geq 1$
- Test case := {test step 1, test step 2, ..., test step N},  $N \geq 2$
- Test step := transmission / wait / replay / verification operation

### Explanation

- Test Setup: Test setup file contains two sections Header and Test Case List
- Header: Header contains the basic information regarding to the test setup file, like versions, report file path, database file path, ECU name, tester information etc. User has to provide the information. Some values are optional and some are compulsory. Database path is a compulsory value. Check the table below for the required and optional fields.
- Test Case List: Test Case List contains a collection of test cases. User has to create the test cases.
- Test case: A test case is the collection of test steps such as send, wait, replay, verify.
- Send: This is a collection of send\_messages. This test step instructs to send the specified messages.
- Send Message: This provides the details of message to be send. User has to initialize the messages and its signals. The default value assumed to the signals is 0. The message value may be given in engineering value mode or in raw value mode.
- Wait: Wait node instruct to wait certain period of time, expressed in terms of milliseconds.
- Replay: Replay node instructs to replay BUSMASTER log file.
- Verify: This is a collection of verify\_messages. This test step instructs to verify the specified messages (both Rx and Tx).
- Verify Response: This test step verifies the specified message responses (Rx Messages) within specified time. So this step requires a time interval.
- Verify Message: This provides the details of message to be verify. The user needs to formulate the validation condition. In the formula current signal value shall be denoted by 'x' following the algebraic notation. The presently supported logical operators are the eight: ==, >, <, >=, <=, !=, ||, and &&. By combining them suitably the following validation operations may be carried out:
  - Range of values; e.g.,  $(x \leq 10) \ \&\& \ (x \geq 50)$
  - Set of discrete values; e.g.,  $(x == 10) \ || \ (x == 20) \ || \ (x == 50)$
  - Formulation of any other validation procedure.

Here is a sample test file: [SampleTestSetupFile.xml](#).



The table below contains a concise description of each of the section details and error handling procedure in case of absence of any information.

Section (tag)	Description	Assumed value if absent	Error condition if absent
Test setup (testsetup)	The root node. Accompanied by its title (title) and version information (version)	-	Fatal
Database file (database)	Database file		Fatal
Version (version)	Version information of the test setup	1.0	No error
Module Name (module name)	Module focused on for the testing	-	No error
Engineer's name	Test engineer's name	-	No error
Engineer's role	And role / designation	-	No error
Report file path (path)	Particular of the report file to be generated.	Current working directory with the name same as the test setup.	Error
Report file format (format)	Format of the report file. Can be one of TXT and HTM	TXT	Warning
Report file time mode (timemode)	Time mode. Can be one of SYS (system), REL (relative) and ABS (absolute)	SYS	Warning
Bus type (bustype)	Bus type. At present can be only CAN	CAN	Fatal
Test case list (list_of_test_cases)	Collection of test cases.	Nil	Error. There must be at least one entry.
Test case (testcase)	Collection of test steps. A test case contains identifier, title and exception handler. The last one instructs if in case of failure to continue or exit.	Nil	Error. There must be at least an entry.
Test case title (title)	Test case title	-	No error
Test case exception handler (exp_handler)	Instructs if in case of failure the testing process exists or continues. Can be one of continue or exit	continue	Warning

Section (tag)	Description	Assumed value if absent	Error condition if absent
Transmission (send)	Collection of the messages to be transmitted.	-	No error
Transmission message details (send_message)	Details of the message list to be transmitted.	Nil	Warning
Send message id (identifier)	Identifier of the message.	-	Error. The test case shall be dropped.
Send message unit (unit)	Unit type of the signals. Can be either raw (raw) or engineering (eng)	Engineering value	Warning
Signal (signal)	Details the signal with its name (name) and value.	-	Error. The test case shall be dropped.
Verification (verify)	Verification instruction set. Contains a collection of verification messages.	Nil	Error. A test case must have a validation routine. Test case shall be dropped.
Failure classification (failure)	For a verification procedure – how to classify validation failure. Can be one of warning, error, fatal	Error	Warning.
Verify message details (verify_message)	Details of the message list to be verified / validated.	Nil	Error. The test case shall be dropped.
Verify message signal detail (signal)	Details of a signal under a verify message node. The attribute required is the signal's name (name). The node value shall be a string with formulation of the condition. This shall follow the syntax mentioned in the table below.	Nil	Error. The test case shall be dropped.

So, As explained above the test setup file has to write in XML format. So user has to know the syntax of XML and the test set up file. But To simplify this process BUSMASTER provides an editor called Test Setup Editor.

## Test Setup Editor

Test setup Editor is useful to create and edit a test setup file. Here is the list of different services rendered by the editor.

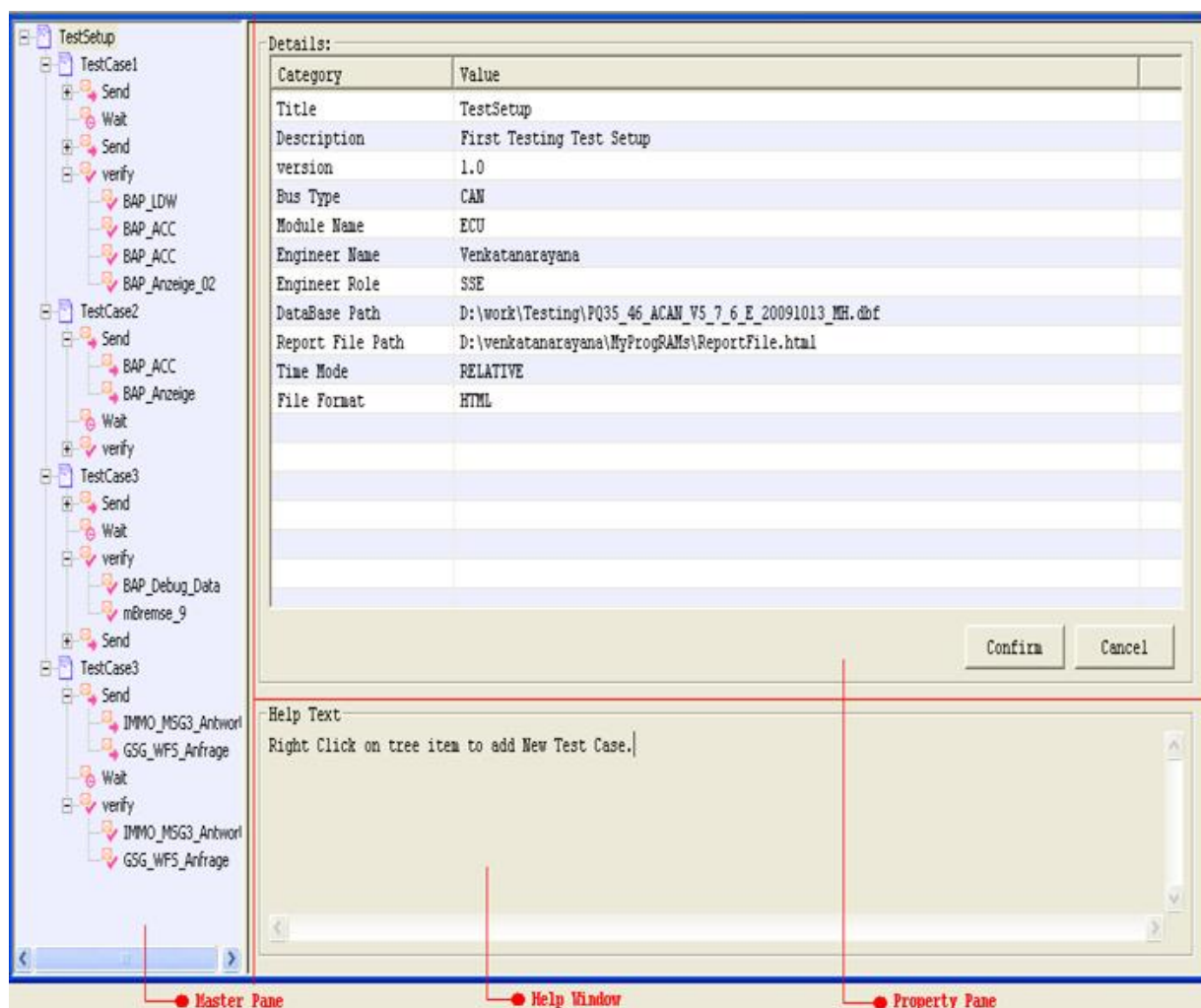
### Features provided by test setup editor

- Create a new test setup file
- Save a test setup file
- Load an existing test setup file
- Create, edit and update a test case
- Define a test case by adding its sub nodes like send, wait, verify, and replay
- Reposition a test case
- Delete a test case
- Create, edit, and update a new test case node
- Adding, deleting a send message to send node
- Initialization of a send message node
- Adding and deleting a verify message node to verify node
- Create a validation procedure for each signal in the verify message
- Create a wait node
- Repositioning a test case sub node
- Copy, cut, paste operation on Test case and its sub nodes
- Validate the test setup file

### Invoking Test setup editor

To open the test setup editor, In BUSMASTER click on menu Item **CAN --> Test Automation --> Editor**.

The first look of Automation Editor will be as shown in the figure below. To make things easier the BUSMASTER Menu will be replaced with the Test Automation Editor.



**Master Pane:** The master pane or right pane can be used to add or update the test cases.

**Property Pane:** The user can use the Property pane or Left pane to update the details of a Test case or its sub nodes.

- It contains a table with two columns **Category** and **Value**. The value in **Category** field can not be changed and it's like a question. To update the value in any row of **Value** column double click on the cell item. An edit box or a list control will appear according to the context.
- Also the pane contains two buttons **Confirm** and **Cancel**. The **Confirm** button can be used to save the current changes made to the node. Note that these changes will not be saved to file. For saving into a file select **File > Save** (see following section for menus). The **Cancel** button Will cancel all the changes made and display the previously saved data.

**Help Window:** The help window will provide help on every node. Click on any item on right pane to get the details of that node.

## Test Setup Editor Menu

The functionalities, provided by the Test Setup editor, are grouped under the Test setup editor Menu. This Menu will be shown in BUSMASTER when the editor is in active mode or user clicked on the Editor.

**File :** The **File** menu contains all most all the functionalities provided by the editor. It contains the following sub menus.

- **File > New :** Use to create a new test setup file. **Ctrl + N** is the keyboard short cut.
- **File > Open :** Use to Open an existing test setup file. **Ctrl + O** is the keyboard short cut.
- **File > Close :** Closes the current file.
- **File > Save :** Saves the current changes to the file. **Ctrl + S** is the keyboard short cut.
- **File > SaveAs :** Saves the current data into another file.
- **File > Validate :** Validates the current file according to the table under Test Setup File.
- **File > Exit :** Closes the editor.

**Edit :** The **Edit** menu will provide the operations such as cut, copy, and paste.

- **Edit > Copy :** Any item on the right pane can be copied using this menu. **Ctrl + C** is the keyboard short cut.
- **Edit > Cut :** Using this menu any item on the right pane can be deleted by copying it. **Ctrl + X** is the keyboard short cut.
- **Edit > Paste :** The copied item can be inserted under any parent item by selecting the parent item and this menu. For example the copied `send_message` can be inserted in any send node of any test case.

**Display :** The **Display** menu is used to customize the GUI.

**Help :** The **Help** menu provide the version details about the editor and also opens this help file.

## Using Editor

- Creating a new test setup file: Select **File > New** menu. A file browser will be displayed. Select a required folder and enter the file name. Click on **OK**. The editor will create a new test setup file and a new test setup with some initial values.
- Updating test setup: Initially the name of test setup will be **<New Test SetUp>** displayed in right pane. Click on this item (test setup node) and update its details such as test setup name, description, version, bus type, module name, engineer info, report file path and database in left pane. The database path is very important.
- Creating a test case: Right click on the test setup node on right pane. A pop up menu will appear click on **New Test Case**. A new test case with Initial name **Untitled TestCase** will be created.
- Updating a test case: Click on required test case node. The left pane will show the details of test case and you can edit the details and click **Confirm** button.
- Deleting a test case: Right click on required test case node. A pop up menu will displayed. Click on **Delete** item. The test case will be deleted from the test setup.
- Adding a new test sequence: Right click on required test case node. A pop up menu will be displayed. Click on **New** menu and select the required node.
- Updating a test sequence: Click on any test sequence item. And edit its detail in left pane and click on **Confirm** button.

- Deleting a test sequence: Right click on any test sequence item. A pop up menu will appear. Click on **Delete** item to delete the node.
- Adding a message: To add the messages in send, verify etc nodes, Click on the required send node. Double click on the **[Add message]** cell on right side. If a database is added in the Test setup node, A list box containing the messages will appear. Select a message to add in list. After adding a new row with **[Add Message]** will be added in list box in order to add another message.
- Delete a message: To delete a message double click on that message. Select **[Delete Message]** in list in order to delete the message.

## Test Suite Executor

Test suite executor is used to execute one or more test setup files sequentially. The result of execution will be logged into the result file specified in test setup file. The collection of test setup files are called test suite. Here is the list of different services rendered by the editor.

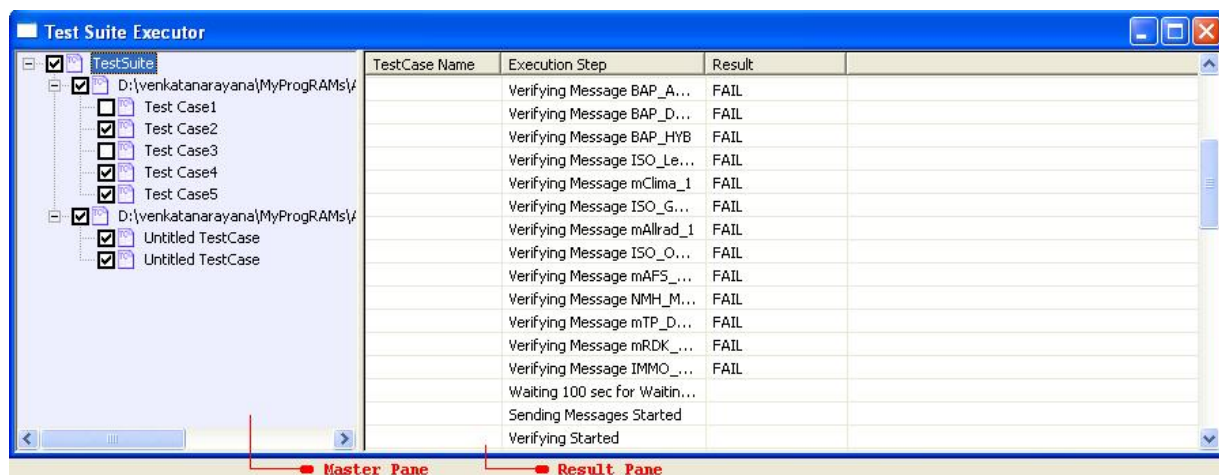
### Features provided by test suite Executor

- Adding a test setup files
- Delete a test setup file from the execution
- Select/Deselect a test setup file for execution
- Select/Deselect a test case for execution
- Execute the test suite

### Invoking Test suite Executor

To open the test suite editor, in BUSMASTER click on menu Item **CAN --> Test Automation --> Executor**.

The first look of test suite is shown in the following figure:



**Master pane:** Using this pane we can add test setup files and select and deselect a test case. All the functionalities described in the following section can be performed using this pane.

**Result pane:** The **Result pane** will display the current execution status of the test suite.

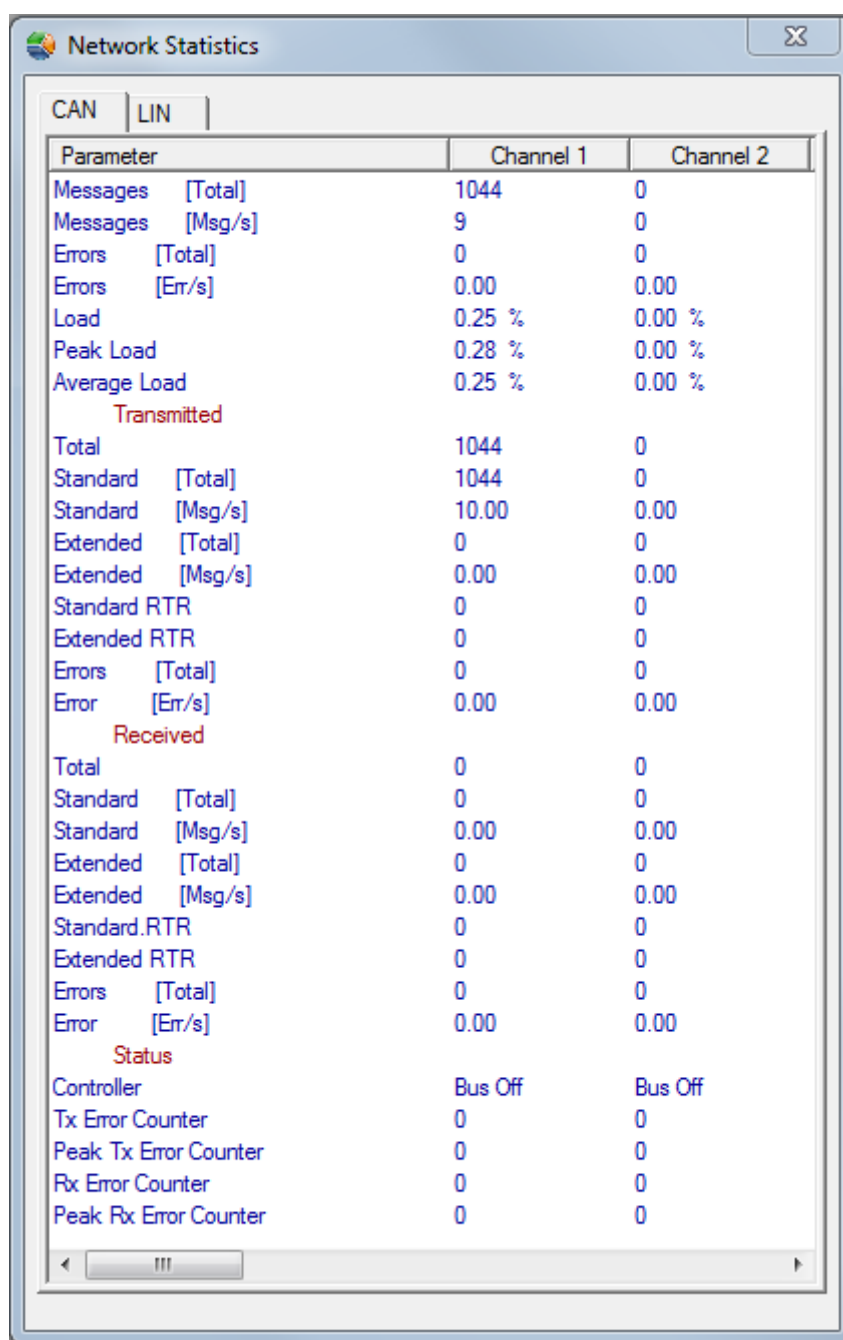
### Using Executor

- Naming a test suite: Double click on the top most tree node (test suite node) on master pane. A edit box will appear, give a suitable name and press **enter**.
- Adding a test Suite: Right click on the test suite node. A pop up menu will displayed. Click on **Add Menu**. A file browser will appear where you can select a test setup file. If the file is correct one the executor will add it in test suite and displays all its test cases.
- Select/Deselect a test suite: To select or deselect test setup for execution click on the check box located near the test setup file.
- Delete a test setup file: Right click on the required test setup file and select **Delete** in the pop up menu.

- Select/Deselect a test case: Click on the check box of particular test case to enable or disable it for execution. Note that if the test setup is deselected from the execution then all its test cases are not executed.
- Execute test suite: Right click on the test suite node and select **Execute** in the pop up menu. Each selected test case is executed and the summary will be displayed in **Result** view.

## Network Statistics

Network statistics dialog gives details about the messages transmitted and received on the bus. This information includes the number of Standard, Extended, RTR and Error messages transmitted and received by BUSMASTER and current rate of these parameters. This is updated once in a second. Message rate per second and Network load in terms of Bus traffic is also presented. The peak network load will show the peak traffic during that session. This information can be used to find bus utilisation. Statistics information will be cleared during connect and during controller reset.



Parameter	Channel 1	Channel 2
Messages [Total]	1044	0
Messages [Msg/s]	9	0
Errors [Total]	0	0
Errors [Err/s]	0.00	0.00
Load	0.25 %	0.00 %
Peak Load	0.28 %	0.00 %
Average Load	0.25 %	0.00 %
<b>Transmitted</b>		
Total	1044	0
Standard [Total]	1044	0
Standard [Msg/s]	10.00	0.00
Extended [Total]	0	0
Extended [Msg/s]	0.00	0.00
Standard RTR	0	0
Extended RTR	0	0
Errors [Total]	0	0
Error [Err/s]	0.00	0.00
<b>Received</b>		
Total	0	0
Standard [Total]	0	0
Standard [Msg/s]	0.00	0.00
Extended [Total]	0	0
Extended [Msg/s]	0.00	0.00
Standard RTR	0	0
Extended RTR	0	0
Errors [Total]	0	0
Error [Err/s]	0.00	0.00
<b>Status</b>		
Controller	Bus Off	Bus Off
Tx Error Counter	0	0
Peak Tx Error Counter	0	0
Rx Error Counter	0	0
Peak Rx Error Counter	0	0

To invoke Network Statistics Dialog, select the menu **Window --> Network Statistics**.

## Configuration settings in a file

---

User can save your preferences of the tool into ".cfx" file. The last loaded configuration file will be loaded automatically when the tool is run for the next session. If the configuration file is not found then, the application will load the default configuration settings and the status of the loaded configuration filename will be shown on the status bar.

### Creating New Configuration file

1. Select **File --> New** menu option. This will invoke file Save dialog box.
2. Enter the new configuration file name. And select Save button. The new configuration file will be loaded and the same filename can be seen on the status bar.

### Loading a Configuration File

1. Select **File --> Load...** menu option. This will invoke file Open dialog box.
2. Select the configuration file name. And select Open button. The selected configuration file will be loaded and the loaded configuration file will be displayed in the status bar. The same configuration file will be displayed on the top of MRU configuration file list ( **File > Recent Configuration** ).
3. Selecting a configuration file name from the MRU list will also do loading of the configuration file. If load is successful then the same configuration file will be displayed on the top of MRU configuration file list.



#### Note:

- While loading BUSMASTER with parallel port interface created configuration file in to USB interface, checks have been made to find unsupported options. If anything found user will be informed about that and BUSMASTER will changes those values to default internally. These changes will not be saved unless the user selects File Configuration Save. Configuration file created in BUSMASTER with USB interface can be loaded in to BUSMASTER with Parallel port interface.

### Saving a configuration file

1. Select **File --> Save** menu option. This will invoke File Save dialog box.
2. Select the configuration file name. And select Save button.
3. The selected configuration file will be saved. The same configuration file will be displayed on the top of MRU configuration file list ( **File > Recent Configuration** ).

### Saving a configuration file with new name

1. Select **File --> Save As** menu option. This will invoke File Save As dialog box.
2. Enter new configuration file name. And select Save button. The selected configuration file will be saved.

If the loaded configuration file is changed during the usage of the tool, a save confirmation message is displayed to the user before closing the application.

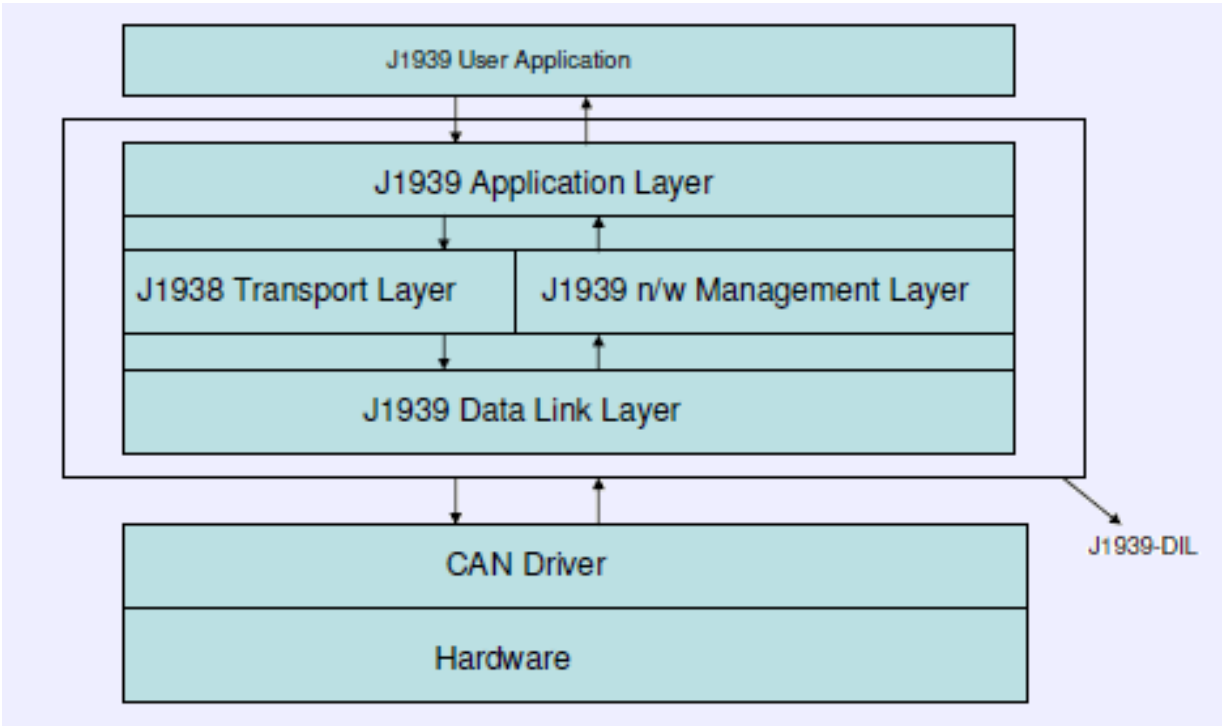
## J1939

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### Introduction

J1939 is a CAN-based layer 7 protocol mainly used in Truck and Bus control and communications. The typical properties of J1939 are:

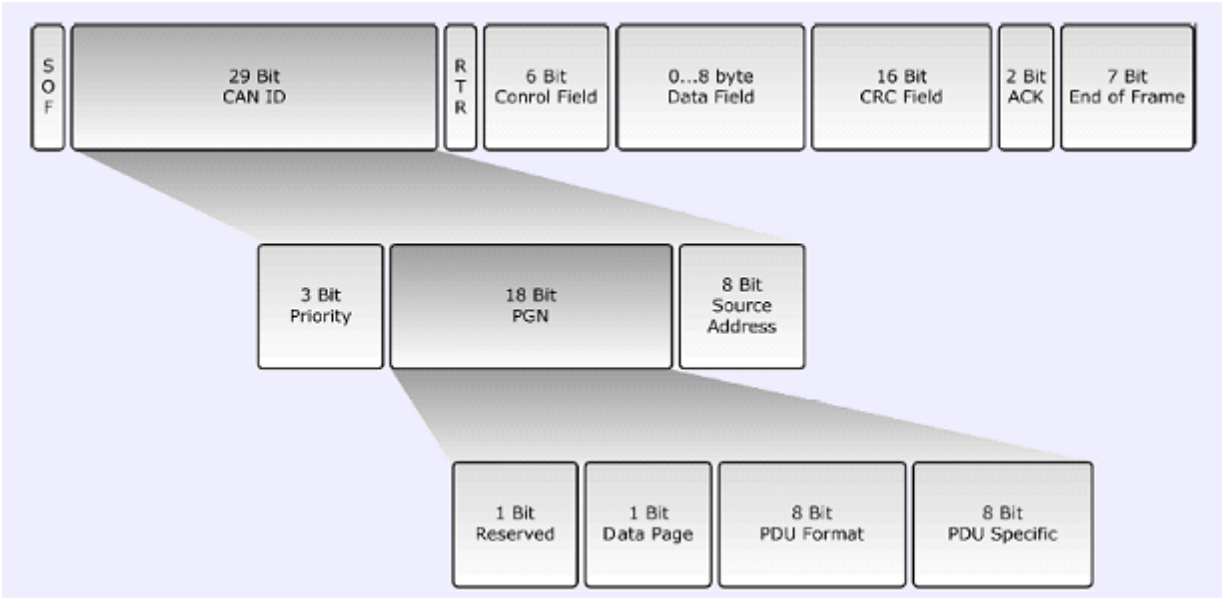
- 29 bit extended CAN identifier.
- Point-to-point and broadcast communication.
- Transmission up to 1785 bytes.



**J1939 Protocol Stack**

**Parameter Group Number (PGN):**

PGN identifies the Parameter Group (PG). PGs point to information of parameter assignments within 8 byte CAN data field, repetition rate and priority. The structure of PGN allows a total of 8672 different Parameter Groups per page – 2 pages are available.



**Parameter Group Number**

**Transport protocol function**

Transport protocol functions are mainly used for transmission and reception of multi-packet messages which can extend upto 1785 bytes. Function involves packaging into sequence of 8 byte size messages during transmission, re-assemble of such data at the receiver side.

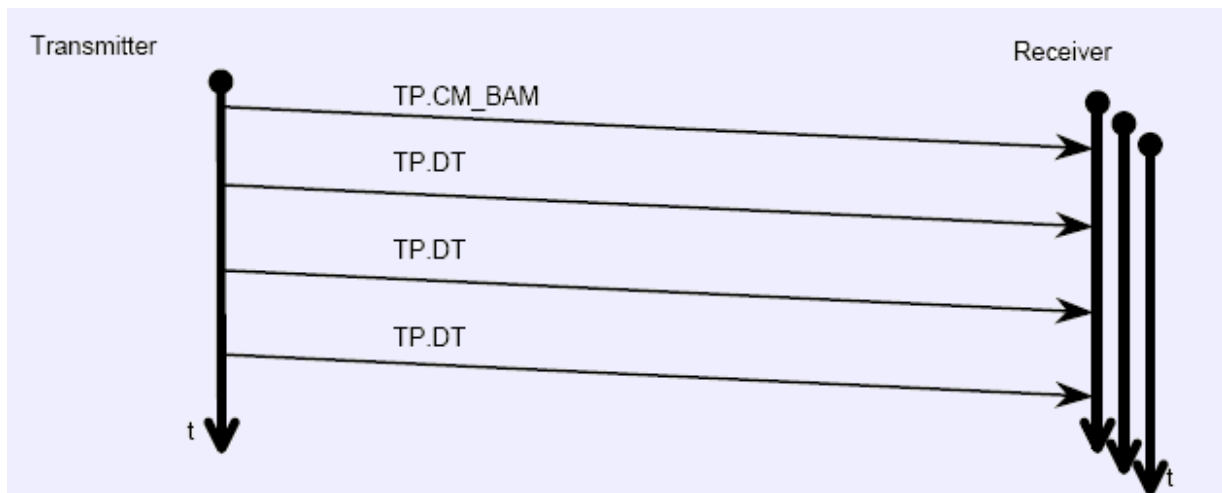


### 1. Multi-packet broadcast

A broadcast message is broadcasted to all nodes in the network. Sender node must first send a Broadcast Announce Message (BAM) followed by sequence of 8 byte data. Receiving nodes can prepare for reception if interested.

BAM message contains following information.

1. PGN to be sent
2. Size of multi-packet message
3. Number of packages



### Multi-packet broadcast data transfer

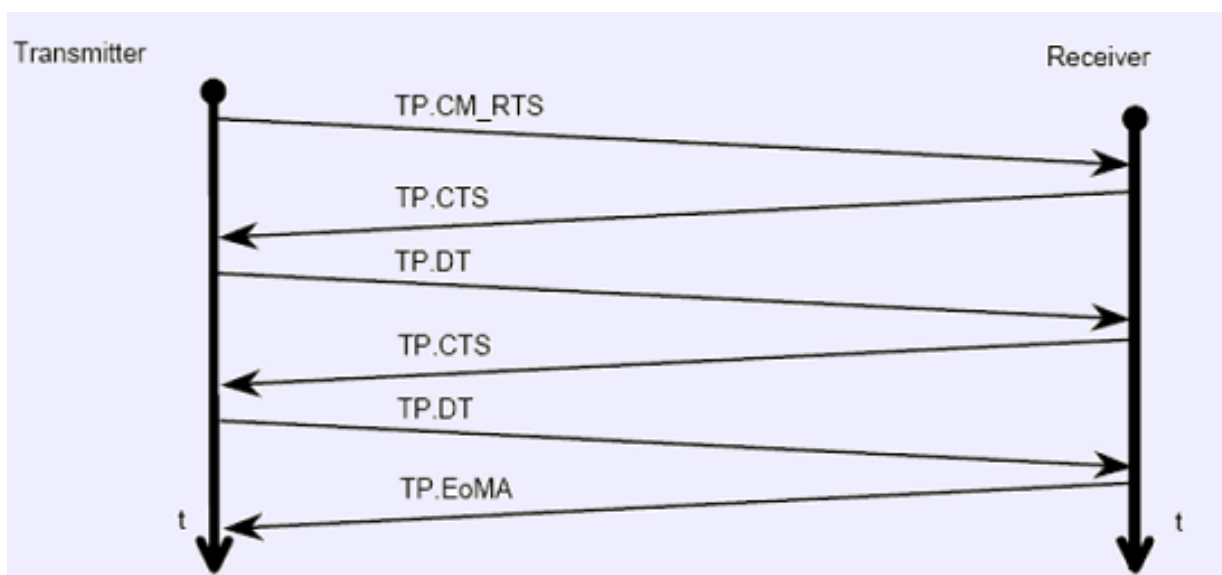
#### 2. Multi-packet peer-to-peer

For destination specific data transmission, communication needs to be established hence subject to flow control. Transport protocol function is applied in three steps.

**1. Connection Initialization** - The sender of a message transmits a Request to Send message. The receiving node responds with either a Clear to Send message or a Connection abort message incase it decides not to establish connection.

**2. Data Transfer** - Sender transmits data after receiving Clear to Send message.

**3. Connection Closure** - The receiver of the message , upon reception sends End of Message ACK message.

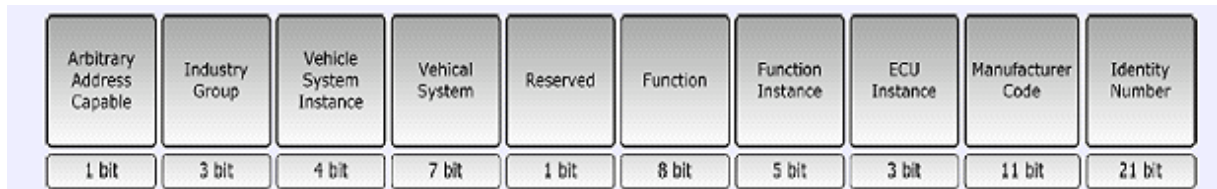


## Multi-packet peer-to-peer data transfer

### Network management

Each ECU in a J1939 network must hold at least one NAME and claim one 8 bit address for identification purposes.

**1. ECU NAME** - 64 bit identifier includes an indication of the ECU's main function performed at the ECU's address.



### J1939 NAME Fields

**2. ECU Address** - 8-bit ECU address defines the source or destination for messages.

### Address claiming procedure

The address claim feature considers two possible scenarios

**1. Sending an address claimed message (ACL)** - At the network startup, an ECU will cliam an address and send Address Claimed message. All ECUs receiving the address claim will record and verify the newly claimed address with their internal address table. In case of an address conflict, the ECU with the lowest NAME will succeed.

**2. Request for Address Claimed message** - An ECU Requests ACL message from all nodes in the network and claims available address.

## BUSMASTER.J1939

### Initialisation

Prerequisite of employing the J1939 functionalities is getting hold of J1939 interface, and this is the sole purpose of this function. This will query for the available J1939 interface. Once this is available, the associated menu item and button will be disabled. The query operation involves DIL.J1939 interface initialisation, a J1939 client registration and finally the J1939 logger interface query and initialisation. Outcome of the query operation can be seen on the Trace window.

### Configure Logging

This invokes the logging configuration dialog box whose layout and the configuration procedure is exactly same as that of CAN. Only difference is that for J1939 a message is identified not by CAN identifier, but by its PGN number.

### Start Network

This function connects the application to the J1939 network. Both the associated menu item and toolbar icon are toggling in nature and hence shuttle between "Go Online" and "Go Offline" modes.

### Transmit Message

This brings in the J1939 transmit message window in which the presently transmittable message can be configured and sent in both monoshot and cylcic mode.

## Logging

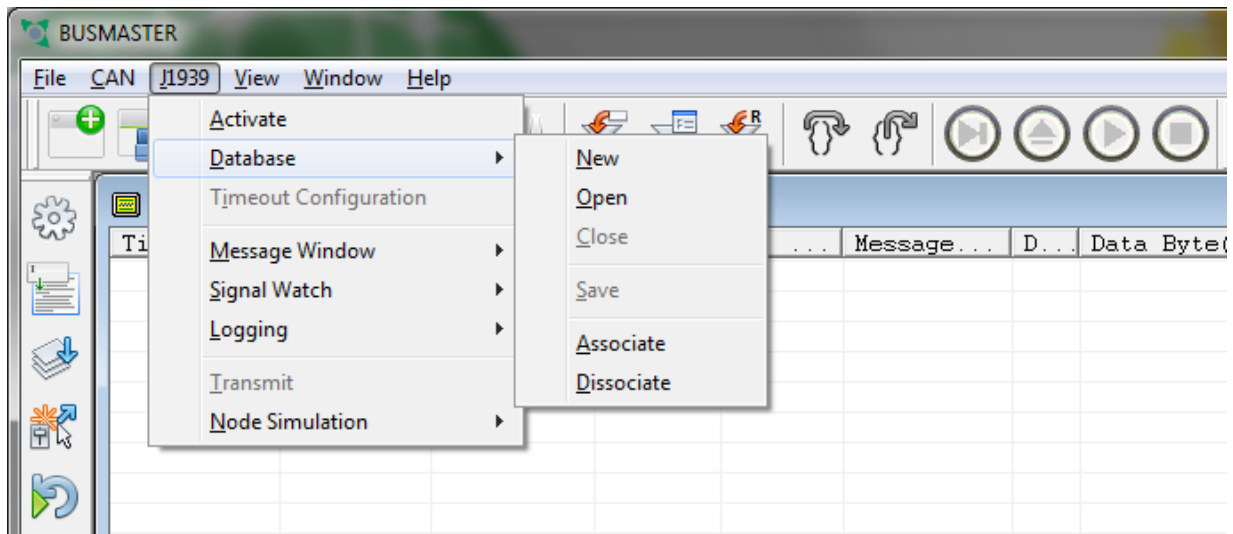
**<Time>	<Channel>	<CAN ID>	<PGN>	<Type>	<Src>	<Dest>	<Priority>	<Tx/Rx>	<DLC>	<DataBytes>	**
25:24:14:6112	1	18eeff00	00EE00	ACL	00	FF	006	Tx	8	01 00 00 00 00 00 00 80	
25:24:14:6124	1	18eeff00	00EE00	ACL	00	FF	006	Rx	8	01 00 00 00 00 00 00 80	
22:16:26:5893	2	18eeff00	00EE00	ACL	00	FF	006	Rx	8	01 00 00 00 00 00 00 80	
22:16:26:5905	2	18eeff00	00EE00	ACL	00	FF	006	Tx	8	01 00 00 00 00 00 00 80	
22:16:30:2136	2	1ceefffe	00EE00	ACL	FE	FF	007	Rx	8	01 00 00 00 00 00 00 80	
25:24:18:2355	1	1ceefffe	00EE00	ACL	FE	FF	007	Tx	8	01 00 00 00 00 00 00 80	
22:16:30:2148	2	1ceefffe	00EE00	ACL	FE	FF	007	Tx	8	01 00 00 00 00 00 00 80	
25:24:18:2367	1	1ceefffe	00EE00	ACL	FE	FF	007	Rx	8	01 00 00 00 00 00 00 80	
25:24:19:2432	1	1ceafffe	00EA00	RQST_ACL	FE	FF	007	Tx	3	00 EE 00	
25:24:19:2440	1	1ceafffe	00EA00	RQST_ACL	FE	FF	007	Rx	3	00 EE 00	
22:16:31:2213	2	1ceafffe	00EA00	RQST_ACL	FE	FF	007	Rx	3	00 EE 00	
22:16:31:2221	2	1ceafffe	00EA00	RQST_ACL	FE	FF	007	Tx	3	00 EE 00	
25:24:20:1554	1	1cecffff	00EC00	BAM	FE	FF	007	Tx	8	20 09 00 02 FF 00 EE 00	
22:16:32:1336	2	1cecffff	00EC00	BAM	FE	FF	007	Rx	8	20 09 00 02 FF 00 EE 00	
22:16:32:1347	2	1cecffff	00EC00	BAM	FE	FF	007	Tx	8	20 09 00 02 FF 00 EE 00	
25:24:20:1565	1	1cecffff	00EC00	BAM	FE	FF	007	Rx	8	20 09 00 02 FF 00 EE 00	
22:16:32:2337	2	1cebffff	00EB00	TPDT	FE	FF	007	Rx	8	01 01 00 00 00 00 00 00	
22:16:32:2349	2	1cebffff	00EB00	TPDT	FE	FF	007	Tx	8	01 01 00 00 00 00 00 00	
25:24:20:2555	1	1cebffff	00EB00	TPDT	FE	FF	007	Tx	8	01 01 00 00 00 00 00 00	
25:24:20:2567	1	1cebffff	00EB00	TPDT	FE	FF	007	Rx	8	01 01 00 00 00 00 00 00	
22:16:32:3342	2	1cebffff	00EB00	TPDT	FE	FF	007	Rx	8	02 80 FE FF FF FF FF FF	
22:16:32:3342	2	1ceefffe	00EE00	BROADCAST	FE	FF	007	Rx	9	01 00 00 00 00 00 00 80 FE	

## J1939 Log File

## Message Database

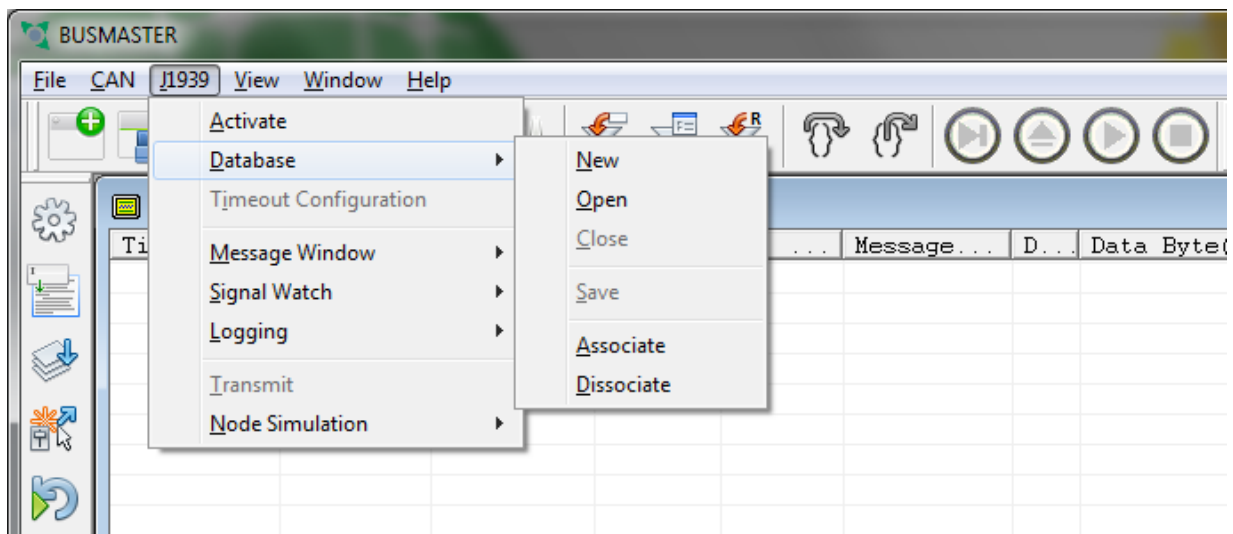
### 1. Database Editor:

J1939 database editor is similar to CAN database editor. User can define a new message based on its PGN and it can have maximum data size of 1785 bytes.



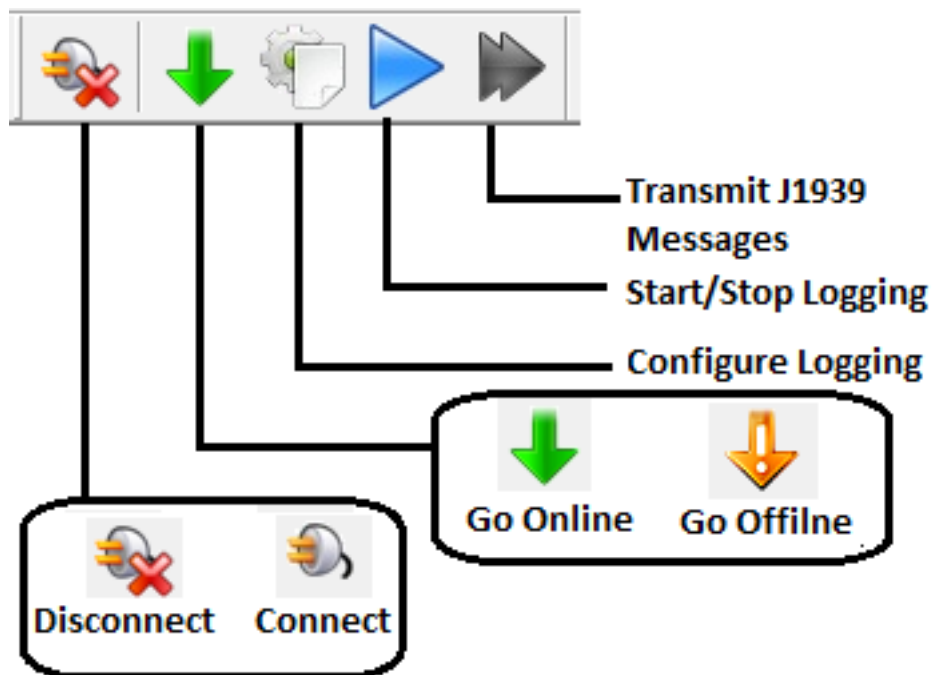
### 2. Database Function:

User can associate/dissociate J1939 database files.



### Toolbar

A separate toolbar is available for J1939 option.

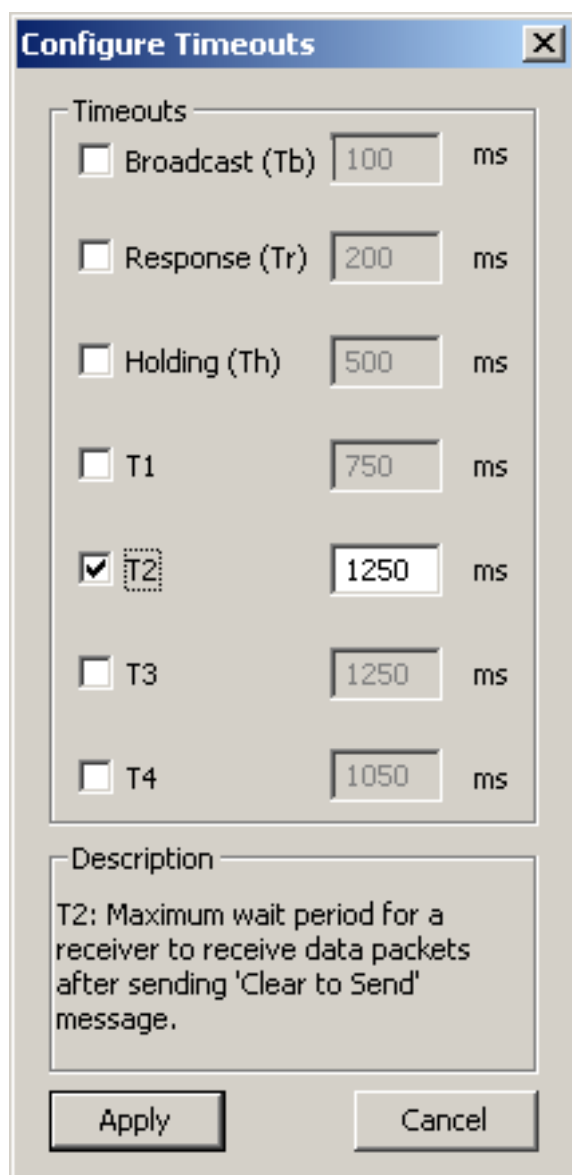


### Configure Timeouts

User can configure timeouts which will be considered when flow control messages are being sent or received.

Corresponding dialog box can be invoked by clicking the menu **J1939 --> Timeout Configuration**.

Timeout's description will appear on clicking the corresponding check box.



**Tb:** Time interval between two packets in broadcast transmission.

**Tr:** Maximum wait period for a sender to receive a response from the receiver.

**Th:** Time interval between two 'Clear to Send' message when delaying the data.

**T1:** Maximum wait period for a receiver when more packets were expected.

**T2:** Maximum wait period for a receiver to receive data packets after sending 'Clear to Send' message.

**T3:** Maximum wait period for a sender to receive 'End of Message Acknowledgement' after sending last data packet.

**T4:** Maximum wait period for a sender to receive another 'Clear to Send' message after receiving one to delay the data.

### Signal Watch

J1939 signal watch window is similar to CAN signal watch window. User can add SPNs(Signals) of the PGN defined in database.

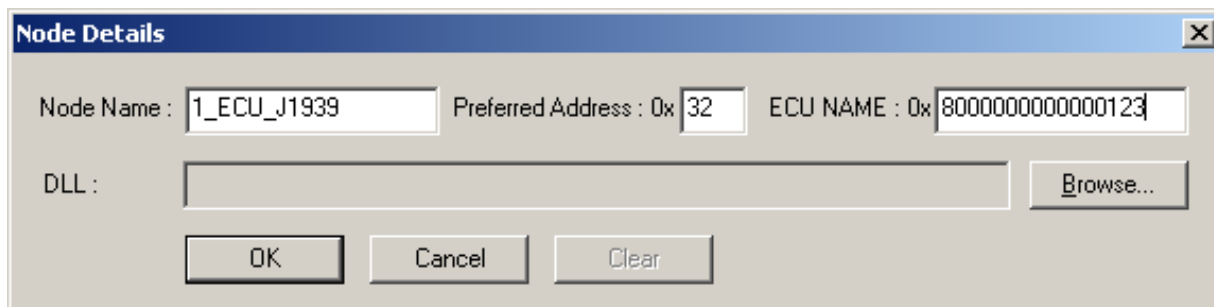
### Node Programming

Separate menu items are available for configuring J1939 node programming. Use '**J1939 --> Node Simulation --> Configure**' menu for configuring nodes and '**J1939 --> Node Simulation --> User Program**' menu for

Building, Loading and Execution of user dll handlers. Most of the features of J1939 node programming remain same as that of CAN. Few differences are listed down.

**1. Node Addition :** User has to provide following information to create a new node.

a. Node Name b. Preferred Address c. 64 bit ECU name.



The 'Node Details' dialog box contains the following fields and buttons:

- Node Name :** Text box containing '1\_ECU\_J1939'
- Preferred Address : 0x** Spin box set to '32'
- ECU NAME : 0x** Text box containing '80000000000000123'
- DLL :** Empty text box with a 'Browse...' button to its right.
- Buttons:** 'OK', 'Cancel', and 'Clear' at the bottom.

**2. Function Editor :** J1939 Function Editor is similar to CAN Function Editor. In addition to the handlers available in the CAN Function Editor it has **Event Handlers** where user can configure

- **Data confirmation event :** Handler is executed whenever a long(> 8 bytes) message is transmitted.


**void OnEvent\_DataConf(UINT32 unPGN, BYTE bySrc, BYTE byDest, BOOL bSuccess);**

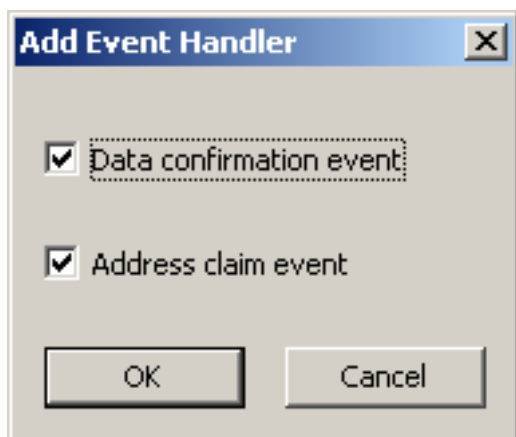
**unPGN** - PGN of the message transmitted. **bySrc** - Source node. **byDest** - Destination node. **bSuccess** - Result of transmission. ( TRUE-success, FALSE-failure)

- **Address confirmation event :** Handler is executed whenever a node claims or loses an address.

**void OnEvent\_AddressClaim(BYTE byAddress) ;**

**byAddress** - New Address claimed by the node. Address lost If the value is 254.

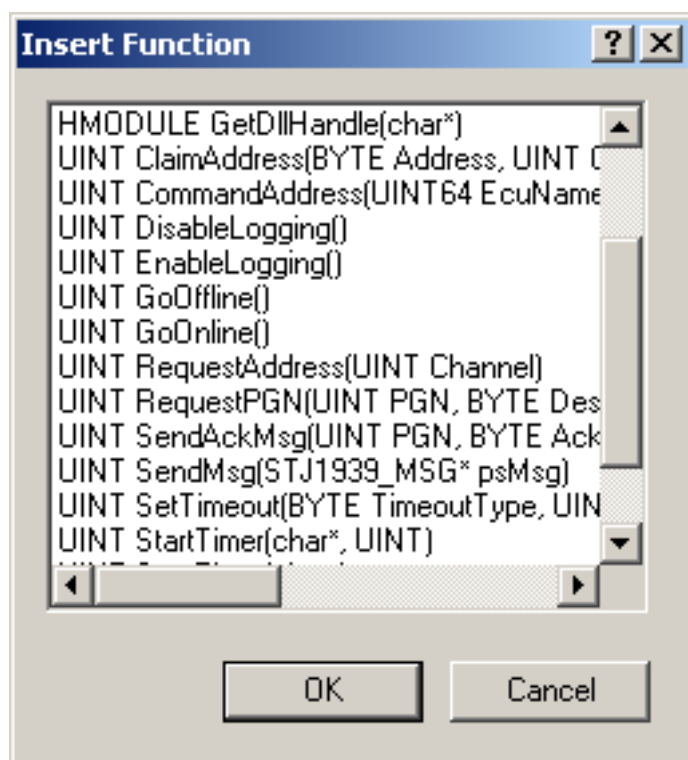
 **Note:** These event handlers are always enabled once added.



The 'Add Event Handler' dialog box contains the following elements:

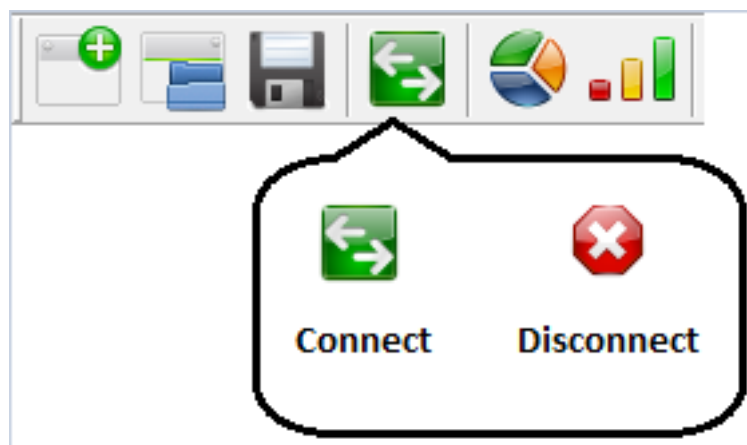
- ☒ **Data confirmation event**
- ☒ **Address claim event**
- Buttons:** 'OK' and 'Cancel' at the bottom.

**3. J1939 API Reference :** A new set of API is introduced in-order to perform functions on J1939 bus. Please refer following section API Reference J1939 for further details.



## Connect and Disconnect

User can connect/disconnect the tool from the CAN-bus by pressing/releasing a toggle toolbar button shown in the figure below.



The tool can also be connected by selecting **CAN > Connect** menu option (available only in disconnected state) or by pressing F2 function key. The same can be disconnected by selecting **CAN > Disconnect** menu option (available only in Connected state) or by pressing Esc key. When the tool is in connected state, the menu option will become Disconnect and when the tool is in disconnected state, the menu option will be displayed is Connect.

Transmission and reception of messages can be done only when the tool is in the connected state.

## Format Converters

### Format Converters:

Currently Five external tools are integrated with BUSMASTER.

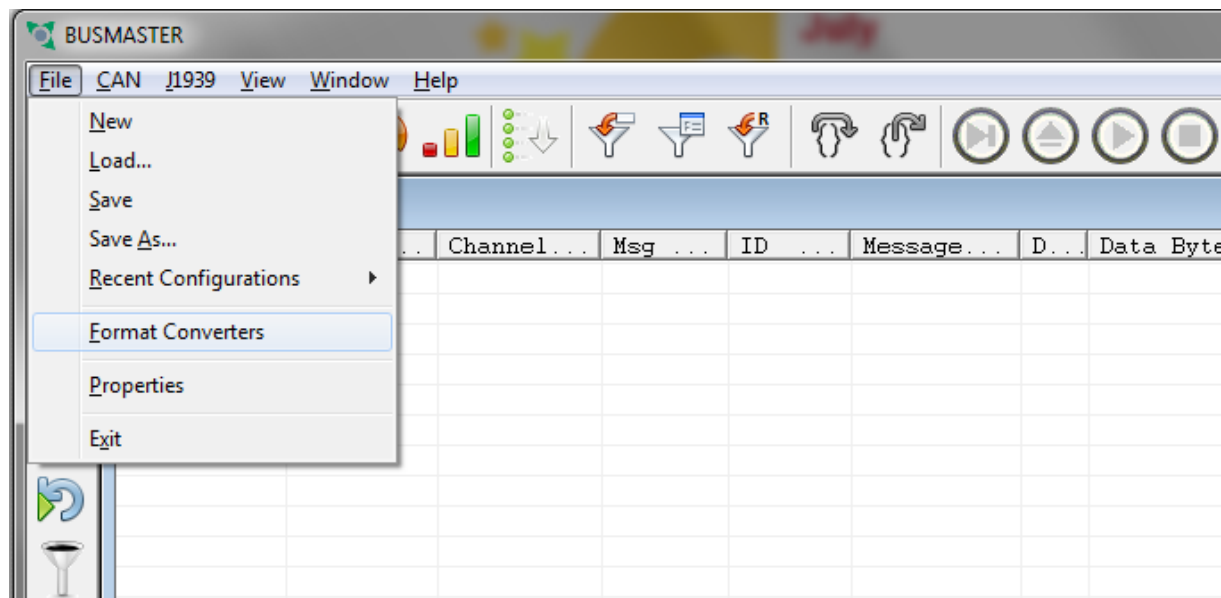
- CAPL To CPP Converter: Converts CAPL (\*.can) file into BUSMASTER CPP (\*.cpp) file.



- DBC To DBF Converter: Converts DBC (\*.dbc) file into BUSMASTER database (\*.dbf) file.
- DBF To DBC Converter: Converts BUSMASTER database (\*.dbf) file into DBC (\*.dbc) file.
- ASC TO LOG Converter: Converts CANoe log file (\*.asc) to BUSMASTER log file (\*.log)
- LOG To ASC Converter: Converts BUSMASTER log file (\*.log) to CANoe Log file (\*.log)
- Log To Excel Converter: Exports BUSMASTER log file (\*.log) to CSV (Comma Separated Values) Format.

#### Usage:

- To use the Converters select **File --> Format Converters** As Shown in the below figure.



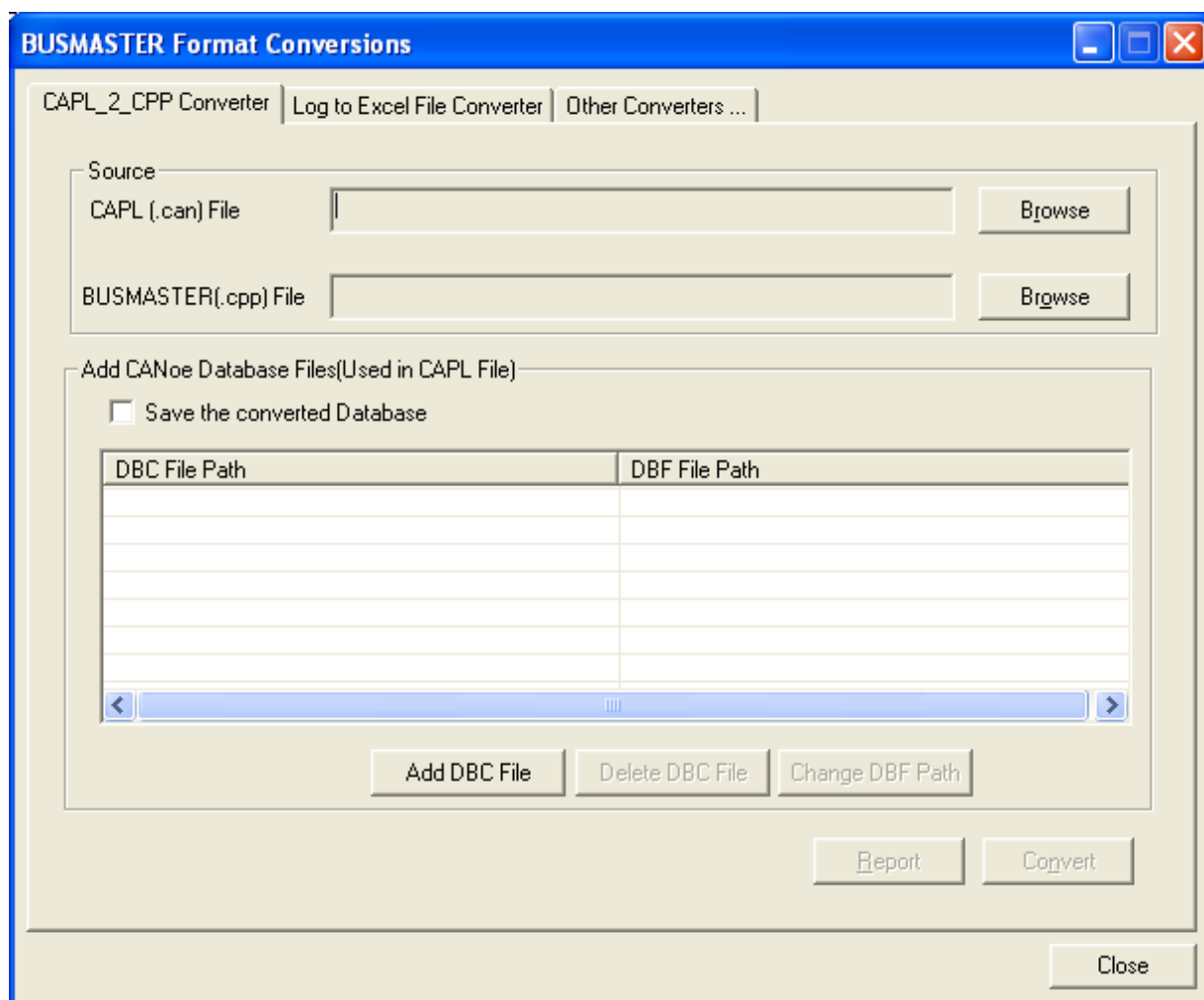
- A window is displayed with 3 tabs in it which caters to various conversions.

#### CAPL to CPP Conversion

CAPL to CPP Converter is used to convert the CAPL file (.can) to CPP (.cpp) files to be used with BUSMASTER. Once the CAPL file is selected for conversion, the entry for output file name will be automatically filled with input file name but with the extension of .cpp

Any database associated with the CAPL file has to be added using the Add DBC file option. The DBC file will be converted to DBF file and will be used for conversion. The converted DBF file will be saved in the same path by default.

Select the convert button to convert the file

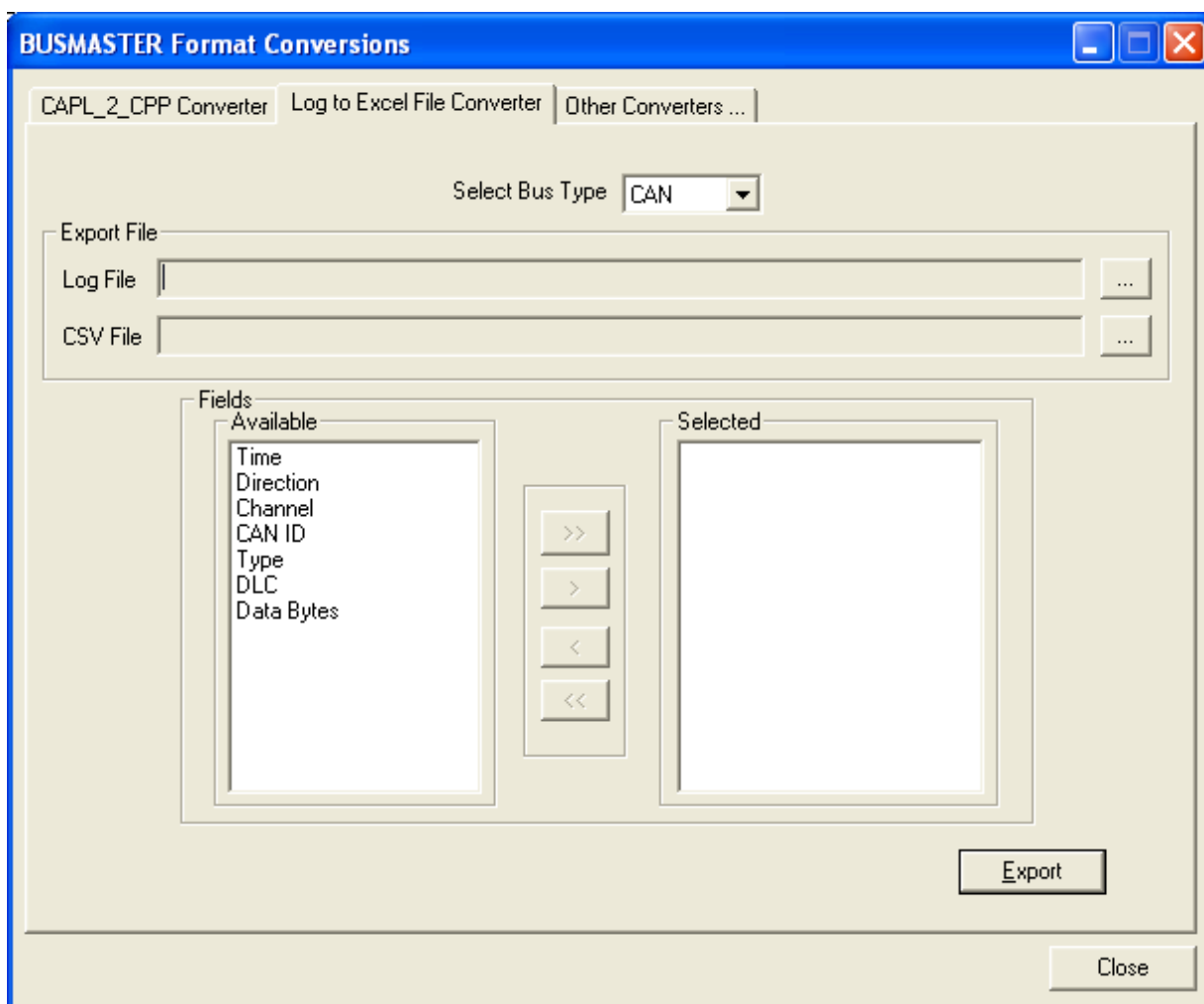


### Log To Excel Converter

Log to Excel Converter is used to convert the log file (.log) in to an .xls file. The messages recorded by BUSMASTER using the logging feature can be neatly updated in a .xls file using this conversion.

Once the input file is selected the output file is filled automatically in the same path of input file with input file's name with the extension of .xls. Either specific fields or all the fields can be used for conversion. Only the selected fields data will be converted.

Select the Export button to convert the file

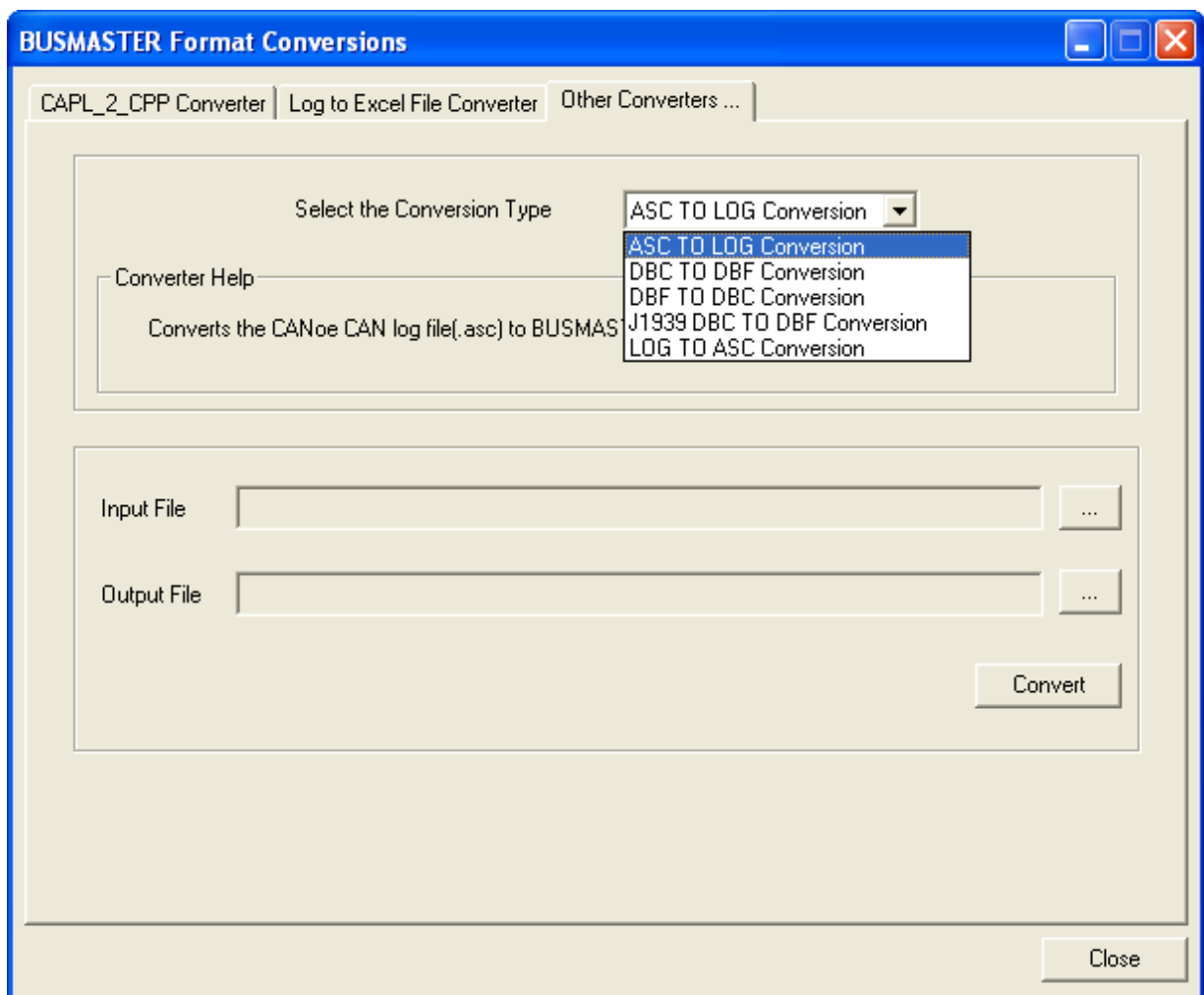


### Other Converters

This supports the following conversion:

- ASC to LOG - Converts log files in ASC format to BUSMASTER format files (.log)
- DBC to DBF - Converts database files in DBC format to BUSMASTER format files (.dbf)
- DBF to DBC - Converts BUSMASTER database files to DBC format files (.dbc)
- J1939 DBC to DBF - Converts J1939 database files in DBC format to BUSMASTER format files (.dbf)
- LOG to ASC - Converts BUSMASTER log files to ASC format files (.asc)

Select the convert button to convert the files



## API Reference

### STCAN\_MSG Structure

STCAN\_MSG Structure Definition

```
struct STCAN_MSG
{
    unsigned int    m_unMsgID;        // 11/29 Bit- Message ID
    unsigned char   m_ucEXTENDED;     // true, for (29 Bit) Frame
    unsigned char   m_ucRTR;          // true, for Remote Request
    unsigned char   m_ucDLC;          // Data len (0..8)
    union
    {
        unsigned char   m_aucData[8]; // Byte Data
        unsigned short   int m_auwData[4]; // Word Data
        unsigned long    int m_aulData[2]; // Long Data
    } m_sWhichBit; // Data access member
    unsigned char m_ucChannel;
};
```

Required Include header file is struct.h

```
STCAN_MSG sMsg;

// Initialise message structure
sMsg.m_unMsgID = 0x100; // Message ID
sMsg.m_ucEXTENDED = FALSE; // Standard Message type
sMsg.m_ucRTR = FALSE; // Not RTR type
```

```
sMsg.m_ucDLC = 8; // Length is 8 Bytes
sMsg.m_sWhichBit.m_aulData[0] = 10; // Lower 4 Bytes
sMsg.m_sWhichBit.m_aulData[1] = 20; // Upper 4 Bytes
sMsg.m_ucChannel = 1; // First CAN channel

// Send the message
SendMsg(sMsg);
```

#### SCAN\_ERR Structure Definition

```
struct SCAN_ERR
{
    unsigned char m_ucTxError; // Tx Error Counter Value
    unsigned char m_ucRxError; // Rx Error Counter Value
    unsigned char m_ucChannel; // Channel Number
};
```

Required Include header file is struct.h

```
// Error Active Handler which will print error counter values
// and channel number
void OnError_Active(SCAN_ERR ErrorMessage)
{
    Trace( "Tx Error: %d Rx Error: %d Channel: %d",
           ErrorMessage.m_ucTxError,
           ErrorMessage.m_ucRxError,
           ErrorMessage.m_ucChannel );
}
```

#### Accessing database message signal values

Database message structures can be meaningfully interpreted. Database message structures will have signal members as defined in the database. Signal raw value can be directly assigned by using member of database message structure with the signal name.

CAN\_Request is a database message that has signals Sig1, Sig2 and Sig3. Each signal is 2 bytes of length. To assign raw value of a signal use message name structure and use signal name as member.

```
// Message Declaration
CAN_Request sMsgStruct = { 0x100, 0, 0, 8, { 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 } };


// Use signal member

// Sig1
sMsgStruct.m_sWhichBit.Sig_1 = 10;


// Sig2
sMsgStruct.m_sWhichBit.Sig_2 = 20;

// Sig3
sMsgStruct.m_sWhichBit.Sig_3 = 30;

// Send the message now
SendMsg(*( (STCAN_MSG *)&sMsgStruct));
```

 **Note:** Right click on edit area of function editor. Select "Insert Message" or "Insert Signal" option to insert message structure or signal structure. Select the option "Yes, I want to declare selected message structure variable" option in the "Message and Signal List" to initialise message with its struct definition.

Required Include header file Unions.h

 **Note:**

- Unions.h file will be automatically generated by BUSMASTER during database import.

- This file will be in the database file directory

## API Listing

BUSMASTER API Listing

### SendMsg : To send a CAN frame

#### Synopsis

```
UINT SendMsg ( STCAN_MSG )
```

#### Description

This function will put the message on the CAN bus. The message structure STCAN\_MSG will be filled with ID, length, frame format and data. Big/Little endian packing will be taken care if it is a database message.

#### Inputs

STCAN\_MSG - CAN Message Structure

#### Returns

Zero on successful transmission. Non-zero value on failure.

### EnableLogging : To start logging

#### Synopsis

```
UINT EnableLogging ( )
```

#### Description

This function will enable logging. The return value of this function will be 0 or 1.

#### Inputs

-

#### Returns

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case logging is already ON

### DisableLogging : To stop logging

#### Synopsis

```
UINT DisableLogging ( )
```

#### Description

This function will disable logging. The return value of this function will be 0 or 1.

#### Inputs

-

#### Returns

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case logging is already OFF

**WriteToLogFile : To send string to log file****Synopsis**

```
UINT WriteToLogFile ( char* msg )
```

**Description**

This function will output text passed as parameter "msg" to all log files. The return value of this function will be 0 or 1.

**Inputs**

msg - Pointer to characterarray

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case logging is OFF or user has passed a NULL pointer.

**Trace : To send string to Trace window****Synopsis**

```
UINT Trace ( char* format, ... )
```

**Description**

This function will format the passed parameters based on format specified and will show the formatted text inTRACE window. The return value of this function will be 0 or 1.

**Inputs**

msg - Pointer to character array

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case user has passed a NULL pointer. If the TRACE window is visible, it will be made visible

**ResetController : To reset CAN controller****Synopsis**

```
void ResetController ( BOOL bResetType)
```

**Description**

This function will reset the controller. If the parameter passed is TRUE, a hardware reset will be given to controller. In case of hardware reset, the buffer of controller will be flushed off and error counter value will be set to zero. If the parameter passed is FALSE, a software reset will be given to controller. Only driver buffer will be cleared. The status of controller error counter will not be effected.

**Inputs**

bResetType - 1 for Hardware reset of CAN controller 0 for Software reset of CAN controller

**Returns**

-

**GoOnline : To enable all event handlers****Synopsis**

```
UINT GoOnline ( )
```

**Description**

This function will enable all handlers. The return value of this function will be 0 or 1. This function can return 0 in case handlers are already enabled, i.e. "All Handler" toolbar/menu is already enabled.

**Inputs**

-

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**GoOffline : To disable all event handlers****Synopsis**

```
UINT GoOffline ( )
```

**Description**

This function will disable all handlers. The return value of this function will be 0 or 1. This function can return 0 in case handlers are already disabled, i.e. "All Handler" toolbar/menu is already disabled.

**Inputs**

-

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**Disconnect : To disconnect CAN controller from CAN bus****Synopsis**

```
UINT Disconnect (DWORD dwClientId )
```

**Description**

This function will disconnect the tool from CAN bus. The return value of this function will be 0 or 1. This function can return 0 in case tool is already disconnected. dwClientId is reserved for future use.

**Inputs**

Client ID. Currently unused.

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**Connect : To connect CAN controller to CAN bus****Synopsis**

```
UINT Connect (DWORD dwClientId )
```



**Description**

This function will connect the tool to CAN bus. The return value of this function will be 0 or 1. This function can return 0 in case tool is already connected. dwClientId is reserved for future use.

**Inputs**

Client ID. Currently unused.

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**StartTimer : To start a timer in specific mode****Synopsis**

```
UINT StartTimer ( char* strTimerName, UINT nTimerMode )
```

**Description**

This function will start timer having name passed as parameter strTimerName in monoshot or cyclic mode. The function takes first parameter as timer name and second as mode, monoshot or cyclic. If the named timer is already running or timer name is not matched, the function will return FALSE. Otherwise function be return TRUE.

**Inputs**

strTimerName - Name of the timer. i.e. OnTimer\_Tester\_Present\_100 nTimerMode - Mode of the timer. 1 - Start in Cyclic mode 0 - Start in Monoshot mode

**Returns**

1 on success. 0 if the timer is already running or timer name not found

**StopTimer : To stop a running timer****Synopsis**

```
UINT StopTimer ( char* strTimerName)
```

**Description**

This function will stop timer having name passed as parameter strTimerName. If the named timer is not running or timer name is not matched, the function will return FALSE. Otherwise function be return TRUE.

**Inputs**

strTimerName - Name of the timer. i.e. OnTimer\_Tester\_Present\_100

**Returns**

1 on success. 0 if the timer is already running or timer name not found

**SetTimerVal : To set a new time value for a timer****Synopsis**

```
UINT SetTimerVal ( char* strTimerName, UINT nTimeInterval )
```

**Description**

This function will change the timer value. The timer value and name of timer whose time value is to be changed has to be passed through the parameter strTimerName. The second parameter will take time value. If the timer is

running in cyclic mode or next instance of timer is to be fired this function will return FALSE otherwise if will return TRUE.

### Inputs

strTimerName - Name of the timer. i.e. OnTimer\_Tester\_Present\_100 nTimeInterval - Time value of the timer.

### Returns

1 on success. 0 if the timer is already running or timer name not found BOOL

### EnableMsgHandlers : To enable or Disable message event handlers

#### Synopsis

```
EnableMsgHandlers ( BOOL bEnable)
```

#### Description

This function will enable or disable message handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.

#### Inputs

bEnable - TRUE to Enable message handler. FALSE to disable

#### Returns

TRUE success. FALSE if the handler is already in the specified state

### EnableErrorHandlers : To enable or Disable error event handlers

#### Synopsis

```
BOOL EnableErrorHandlers ( BOOL bEnable)
```

#### Description

This function will enable or disable error handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.

#### Inputs

bEnable - TRUE to Enable error handler. FALSE to disable

#### Returns

TRUE success. FALSE if the handler is already in the specified state

### EnableKeyHandlers : To enable or Disable key event handlers

#### Synopsis

```
BOOL EnableKeyHandlers ( BOOL bEnable)
```

#### Description

This function will enable or disable key handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.

#### Inputs

bEnable - TRUE to Enable message handler. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**EnableDisableMsgTx: To enable or disable message transmission from the node****Synopsis**

```
BOOL EnableDisableMsgTx ( BOOL bEnable)
```

**Description**

This function will enable or disable message transmission from a node. User can pass parameter as TRUE to enable and FALSE to disable outgoing message from a node. The node can receive the messages in both state. Function will return TRUE, if state change was successful otherwise it will return FALSE.

**Inputs**

bEnable - TRUE to Enable message transmission. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**hGetDllHandle: To get handle of dll attached to a node from the node****Synopsis**

```
HANDLE hGetDllHandle ( char* strNodeName)
```

**Description**

This function returns the handle of the dll attached to a node. The node name will be passed as parameter.

**Inputs**

Node name

**Returns**

Dll handle on success else NULL

## J1939 API Reference

---

### J1939 Structures

```
/* TYPES OF TIMEOUT */
typedef enum ETYPE_TIMEOUT
{
    TYPE_TO_BROADCAST = 0,
    TYPE_TO_RESPONSE,
    TYPE_TO_HOLDING,
    TYPE_TO_T1,
    TYPE_TO_T2,
    TYPE_TO_T3,
    TYPE_TO_T4
};

/* TYPES OF ACKNOWLEDGEMENT */
typedef enum ETYPE_ACK { ACK_POS = 0, ACK_NEG }; /* ECU NAME STRUCTURE */

typedef struct tagSECU_NAME
```

```

{
    UINT32 m_unID : 21;
    UINT32 m_unSAE_MF_CODE : 11;
    BYTE m_byECU_INST : 3;
    BYTE m_byFUNC_INST : 5;
    BYTE m_bySAE_FUNCTION : 8;
    BYTE m_bySAE_RESERVED : 1;
    BYTE m_bySAE_VHL_SYS : 7;
    BYTE m_byVHL_SYS_INST : 4;
    BYTE m_bySAE_IND_GRP : 3;
    BYTE m_byARB_ADRS_CPL : 1;
} STRUCT_ECU_NAME;

/* J1939 PGN structure */
typedef struct tagSTRUCT_PGN
{
    BYTE m_byPDU_Specific : 8; // PDU Specific (PS)
    BYTE m_byPDU_Format : 8; // PDU Format (PF), Indicates Peer_2_peer or
    Broadcast.
    BYTE m_byDataPage : 1; // DataPage (DP), Set to 0 currently.
    BYTE m_byReserved : 1; // Reserved, Set to 0.
    BYTE m_byPriority : 3;
} STRUCT_PGN;

typedef union tagUPGN
{
    UINT32 m_unPGN : 21;
    STRUCT_PGN m_sPGN;
} UNION_PGN;

/* J1939 Extended 29 bit ID */
typedef struct tagSTRUCT_29_BIT_ID
{
    BYTE m_bySrcAddress : 8; // Sender node address.
    UNION_PGN m_uPGN; // Parameter group number(PGN). SAE lists various PGNS
    and its SPNS.
} STRUCT_29_BIT_ID;

typedef union tag29BitID
{
    UINT32 m_unExtID : 29;
    STRUCT_29_BIT_ID m_s29BitId;
} UNION_29_BIT_ID;

/* J1939 message type */
typedef enum EJ1939_MSG_TYPE
{
    MSG_TYPE_NONE = 0x0,
    MSG_TYPE_COMMAND,
    MSG_TYPE_REQUEST,
    MSG_TYPE_DATA,
    MSG_TYPE_BROADCAST,
    MSG_TYPE_ACKNOWLEDGEMENT,
    MSG_TYPE_GROUP_FUNCTIONS,
    MSG_TYPE_NM_ACL,
    MSG_TYPE_NM_RQST_ACL,
    MSG_TYPE_NM_CMD_ADDRESS,
    MSG_TYPE_NM_TPCM_BAM,
    MSG_TYPE_NM_TPCM_RTS,
    MSG_TYPE_NM_TPCM_CTS,
    MSG_TYPE_NM_TPCM_EOM_ACK,
    MSG_TYPE_NM_TPCM_CON_ABORT,
    MSG_TYPE_NM_TPDT
};

```

```

typedef enum EDIRECTION
{
    DIR_RX = 'R',
    DIR_TX = 'T',
    DIR_ALL
};

/* J1939 message properties */
typedef struct tagSTJ1939_MSG_PROPERTIES
{
    UINT64 m_un64TimeStamp; // Timestamp.
    BYTE m_byChannel; // Channel number.
    enum EJ1939_MSG_TYPE m_eType;
    enum EDIRECTION m_eDirection; // DIR_TX, DIR_RX
    UNION_29_BIT_ID m_uExtendedID; // 29 bit extended ID
} STJ1939_MSG_PROPERTIES;

typedef struct tagSTJ1939_MSG
{
    STJ1939_MSG_PROPERTIES m_sMsgProperties;
    UINT m_unDLC; // Data length. 0 <= m_unDLC <= 1785 bytes.
    BYTE* m_pbyData; // J1939 message data.
} STJ1939_MSG;

```

Required Include header file is struct\_J1939.h

## J1939 API Listing

BUSMASTER J1939 API Listing

### SendMsg : To send a J1939 message

#### Synopsis

```
UINT SendMsg ( STJ1939_MSG* )
```

#### Description

This function will put the message on the J1939 network. The message structure STJ1939\_MSG will be filled with ID, length, data, channel.

#### Inputs

STJ1939\_MSG\* - Pointer to J1939 Message Structure

#### Returns

1 on successful transmission. 0 value on failure.

### EnableLogging : To start logging

#### Synopsis

```
UINT EnableLogging ( )
```

#### Description

This function will enable logging. The return value of this function will be 0 or 1.

#### Inputs

-

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case logging is already ON

**DisableLogging : To stop logging****Synopsis**

```
UINT DisableLogging ( )
```

**Description**

This function will disable logging. The return value of this function will be 0 or 1.

**Inputs**

-

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case logging is already OFF

**WriteToLogFile : To send string to log file****Synopsis**

```
UINT WriteToLogFile ( char* msg )
```

**Description**

This function will output text passed as parameter "msg" to all log files. The return value of this function will be 0 or 1.

**Inputs**

msg - Pointer to characterarray

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case logging is OFF or user has passed a NULL pointer.

**Trace : To send string to Trace window****Synopsis**

```
UINT Trace ( char* format, ... )
```

**Description**

This function will format the passed parameters based on format specified and will show the formatted text inTRACE window. The return value of this function will be 0 or 1.

**Inputs**

msg - Pointer to character array

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case user has passed a NULL pointer. If the TRACE window is visible, it will be made visible

**ResetController : To reset CAN controller****Synopsis**

```
void ResetController ( BOOL bResetType)
```

**Description**

This function will reset the controller. If the parameter passed is TRUE, a hardware reset will be given to controller. In case of hardware reset, the buffer of controller will be flushed off and error counter value will be set to zero. If the parameter passed is FALSE, a software reset will be given to controller. Only driver buffer will be cleared. The status of controller error counter will not be effected.

**Inputs**

bResetType - 1 for Hardware reset of CAN controller 0 for Software reset of CAN controller

**Returns**

-

**GoOnline : To enable all event handlers****Synopsis**

```
UINT GoOnline ( )
```

**Description**

This function will join all the nodes to the J1939 network. The return value of this function will be 0 or 1.

**Inputs**

-

**Returns**

A value 1 indicate success condition while a value 0 indicate a failure condition.

**GoOffline : To disable all event handlers****Synopsis**

```
UINT GoOffline ( )
```

**Description**

This function will remove all nodes from J1939 network. The return value of this function will be 0 or 1.

**Inputs**

-

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**Disconnect : To disconnect CAN controller from CAN bus****Synopsis**

```
UINT Disconnect (DWORD dwClientId )
```

**Description**

This function will disconnect the tool from CAN bus. The return value of this function will be 0 or 1. This function can return 0 in case tool is already disconnected. dwClientId is reserved for future use.

**Inputs**

Client ID. Currently unused.

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**Connect : To connect CAN controller to CAN bus****Synopsis**

```
UINT Connect (DWORD dwClientId )
```

**Description**

This function will connect the tool to CAN bus. The return value of this function will be 0 or 1. This function can return 0 in case tool is already connected. dwClientId is reserved for future use.

**Inputs**

Client ID. Currently unused.

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**StartTimer : To start a timer in specific mode****Synopsis**

```
UINT StartTimer ( char* strTimerName, UINT nTimerMode )
```

**Description**

This function will start timer having name passed as parameter strTimerName in monoshot or cyclic mode. The function takes first parameter as timer name and second as mode, monoshot or cyclic. If the named timer is already running or timer name is not matched, the function will return FALSE. Otherwise function be return TRUE.

**Inputs**

strTimerName - Name of the timer. i.e. OnTimer\_Tester\_Present\_100 nTimerMode - Mode of the timer. 1 - Start in Cyclic mode 0 - Start in Monoshot mode

**Returns**

1 on success. 0 if the timer is already running or timer name not found

**StopTimer : To stop a running timer****Synopsis**

```
UINT StopTimer ( char* strTimerName)
```

**Description**

This function will stop timer having name passed as parameter strTimerName. If the named timer is not running or timer name is not matched, the function will return FALSE. Otherwise function be return TRUE.



**Inputs**

strTimerName - Name of the timer. i.e. OnTimer\_Tester\_Present\_100

**Returns**

1 on success. 0 if the timer is already running or timer name not found

**SetTimerVal : To set a new time value for a timer****Synopsis**

```
UINT SetTimerVal ( char* strTimerName, UINT nTimeInterval )
```

**Description**

This function will change the timer value. The timer value and name of timer whose time value is to be changed has to be passed through the parameter strTimerName. The second parameter will take time value. If the timer is running in cyclic mode or next instance of timer is to be fired this function will return FALSE otherwise if will return TRUE.

**Inputs**

strTimerName - Name of the timer. i.e. OnTimer\_Tester\_Present\_100 nTimeInterval - Time value of the timer.

**Returns**

1 on success. 0 if the timer is already running or timer name not found BOOL

**EnableMsgHandlers : To enable or Disable message event handlers****Synopsis**

```
EnableMsgHandlers ( BOOL bEnable )
```

**Description**

This function will enable or disable message handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.

**Inputs**

bEnable - TRUE to Enable message handler. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**EnableErrorHandlers : To enable or Disable error event handlers****Synopsis**

```
BOOL EnableErrorHandlers ( BOOL bEnable )
```

**Description**

This function will enable or disable error handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.

**Inputs**

bEnable - TRUE to Enable error handler. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**EnableKeyHandlers : To enable or Disable key event handlers****Synopsis**

```
BOOL EnableKeyHandlers ( BOOL bEnable)
```

**Description**

This function will enable or disable key handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.

**Inputs**

bEnable - TRUE to Enable message handler. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**EnableDisableMsgTx: To enable or disable message transmission from the node****Synopsis**

```
BOOL EnableDisableMsgTx ( BOOL bEnable)
```

**Description**

This function will enable or disable message transmission from a node. User can pass parameter as TRUE to enable and FALSE to disable outgoing message from a node. The node can receive the messages in both state. Function will return TRUE, if state change was successful otherwise it will return FALSE.

**Inputs**

bEnable - TRUE to Enable message transmission. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**hGetDllHandle: To get handle of dll attached to a node from the node****Synopsis**

```
HANDLE hGetDllHandle ( char* strNodeName)
```

**Description**

This function returns the handle of the dll attached to a node. The node name will be passed as parameter.

**Inputs**

Node name

**Returns**

Dll handle on success else NULL

**RequestPGN: To request PGN from a node.****Synopsis**

```
UINT RequestPGN ( UINT PGN, BYTE DestAdres, UINT Channel)
```

## Description

This function will request a PGN from a node in the network.

## Inputs

PGN - PGN to be requested.  
DestAdres - From the node.  
Channel - Channel number

## Returns

1 on success. 0 on failure.

## SendAckMsg: To send a acknowledge message

## Synopsis

```
UINT SendAckMsg ( UINT PGN, BYTE AckType, BYTE DestAdres, UINT Channel )
```

## Description

This function will be used to send a acknowledgement message based on the request.

## Inputs

PGN - PGN to requested.  
AckType - 0 for positive, 1 for negative acknowledgement.  
DestAdres - Destination node.  
Channel - Channel number.

## Returns

1 on success. 0 on failure.

## ClaimAddress: To claim a different address for current node

## Synopsis

```
UINT ClaimAddress ( BYTE Address, UINT Channel )
```

## Description

This function will claim a different address for the current node.

## Inputs

Address - Address to be claimed.  
Channel - Channel number.

## Returns

1 on success. 0 on failure.

## RequestAddress: To request addresses of currently active nodes in the network

## Synopsis

```
UINT RequestAddress ( UINT Channel )
```

## Description

This function will request the address of each node in the J1939 network.

**Inputs**

Channel - Channel number.

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**CommandAddress: To command a address for a node****Synopsis**

```
UINT CommandAddress (UINT64 EcuName, BYTE NewAddress, UINT Channel)
```

**Description**

This function will command a address to the node having ECU NAME as specified.

**Inputs**

EcuName - ECU NAME of a node for which the address has to be commanded.

NewAddress - The new address.

Channel - Channel number.

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**SetTimeout: To configure flow control timeouts of J1939 network****Synopsis**

```
UINT SetTimeout (BYTE TimeoutType, UINT TimeoutValue )
```

**Description**

This function can be used to configure flow control timeouts in J1939 network.

**Inputs**

TimeoutType - Timeout type. Possible values are

- a. Tb (0): Time interval between two packets in broadcast transmission.
- b. Tr (1): Maximum wait period for a sender without receiving response from the receiver.
- c. Th (2): Time interval between two 'Clear to Send' message when delaying the data.
- d. T1 (3): Maximum wait period for a receiver when more packets were expected.
- e. T2 (4): Maximum wait period for a receiver to receive data packets after sending 'Clear to Send' message.
- f. T3 (5): Maximum wait period for a sender to receive 'End of Message Acknowledgement' after sending last data packet.
- g. T4 (6): Maximum wait period for a sender to receive another 'Clear to Send' message after receiving one to delay the data.

TimeoutValue(ms) - Value to be set for the corresponding timeout type.

**Returns**

TRUE success. FALSE if the handler is already in the specified state

## COM Interface

---

**BUSMASTER COM interface**

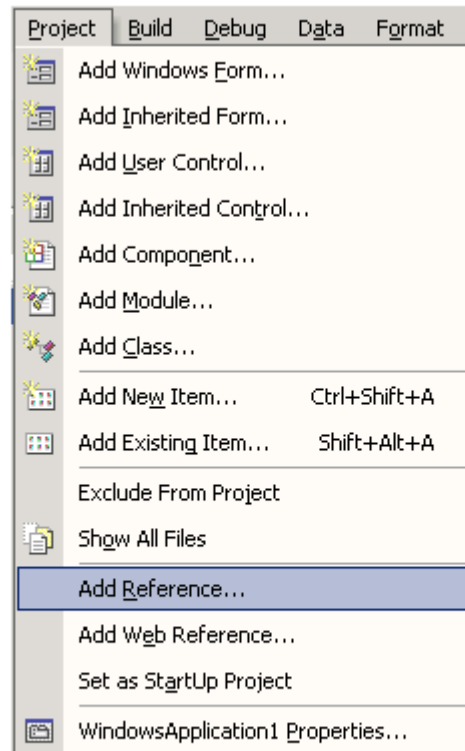
Using BUSMASTER Automation Object:

User can use all the APIs exposed by BUSMASTER, as COM interface functions in his own application by following ways:

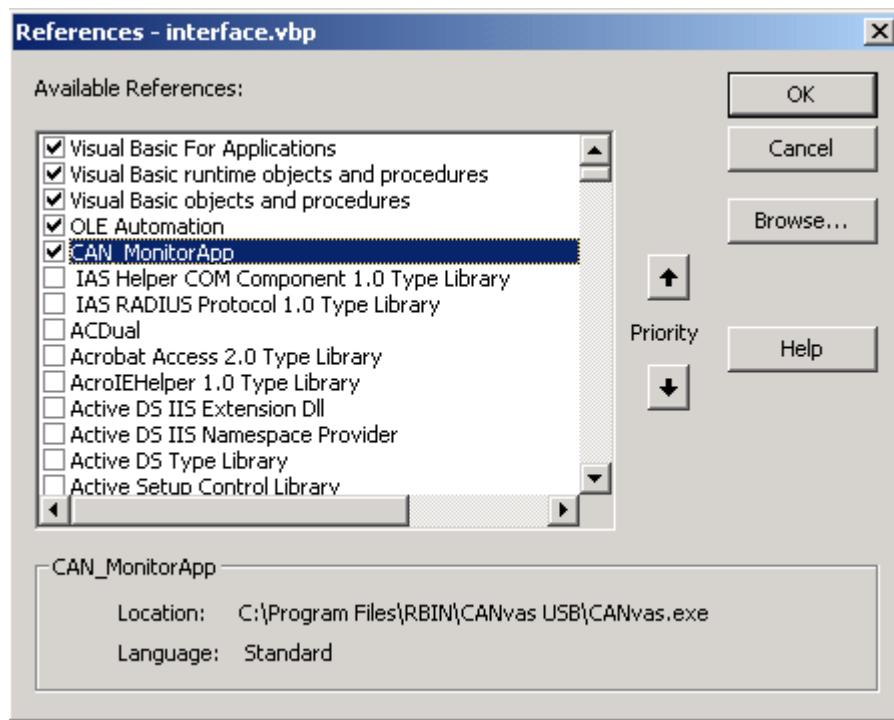
FROM VB:

If the client application is developed using VB the steps are:

1. Project->Add Reference ie.



2. Select the CAN\_Monitor 1.0 Type Library



Now all the BUSMASTER COM APIs can be used in the client application. Once the VB project is configured to use CAN\_Monitor type library, a global variable is needed to be declared and initialised so that the COM server can be accessed. This can be accomplished using following statement:

```
Dim gBUSMASTERApp As CAN_MonitorApp.Application
Set gBUSMASTERApp = New CAN_MonitorApp.Application
```

Now the variable gBUSMASTERApp can be used to access all the COM members.

For connecting the tool following code is required:

```
gBUSMASTERApp .Connect 1
```

From C++

Let's start with a very simple C++ application. Make a simple dialog-based application with the class wizard, be it an MFC or an ATL/WTL application. Just make sure that `CoInitialize()` and `CoUninitialize()` are called somewhere (that is done automatically in ATL applications). Put a button on the dialog somewhere, wire it up, and put the following in the message handler for the `BN_CLICKED` handler:

```
HResult hr;
hr = ::CoCreateInstance(CLSID_Application, NULL, CLSCTX_LOCAL_SERVER,
    IID_IApplication, (void*)&m_IApplication);
if(SUCCEEDED(hr))
{
    if (m_IApplication) {
        m_IApplication->Connect ( 1 );
    }
}
```

In the header for the dialog, declare a member like this:

```
IApplication* m_IApplication;
```

Now, all you need to do is include the file `CAN_Monitor_Interface.h` which is provided in the BUSMASTER installation folder. When you go looking for this file, you'll notice another file: `CAN_Monitor_Interface.c`. This file contains the implementation of the interface and is needed by the linker. So, again, you can copy it, or add it to your project directly.

Now, build your application, click the button you've made, and - there is your application!

To receive CAN messages from Busmaster makes use of the new `interface_IAppEvents` (connection points).

To know more, refer Example folder in BUSMASTER installation folder.

## COM Interface API Listing

BUSMASTER COM Interface API Listing

**Connect : To connect BUSMASTER to the bus**

### Description

This function connects / disconnects BUSMASTER to the bus.

### Inputs

TRUE - connect, FALSE - Disconnect

### Cause of failure

NA

**ResetHW : To reset the hardware**

### Description

This function resets the hardware.

### Inputs

void

### Cause of failure

NA

**GetErrorCounter : Getter for both Rx and Tx error, given the channel number**

### Description

This function will provide the TX and RX error count of the specified channel from BUSMASTER.

### Inputs

Channel number, pointers to variables for RX and TX error

### Cause of failure

NA

**SendCANMSG : To send a CAN message**

### Description

This function will put the message on the CAN bus. The message structure CAN\_MSGS will be filled with ID, length, frame format and data.

### Inputs

CAN\_MSGS - CAN Message Structure

### Cause of failure

Tool not connected

**GetMsgInfo** : Retrieves the message parameters from the loaded database, given the message name

### Description

This function will get the details about a database message.

### Inputs

Message name, Structure sMESSAGESTRUCT { double m\_dMessageCode; double m\_dNumberOfSignals; double m\_dMessageLength; BOOL m\_bMessageFrameFormat; int m\_nMsgDataFormat; }

### Cause of failure

message name not in database, data base file is not imported to BUSMASTER

**GetNetworkStatistics** : To get all the statistics of a channel

### Description

This function will provide the channel's statistics.

### Inputs

Channel number and Pointer to the structures CHANNELSTATISTICS { DOUBLE m\_dBusLoad; DOUBLE m\_dPeakBusLoad; float m\_fTotalMsgCount; float m\_unMsgPerSecond; float m\_fTotalTxMsgCount; DOUBLE m\_dTotalTxMsgRate; float m\_fTxSTDMsgCount; DOUBLE m\_dTxSTDMsgRate; float m\_fTxEXTDMsgCount; DOUBLE m\_dTxEXTMsgRate; float m\_fTxSTD\_RTRMsgCount; float m\_fTxEXTD\_RTRMsgCount; float m\_fTotalRxMsgCount; DOUBLE m\_dTotalRxMsgRate; float m\_fRxSTDMsgCount; DOUBLE m\_dRxSTDMsgRate; float m\_fRxEXTDMsgCount; DOUBLE m\_dRxEXTMsgRate; float m\_fRxSTD\_RTRMsgCount; float m\_fRxEXTD\_RTRMsgCount; float m\_fErrorTxCount; DOUBLE m\_dErrorTxRate; float m\_fErrorRxCount; DOUBLE m\_dErrorRxRate; float m\_fErrorTotalCount; DOUBLE m\_dErrorRate; float m\_fDLCCCount; DOUBLE m\_dBaudRate; DOUBLE m\_dTotalBusLoad; int m\_nSamples; DOUBLE m\_dAvarageBusLoad; UCHAR m\_ucTxErrorCounter; UCHAR m\_ucRxErrorCounter; UCHAR m\_ucTxPeakErrorCount; UCHAR m\_ucRxPeakErrorCount; UCHAR m\_ucStatus; }

### Cause of failure

NA

**LoadAllDII** : To load all user DLLs

### Description

This function loads all the user DLLs associated to the presently active simulated system.

### Inputs

NA

### Cause of failure

NA

**UnLoadAllDII** : To Unload all DLLs

### Description

This function unloads all the currently loaded user DLLs associated to the presently active simulated system.



**Inputs**

NA

**Cause of failure**

NA

**SendKeyValue : To simulate a particular key stroke****Description**

This function can be used to capture any key pressed in client application and pass it to BUSMASTER. The function takes ascii character of the key. Only alphanumeric key is allowed.

**Inputs**

Ascii value of key.

**Cause of failure**

The Ascii value doesn't correspond to any Alphanumeric character.

**EnableDisableHandlers : To enable or disable DLL handlers****Description**

This function will enable or disable different handlers depending upon the argument passed to it.

**Inputs**

Enum eHandlerType { all = 0, timers = all + 1, key = timers + 1, message = key + 1, error = message + 1 }

**Cause of failure**

Invalid Enum type.

**ImportDatabase : To import a database file in BUSMASTER****Description**

This function will import the specified file to BUSMASTER.

**Inputs**

Database file path

**Cause of failure**

Dlls are loaded, File absent

**LoadConfiguration : To load a configuration file in BUSMASTER****Description**

This function will load the configuration file specified by client.

**Inputs**

Configuration file path.

**Cause of failure**

File absent, tool is connected, DLLs are loaded

**SaveConfiguration : To save current configuration file****Description**

This function saves the current configuration file of BUSMASTER tool.

**Inputs**

-

**Cause of failure**

NA

**SaveConfigurationAs : To save current configuration in a particular file****Description**

To save current configuration in a particular configuration file.

**Inputs**

BSTR ConfigPath - Configuration file path.

**Cause of failure**

NA

**GetTxBlockCount : Getter for current transmission block count****Description**

Getter for current transmission block count.

**Inputs**

USHORT\*

**Result**

The [out] parameter to receive the result.

**Cause of failure**

NA

**ClearTxBlockList : Deletes all the transmission blocks****Description**

Deletes all the transmission blocks.

**Inputs**

-

**Cause of failure**

NA

### **StartTxMsgBlock : To start sending messages**

#### **Description**

This function starts the message transmission if message blocks are configured.

#### **Inputs**

-

#### **Cause of failure**

NA

### **StopTxMsgBlock : To stop sending messages**

#### **Description**

This function stop the ongoing message transmission.

#### **Inputs**

-

#### **Cause of failure**

NA

### **EnableFilterSch : Enables / disables a particular filtering scheme**

#### **Description**

Enables / disables filtering scheme for the particular module passed.

#### **Inputs**

EFILTERMODULE eModule - Can be one of { Log, Display } BOOL bEnable - TRUE to enable, else FALSE.

#### **Cause of failure**

NA

### **GetLoggingBlockCount : Getter for total number of logging blocks**

#### **Description**

This function is a getter of logging blocks defined.

#### **Inputs**

USHORT\* BlockCount = An [out] parameter for the logging block count.

#### **Cause of failure**

NA

### **RemoveLoggingBlock : To remove a particular logging block**

#### **Description**

This function removes a particular logging block

**Inputs**

USHORT BlockIndex - The zero based logging block index

**Cause of failure**

Will fail in case block index passed is wrong.

**ClearLoggingBlock : Clears the current logging blocks defined****Description**

This function clears the current logging blocks defined

**Inputs**

NA

**Cause of failure**

NA

**StartLogging : To start logging****Description**

This function enables logging.

**Inputs**

NA

**Cause of failure**

Log file absent in configuration

**StopLogging : To stop logging****Description**

This function disables logging.

**Inputs**

NA

**Cause of failure**

NA

**WriteToLogFile : Writes a text in the log file currently open****Description**

This function writes a text in the log file currently open.

**Inputs**

bstrStr - The input string in BSTR

**Cause of failure**

Logging not enabled, log file not present

**Usage in COM Client**



# FlexRay

---

## Introduction

## FlexRay Simulation in BUSMASTER

---

### Introduction:

BUSMASTER can be used to Transmit or Receive (Monitor) the FlexRay messages. The following steps are required to Configure the BUSMASTER for Transmit\Receive the FlexRay Messages.

#### 1. Cluster Configuration:

To Transmit\Receive the FlexRay Messages a proper FIBEX File has to be Imported in BUSMASTER. Refer **Cluster Configuration** Section for more Information.

#### 2. Controller (Driver) Selection:

BUSMASTER can be connected to Physical FlexRay Network using FlexRay Controller. Refer **Controller Selection** section for more Information.

#### 3. Connect to Network:

Once the Cluster & Controllers are properly configured BUSMASTER can be connected to Network using **FlexRay->Connect.** menu or the FlexRay Connect Tool bar Button as shown in following figure.



#### 4. Transmit Messages:

FlexRay Messages Can be transmitted ovr FlexRay network using FlexRay Tx Window. Refer **FlexRay Transmission Window** Section for more information.

#### 5. Monitoring Messages:

BUSMASTER Message Window can be used to monitor the FlexRay messages of FlexRay Network. Refer **FlexRay Message Window** section for more information.

## Cluster Configuration

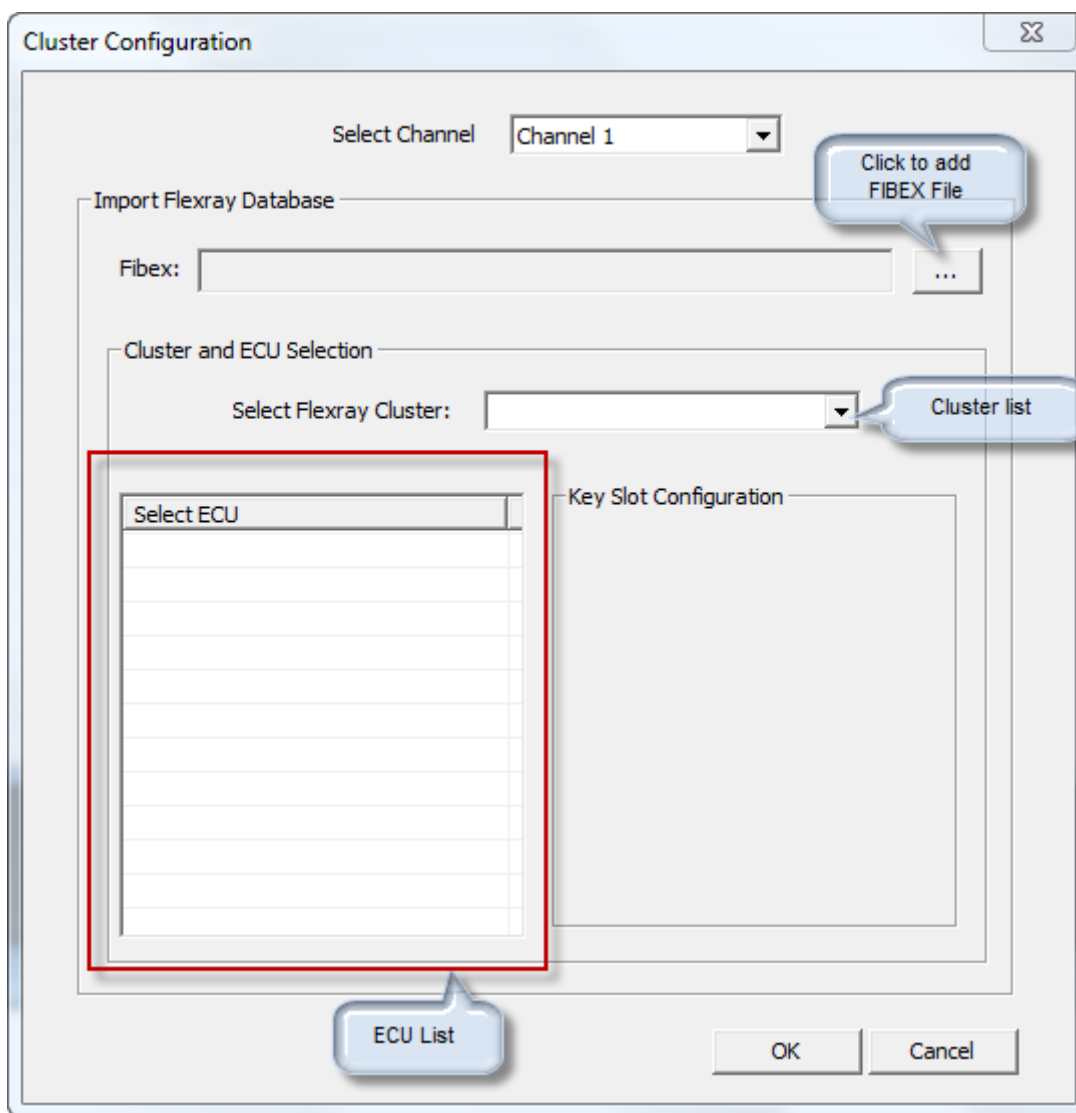
---

### Introduction:

To connect BUSMASTER to the FlexRay Network first it has to be configured with the proper FIBEX File. This can be done using **Cluster Configuration window.**

### Configuration:

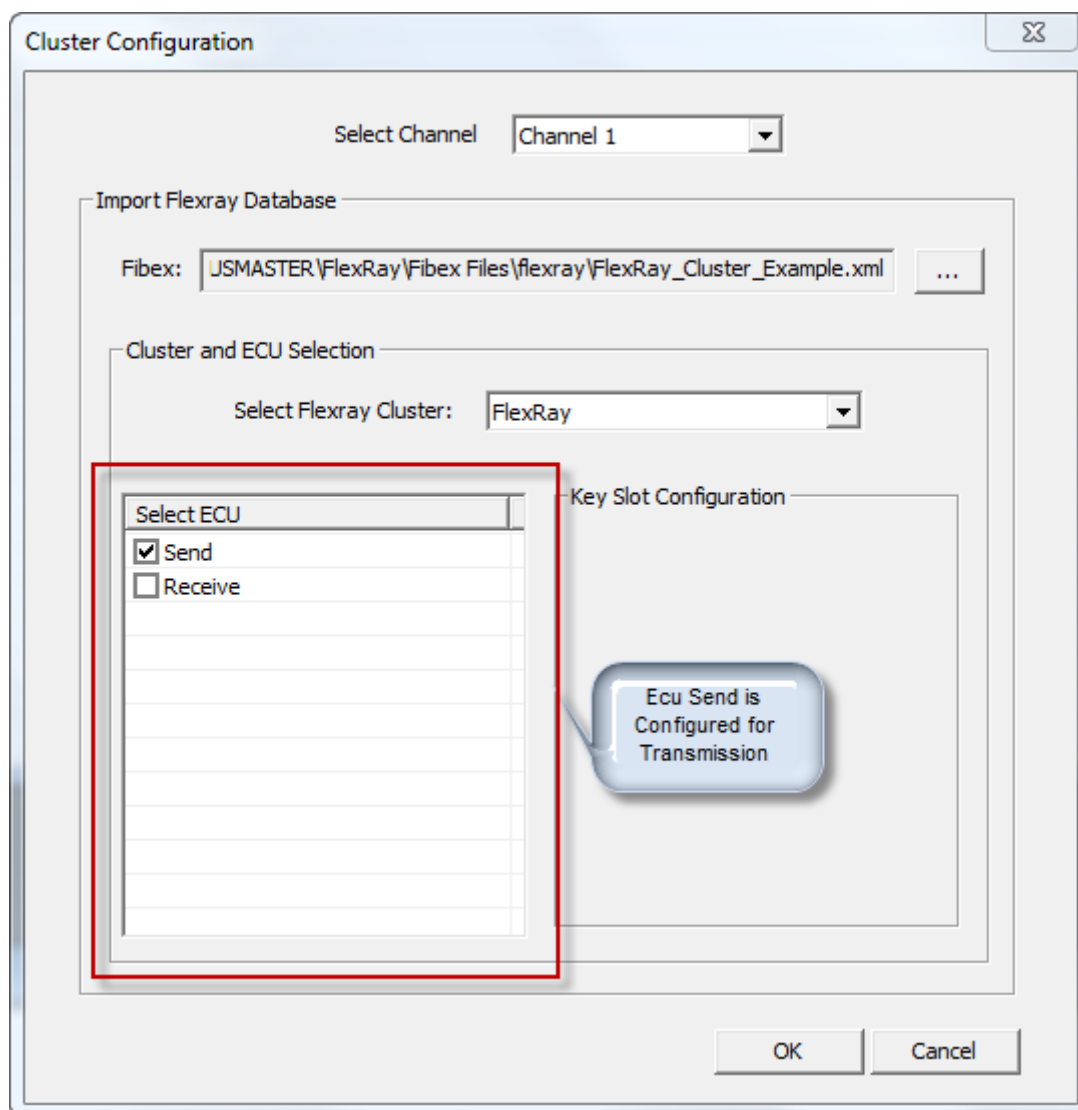
To configure the Cluster use **FlexRay->Cluster Configuration** menu. This will display the Window as shown in following Figure.



#### Adding FIBEX File:

Click the Browse button as shown in above figure to add the FIBEX File. Once the file is added the Window will display the Clusters available in **Select FlexRay Cluster** combo box. The **Select ECU List Box** will display all ECUs configured for the selected cluster. An Example Cluster Configuration is shown in following figure.

Current BUSMASTER Supports FIBEX Versions 2.0, 3.0, 4.0.



ECU **Send** is selected for Simulation in BUSMASTER. So all the Tx Message configured for **Send** ECU will be available for transmission in Tx Window. Check **FlexRay Transmission Window** Topic for more information on How to Transmit the FlexRay Messages over FlexRay Bus.

## FlexRay Controller Configuration

### Introduction:

BUSMASTER Can be connected to FlexRay physical channel using FlexRay Controller.

Currently BUSMASTER Supports the following FlexRay Controllers.

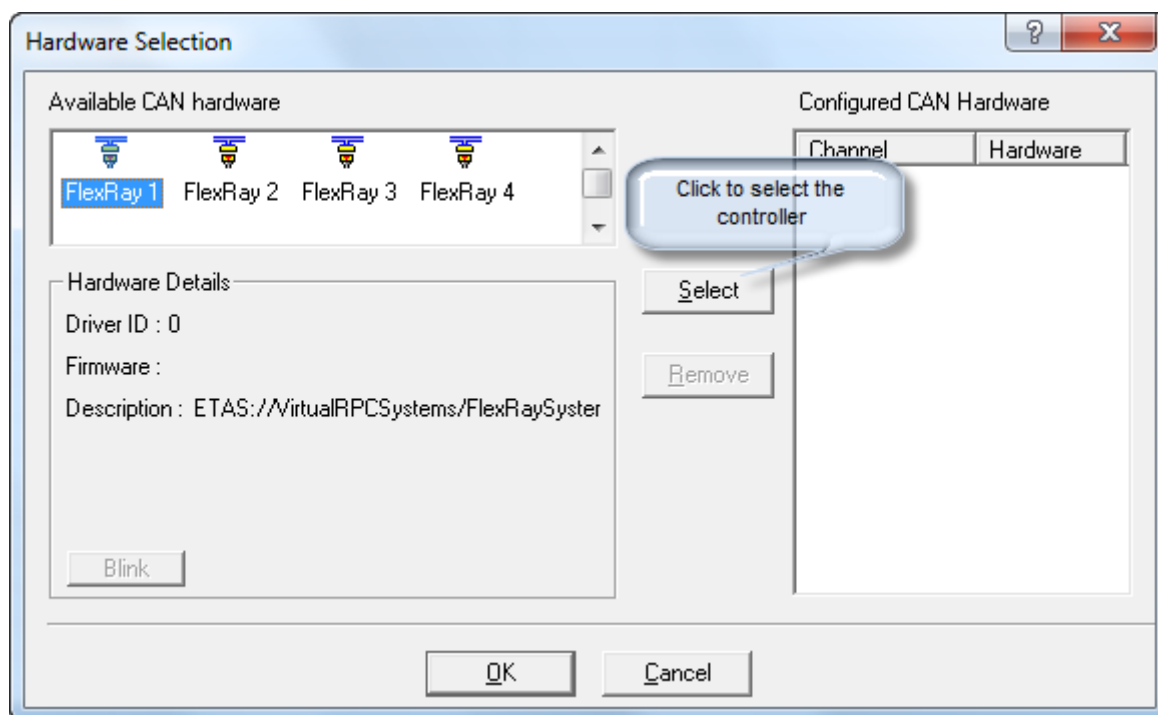
1. ETAS BOA Controllers.

### Selecting Controller:

Before Selecting the controller the BUSMASTER has to be configured with the proper FIBEX File. Refer **Cluster Configuration** for more information.

To select controller use FlexRay->Driver Selection->{Driver} For example to select ETAS BOA Driver use **FlexRay->Driver Selection->ETAS BOA**. If only one controller is connected to PC that controller will be selected automatically. Otherwise Hardware Selection window with all the available controllers will be displayed as shown in following figure.

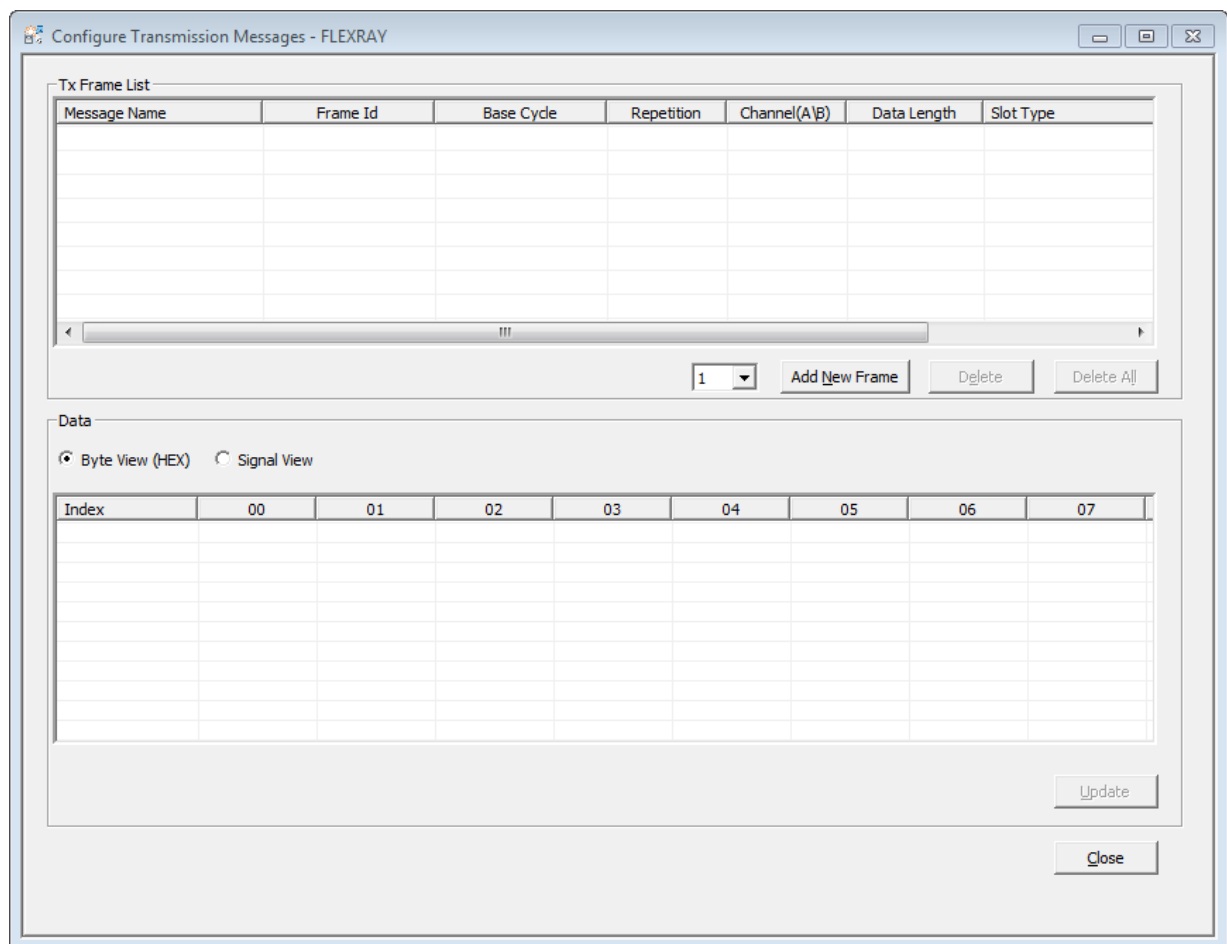




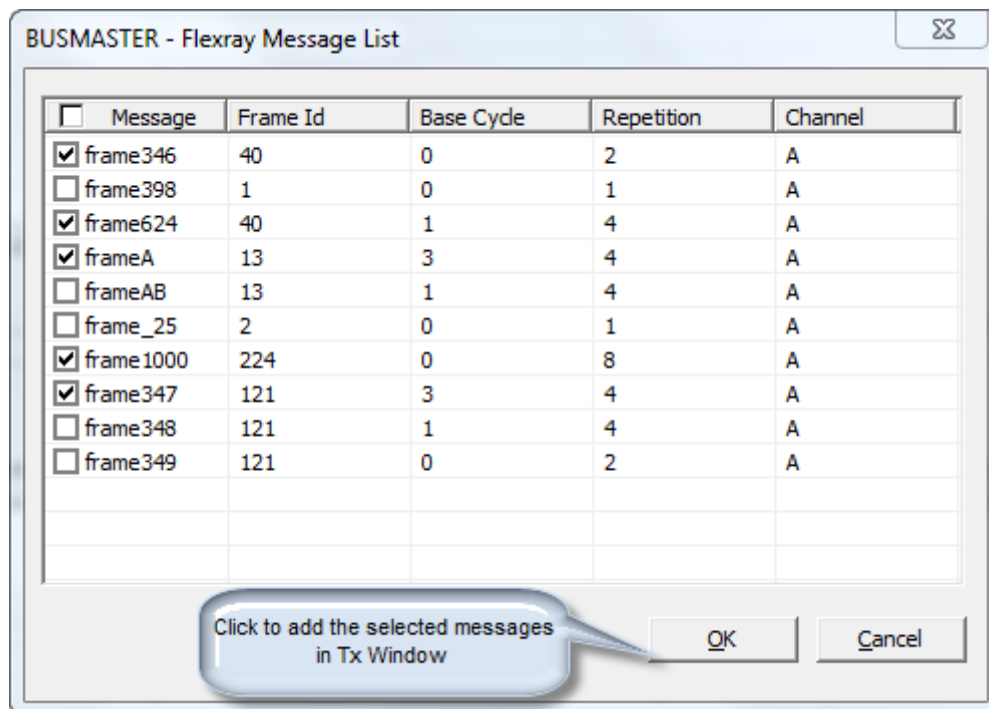
Once the Cluster & Controller is configured BUSMASTER Can be connected to FlexRay network using **FlexRay->Connect** Menu.If any Error occur during the initialisation of Controller the information will be displayed in BUSMASTER Trace Window.

## Transmit Messages

**FlexRay Transmit Window** can be used to send FlexRay Messages over FlexRay bus using.Select **FlexRay->Transmit->Configure** menu option.This Will Display\Hide the FlexRay Tx Window as shown in figure below.

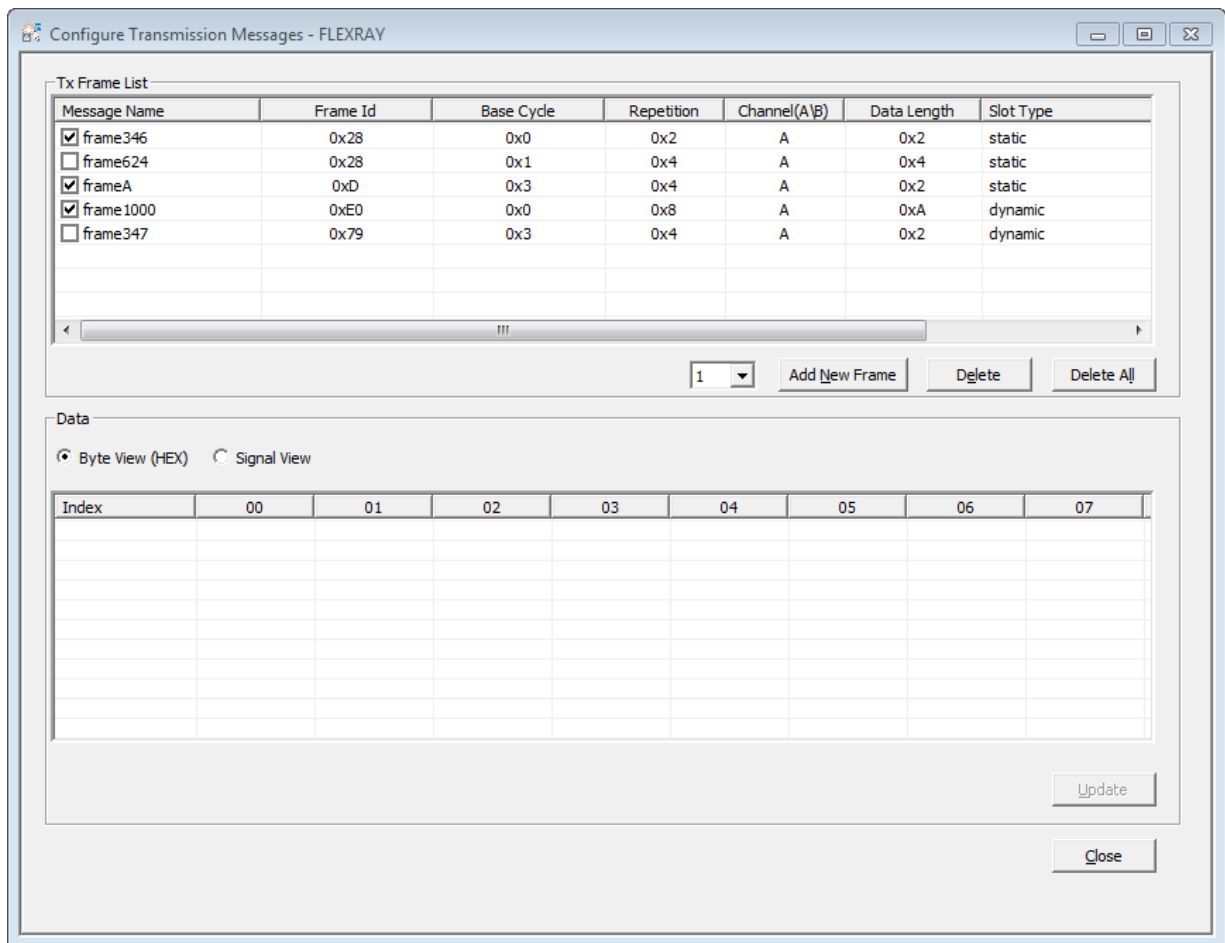


To Add messages Use **Add New Frame** button. This Will display a window, as shown below, containing all the Tx Messages of Selected ECU's. To add the messages in Transmit Window select the message using check box click on the **OK** Button.



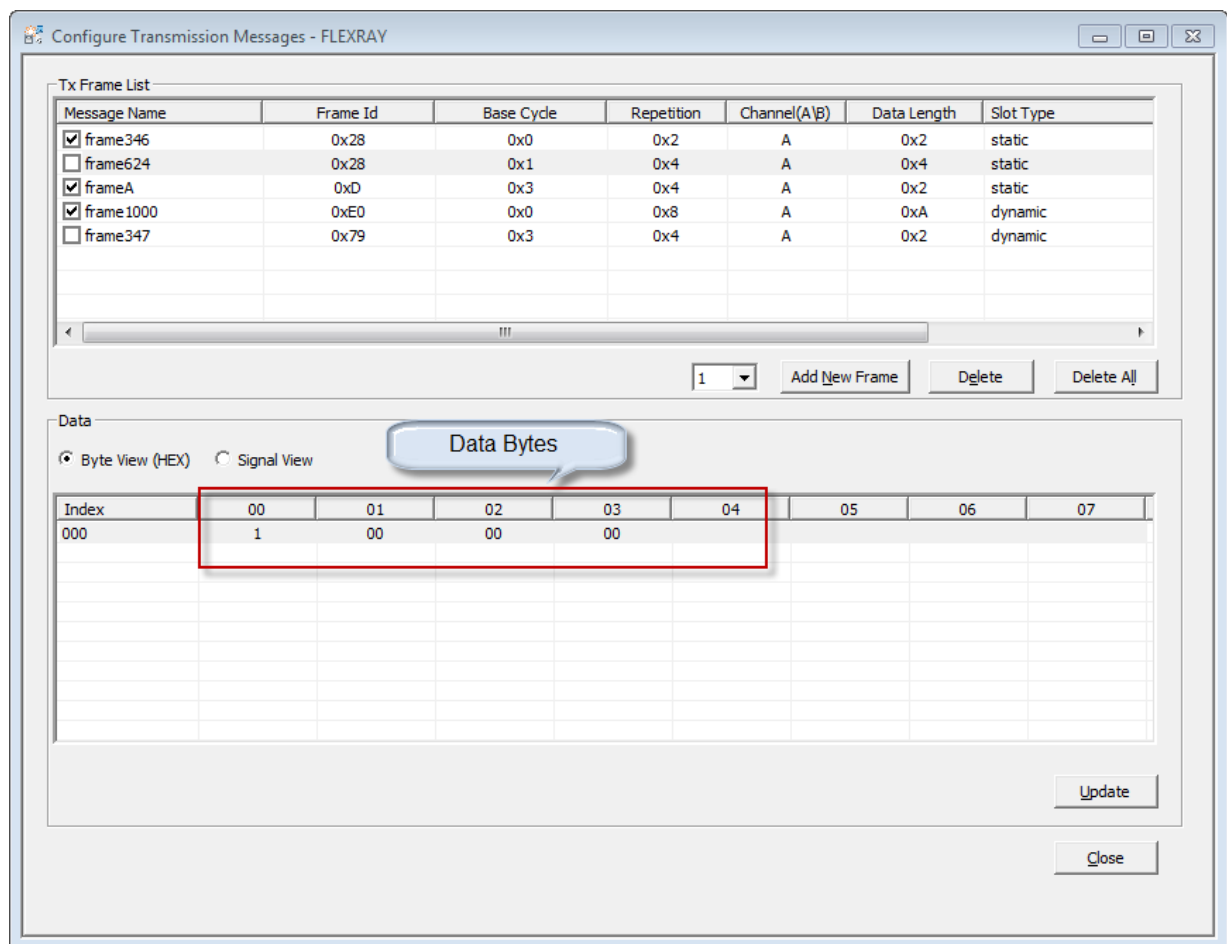
**Transmitting Message Over FlexRay BUS:**

After Configuring the messages they will be displayed in Transmit Window as shown in below figure. Click on the check box beside a message to select the message for transmission. Once the BUSMASTER Connected to the FlexRay network all the selected message will be sent on the network in their schedule time.



### Updating Data Bytes:

To Change the Data bytes of a message click on the message. This will display the current data bytes of the Message. in Data Window as shown in below image. To change the Data bytes double click on the required data byte. Use Tab or Arrow Keys to move to the next data bytes. Click on Update button to Apply the changes.



**Signal View:**

To View the Signals of a any Frame click on it and select the Signal View.This will display the signals & their Raw\Physical values as shown in below.



Time	Tx/Rx	Frame Id	Frame Type	Slot Typ	Descriptio	Cycle	Chann	D	Data Byte(s)
15:24:59.6298	Rx	0001	sync, startup	static		22	A	16	000 000 000 000 000 000 ...
15:24:59.6298	Rx	0002	sync, startup	static		22	A	16	000 000 000 000 000 000 ...
15:24:59.6202	Rx	0013 [0, 2]	Data	static	ABSInfo	20	A	16	000 000 000 000 000 000 ...
					GearLock	0			0.000000
					Diagnostics	0			0.000000
					AccelerationForce	0			0.000000
					CarSpeed	0			0.000000
15:24:59.6253	Rx	0016 [0, 1]	Data	static	BrakeControl	21	A	16	000 000 000 000 000 000 ...
					ABSWarningLamp	0			0.000000
					ASMode	0			0.000000
					BrakePressure	0			0.000000
					ESPWarningLamp	0			0.000000
					BrakeWarningLamp	0			0.000000
15:24:59.6256	Rx	0025 [0, 1]	Data	static	EngineData	21	A	16	000 000 000 000 000 000 ...
					EngForce	0			0.000000
					EngPower	0			0.000000
					PetrolLevel	0			0.000000
					IdleRunning	0			0.000000
					EngSpeed	0			0.000000
					EngTemp	0			-50.000000
15:24:59.6214	Rx	0051 [0, 2]	Data	static	BackLightInfo	20	A	16	000 000 000 000 000 000 ...
					BrakeLight	0			0.000000
					BackUpLight	0			0.000000
15:24:59.6252	Rx	0013	Null	static		21	A	16	000 000 000 000 000 000 ...
15:24:59.6264	Rx	0051	Null	static		21	A	16	000 000 000 000 000 000 ...

The Following section will explain the Columns Displayed in Message window with explanation.

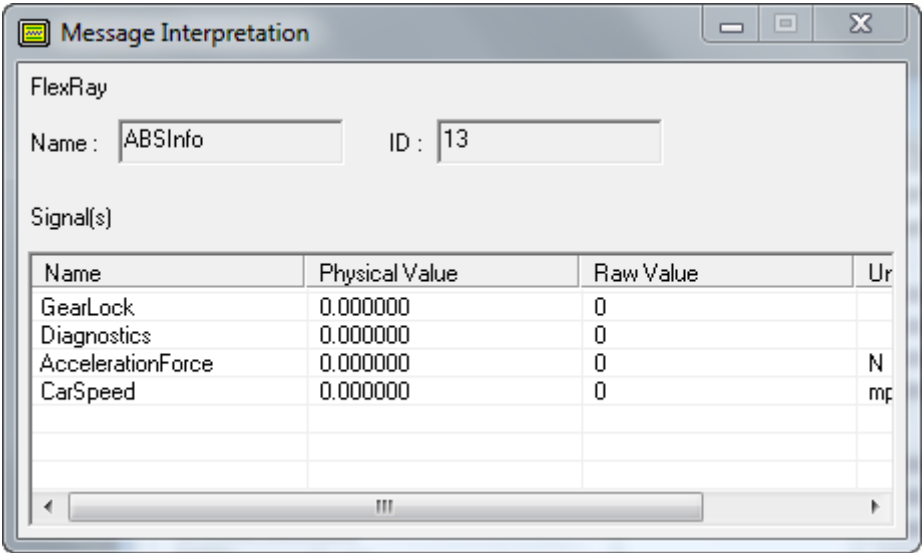
**Table 1:**

Column	Explanation
<b>Time</b>	This Will display the time at which message is received\Sent on FlexRay BUS.The time mode can be changed to Absolute\System\Relative Mode using <b>FlexRay-&gt;Message Window-&gt;Time Mode</b> menu
<b>Tx/Rx</b>	This Menu will display weather the message is received or sent from BUSMASTER.Tx Represents the message is sent From BUSMASTER.Rx Represent Message is received in BUSMASTER
<b>Frame Id</b>	This Column gives the information about the Scheduling of Message.The information will be displayed in the format of <i>slot_id [base_cycle, repetition]</i> .
<b>Frame Type</b>	This Column will tell the Frame type.The following are the Frame types displayed in this column. <ul style="list-style-type: none"> <li>• sync</li> <li>• startup</li> <li>• sync, startup</li> <li>• Null</li> <li>• Data</li> </ul>
<b>Slot Type</b>	This column will tell weather the message is Transmitted\Received in static\Dynamic Slot.
<b>Description</b>	This column will give the Message Name associated with the ID.
<b>Cycle</b>	This column will display the Cycle in which the message was received
<b>Channel</b>	:This column will display on which channel ( A, B or AB ) the message was received.
<b>DLC</b>	This column will display the Length of Frame in Bytes.

Column	Explanation
Data Byte (s)	This column will display the Data Bytes received\Transmitted of the Frame

**Message Interpretation window:**

It is possible to Monitor the interpretation of a single message in separate window called **Message Interpretation**.Double click on any message in Message window to Activate the Message Interpretation window.An Instance of this window is shown in following figure.



# LIN

---

## Introduction

## LIN Simulation in BUSMASTER

---

### Introduction:

Currently BUSMASTER can be used as slave to Respond to Master Requests and to Monitor the LIN messages. The following steps are required to Configure the BUSMASTER for Transmit\Receive the LIN Messages.

#### 1. Cluster Configuration:

To Transmit\Receive the LIN Messages BUSMASTER has to be configured with LIN Baud Rate and Version. Refer **Cluster Configuration** Section for more Information.

#### 2. Controller (Driver) Selection:

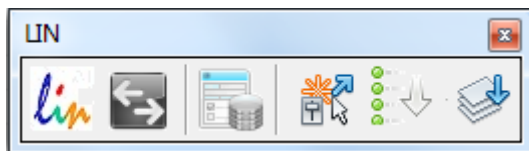
BUSMASTER can be connected to Physical LIN Network using LIN Controller. Refer **Controller Selection** section for more Information.

#### 3. Transmit Messages:

LIN Slave Messages Can be transmitted over LIN network using LIN Tx Window. Refer **LIN Transmission Window** Section for more information.

#### 4. Connect to Network:

Once the Cluster & Controllers are properly configured BUSMASTER can be connected to Network using **LIN->Connect**. menu or the LIN Connect Tool bar Button as shown in following figure.



#### 5. Monitoring Messages:

BUSMASTER Message Window can be used to monitor the LIN messages of LIN Network. Refer **LIN Message Window** section for more information.

## LIN Cluster Configuration

---

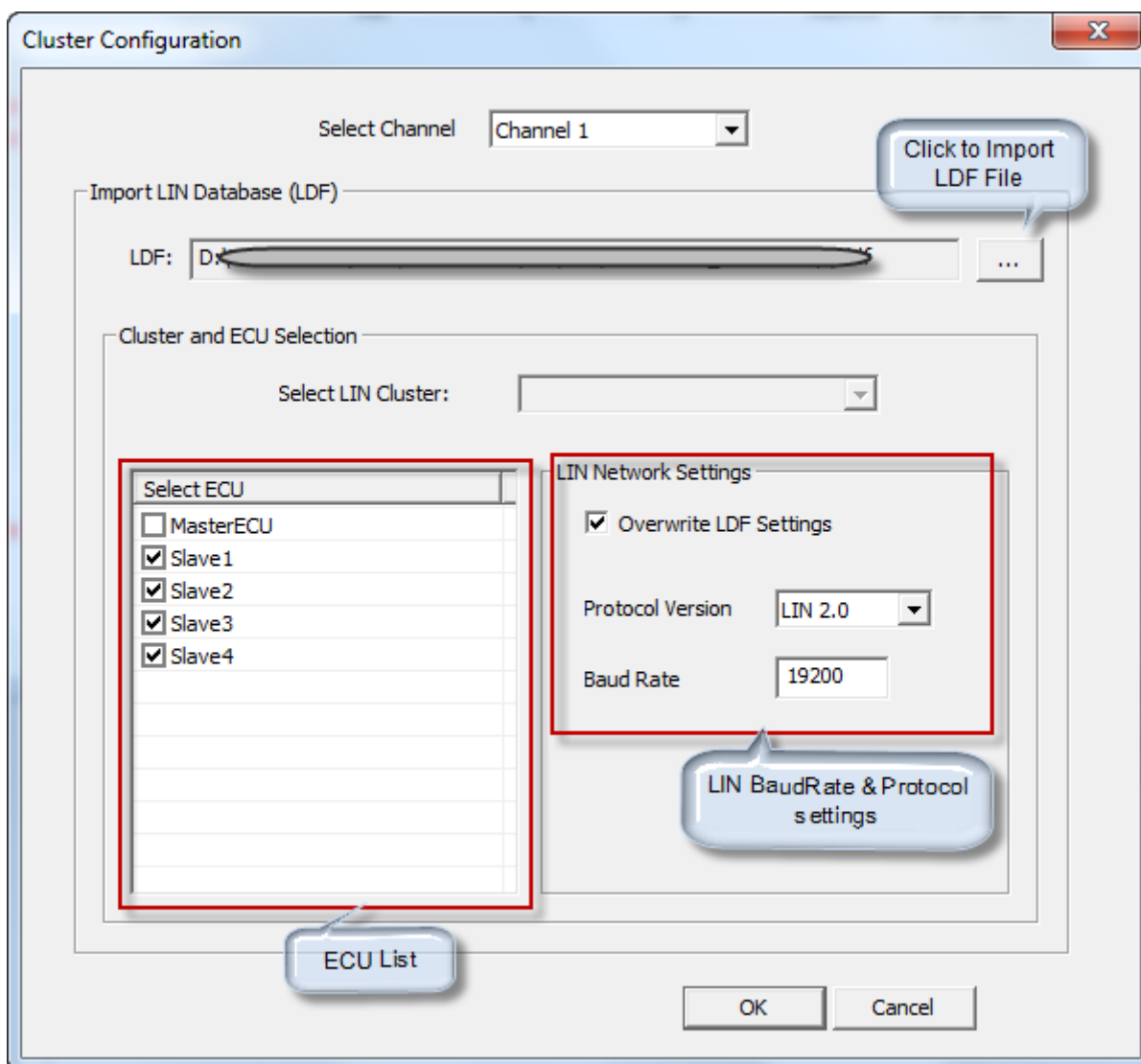
### Introduction:

To connect BUSMASTER to the LIN Network first it has to be configured with the proper LIN Baud Rate and LIN Protocol Version. This can be done using by importing a LDF or using manual settings

### Configuration:

To configure the Cluster use **LIN->Cluster Configuration** menu. This will display the Window as shown in following Figure.





LIN Baud Rate & Protocol version can be set either by Loading the LDF File or using **LIN Network Settings** section by Enabling **Overwrite LDF Settings** as shown in above figure.

## LIN Controller Configuration

### Introduction:

BUSMASTER Can be connected to LIN physical channel using LIN Controller.

Currently BUSMASTER Supports the following LIN Controllers.

1. ETAS BOA (To monitor messages associating LDF file is required for LIN ETAS BOA)
2. ETAS ISOLAR-EVE
3. Vector XL

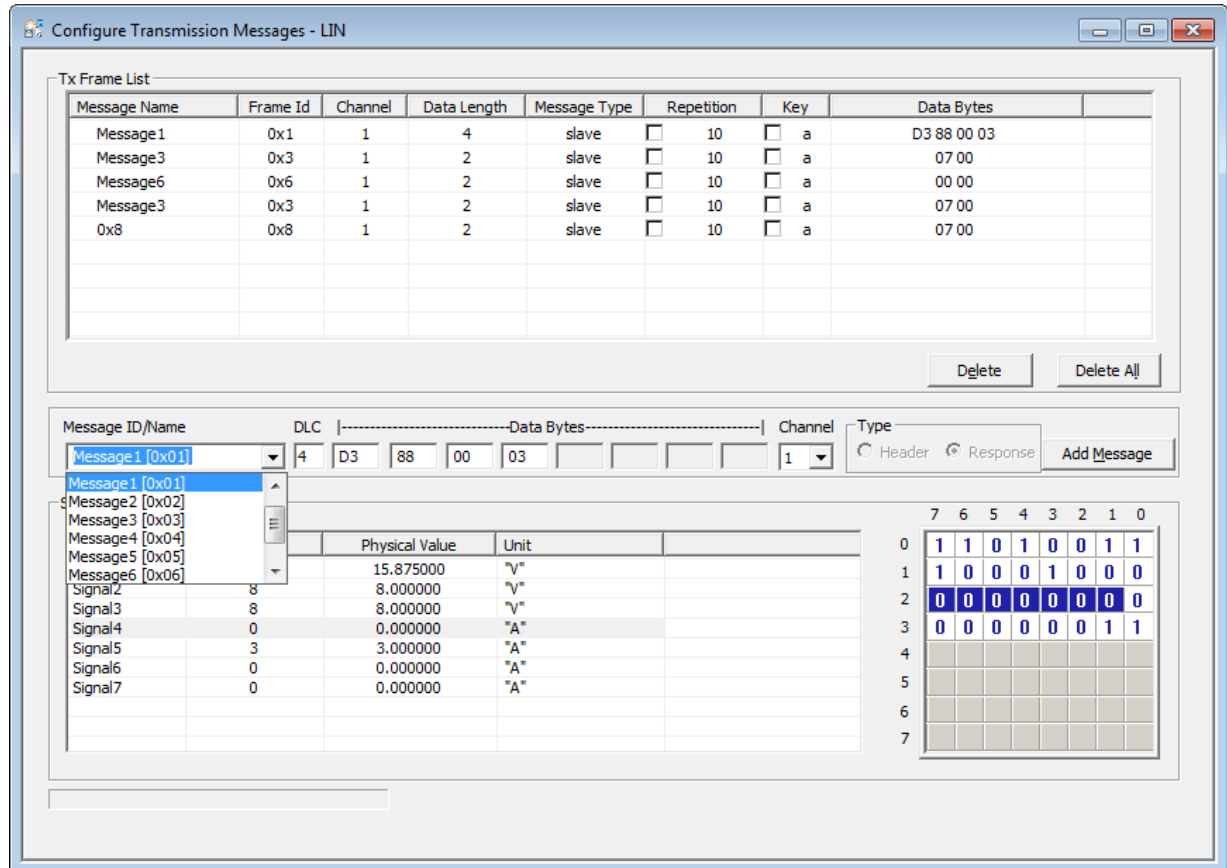
### Selecting Controller:

To select controller use LIN->Driver Selection->*{Driver}* For example to select ETAS ISOLAR EVE Driver use **LIN->Driver Selection->ETAS ISOLAR-EVE**.

Once the Controller is configured BUSMASTER Can be connected to LIN network using **LIN->Connect** Menu.

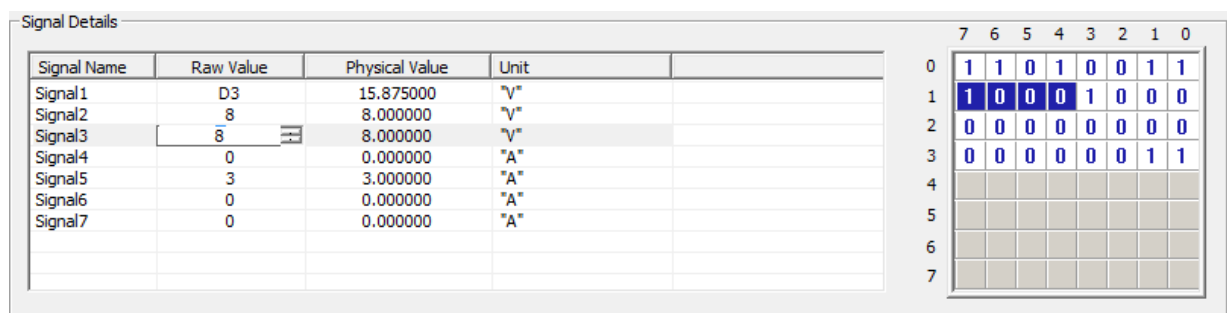
## Transmit Messages

Slave can respond to the Master request over LIN-bus using LIN Transmit Window. Use **LIN --> Transmit --> Configure** menu option, to open the LIN Transmission Window.



### Configure Slave Responses:

- Once a LDF File is imported the Messages( DB Messages ) in LDF file will be populated in **Message ID/Name** List Box as shown in above figure. It is also possible to add Non-db Messages by typing Message id in List Box. Once the Message is selected in List Box, Click on **Add Message** Button to add it in **Tx Frame List**.
- The DLC and data byte values can be changed using DLC and Data Bytes edit box windows.
- If the Message is a DB Messages and if it has signals associated, then they will be displayed in Signal List as shown in following figure. The Raw/Physical value of the signal can be changed by double clicking the corresponding cell.



### Cyclic Transmission of Message:

The message can be transmitted periodically by Enabling Repetition. Cyclic Transmission will be useful to transmit the message with different data bytes periodically.

#### Transmission on Event:

The Message can be sent to the controller on pressing key. Each message in Tx FrameList can be assigned an alpha-numeric key.

## Connect and Disconnect

User can connect/disconnect the tool from the LIN-bus by pressing/releasing a toggle tool bar button shown in the figure below.



The tool can also be connected by selecting **LIN > Connect** menu option (available only in disconnected state). The same can be disconnected by selecting **LIN > Disconnect** menu option (available only in Connected state) or by pressing Esc key. When the tool is in connected state, the menu option will become Disconnect and when the tool is in disconnected state, the menu option will be displayed is Connect.

Transmission and reception of messages can be done only when the tool is in the connected state.

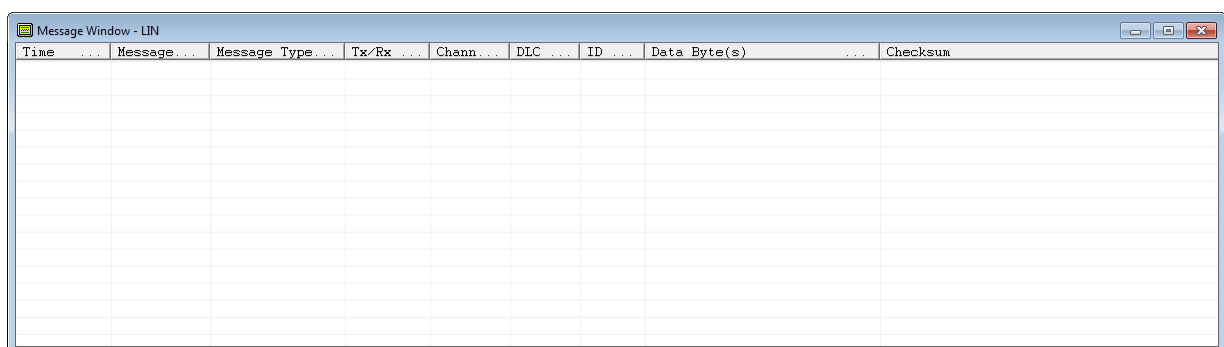
## LIN Message Window

#### Introduction:

On-line LIN Network Monitoring can be done using FlexRay Message window.

#### Activation:

Use **LIN->Message Window->Activate** menu to Activate the Message window. This will display Message Window as shown in following figure.



Once the BUSMASTER is connected to LIN Network the Message window will display all the Messages Transmitted on the network. Also the Message window will display the LIN Error Messages & other LIN Events. Currently the following Error or Event messages were supported.

- CRC Error
- Sync Error
- Slave Not Responding Error
- Sleep Event

### Enabling Interpretation:

The Signal values of LIN Messages can be analysed using Interpretation mode. To enable the interpretation the Message window should be in overwrite mode. Use **LIN->Message Window->Overwrite**. menu to enable the overwrite mode. After this use **LIN->Message Window->Interpret**.

The below figure shows Message window when it BUSMASTER is connected to LIN Network.

Time	Message	Message Type	Tx/Rx	Chann	DLC	ID	Data Byte(s)	Checksum
10:52:41:2678	0x29	LIN Message	Rx	1	4	0x029	88 88 01 83	0x80 ("Enhanced")
10:52:41:3211	Message1	LIN Message	Tx	1	4	0x001	D3 88 00 03	0xDE ("Enhanced")
Signal1	211	15.875000	"V"					
Signal2	8	8.000000	"V"					
Signal3	8	8.000000	"V"					
Signal4	0	0.000000	"A"					
Signal5	3	3.000000	"A"					
Signal6	0	0.000000	"A"					
Signal7	0	0.000000	"A"					
10:52:41:3169		Error - Slave Not Responding		1		0x012		
10:52:40:3263	0xF	LIN Message	Rx	1	2	0x00F	F0 FF	0x3F ("Enhanced")
10:52:41:2896	0xFF	Error - Unknown		1				
10:52:41:2939	Message5	Error - Slave Not Responding		1		0x005		
10:52:40:1340		Event - Wake up		1				
10:52:40:1469		Error - Slave Not Responding		1		0x018		
10:52:41:2340		Error - Slave Not Responding		1		0x026		

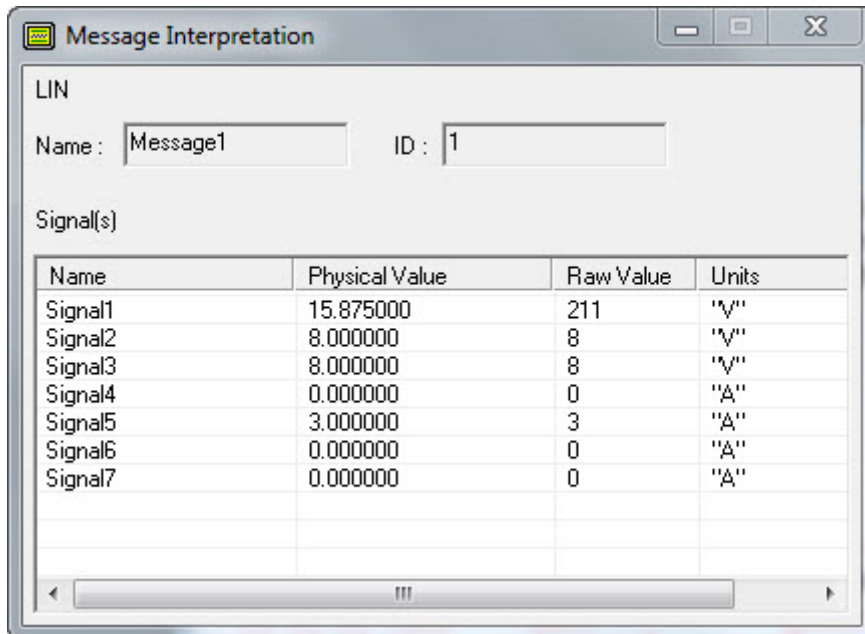
The Following section will explain the Columns Displayed in Message window with explanation.

**Table 2:**

Column	Explanation
<b>Time</b>	This Will display the time at which message is received\Sent on LIN BUS. The time mode can be changed to Absolute\System\Relative Mode using <b>LIN-&gt;Message Window-&gt;Time Mode</b> menu
<b>Tx/Rx</b>	This Menu will display whether the message is received or sent from BUSMASTER. Tx Represents the message is sent From BUSMASTER. Rx Represent Message is received in BUSMASTER
<b>Message</b>	Displays the Name of message if available in LDF file
<b>Message Type</b>	This Column will tell the Frame type. The following are the Frame types displayed in this column. <ul style="list-style-type: none"> <li>LIN Frame</li> <li>Error - Slave No Response</li> <li>Error - CRC Error</li> <li>Event - Sleep</li> <li>Event - Wakeup</li> </ul>
<b>ID</b>	Displays the LIN Message ID.
<b>Checksum</b>	This column will give the Checksum value and Checksum type.
<b>Channel</b>	This column will display on which channel ( A, B or AB ) the message was received.
<b>DLC</b>	This column will display the Length of Frame in Bytes.
<b>Data Byte (s)</b>	This column will display the Data Bytes received\Transmitted of the Frame

**Message Interpretation window:**

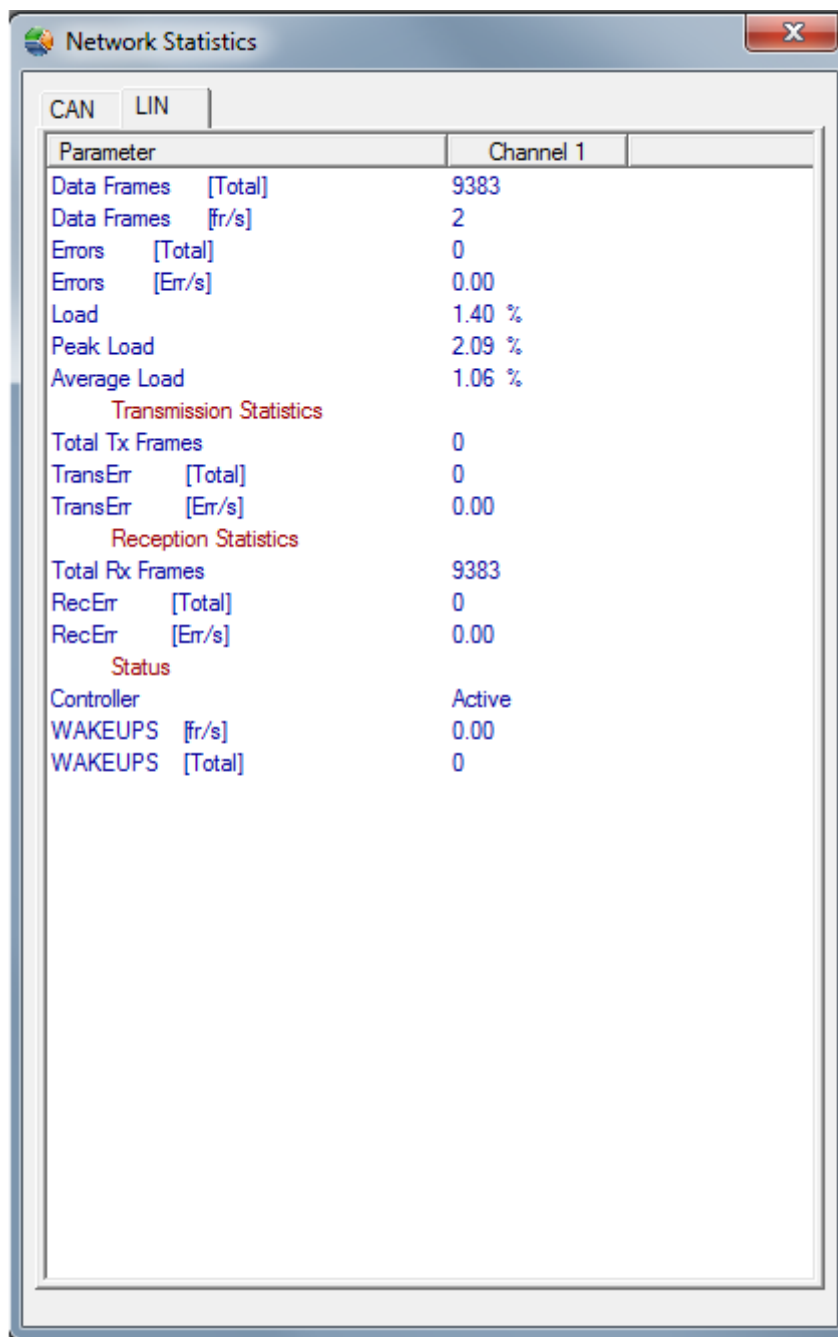
It is possible to Monitor the interpretation of a single message in separate window called **Message Interpretation**. Double click on any message in Message window to Activate the Message Interpretation window. An Instance of this window is shown in following figure.



## Network Statistics

---

Network statistics dialog gives details about the messages transmitted and received on the bus. This information includes the number of Data Frames and Error messages transmitted and received by BUSMASTER and current rate of these parameters. Also information related to the total Wakeups and its rate will be displayed. This is updated once in a second. Message rate per second and Network load in terms of Bus traffic is also presented. The peak network load will show the peak traffic during that session. This information can be used to find bus utilisation. Statistics information will be cleared during connect and during controller reset.



The image shows a 'Network Statistics' dialog box with a tabbed interface. The 'LIN' tab is selected. The dialog displays a table of statistics for 'Channel 1'. The statistics are grouped into sections: General, Transmission Statistics, Reception Statistics, and Status. The values are as follows:

Parameter	Channel 1
Data Frames [Total]	9383
Data Frames [fr/s]	2
Errors [Total]	0
Errors [Err/s]	0.00
Load	1.40 %
Peak Load	2.09 %
Average Load	1.06 %
<b>Transmission Statistics</b>	
Total Tx Frames	0
TransErr [Total]	0
TransErr [Err/s]	0.00
<b>Reception Statistics</b>	
Total Rx Frames	9383
RecErr [Total]	0
RecErr [Err/s]	0.00
<b>Status</b>	
Controller	Active
WAKEUPS [fr/s]	0.00
WAKEUPS [Total]	0

To invoke Network Statistics Dialog, select the menu **Window --> Network Statistics**.

## Signal Watch

User can watch the value of a signal using the signal watch window as and when a message having that signal is received. The Physical and Raw values will be listed and updated as and when the message arrives. Click on the tool bar button shown below to display the signal watch window.

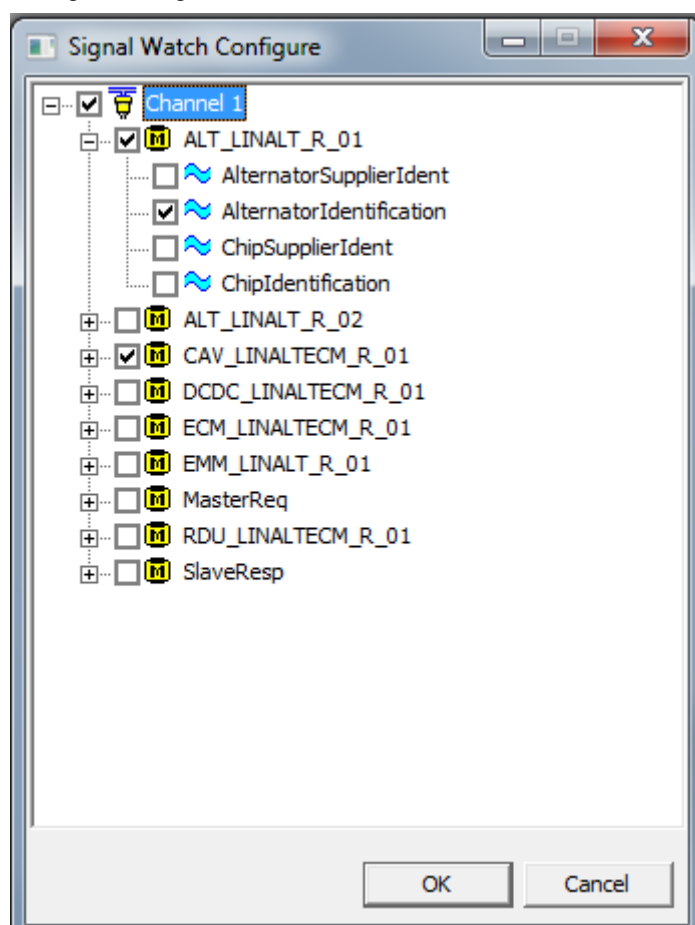


**Show/Hide Signal Watch**

### Add/ Delete Signals

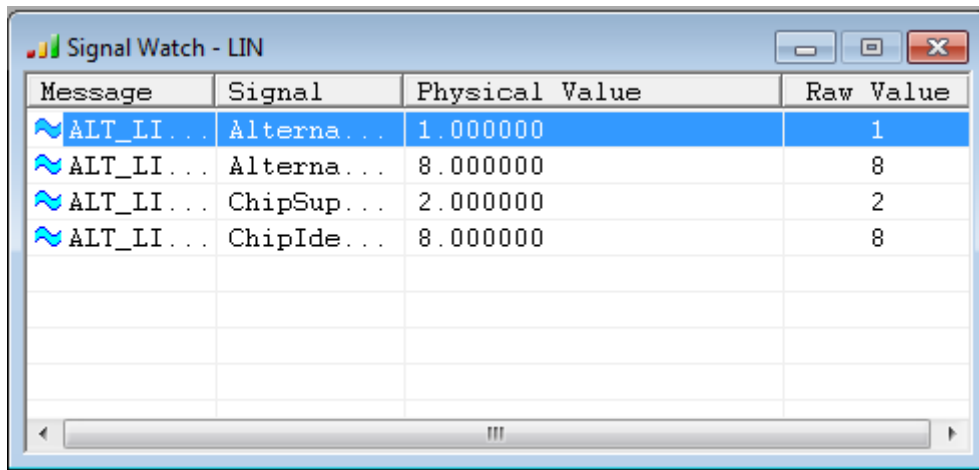
Signal watch list can be interactively populated. The following list describes the steps to Add/Delete signals.

- Click on **LIN --> Signal Watch --> Activate**.
- A dialog box will be displayed then do right click and select Configure Signals from the menu. This will show the signal configuration Window.



- Select a message and select associated signal from the Signal list. Check the signals to move the selected signal in to Watch List. Multiple signals can be checked. All signals belonging to a message can be added in to the watch list by checking the message check-box.
- Signal from the Watch List can be deleted by unchecking the entry.
- Signal Watch List can be cleared by selecting Delete All button.
- Changes will be saved and applied on selection of Ok. Cancel will ignore the changes.
- The Signal Watch List will be saved in the configuration file and will be reloaded during the load of that configuration file.

### Show Signal Watch Window



Message	Signal	Physical Value	Raw Value
ALT_LI...	Alterna...	1.0000000	1
ALT_LI...	Alterna...	8.0000000	8
ALT_LI...	ChipSup...	2.0000000	2
ALT_LI...	ChipIde...	8.0000000	8

After receiving a message BUSMASTER will update the signal watch window if the signals of received message are included in the signal watch list. The signal watch list will show Raw and Physical value of the signal with the Unit along with Message and Signal name.

### Close signal watch window

User can directly close the window by clicking on Close [X] button.

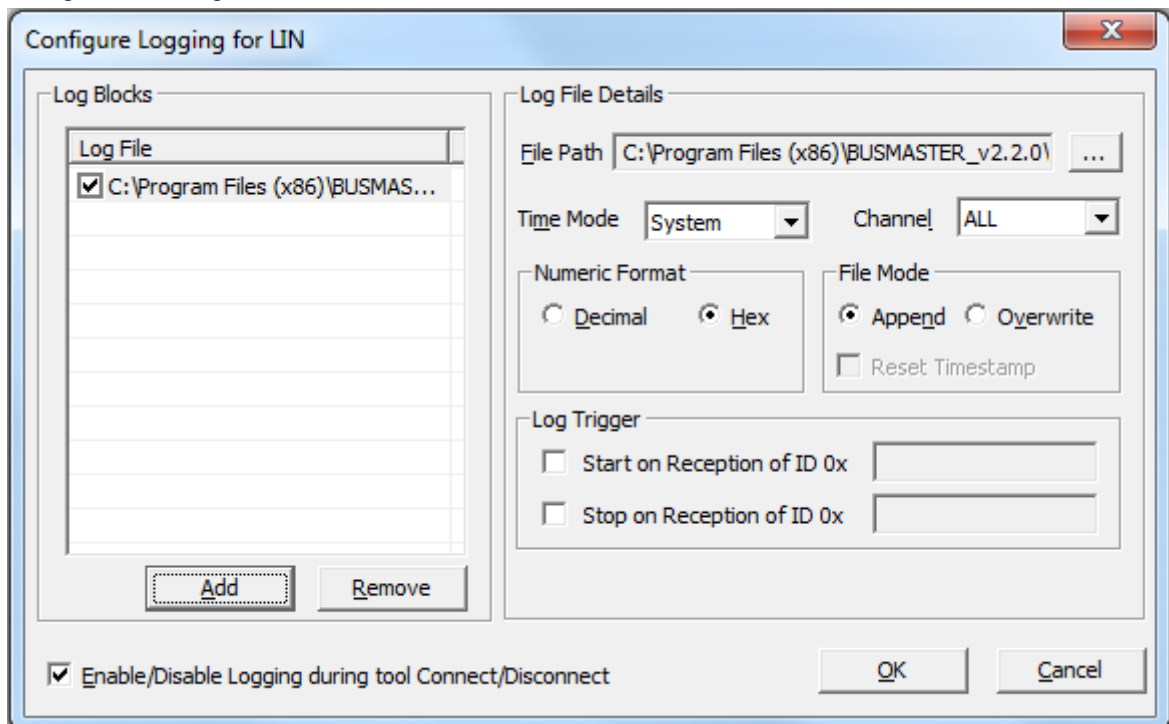
OR

1. Click on the drop-down button associated with the tool bar button shown above. This will pop-up a menu.
2. Click on Close menu option to close the signal watch window.

## Logging

### Logging

User can configure log file setting using **LIN --> Logging --> Configure** menu. This will show log file configuration dialog as shown below.



**Configure Logging for LIN**

**Log Blocks**

Log File
<input checked="" type="checkbox"/> C:\Program Files (x86)\BUSMAS...

**Log File Details**

File Path: C:\Program Files (x86)\BUSMASTER\_v2.2.0\ ...

Time Mode: System Channel: ALL

**Numeric Format**

☐ Decimal ☒ Hex

**File Mode**

☒ Append ☐ Overwrite

☐ Reset Timestamp

**Log Trigger**

☐ Start on Reception of ID 0x

☐ Stop on Reception of ID 0x

☒ Enable/Disable Logging during tool Connect/Disconnect



## Log Files

User can add as many as log files in to the list of Log Files. This list will show the log files that are already configured. To add a new Log file select Add button. This will add a log file with default file name. User can change the file name using "..." button in the Log File Details section. The check box associated with the log file will make the log file eligible for logging. If the check box is not checked logging will not happen to that particular file.

## Log File Details

Log file details will give configuration of the selected log file. This will give info of log file path, time mode, numeric mode, file mode, log triggers.

## Log File Path

The file path text box will give the selected log file path. To change the path select "..." button. This will show file selection dialog. On selection of a log file, the file path text box will be updated with selected file path.

## Log File Size

Log file size is fixed to a limit of 50 MB. This limit is set as most of the editors will take lot of time to open if the file size is large.

## Time Mode

Logging of messages can be done in three different time modes. System time, Absolute time and Relative time mode. In system time mode time stamping of message is done using real time clock of the system. In absolute time mode the time stamping is done with respect to the absolute timer that will be stated during connect. In relative time mode the time stamping of a message is with respect to previously received message.

Reset Timestamp for every enable logging is provided. If this option is selected then the absolute time will be reset whenever the logging is enabled.

## Numeric Mode

This tells the numeric format of log file entries. It has two options Hex and Decimal. Message ID and data bytes of a LIN message will use this as a base while format for logging.

## File Mode

In Append file mode, log sessions will be appended at the end of the file. Each logging session will have its own session header and footer. In Overwrite file mode the file will be overwritten for the first session. For consecutive sessions the file name will be suffixed with an incrementing number and each session will be logged in new files. The log file name will be incremented every-time when you stop the logging process.

If already log files are created in the previous session and if a new session is started, then the log files created already will be overwritten in both overwrite and append mode. In this case, the successive files already created in the previous session will contain old session data.

## Logging Indication

Recording or logging is indicated in the status bar for LIN. When the logging is enabled and data is logged in to the file, an icon will be shown in the status bar with glowing on and glowing off continuously till the logging is stopped. When the logging is stopped then icon will be disabled.

### Example

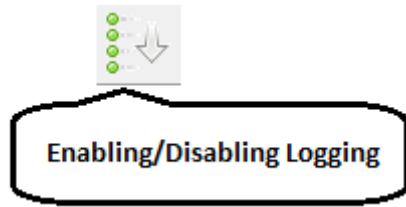
If the log file name is abc.log for the first time, then for the next time the log file name will be abc0.log.

Similarly, if the log file name is abcn.log for the first time, where n – is any number, then for the next time the log file name will be abcm.log, where  $m = n + 1$ .

## Message Log

LIN messages can be logged to a file for analysis. Log file name shall be selected as described in section Logging.

To start message logging select Log Start or press the Tool Bar Button shown in the figure below. The tool bar is toggle button. Clicking on the button or selecting the menu again will stop logging. Once the logging has started, the messages received and transmitted will be logged in to the file with time of message reception.



### Note:

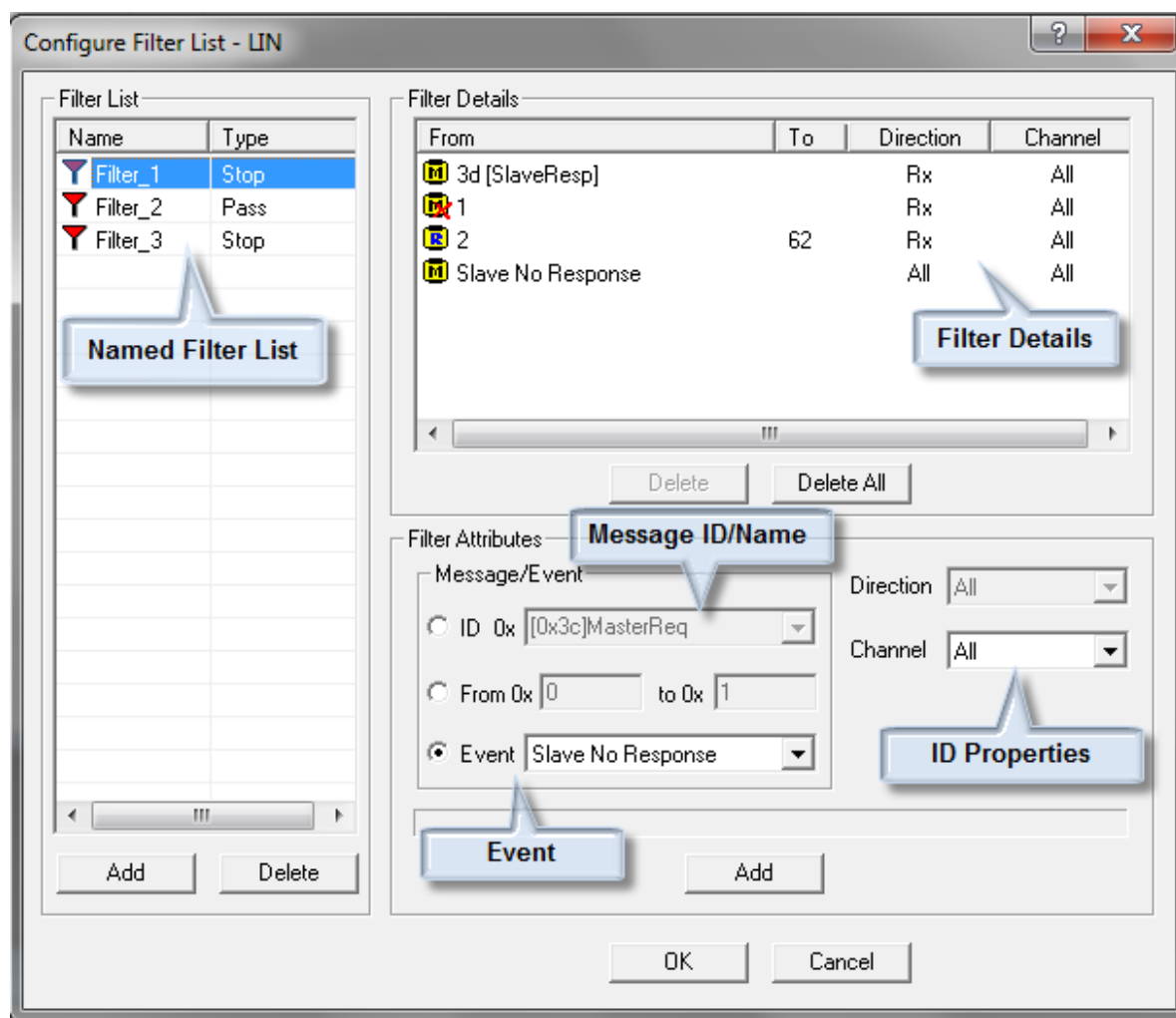
- Logging will fail if the log file is not present in the specified location.
- Logging status is stored in configuration file and logging will be started automatically during application startup if it is enabled and saved in the configuration file.

## App Filter

---

User can configure filter list by choosing messages/events to be filtered. To configure the filter list, follow the steps given below

- Select **LIN --> Filter Configuration**.
- The dialog box specified below will be displayed.



### Filter List

It is a list of filters that are identified by the name. The name of the filter should be unique and can have any kind of special characters also. The second parameter tells about the type of the filter, pass or stop. Pass filter allows only the configure message or range of message to pass. On the other size stop filter blocks the configured messages. These filters shall be used in display, logging and replay filters.

### Filter Details

This section shows list of message names, ID and range along with ID type, message frame type, direction and channel number. Type is denoted by different icons. Selecting an entry from the list updates the details of the filter in Filter Attributes section.

### Filter Attributes

Filter attributes gives more details of selected filter entry. Message Name or ID in case of single id filtering and message ID range in case of range filter will be update. Direction field will show whether the message is transmitted or received. If it is all then direction will be ignored. Channel filed associates the message with particular channel. Channel all makes the message independent of channels.

Database message names shall be selected from the Message ID combo box. Message ID shall be directly typed in this combo box. If the filter is for a range of messages then the Range radio button shall be selected. This will enable range edit boxes. Filter attributes shall be selected based on the filter requirements.

Event radio button shall be selected for Event filter. This will enable Event combo box, from which event type can be selected. Channel combo box will enabled.

The Add button in the Filter Attributes section will add configured filter in to the selected named filter list. This button will be disabled in case of invalid parameter entered by the user and appropriate error message will be displayed in the status bar.

Once the filter is added in to the Filter List then the name of the filter will appear in the Filter Configuration List to select. Any modification on these filter will immediately reflect in the all modules that are using these filters.

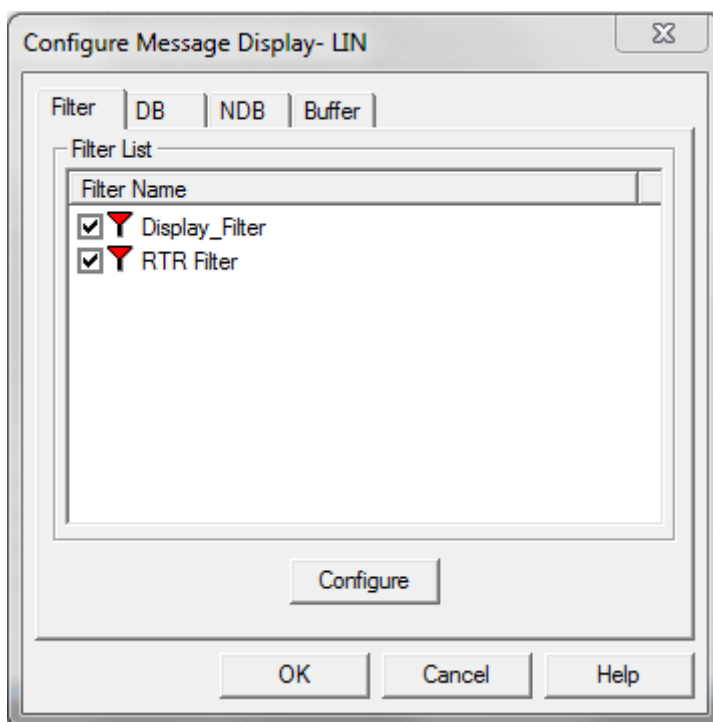
Filter list will be saved in configuration file and will be updated while loading a configuration file. While loading a configuration file created with BUSMASTER 3.06.02.X.XXX version one filter entry will be created with the previous filter information.

## Message Display

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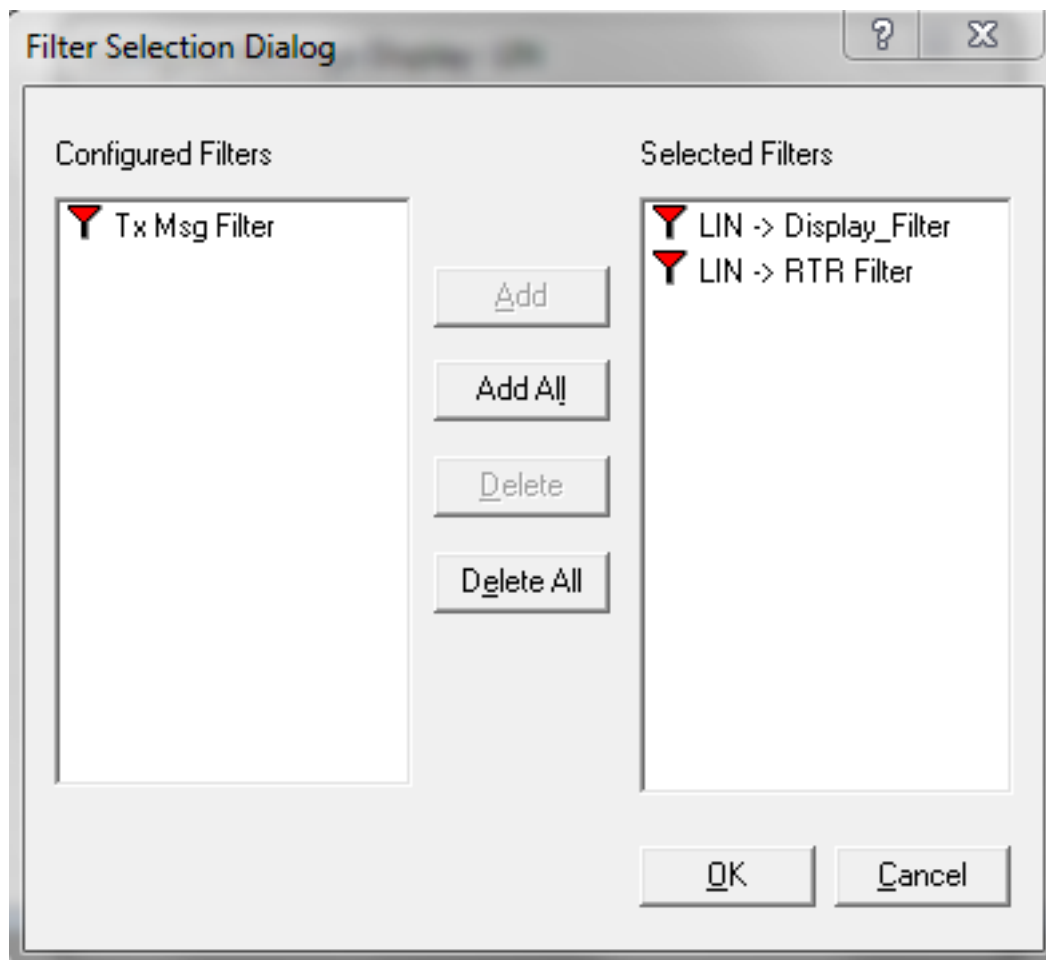
### Message Filter

Filters for message display can be configured by selecting **LIN --> Message Window --> Configure** and by selecting Filter tab. This will show list of filters configured for Message Display.



### Display Filter

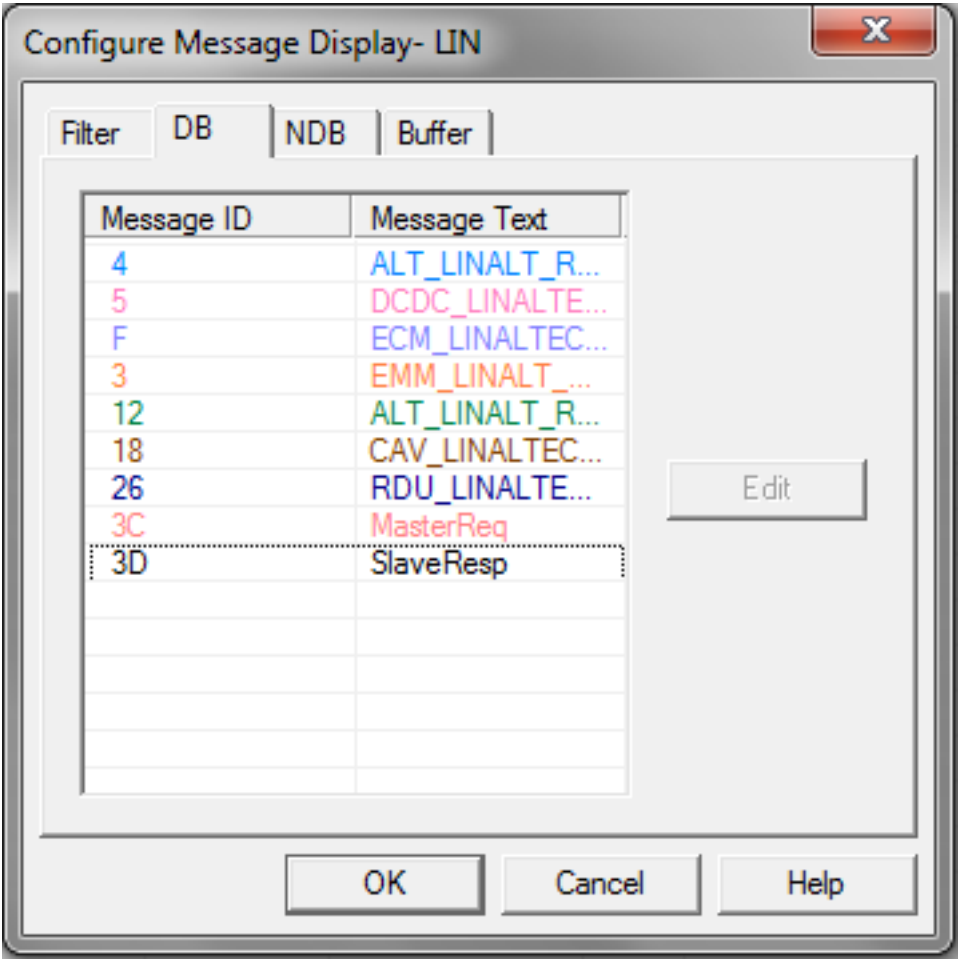
To configure display filter list select Configure button which will list available filters and selected filters.

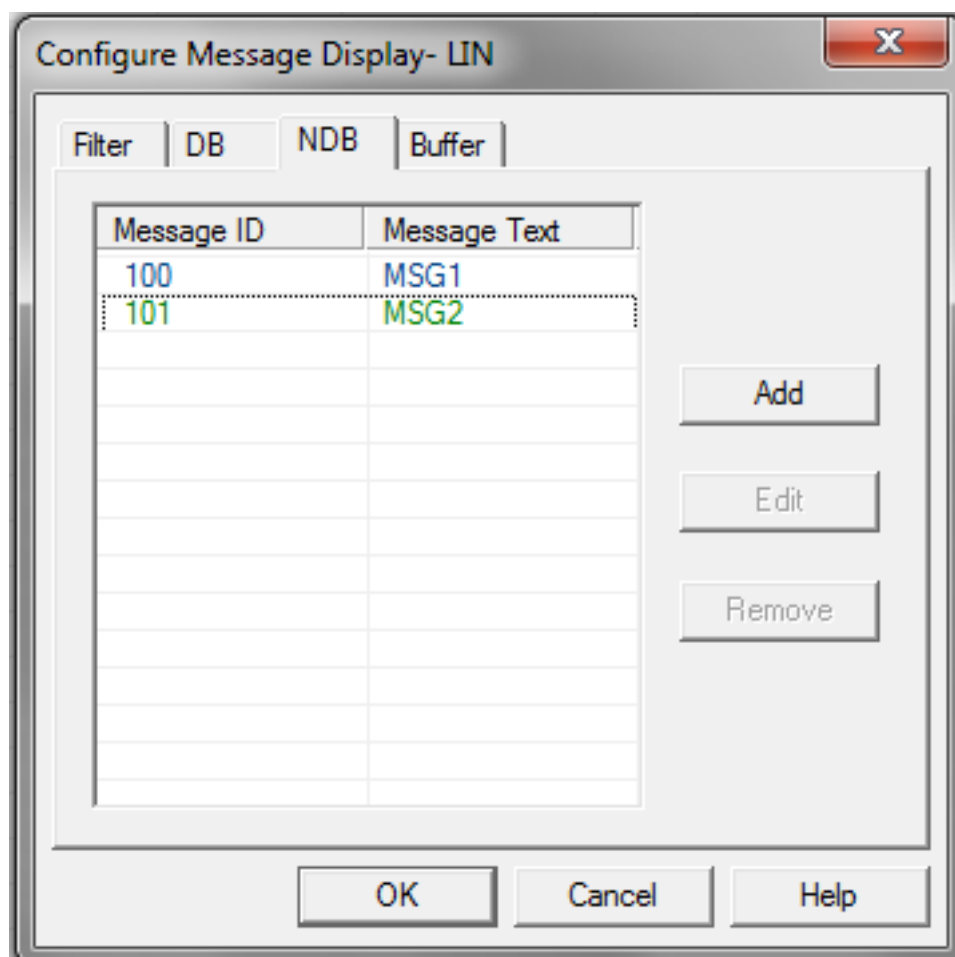


### Message Coloring

User can configure the color with which the message will be displayed and associate a textual description to message.

By default all messages are displayed in black color and the message ID itself as the associated text. For the database message user can only edit the color.

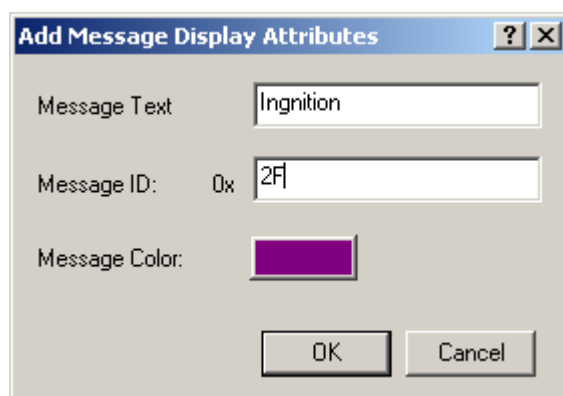




### Adding message attribute

To configure a message display option, please follow the steps given below

1. Select **LIN --> Message Window --> Configure**
2. Dialog box Configure Message Display as in above figure will be displayed
3. Click on Add button
4. One more dialog box Add Message Display Attributes as shown below will pop up.



5. Enter the message ID and Message text
6. Click on the colored button to select a color, This click pops up a color palette as shown above.
7. Select a suitable color
8. Select OK button to confirm

Subsequent reception / transmission of the message that has been configured will be displayed with associated text & color.

### Editing a message attribute

To edit the message attributes please follow the steps given below

1. Select **LIN --> Message Window --> Configure**.
2. Dialog box Configure Message Display will be displayed.
3. Select the message entry to be edited from the message list.
4. Either click on Edit button or double click on the selected entry.
5. One more dialog box Edit Message Attributes will pop up.
6. Change the required Message attributes.
7. Select OK buttons to confirm.

Subsequent reception/transmission of the message that has been configured will be displayed with associated text & color.

### Deleting message display attribute

To delete an entry from the Message List follow the steps given below

1. Select **LIN --> Message Window --> Configure**.
2. A dialog box will pop up. Select the message entry to be deleted from the message entry list.
3. Click on Remove button. A delete confirmation message box will be displayed.
4. Select Yes to confirm deletion.
5. Select OK button to confirm the modification of entries.

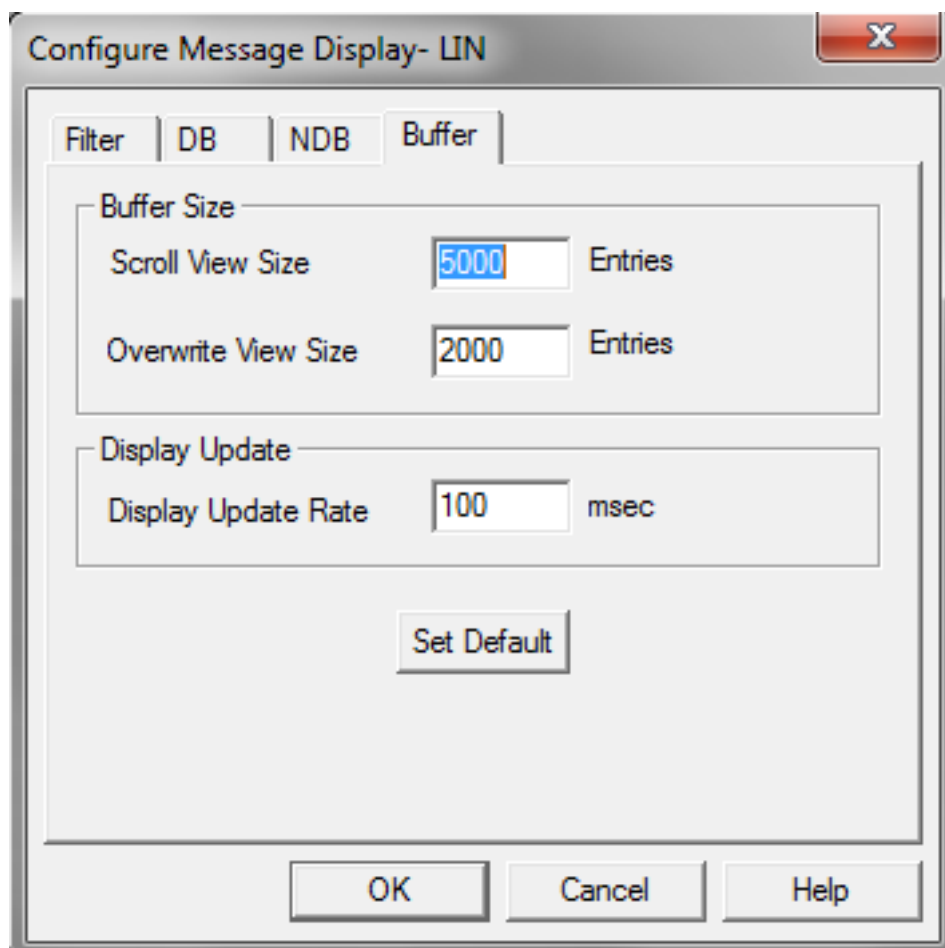
On subsequent reception/transmission, the message will be displayed in black color.

### Display Buffer size & Update Rate configuration

To configure Append and overwrite buffer size, follow the steps given below

1. Select **LIN --> Message Window --> Configure**.
2. A dialog box will pop up. Select the Buffer page.





3. The buffer size can be from 200 to 32500 display entries. The display update rate can be from 50 to 20000 milliseconds.
4. Set entries for Append buffer and overwrite buffer. Set display update rate.
5. Select OK button to confirm the modification of entries.
6. Select Set Default button to set the default values.

### Show Last Option

This option can be used to set the focus of the list item to the latest item in Scroll mode. In append mode latest message entries will be added at the end. To make the latest entries visible always select **LIN --> Message Window --> Show Last**.



#### Note:

- In overwrite mode this option will be disabled to avoid rolling of selection.
- Selection will be update only during display update.

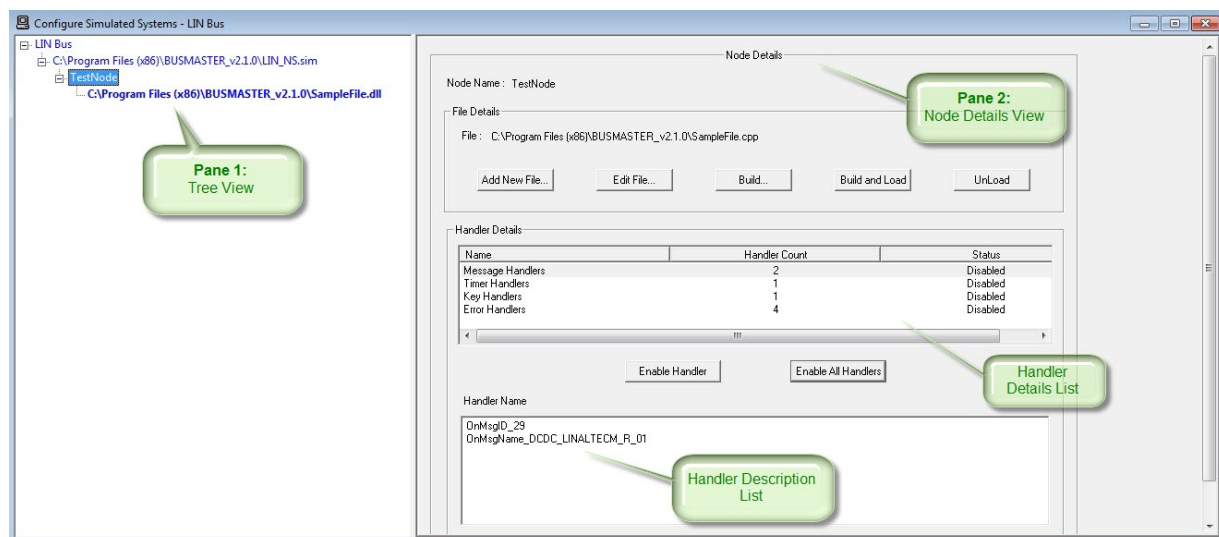
## Node Simulation

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### Configuration

Simulated systems can be configured under the LIN-bus by following the steps given below. Select **LIN --> Node Simulation --> Configure** menu option. This will display the window as shown in figure below.

There are two panes in the **Configure Simulated Systems** window as shown in figure below.



### Left Pane

This will have the details of all simulated systems listed in a tree fashion. Will be called Pane 1.

### Right Pane

This pane will display the details of each node that you select from the Pane1. Will be called Pane 2.

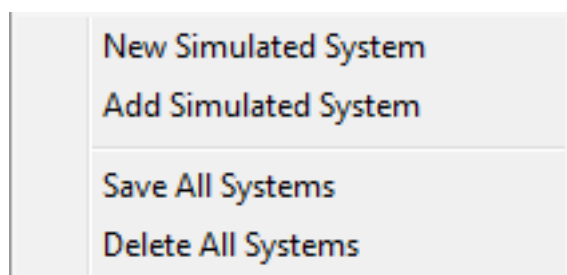
By default no simulated system is configured. Once the user adds or creates simulated systems under LIN Bus it will be stored across sessions.

### New Simulated System

To configure a new simulated system under LIN Bus, please follow the steps given below

1. Select root item in Pane 1 and right click.
2. A pop-up menu will be displayed as shown in figure below.
3. Select **New Simulated System** menu option.
4. A dialog box will be displayed.
5. Key in the new simulated system name and select **Save**.

The new simulated system path is added as last item in the Pane 1.



### Add Simulated System

To add an existing simulated system under LIN Bus, please follow the steps given below

1. Select root item in Pane 1 and right click.
2. A pop-up menu will be displayed as shown in figure above.
3. Select **Add Simulated System** menu option.
4. A dialog box will be displayed.
5. Select a simulated system and say **Add**.

The simulated system path and its details are added as last item in the Pane 1.



**Note:**

- The node name and the DLL should be unique under the LIN bus across all the simulated systems.
- Only when the simulated system which is to be added has the node name or the DLL which is not present under the LIN Bus, it can be added.

### Save All Systems

To save all the simulated system configuration files under LIN Bus, please follow the steps given below

- Select root item in Pane 1 and right click.
- A pop-up menu will be displayed as shown in figure above.
- Select **Save All Systems** menu option.

The simulated system details are saved into its respective ".sim" files.

### Delete All Systems

To delete all the simulated systems under LIN Bus, please follow the steps given below

- Select root item in Pane 1 and right click.
- A pop-up menu will be displayed as shown in figure above.
- Select **Delete All Systems** menu option.
- A confirmation dialog box will be displayed.
- On selecting **Yes** all the simulated systems will be deleted from the Pane 1.

All the simulated systems are deleted from Pane 1 under the LIN Bus.



**Note:**

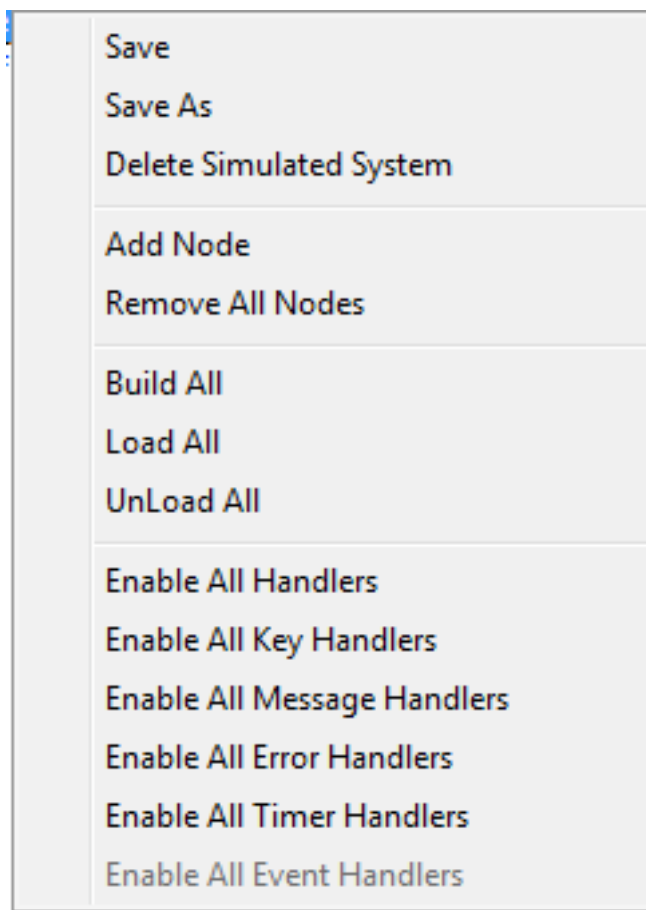
- **Delete All Systems** option is enabled only when there are any simulated systems under the LIN Bus.
- All the systems under the LIN Bus can be deleted only when all the DLLs under it are not loaded.
- The simulated systems under the LIN Bus can be saved by saving the tool's configuration by **File > Save** into its respective ".cfx" file.

### Save

To save the selected simulated system configuration file under LIN Bus, please follow the steps given below

- Select the simulated system in Pane 1 and right click.
- A pop-up menu will be displayed as shown in figure below.
- Select **Save** menu option.

The selected simulated system details are saved into its ".sim" files.



### Save As

To save the selected simulated system configuration file as a different file, please follow the steps given below

- Select the simulated system in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select **Save As** menu option.
- A dialog box will be displayed.
- Key in the new simulated system name and select **Save**.

### Delete Simulated System

To delete the simulated system under LIN Bus, please follow the steps given below

- Select the simulated system in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select **Delete Simulated System** menu option.
- A confirmation dialog box will be displayed.
- On selecting **Yes** the simulated system will be deleted from the Pane 1.



#### Note:

- Simulated System can be deleted only when the DLLs under it are not loaded.
- The simulated systems under the LIN Bus can be saved by saving the tool's configuration by **File > Save** into its respective ".cfx" file.

### Add Node

To configure a node under a simulated system, please follow the steps given below

- Select the simulated system in Pane 1 and right click.

- A pop-up menu will be displayed.
- Select **Add Node** menu option.
- Dialog box Node Details as in the figure below will be displayed.
- Enter the Node name and select the DLL which is unique under the LIN Bus.
- **Clear** button can be used to remove the selected DLL from the node.
- Select **OK** button to confirm.

The node details will be shown under the selected simulated system in Pane 1.

### Remove All Nodes

To remove all the nodes under a simulated system, please follow the steps given below

- Select the simulated system in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select **Remove All Nodes** menu option.
- A confirmation dialog box will be displayed.
- On selecting **Yes** all the nodes will be removed from the Pane 1 under the selected simulated system.



#### Note:

- **Remove All Nodes** option is enabled only when there are any nodes under the simulated system.
- All the nodes from any simulated system can be removed only when the DLLs under it are not loaded.
- The configuration of the simulated system under the LIN Bus can be saved into the ".sim" file.

### Edit Node

To edit a node under a simulated system, please follow the steps given below

- Select the node which is to be edited in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select **Edit Node** menu option.
- Dialog box Node Details as in the figure below will be displayed.
- Enter the Node name and select the DLL which is unique under the LIN Bus.
- **Clear** button can be used to remove the selected DLL from the node.
- Select **OK** button to confirm.

The edited node details will be shown in Pane 1.



#### Note:

- Any node can be edited only when the DLL under it is not loaded.
- The configuration of the simulated system under the LIN Bus can be saved into the ".sim" file.

### Remove Node

To remove a node under a simulated system , please follow the steps given below

- Select the node which is to be removed in Pane 1 and right click.
- A pop-up menu will be displayed.
- Select Remove Node menu option. The node will be removed from the simulated system in Pane 1.



#### Note:

- Any node can be removed only when the DLL under it is not loaded.
- The configuration of the simulated system under the LIN Bus can be saved into the ".sim" file.

### Open File

To change the associated C/C++ file with a node and open it, please follow the steps given below

- Select the node for which you want to change the associated C/C++ file in Pane 1. The details will be displayed in the Pane 2.
- Click on **Open File** button in Pane 2.

- Select **Edit Node** menu option.
- A confirmation dialog box will be displayed. Select **Yes** in it.
- A dialog box will be displayed which allows you to browse through the directories to select the C/C++ file.
- Select a C/C++ file and click **Open**.
- The selected C/C++ file will be opened in Function editor.

The edited node details will be shown in Pane 1 and also in Pane 2.



**Note:**

- The C file associated with any node can be changed only when the DLL under it is not loaded.
- The configuration of the simulated system under the LIN Bus can be saved into the ".sim" file.

## Edit File

To edit the C file associated with a node, please follow the steps given below

- Select the node for which you want to edit the C file in Pane 1. The details will be displayed in the Pane 2.
- Click on **Edit File** button in Pane 2.
- The C file associated with the node will be opened with the Function editor for the user to edit.

## Execute Handlers

## Function Editor

BUSMASTER can work as a programmable node over a LIN bus. User can program different event handlers using function editor. The programming language is C/C++.

Six types of event handlers are supported.

- Bus Events
- Message Handlers
- Timer Handlers
- Key Handlers
- Error Handlers
- DLL Handlers

These function handlers when built and loaded are executed on

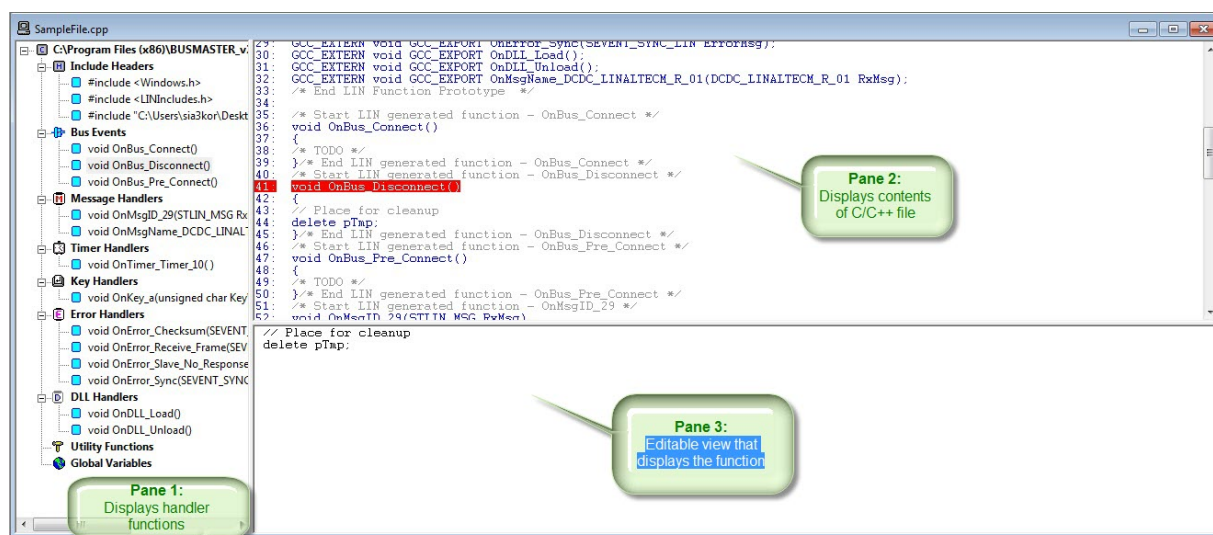
- Bus connect and disconnect
- Receipt of a Message.
- Elapse of a time interval.
- Press of a Key
- Detection of error or change in error state
- Loading / unloading of DLL.

User can also include Header File names, add Global Variables and Utility Functions while programming the event handlers. All these functions can be edited and saved in a file with extension ".cpp". The source file can be built to a DLL. This DLL can be loaded dynamically.

There are three panes in function editor as shown below

- Left Pane : Will be called Pane 1.
- Right Top Pane : Will be called Pane 2.
- Right Bottom Pane : Will be called Pane 3.

Pane 1 displays the list of functions, included header files and global variables defined. Pane 2 displays the contents of the source file. Through Pane 3 User can edit the body of function selected.



## General access to the function editor

Go to **LIN --> Node Simulation --> Configure** to open the window **Configure Simulated Systems**. Right click on **LIN Bus** in the left pane and select **New Simulated System** or **Add Simulated System**. Select then the "sim" file.

Right click on the new simulated system and select **Add Node**. The name will also be used as basename for the generated DLL. The **Node Details** will become visible in the right pane.

## Create a new function

Follow the description in the previous chapter "General access to the function editor".

Select **Add New File...** in the right pane under **File Details** to add new functions to the node. The function editor will open automatically.

## Edit an existing function

Follow the description in the previous chapter "General access to the function editor".

Select **Edit File...** in the right pane under **File Details** to edit an existing function of the node.

## Include Header file

User can include a header filename while programming event handlers. To do so please follow the steps given below:

1. Select **Include Headers** category in the Pane 1 and right click.
2. A pop-up menu comes up. Select **Add**. A dialog box appears.
3. Click on **Browse** button to select the required header file name and click on **OK** button.
4. The selected header filename will be added to the source file in the Pane 2 and also under **Include Headers** category in Pane 1.

## Edit Include Header File Name

User can edit the name of the header file, to do so please follow the steps given below

1. Select the **Include Header** filename under **Include Header** category to be edited in the Pane 1 and Right click.
2. A pop-up menu will be displayed.
3. Select **Edit**.
4. A dialog box will be displayed.
5. Click on **Browse** button to select the required header file and click on **OK** button.

The selected header file will be replaced with the previous header file in the source file in the Pane 2 and also under **Include Headers** category in Pane 1.

### Delete Handlers

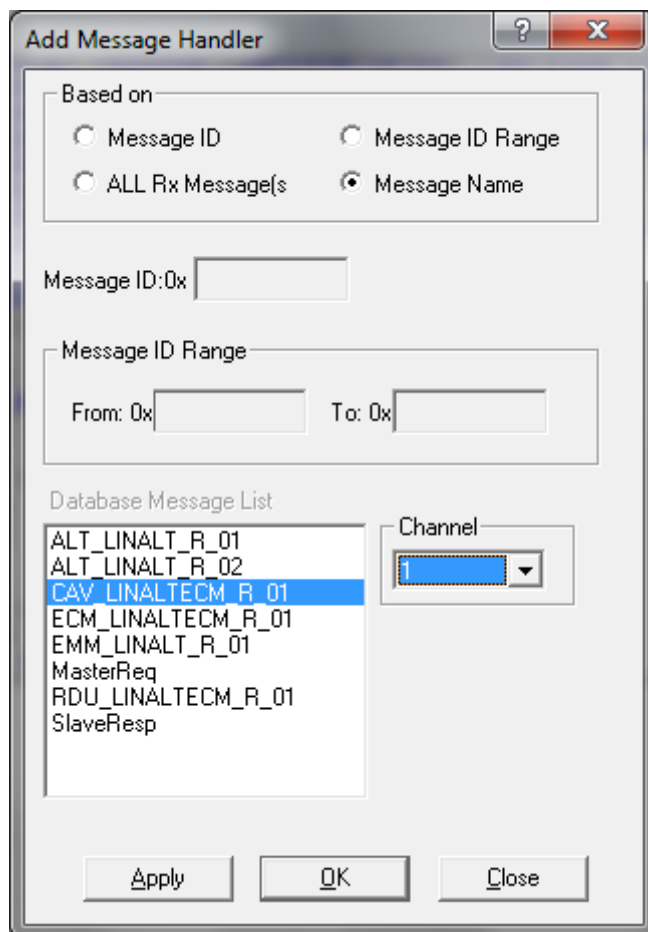
User can delete Header files, Message Handlers, Timer Handlers, Key Handlers, Error handlers, DLL handlers and Utility Functions in source file opened for editing, to do so follow the steps given below:

1. Select the item to be deleted in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select **Delete**.
4. A confirmation message is displayed.
5. Select **Yes**.

The selected item's definition will be deleted from the source file in the Pane 2 and also in Pane 1.

### Add Message Handler

1. Select **Message Handlers** category in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. On selecting **Add** menu. A dialog as shown below pops up.



4. From this dialog message handlers of different type can be selected. The different types of message handlers supported are
  - Message handler based on the message name.
  - Message handler based on message ID.
  - Message handler based on range of message ID.
  - Message handler for all received messages.



The type of message handler can be selected using the radio buttons. To add handler based on the message name the corresponding message should be available in the imported database. Multiple messages can be added from this dialog box by clicking on **Apply** button after selecting a message handler.

Function definition will be added to the source file in the Pane 2 and the prototype under Message Handlers category in Pane 1.

### Add Timer Handler

1. Select **Timer Handlers** category in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select **Add**. A dialog box appears.
4. Enter Timer Handler Name like e.g., "Time\_One" and the Timer Value in milliseconds.
5. Select **OK** button.
6. Function definition will be added to the source file automatically in the Pane 2 and the prototype under Timer Handlers category in Pane 1.



#### Note:

- Adding a Sleep function inside a Timer handler might have an adverse effect on the application.
- Maximum of 16 timers can run simultaneously in cyclic mode. Anything above 16 will fail to start.

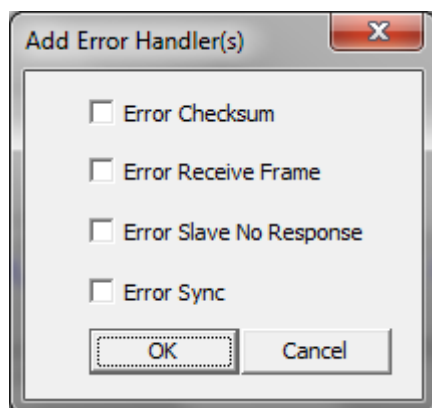
### Add Key Handler

1. Select **Key Handlers** category in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select **Add**. A dialog box appears asking the user to press a key.
4. Press a key for which User want to write the handler. The same will be displayed in the dialog box.
5. Select **OK** button or **Apply** button if more key handlers are to be added from the same dialog.

Function definition will be added to the source file automatically in the Pane 2 and the prototype under Key Handlers category in Pane 1.

### Add Error Handler

1. Select **Error Handlers** category in the Pane 1 and right click.
2. A pop-up menu will be displayed.
3. Select **Add**. A dialog as shown below pops up from this dialog select the type of error handlers to be handled by your program and click on **OK** button.



Function definition will be added to the source file automatically in the Pane 2 and the prototype under Error Handlers category in Pane 1.

### Add DLL Handler

DLL handlers are invoked at the time of loading the DLL or while unloading the DLL. The procedure for adding DLL handlers is similar to that of adding error handlers.

## Add Utility Function

1. Select **Utility Functions** category in the Pane 1 and right click.
2. A pop-up menu comes up.
3. Select **Add**. A dialog box appears.
4. Return Type of the utility function can be selected from the combo box or directly typed. The combo box will have primitive data types and database message structure names.
5. Enter the Function Prototype in the Edit control like e.g., "Func\_One( int a, int b )".
6. Select **OK** button.

Function definition will be added to the source file automatically in the Pane 2 and the prototype under Utility Functions category in Pane 1.

## Global Variables

To add/delete/modify global variables follow the steps given below.

1. Select **Global Variables** category in the Pane 1 and double click.
2. The Pane 3 will become editable and will show global variable block.
3. Change this block to Add/Delete/Modify the global variables.

Variable declaration will be added to the source file automatically in the Pane 2.



### Note:

- Use global variable block to use macros, structure or union definitions. The scope of variables and definitions given in this block is throughout the program.

## Edit Function Body

User can edit any function body by double clicking the prototype of the function displayed in Pane 1. On double click of the function prototype, the function body will be displayed in the Pane 3 and will be ready for editing.

## Variable of Message Type

BUSMASTER defines structures for messages define in the database. User can use these structures while programming. Please follow the steps below to add variable of the message type

1. Edit the function for which database message name is to be added. (Refer: section Edit Function Body)
2. Right click in the Pane 3.
3. A pop-up menu is displayed.
4. Select **Insert Message**. A dialog box is displayed with all the database messages under Message list.
5. Choose a message from the list.
6. Select the check box option in the dialog box.
7. Click on **Select** button.

The selected message variable will be displayed in the Pane 3 and the same is updated in the Pane 2.

## Insert Message name

User can add a tag of message structure and this could be used for defining variables. Please follow the steps below to insert a message structure tag into the function.

1. Edit the function for which database message name is to be added. (Refer: section Edit Function Body)
2. Right click in the Pane 3.
3. A pop-up menu is displayed.
4. Select **Insert Message**. A dialog box is displayed with all the database messages under Message list.
5. Choose a message from the list and click on **Select** button.
6. The selected message will be displayed in the Pane 3 and the same is updated in the Pane 2.

## Insert Signal name

User can use signal names while programming. The signal names have to be used in conjunction with the corresponding message variable. It is member of message structure. Please follow the steps below to insert a signal name into the function.

1. Edit the function in which signal name is to be added. (Refer: section Edit Function Body edit\_function\_body)
2. Right click in the Pane 3. A pop-up menu is displayed.
3. Select **Insert Signal**. A dialog box is displayed with all the database messages under Message list.
4. Choose a message from the list. A list of signals will be displayed under Signals list.
5. Select a signal and click on **Select** button.
6. The selected signal will be displayed in the Pane 3 and the same is updated in the Pane 2.

## Insert a Function

BUSMASTER provides API functions, which can be used while programming. These functions can be used to interact with BUSMASTER application. Please follow the steps below to insert a function

1. Edit the function for which prototype is to be added. (Refer: Editing Function Body)
2. Right click in the Pane 3. A pop-up menu is displayed.
3. Select **Insert Function**. A dialog box is displayed with a set of function prototypes. (API Listing)
4. Choose required function prototype from the list and click on **OK** button.
5. The selected function prototype will be displayed in the Pane 3 and the same is updated in the Pane 2.

## Execution

Once the program is written it can be built as a DLL and loaded. The GCC compiler is used for this purpose. You can either build or build and load on the fly. You can also unload any loaded DLL. Once the DLL is loaded, all the handler function can be invoked/revoked selectively. Once the user program is loaded in to the BUSMASTER application handlers are exposed to the application.

### Build

To make a build the program file should be associated with a node under a simulated system. (Refer section Simulated Systems) Selecting Build All from **LIN --> Node Simulation --> Build All** will start building all the C/C++ files under all the simulated systems configured in that session. The build status will be displayed in the Output Window. If any errors found in the program, it will be listed with the line number. Clicking the error line in the output window will open that particular file in Function editor and highlights the code in source window and will select the corresponding line in the Pane 2 (Refer section Function Editor) and makes the same editable in Pane 3. (Refer section Function Editor) If there is no error in the program, the DLLs will be generated and user will be notified of successful creation of DLLs. User can load these DLLs using **LIN --> Node Simulation --> Load All** menu.

All the program files under the simulated system(s) can also be built by right clicking on any simulated system and selecting **Build All** in simulated system window Pane 1. The program file under the node can be built by selecting **Build** in the simulated system window Pane 2.

### Build and Load

User can build and load a DLL in one step. After associating the program file(s) to the node(s), select **LIN --> Node Simulation --> Build & Load All**. It will first build the DLLs. Once the DLLs are built successfully, they will be loaded automatically. The loaded DLLs will be unloaded before loading the selected DLLs. Once DLLs are loaded all handler functions written in the corresponding source files can be invoked.

The program file under the node can be built and loaded by selecting **Build and Load** in the **Configure Simulated Systems** window Pane 2.

### Load

User can load BUSMASTER DLLs built earlier. Select **LIN --> Node Simulation --> Load All** to load the DLLs associated with the nodes under the simulated systems. Once DLLs are loaded successfully you will be notified with message. The already loaded DLLs will be unloaded before loading all the DLL(s). There will

be no warning before unloading the DLLs. Once DLLs are loaded all the handler function(s) written in the corresponding source files can be executed.

All the DLLs under the simulated system(s) can also be loaded by right clicking on any simulated system and selecting **Load All** in simulated system window Pane 1. The DLL under the node can be loaded by selecting **Load** in the **Configure Simulated Systems** window Pane 2.

## Unload

User can unload the DLLs from BUSMASTER. To unload the DLL select **LIN --> Node Simulation --> Unload All**. Once the DLLs are unloaded all the handlers defined in those DLLs are no more available. If any handlers are executed that time, those will be informed about unload. If all handlers are completed its execution then the DLLs will be unloaded. If any timer handlers are heavily loaded and didn't complete its execution, unload will show a warning message and unload will be suspended. In this case user shall initiate unload again to forcibly unload the DLLs.

All the DLLs under the simulated system(s) can also be unloaded by right clicking on any simulated system and selecting **UnLoad All** in **Configure Simulated Systems** window Pane 1. The DLL under the node can be unloaded by selecting **UnLoad** in the **Configure Simulated Systems** window Pane 2.

## Responding to Master Request

To respond to the master request, slave response of the particular identifier needs to be pre-configured on Pre Connect Event.

### Example:

For example to respond to the master request with an identifier 0x4, Pre-Connect event shall be configured as shown below:

```
void OnBus_Pre_Connect()
{
    STLIN_MSG sMsg;

    sMsg.m_ucMsgTyp = 1; // Slave Response
    sMsg.m_ucChksumTyp = 0; // Classic
    sMsg.m_ucDataLen = 8;
    sMsg.m_ucMsgID = 0x4; // Message Identifier
    sMsg.m_sWhichBit.m_auData[0] = 10; // Lower 4 Bytes
    sMsg.m_sWhichBit.m_auData[1] = 20; // Upper 4 Bytes
    sMsg.m_ucChannel = 1;

    // Send the message
    SendMsg(sMsg);
}
```

Required Include header file is LINIncludes.h

## LIN API Reference

### STLIN\_MSG Structure

STLIN\_MSG Structure Definition

```
struct sTLIN_MSG
{
    unsigned char m_ucMsgTyp;           // Header - 0, Slave Response - 1
    unsigned char m_ucChksumTyp;        // Checksum Type (0 - Classical / 1 -
Enhanced)
    unsigned char m_ucDataLen;          // Data length (0..8)
    unsigned char m_ucMsgID;            // LIN Identifier

    union
    {
        UCHAR m_auData[8];              // Byte Data
        USHORT m_auwData[4];             // Word Data
        UINT m_aulData[2];               // Long Data
    } m_sWhichBit;                      // Data access member
}
```

```

    unsigned long m_ulTimeStamp;
    unsigned char m_ucChannel;           // Channel Number
    unsigned char m_ucCRC;              // Checksum - Read Only
} STLIN_MSG;

```

Required Include header file is LINIncludes.h

#### Input Parameters:

##### **m\_ucMsgTyp**

0 - Sets message type as Header

1 - Sets message type as Response

##### **m\_ucChksumTyp**

0 - Sets checksum type as Classic

1 - Sets checksum type as Enhanced

##### **m\_ucDataLen**

dlc of the LIN message. Valid range of LIN data length is 0..8.

##### **m\_ucMsgID**

LIN message identifier

##### **m\_aucData, m\_auwData, m\_aulData**

Contains data bytes

##### **m\_sWhichBit**

To access/update Data bytes

##### **m\_ulTimeStamp**

Actual time stamp of the received message

##### **m\_ucChannel**

Channel number

##### **m\_ucCRC**

Checksum value of the received message

STLIN\_Msg Example:

```

STLIN_MSG sMsg;

sMsg.m_ucMsgTyp = 1; // Slave Response
sMsg.m_ucChksumTyp = 0; // Classic
sMsg.m_ucDataLen = 8;
sMsg.m_ucMsgID = 0x4;
sMsg.m_sWhichBit.m_aulData[0] = 10; // Lower 4 Bytes
sMsg.m_sWhichBit.m_aulData[1] = 20; // Upper 4 Bytes
sMsg.m_ucChannel = 1;

// Send the message
SendMsg(sMsg);

```

#### Event Structure:

SEVENT\_CHECKSUM\_LIN Structure Definition

```

struct SEVENT_CHECKSUM_LIN
{
    unsigned char m_ucId;
    unsigned char m_ucCrc;
    unsigned char m_ucChannel;
    unsigned int m_ulTime;
};

```

## SEVENT\_RECEIVE\_LIN Structure Definition

```
struct SEVENT_RECEIVE_LIN
{
    unsigned int    m_ulTime;
};
```

## SEVENT\_SLAVE\_NORESP\_LIN Structure Definition

```
struct SEVENT_SLAVE_NORESP_LIN
{
    unsigned char m_ucId;
    unsigned char m_ucChannel;
    unsigned int  m_ulTime;
};
```

## SEVENT\_SYNC\_LIN Structure Definition

```
typedef struct SEVENT_SYNC_LIN
{
    unsigned char m_ucChannel;
    unsigned int  m_ulTime;
};
```

Required Include header file is LINIncludes.h

Accessing database message signal values

Database message structures can be meaningfully interpreted. Database message structures will have signal members as defined in the database. Signal raw value can be directly assigned by using member of database message structure with the signal name.

LIN\_Request is a database message that has signals Sig1, Sig2 and Sig3. Each signal is 2 bytes of length. To assign raw value of a signal use message name structure and use signal name as member.

```
// Message Declaration
LIN_Request sMsgStruct = { 1, 0, 8, 0x4, { 0, 0, 0, 0, 0, 0, 0, 0 } };

// Use signal member

// Sig1
sMsgStruct.m_sWhichBit.Sig_1 = 10;

// Sig2
sMsgStruct.m_sWhichBit.Sig_2 = 20;

// Sig3
sMsgStruct.m_sWhichBit.Sig_3 = 30;

// Send the message now
SendMsg(*( (STLIN_MSG *) &sMsg ));
```

Right click on edit area of function editor. Select "Insert Message" or "Insert Signal" option to insert message structure or signal structure. Select the option "Yes, I want to declare selected message structure variable" option in the "Message and Signal List" to initialise message with its struct definition.

Required Include header file Unions.h

**Note:**

- Unions.h file will be automatically generated by BUSMASTER during database import.
- This file will be in the database file directory

**API Listing**

BUSMASTER API Listing

**SendMsg : To send a LIN frame****Synopsis**

```
UINT SendMsg ( STLIN_MSG )
```

**Description**

This function will put the message on the LIN bus. The message structure STLIN\_MSG will be filled with ID, length, message type, checksum type and data.

**Inputs**

STLIN\_MSG - LIN Message Structure

**Returns**

Zero on successful transmission. Non-zero value on failure.

**Trace : To send string to Trace window****Synopsis**

```
UINT Trace ( char* format, ... )
```

**Description**

This function will format the passed parameters based on format specified and will show the formatted text in TRACE window. The return value of this function will be 0 or 1.

**Inputs**

msg - Pointer to character array

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition. This function can return 0 in case user has passed a NULL pointer. If the TRACE window is visible, it will be made visible

**Disconnect : To disconnect LIN controller from LIN bus****Synopsis**

```
UINT Disconnect (DWORD dwClientId )
```

**Description**

This function will disconnect the tool from LIN bus. The return value of this function will be 0 or 1. This function can return 0 in case tool is already disconnected. dwClientId is reserved for future use.

**Inputs**

Client ID. Currently unused.

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**Connect : To connect LIN controller to LIN bus****Synopsis**

```
UINT Connect (DWORD dwClientId )
```

**Description**

This function will connect the tool to LIN bus. The return value of this function will be 0 or 1. This function can return 0 in case tool is already connected. dwClientId is reserved for future use.

**Inputs**

Client ID. Currently unused.

**Returns**

A value zero indicate failure condition while a value 1 indicate a success condition.

**StartTimer : To start a timer in specific mode****Synopsis**

```
UINT StartTimer ( char* strTimerName, UINT nTimerMode )
```

**Description**

This function will start timer having name passed as parameter strTimerName in monoshot or cyclic mode. The function takes first parameter as timer name and second as mode, monoshot or cyclic. If the named timer is already running or timer name is not matched, the function will return FALSE. Otherwise function be return TRUE.

**Inputs**

strTimerName - Name of the timer. i.e. OnTimer\_Tester\_Present\_100 nTimerMode - Mode of the timer. 1 - Start in Cyclic mode 0 - Start in Monoshot mode

**Returns**

1 on success. 0 if the timer is already running or timer name not found

**StopTimer : To stop a running timer****Synopsis**

```
UINT StopTimer ( char* strTimerName)
```

**Description**

This function will stop timer having name passed as parameter strTimerName. If the named timer is not running or timer name is not matched, the function will return FALSE. Otherwise function be return TRUE.

**Inputs**

strTimerName - Name of the timer. i.e. OnTimer\_Tester\_Present\_100

**Returns**

1 on success. 0 if the timer is already running or timer name not found

**EnableMsgHandlers : To enable or Disable message event handlers****Synopsis**

```
EnableMsgHandlers ( BOOL bEnable)
```

**Description**

This function will enable or disable message handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.



**Inputs**

bEnable - TRUE to Enable message handler. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**EnableErrorHandlers : To enable or Disable error event handlers****Synopsis**

```
BOOL EnableErrorHandlers ( BOOL bEnable)
```

**Description**

This function will enable or disable error handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.

**Inputs**

bEnable - TRUE to Enable error handler. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**EnableKeyHandlers : To enable or Disable key event handlers****Synopsis**

```
BOOL EnableKeyHandlers ( BOOL bEnable)
```

**Description**

This function will enable or disable key handlers. User can pass parameter as TRUE to enable and FALSE to disable the handlers. Function will return TRUE, if state change was successful otherwise it will return FALSE.

**Inputs**

bEnable - TRUE to Enable message handler. FALSE to disable

**Returns**

TRUE success. FALSE if the handler is already in the specified state

**hGetDllHandle: To get handle of dll attached to a node from the node****Synopsis**

```
HANDLE hGetDllHandle ( char* strNodeName)
```

**Description**

This function returns the handle of the dll attached to a node. The node name will be passed as parameter.

**Inputs**

Node name

**Returns**

Dll handle on success else NULL

# C Library Functions

---

## Standard Library Functions

---

This chapter groups utility functions useful in a variety of programs. The corresponding declarations are in the header file `<stdlib.h>`.

### **abs : integer absolute value (magnitude)**

#### **Synopsis**

```
#include <stdlib.h>
int abs(int i);
```

#### **Description**

`abs` returns the absolute value of `i` (also called the magnitude of `i`). That is, if `i` is negative, the result is the opposite of `i`, but if `i` is nonnegative the result is `i`.

The similar function `labs` uses and returns `long` rather than `int` values.

#### **Returns**

The result is a nonnegative integer.

### **atexit : request execution of functions at program exit**

#### **Synopsis**

```
#include <stdlib.h>
int atexit(void (*function)(void));
```

#### **Description**

You can use `atexit` to enroll functions in a list of functions that will be called when your program terminates normally. The argument is a pointer to a user-defined function (which must not require arguments and must not return a result). The functions are kept in a LIFO stack; that is, the last function enrolled by `atexit` will be the first to execute when your program exits. There is no built-in limit to the number of functions you can enroll in this list; however, after every group of 32 functions is enrolled, `atexit` will call `malloc` to get space for the next part of the list. The initial list of 32 functions is statically allocated, so you can always count on at least that many slots available.

#### **Returns**

`atexit` returns 0 if it succeeds in enrolling your function, -1 if it fails (possible only if no space was available for `malloc` to extend the list of functions).

### **atof, atoff : string to double or float**

#### **Synopsis**

```
#include <stdlib.h>
double atof(const char *s);
float atoff(const char *s);
```

## Description

atof converts the initial portion of a string to a double. atoff converts the initial portion of a string to a float. The functions parse the character string *s*, locating a substring which can be converted to a floating point value. The substring must match the format: `[+|-]digits[.][digits][(e|E)[+|-]digits]`

The substring converted is the longest initial fragment of *s* that has the expected format, beginning with the first non-whitespace character. The substring is empty if *str* is empty, consists entirely of whitespace, or if the first non-whitespace character is something other than `+`, `-`, `.`, or a digit.

atof(*s*) is implemented as strtod(*s*, NULL). atoff(*s*) is implemented as strtodf(*s*, NULL).

## Returns

atof returns the converted substring value, if any, as a double; or 0.0, if no conversion could be performed. If the correct value is out of the range of representable values, plus or minus HUGE\_VAL is returned, and ERANGE is stored in *errno*. If the correct value would cause underflow, 0.0 is returned and ERANGE is stored in *errno*.

atoff obeys the same rules as atof, except that it returns a float.

## atoi, atol : string to integer

### Synopsis

```
#include <stdlib.h>
int atoi(const char *s);
long atol(const char *s);
```

### Description

atoi converts the initial portion of a string to an int. atol converts the initial portion of a string to a long. atoi(*s*) is implemented as (int)strtol(*s*, NULL, 10). atol(*s*) is implemented as strtol(*s*, NULL, 10).

### Returns

The functions return the converted value, if any. If no conversion was made, 0 is returned.

## bsearch : binary search

### Synopsis

```
#include <stdlib.h>
void *bsearch(const void *key, const void *base, size_t nmemb, size_t size,
int (*compar)(const void *, const void *));
```

### Description

bsearch searches an array beginning at *base* for any element that matches *key*, using binary search. *nmemb* is the element count of the array; *size* is the size of each element.

The array must be sorted in ascending order with respect to the comparison function *compar* (which you supply as the last argument of *bsearch*).

You must define the comparison function (*\*compar*) to have two arguments; its result must be negative if the first argument is less than the second, zero if the two arguments match, and positive if the first argument is greater than the second (where "less than" and "greater than" refer to whatever arbitrary ordering is appropriate).

### Returns

Returns a pointer to an element of array that matches *key*. If more than one matching element is available, the result may point to any of them.

## calloc : allocate space for arrays

### Synopsis

```
#include <stdlib.h>
void *calloc(size_t n, size_t s);
void *calloc_r(void *reent, size_t <n>, <size_t> s);
```

### Description

Use calloc to request a block of memory sufficient to hold an array of n elements, each of which has size s.

The memory allocated by calloc comes out of the same memory pool used by malloc, but the memory block is initialized to all zero bytes. (To avoid the overhead of initializing the space, use malloc instead.)

The alternate function \_calloc\_r is reentrant. The extra argument reent is a pointer to a reentrancy structure.

### Returns

If successful, a pointer to the newly allocated space. If unsuccessful, NULL.

## div : divide two integers

### Synopsis

```
#include <stdlib.h>
div_t div(int n, int d);
```

### Description

Divide returning quotient and remainder as two integers in a structure div\_t.

### Returns

The result is represented with the structure typedef struct { int quot; int rem; } div\_t;

where the quot field represents the quotient, and rem the remainder. For nonzero d, if `r = div(n,d);' then n equals `r.rem + d\*r.quot'.

To divide long rather than int values, use the similar function ldiv.

## ecvt,ecvtf,fcvt,fcvtf : double or float to string

### Synopsis

```
#include <stdlib.h>
char *ecvt(double val, int chars, int *decpt, int *sgn);
char *ecvtf(float val, int chars, int *decpt, int *sgn);
char *fcvt(double val, int decimals, int *decpt, int *sgn);
char *fcvtf(float val, int decimals, int *decpt, int *sgn);
```

### Description

ecvt and fcvt produce (null-terminated) strings of digits representing the double number val. ecvtf and fcvtf produce the corresponding character representations of float numbers. (The stdlib functions ecvtbuf and fcvtbuf are reentrant versions of ecvt and fcvt.)

The only difference between ecvt and fcvt is the interpretation of the second argument (chars or decimals). For ecvt, the second argument chars specifies the total number of characters to write (which is also the number of significant digits in the formatted string, since these two functions write only digits). For fcvt, the second argument decimals specifies the number of characters to write after the decimal point; all digits for the integer part of val are always included.

Since `ecvt` and `fcvt` write only digits in the output string, they record the location of the decimal point in `*decpt`, and the sign of the number in `*sgn`. After formatting a number, `*decpt` contains the number of digits to the left of the decimal point. `*sgn` contains 0 if the number is positive, and 1 if it is negative.

### Returns

All four functions return a pointer to the new string containing a character representation of `val`.

## gcvvt, gcvtf : format double or float as string

### Synopsis

```
#include <stdlib.h>
char *gcvvt(double val, int precision, char *buf);
char *gcvtf(float val, int precision, char *buf);
```

### Description

`gcvvt` writes a fully formatted number as a null-terminated string in the buffer `*buf`. `gcvtf` produces corresponding character representations of float numbers.

`gcvvt` uses the same rules as the `printf` format `%.precisiong`: only negative values are signed (with `'-'`), and either exponential or ordinary decimal-fraction format is chosen depending on the number of significant digits (specified by precision).

### Returns

The result is a pointer to the formatted representation of `val` (the same as the argument `buf`).

## ecvtbuf, fcvtbuf : double or float to string

### Synopsis

```
#include <stdio.h>
char *ecvtbuf(double val, int chars, int *decpt, int *sgn, char *buf);
char *fcvtbuf(double val, int decimals, int *decpt, int *sgn, char *buf);
```

### Description

`ecvtbuf` and `fcvtbuf` produce (null-terminated) strings of digits representing the double number `val`.

The only difference between `ecvtbuf` and `fcvtbuf` is the interpretation of the second argument (`chars` or `decimals`). For `ecvtbuf`, the second argument `chars` specifies the total number of characters to write (which is also the number of significant digits in the formatted string, since these two functions write only digits). For `fcvtbuf`, the second argument `decimals` specifies the number of characters to write after the decimal point; all digits for the integer part of `val` are always included.

Since `ecvtbuf` and `fcvtbuf` write only digits in the output string, they record the location of the decimal point in `*decpt`, and the sign of the number in `*sgn`. After formatting a number, `*decpt` contains the number of digits to the left of the decimal point. `*sgn` contains 0 if the number is positive, and 1 if it is negative. For both functions, you supply a pointer `buf` to an area of memory to hold the converted string.

### Returns

Both functions return a pointer to `buf`, the string containing a character representation of `val`.

## exit : end program execution

### Synopsis

```
#include <stdlib.h>
void exit(int code);
```

**Description**

Use `exit` to return control from a program to the host operating environment. Use the argument `code` to pass an exit status to the operating environment: two particular values, `EXIT_SUCCESS` and `EXIT_FAILURE`, are defined in `'stdlib.h'` to indicate success or failure in a portable fashion.

`exit` does two kinds of cleanup before ending execution of your program. First, it calls all application-defined cleanup functions you have enrolled with `atexit`. Second, files and streams are cleaned up: any pending output is delivered to the host system, each open file or stream is closed, and files created by `tmpfile` are deleted.

**Returns**

`exit` does not return to its caller.

**getenv : look up environment variable****Synopsis**

```
#include <stdlib.h>
char *getenv(const char *name);
```

**Description**

`getenv` searches the list of environment variable names and values (using the global pointer `'char **environ'`) for a variable whose name matches the string at `name`. If a variable name matches, `getenv` returns a pointer to the associated value.

**Returns**

A pointer to the (string) value of the environment variable, or `NULL` if there is no such environment variable.

**labs : long integer absolute value****Synopsis**

```
#include <stdlib.h>
long labs(long i);
```

**Description**

`labs` returns the absolute value of `i` (also called the magnitude of `i`). That is, if `i` is negative, the result is the opposite of `i`, but if `i` is nonnegative the result is `i`.

The similar function `abs` uses and returns `int` rather than long values.

**Returns**

The result is a nonnegative long integer.

**ldiv : divide two long integers****Synopsis**

```
#include <stdlib.h>
ldiv_t ldiv(long n, long d);
```

**Description**

Divide returning quotient and remainder as two long integers in a structure `ldiv_t`.

**Returns**

The result is represented with the structure

```
typedef struct { long quot; long rem; } ldiv_t;
```

where the quot field represents the quotient, and rem the remainder. For nonzero d, if ``r = ldiv(n,d);`' then n equals ``r.rem + d*r.quot'`.

To divide int rather than long values, use the similar function `div`.

## malloc, realloc, free : manage memory

### Synopsis

```
#include <stdlib.h>
void *malloc(size_t nbytes);
void *realloc(void *aptr, size_t nbytes);
void free(void *aptr);
void *_malloc_r(void *reent, size_t nbytes);
void *_realloc_r(void *reent, void *aptr, size_t nbytes);
void _free_r(void *reent, void *aptr);
```

### Description

These functions manage a pool of system memory.

Use `malloc` to request allocation of an object with at least `nbytes` bytes of storage available. If the space is available, `malloc` returns a pointer to a newly allocated block as its result.

If you already have a block of storage allocated by `malloc`, but you no longer need all the space allocated to it, you can make it smaller by calling `realloc` with both the object pointer and the new desired size as arguments. `realloc` guarantees that the contents of the smaller object match the beginning of the original object.

Similarly, if you need more space for an object, use `realloc` to request the larger size; again, `realloc` guarantees that the beginning of the new, larger object matches the contents of the original object.

When you no longer need an object originally allocated by `malloc` or `realloc` (or the related function `calloc`), return it to the memory storage pool by calling `free` with the address of the object as the argument. You can also use `realloc` for this purpose by calling it with 0 as the `nbytes` argument.

The alternate functions `_malloc_r`, `_realloc_r`, and `_free_r` are reentrant versions. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

`malloc` returns a pointer to the newly allocated space, if successful; otherwise it returns `NULL`. If your application needs to generate empty objects, you may use `malloc(0)` for this purpose.

`realloc` returns a pointer to the new block of memory, or `NULL` if a new block could not be allocated. `NULL` is also the result when you use ``realloc(aptr,0)'` (which has the same effect as ``free(aptr)'`). You should always check the result of `realloc`; successful reallocation is not guaranteed even when you request a smaller object.

`free` does not return a result.

## mbtowc : minimal multibyte to wide char converter

### Synopsis

```
#include <stdlib.h>
int mbtowc(wchar_t *pwc, const char *s, size_t n);
```

### Description

This is a minimal ANSI-conforming implementation of `mbtowc`. The only "multi-byte character sequences" recognized are single bytes, and they are "converted" to themselves.

Each call to `mbtowc` copies one character from `*s` to `*pwc`, unless `s` is a null pointer.

In this implementation, the argument `n` is ignored.

**Returns**

This implementation of `mbtowc` returns 0 if `s` is NULL; it returns 1 otherwise (reporting the length of the character "sequence" used).

**qsort : sort an array****Synopsis**

```
#include <stdlib.h>
void qsort(void *base, size_t nmemb, size_t size, int (*compar)(const void *, const void *)) ;
```

**Description**

`qsort` sorts an array (beginning at `base`) of `nmemb` objects. `size` describes the size of each element of the array.

You must supply a pointer to a comparison function, using the argument shown as `compar`. (This permits sorting objects of unknown properties.) Define the comparison function to accept two arguments, each a pointer to an element of the array starting at `base`. The result of `(*compar)` must be negative if the first argument is less than the second, zero if the two arguments match, and positive if the first argument is greater than the second (where "less than" and "greater than" refer to whatever arbitrary ordering is appropriate).

The array is sorted in place; that is, when `qsort` returns, the array elements beginning at `base` have been reordered.

**Returns**

`qsort` does not return a result.

**rand, srand : pseudo-random numbers****Synopsis**

```
#include <stdlib.h>
int rand(void);
void srand(unsigned int seed);
int rand_r(unsigned int *seed);
```

**Description**

`rand` returns a different integer each time it is called; each integer is chosen by an algorithm designed to be unpredictable, so that you can use `rand` when you require a random number. The algorithm depends on a static variable called the "random seed"; starting with a given value of the random seed always produces the same sequence of numbers in successive calls to `rand`.

You can set the random seed using `srand`; it does nothing beyond storing its argument in the static variable used by `rand`. You can exploit this to make the pseudo-random sequence less predictable, if you wish, by using some other unpredictable value (often the least significant parts of a time-varying value) as the random seed before beginning a sequence of calls to `rand`; or, if you wish to ensure (for example, while debugging) that successive runs of your program use the same "random" numbers, you can use `srand` to set the same random seed at the outset.

**Returns**

`rand` returns the next pseudo-random integer in sequence; it is a number between 0 and `RAND_MAX` (inclusive).

`srand` does not return a result.

**strtod, strtodf : string to double or float****Synopsis**

```
#include <stdlib.h>
double strtod(const char *str, char **tail);
float strtodf(const char *str, char **tail);
double _strtod_r(void *reent, const char *str, char **tail);
```



## Description

The function `strtod` parses the character string `str`, producing a substring which can be converted to a double value. The substring converted is the longest initial subsequence of `str`, beginning with the first non-whitespace character, that has the format: `[+|-]digits[.][digits][(e|E)[+|-]digits]`

The substring contains no characters if `str` is empty, consists entirely of whitespace, or if the first non-whitespace character is something other than `+`, `-`, `.`, or a digit. If the substring is empty, no conversion is done, and the value of `str` is stored in `*tail`. Otherwise, the substring is converted, and a pointer to the final string (which will contain at least the terminating null character of `str`) is stored in `*tail`. If you want no assignment to `*tail`, pass a null pointer as `tail`. `strtodf` is identical to `strtod` except for its return type.

This implementation returns the nearest machine number to the input decimal string. Ties are broken by using the IEEE round-even rule.

The alternate function `_strtod_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

## Returns

`strtod` returns the converted substring value, if any. If no conversion could be performed, 0 is returned. If the correct value is out of the range of representable values, plus or minus `HUGE_VAL` is returned, and `ERANGE` is stored in `errno`. If the correct value would cause underflow, 0 is returned and `ERANGE` is stored in `errno`.

## strtol : string to long

### Synopsis

```
#include <stdlib.h>
long strtol(const char *s, char **ptr, int base);
long _strtol_r(void *reent, const char *s, char **ptr, int base);
```

### Description

The function `strtol` converts the string `*s` to a long. First, it breaks down the string into three parts: leading whitespace, which is ignored; a subject string consisting of characters resembling an integer in the radix specified by `base`; and a trailing portion consisting of zero or more unparseable characters, and always including the terminating null character. Then, it attempts to convert the subject string into a long and returns the result.

If the value of `base` is 0, the subject string is expected to look like a normal C integer constant: an optional sign, a possible `'0x'` indicating a hexadecimal base, and a number. If `base` is between 2 and 36, the expected form of the subject is a sequence of letters and digits representing an integer in the radix specified by `base`, with an optional plus or minus sign. The letters `a-z` (or, equivalently, `A-Z`) are used to signify values from 10 to 35; only letters whose ascribed values are less than `base` are permitted. If `base` is 16, a leading `0x` is permitted.

The subject sequence is the longest initial sequence of the input string that has the expected form, starting with the first non-whitespace character. If the string is empty or consists entirely of whitespace, or if the first non-whitespace character is not a permissible letter or digit, the subject string is empty.

If the subject string is acceptable, and the value of `base` is zero, `strtol` attempts to determine the radix from the input string. A string with a leading `0x` is treated as a hexadecimal value; a string with a leading `0` and no `x` is treated as octal; all other strings are treated as decimal. If `base` is between 2 and 36, it is used as the conversion radix, as described above. If the subject string begins with a minus sign, the value is negated. Finally, a pointer to the first character past the converted subject string is stored in `ptr`, if `ptr` is not `NULL`.

If the subject string is empty (or not in acceptable form), no conversion is performed and the value of `s` is stored in `ptr` (if `ptr` is not `NULL`).

The alternate function `_strtol_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

`strtol` returns the converted value, if any. If no conversion was made, 0 is returned.

`strtol` returns `LONG_MAX` or `LONG_MIN` if the magnitude of the converted value is too large, and sets `errno` to `ERANGE`.

## strtoul : string to unsigned long

### Synopsis

```
#include <stdlib.h>
unsigned long strtoul(const char *s, char **ptr, int base);
unsigned long _strtoul_r(void *reent, const char *s, char **ptr, int base);
```

### Description

The function `strtoul` converts the string `*s` to an unsigned long. First, it breaks down the string into three parts: leading whitespace, which is ignored; a subject string consisting of the digits meaningful in the radix specified by base (for example, 0 through 7 if the value of base is 8); and a trailing portion consisting of one or more unparseable characters, which always includes the terminating null character. Then, it attempts to convert the subject string into an unsigned long integer, and returns the result.

If the value of base is zero, the subject string is expected to look like a normal C integer constant (save that no optional sign is permitted): a possible `0x` indicating hexadecimal radix, and a number. If base is between 2 and 36, the expected form of the subject is a sequence of digits (which may include letters, depending on the base) representing an integer in the radix specified by base. The letters `a--z` (or `A--Z`) are used as digits valued from 10 to 35. If base is 16, a leading `0x` is permitted.

The subject sequence is the longest initial sequence of the input string that has the expected form, starting with the first non-whitespace character. If the string is empty or consists entirely of whitespace, or if the first non-whitespace character is not a permissible digit, the subject string is empty.

If the subject string is acceptable, and the value of base is zero, `strtoul` attempts to determine the radix from the input string. A string with a leading `0x` is treated as a hexadecimal value; a string with a leading 0 and no `x` is treated as octal; all other strings are treated as decimal. If base is between 2 and 36, it is used as the conversion radix, as described above. Finally, a pointer to the first character past the converted subject string is stored in `ptr`, if `ptr` is not `NULL`.

If the subject string is empty (that is, if `*s` does not start with a substring in acceptable form), no conversion is performed and the value of `s` is stored in `ptr` (if `ptr` is not `NULL`).

The alternate function `_strtoul_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

`strtoul` returns the converted value, if any. If no conversion was made, 0 is returned.

`strtoul` returns `ULONG_MAX` if the magnitude of the converted value is too large, and sets `errno` to `ERANGE`.

## system : execute command string

### Synopsis

```
#include <stdlib.h>
int system(char *s);
int _system_r(void *reent, char *s);
```

### Description

Use `system` to pass a command string `*s` to `/bin/sh` on your system, and wait for it to finish executing.

Use `system(NULL)` to test whether your system has `/bin/sh` available.

The alternate function `_system_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

`system(NULL)` returns a non-zero value if `/bin/sh` is available, and 0 if it is not.

With a command argument, the result of `system` is the exit status returned by `/bin/sh`.

## wctomb : minimal wide char to multibyte converter

### Synopsis

```
#include <stdlib.h>
int wctomb(char *s, wchar_t wchar);
```

### Description

This is a minimal ANSI-conforming implementation of wctomb. The only "wide characters" recognized are single bytes, and they are "converted" to themselves.

Each call to wctomb copies the character wchar to \*s, unless s is a null pointer.

### Returns

This implementation of wctomb returns 0 if s is NULL; it returns 1 otherwise (reporting the length of the character "sequence" generated).

## Character Type Macros and Functions

---

This chapter groups macros (which are also available as subroutines) to classify characters into several categories (alphabetic, numeric, control characters, whitespace, and so on), or to perform simple character mappings.

The header file `<ctype.h>` defines the macros.

## isalnum : alphanumeric character predicate

### Synopsis

```
#include <ctype.h>
int isalnum(int c);
```

### Description

isalnum is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for alphabetic or numeric ASCII characters, and 0 for other arguments. It is defined for all integer values.

You can use a compiled subroutine instead of the macro definition by undefining the macro using `#undef isalnum`.

### Returns

isalnum returns non-zero if c is a letter (a--z or A--Z) or a digit (0--9).

## isalpha : alphabetic character predicate

### Synopsis

```
#include <ctype.h>
int isalpha(int c);
```

### Description

isalpha is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero when c represents an alphabetic ASCII character, and 0 otherwise. It is defined only when isascii(c) is true or c is EOF.

You can use a compiled subroutine instead of the macro definition by undefining the macro using `#undef isalpha`.

**Returns**

isalpha returns non-zero if c is a letter (A--Z or a--z).

**isascii : ASCII character predicate****Synopsis**

```
#include <ctype.h>
int isascii(int c);
```

**Description**

isascii is a macro which returns non-zero when c is an ASCII character, and 0 otherwise. It is defined for all integer values.

You can use a compiled subroutine instead of the macro definition by undefining the macro using `#undef isascii`.

**Returns**

isascii returns non-zero if the low order byte of c is in the range 0 to 127 (0x00--0x7F).

**iscntrl : control character predicate****Synopsis**

```
#include <ctype.h>
int iscntrl(int c);
```

**Description**

iscntrl is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for control characters, and 0 for other characters. It is defined only when isascii(c) is true or c is EOF.

You can use a compiled subroutine instead of the macro definition by undefining the macro using `#undef iscntrl`.

**Returns**

iscntrl returns non-zero if c is a delete character or ordinary control character (0x7F or 0x00--0x1F).

**isdigit : decimal digit predicate****Synopsis**

```
#include <ctype.h>
int isdigit(int c);
```

**Description**

isdigit is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for decimal digits, and 0 for other characters. It is defined only when isascii(c) is true or c is EOF.

You can use a compiled subroutine instead of the macro definition by undefining the macro using `#undef isdigit`.

**Returns**

isdigit returns non-zero if c is a decimal digit (0--9).

**islower : lower-case character predicate****Synopsis**

```
#include <ctype.h>
int islower(int c);
```

**Description**

islower is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for minuscules (lower-case alphabetic characters), and 0 for other characters. It is defined only when isascii(c) is true or c is EOF.

You can use a compiled subroutine instead of the macro definition by undefining the macro using ``#undef islower'`.

**Returns**

islower returns non-zero if c is a lower case letter (a--z).

**isprint, isgraph : printable character predicate****Synopsis**

```
#include <ctype.h>
int isprint(int c);
int isgraph(int c);
```

**Description**

isprint is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for printable characters, and 0 for other character arguments. It is defined only when isascii(c) is true or c is EOF.

You can use a compiled subroutine instead of the macro definition by undefining either macro using ``#undef isprint'` or ``#undef isgraph'`.

**Returns**

isprint returns non-zero if c is a printing character, (0x20--0x7E). isgraph behaves identically to isprint, except that the space character (0x20) is excluded.

**ispunct : punctuation character predicate****Synopsis**

```
#include <ctype.h>
int ispunct(int c);
```

**Description**

ispunct is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for printable punctuation characters, and 0 for other characters. It is defined only when isascii(c) is true or c is EOF.

You can use a compiled subroutine instead of the macro definition by undefining the macro using ``#undef ispunct'`.

**Returns**

ispunct returns non-zero if c is a printable punctuation character (isgraph(c) && !isalnum(c)). isspace : whitespace character predicate

**isspace : whitespace character predicate****Synopsis**

```
#include <ctype.h>
int isspace(int c);
```

**Description**

isspace is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for whitespace characters, and 0 for other characters. It is defined only when isascii(c) is true or c is EOF.

You can use a compiled subroutine instead of the macro definition by undefining the macro using ``#undef isspace'`.

### Returns

isspace returns non-zero if `c` is a space, tab, carriage return, new line, vertical tab, or formfeed (0x09--0x0D, 0x20).

## isupper : uppercase character predicate

### Synopsis

```
#include <ctype.h>
int isupper(int c);
```

### Description

isupper is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for upper-case letters (A--Z), and 0 for other characters. It is defined only when `isascii(c)` is true or `c` is EOF.

You can use a compiled subroutine instead of the macro definition by undefining the macro using ``#undef isupper'`.

### Returns

isupper returns non-zero if `c` is a upper case letter (A-Z).

## isxdigit : hexadecimal digit predicate

### Synopsis

```
#include <ctype.h>
int isxdigit(int c);
```

### Description

isxdigit is a macro which classifies ASCII integer values by table lookup. It is a predicate returning non-zero for hexadecimal digits, and 0 for other characters. It is defined only when `isascii(c)` is true or `c` is EOF.

You can use a compiled subroutine instead of the macro definition by undefining the macro using ``#undef isxdigit'`.

### Returns

isxdigit returns non-zero if `c` is a hexadecimal digit (0--9, a--f, or A--F).

## toascii : force integers to ASCII range

### Synopsis

```
#include <ctype.h>
int toascii(int c);
```

### Description

toascii is a macro which coerces integers to the ASCII range (0--127) by zeroing any higher-order bits.

You can use a compiled subroutine instead of the macro definition by undefining this macro using ``#undef toascii'`.

### Returns

toascii returns integers between 0 and 127. tolower : translate characters to lower case

**tolower : translate characters to lower case****Synopsis**

```
#include <ctype.h>
int tolower(int c);
int _tolower(int c);
```

**Description**

tolower is a macro which converts upper-case characters to lower case, leaving all other characters unchanged. It is only defined when c is an integer in the range EOF to 255.

You can use a compiled subroutine instead of the macro definition by undefining this macro using `#undef tolower'.

\_tolower performs the same conversion as tolower, but should only be used when c is known to be an uppercase character (A--Z).

**Returns**

tolower returns the lower-case equivalent of c when it is a character between A and Z, and c otherwise.

\_tolower returns the lower-case equivalent of c when it is a character between A and Z. If c is not one of these characters, the behaviour of \_tolower is undefined.

**toupper : translate characters to upper case****Synopsis**

```
#include <ctype.h>
int toupper(int c);
int _toupper(int c);
```

**Description**

toupper is a macro which converts lower-case characters to upper case, leaving all other characters unchanged. It is only defined when c is an integer in the range EOF to 255.

You can use a compiled subroutine instead of the macro definition by undefining this macro using `#undef toupper'.

\_toupper performs the same conversion as toupper, but should only be used when c is known to be a lowercase character (a--z).

**Returns**

toupper returns the upper-case equivalent of c when it is a character between a and z, and c otherwise.

\_toupper returns the upper-case equivalent of c when it is a character between a and z. If c is not one of these characters, the behaviour of \_toupper is undefined.

**I/O Functions**

This chapter comprises functions to manage files or other input/output streams. Among these functions are subroutines to generate or scan strings according to specifications from a format string.

The underlying facilities for input and output depend on the host system, but these functions provide a uniform interface.

The corresponding declarations are in `stdio.h'.

The reentrant versions of these functions use macros

\_stdin\_r(reent) \_stdout\_r(reent) \_stderr\_r(reent)

instead of the globals `stdin`, `stdout`, and `stderr`. The argument `<[reent]>` is a pointer to a reentrancy structure.

## **clearerr : clear file or stream error indicator**

### **Synopsis**

```
#include <stdio.h>
void clearerr(FILE *fp);
```

### **Description**

The `stdio` functions maintain an error indicator with each file pointer `fp`, to record whether any read or write errors have occurred on the associated file or stream. Similarly, it maintains an end-of-file indicator to record whether there is no more data in the file.

Use `clearerr` to reset both of these indicators.

See `error` and `feof` to query the two indicators.

### **Returns**

`clearerr` does not return a result.

## **fclose : close a file**

### **Synopsis**

```
#include <stdio.h>
int fclose(FILE *fp);
```

### **Description**

If the file or stream identified by `fp` is open, `fclose` closes it, after first ensuring that any pending data is written (by calling `fflush(fp)`).

### **Returns**

`fclose` returns 0 if successful (including when `fp` is `NULL` or not an open file); otherwise, it returns `EOF`.

## **fdopen : turn open file into a stream**

### **Synopsis**

```
#include <stdio.h>
FILE *fdopen(int fd, const char *mode);
FILE *_fdopen_r(void *reent, int fd, const char *mode);
```

### **Description**

`fdopen` produces a file descriptor of type `FILE *`, from a descriptor for an already-open file (returned, for example, by the system subroutine `open` rather than by `fopen`). The mode argument has the same meanings as in `fopen`.

### **Returns**

File pointer or `NULL`, as for `fopen`.

## **feof : test for end of file**

### **Synopsis**

```
#include <stdio.h>
int feof(FILE *fp);
```



**Description**

feof tests whether or not the end of the file identified by fp has been reached.

**Returns**

feof returns 0 if the end of file has not yet been reached; if at end of file, the result is nonzero.

**ferror : test whether read/write error has occurred****Synopsis**

```
#include <stdio.h>
int ferror(FILE *fp);
```

**Description**

The stdio functions maintain an error indicator with each file pointer fp, to record whether any read or write errors have occurred on the associated file or stream. Use ferror to query this indicator.

See clearerr to reset the error indicator.

**Returns**

ferror returns 0 if no errors have occurred; it returns a nonzero value otherwise.

**fflush : flush buffered file output****Synopsis**

```
#include <stdio.h>
int fflush(FILE *fp);
```

**Description**

The stdio output functions can buffer output before delivering it to the host system, in order to minimize the overhead of system calls.

Use fflush to deliver any such pending output (for the file or stream identified by fp) to the host system.

If fp is NULL, fflush delivers pending output from all open files.

**Returns**

fflush returns 0 unless it encounters a write error; in that situation, it returns EOF.

**fgetc : get a character from a file or stream****Synopsis**

```
#include <stdio.h>
int fgetc(FILE *fp);
```

**Description**

Use fgetc to get the next single character from the file or stream identified by fp. As a side effect, fgetc advances the file's current position indicator.

For a macro version of this function, see getc.

**Returns**

The next character (read as an unsigned char, and cast to int), unless there is no more data, or the host system reports a read error; in either of these situations, fgetc returns EOF.

You can distinguish the two situations that cause an EOF result by using the ferror and feof functions.

**fgetpos : record position in a stream or file****Synopsis**

```
#include <stdio.h>
int fgetpos(FILE *fp, fpos_t *pos);
```

**Description**

Objects of type FILE can have a "position" that records how much of the file your program has already read. Many of the stdio functions depend on this position, and many change it as a side effect.

You can use fgetpos to report on the current position for a file identified by fp; fgetpos will write a value representing that position at \*pos. Later, you can use this value with fsetpos to return the file to this position.

In the current implementation, fgetpos simply uses a character count to represent the file position; this is the same number that would be returned by ftell.

**Returns**

fgetpos returns 0 when successful. If fgetpos fails, the result is 1. Failure occurs on streams that do not support positioning; the global errno indicates this condition with the value ESPIPE.

**fgets : get character string from a file or stream****Synopsis**

```
#include <stdio.h>
char *fgets(char *buf, int n, FILE *fp);
```

**Description**

Reads at most n-1 characters from fp until a newline is found. The characters including to the newline are stored in buf. The buffer is terminated with a 0.

**Returns**

fgets returns the buffer passed to it, with the data filled in. If end of file occurs with some data already accumulated, the data is returned with no other indication. If no data are read, NULL is returned instead.

**fiprintf : format output to file (integer only)****Synopsis**

```
#include <stdio.h>
int fiprintf(FILE *fd, const char *format, ...);
```

**Description**

fiprintf is a restricted version of fprintf: it has the same arguments and behavior, save that it cannot perform any floating-point formatting--the f, g, G, e, and F type specifiers are not recognized.

**Returns**

fiprintf returns the number of bytes in the output string, save that the concluding NULL is not counted. fiprintf returns when the end of the format string is encountered. If an error occurs, fiprintf returns EOF.

**fopen : open a file****Synopsis**

```
#include <stdio.h>
FILE *fopen(const char *file, const char *mode);
FILE *_fopen_r(void *reent, const char *file, const char *mode);
```

## Description

`fopen` initializes the data structures needed to read or write a file. Specify the file's name as the string `at file`, and the kind of access you need to the file with the string `at mode`.

The alternate function `_fopen_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

Three fundamental kinds of access are available: read, write, and append. `*mode` must begin with one of the three characters ``r'`, ``w'`, or ``a'`, to select one of these:

<b>r</b>	Open the file for reading; the operation will fail if the file does not exist, or if the host system does not permit you to read it.
<b>w</b>	Open the file for writing from the beginning of the file: effectively, this always creates a new file. If the file whose name you specified already existed, its old contents are discarded.
<b>a</b>	Open the file for appending data, that is writing from the end of file. When you open a file this way, all data always goes to the current end of file; you cannot change this using <code>fseek</code> .

Some host systems distinguish between "binary" and "text" files. Such systems may perform data transformations on data written to, or read from, files opened as "text". If your system is one of these, then you can append a ``b'` to any of the three modes above, to specify that you are opening the file as a binary file (the default is to open the file as a text file).

``rb'`, then, means "read binary"; ``wb'`, "write binary"; and ``ab'`, "append binary".

To make C programs more portable, the ``b'` is accepted on all systems, whether or not it makes a difference.

Finally, you might need to both read and write from the same file. You can also append a ``+'` to any of the three modes, to permit this. (If you want to append both ``b'` and ``+'`, you can do it in either order: for example, `"rb+"` means the same thing as `"r+b"` when used as a mode string.)

Use `"r+"` (or `"rb+"`) to permit reading and writing anywhere in an existing file, without discarding any data; `"w+"` (or `"wb+"`) to create a new file (or begin by discarding all data from an old one) that permits reading and writing anywhere in it; and `"a+"` (or `"ab+"`) to permit reading anywhere in an existing file, but writing only at the end.

## Returns

`fopen` returns a file pointer which you can use for other file operations, unless the file you requested could not be opened; in that situation, the result is `NULL`. If the reason for failure was an invalid string `at mode`, `errno` is set to `EINVAL`.

## fputc : write a character on a stream or file

### Synopsis

```
#include <stdio.h>
int fputc(int ch, FILE *fp);
```

### Description

`fputc` converts the argument `ch` from an `int` to an unsigned `char`, then writes it to the file or stream identified by `fp`.

If the file was opened with append mode (or if the stream cannot support positioning), then the new character goes at the end of the file or stream. Otherwise, the new character is written at the current value of the position indicator, and the position indicator advances by one.

For a macro version of this function, see `putc`.

**Returns**

If successful, `fputc` returns its argument `ch`. If an error intervenes, the result is `EOF`. You can use ``ferror(fp)'` to query for errors.

**fputs : write a character string in a file or stream****Synopsis**

```
#include <stdio.h>
int fputs(const char *s, FILE *fp);
```

**Description**

`fputs` writes the string at `s` (but without the trailing null) to the file or stream identified by `fp`.

**Returns**

If successful, the result is 0; otherwise, the result is `EOF`.

**fread : read array elements from a file****Synopsis**

```
#include <stdio.h>
size_t fread(void *buf, size_t size, size_t count, FILE *fp);
```

**Description**

`fread` attempts to copy, from the file or stream identified by `fp`, `count` elements (each of size `size`) into memory, starting at `buf`. `fread` may copy fewer elements than `count` if an error, or end of file, intervenes.

`fread` also advances the file position indicator (if any) for `fp` by the number of characters actually read.

**Returns**

The result of `fread` is the number of elements it succeeded in reading.

**freopen : open a file using an existing file descriptor****Synopsis**

```
#include <stdio.h>
FILE *freopen(const char *file, const char *mode, FILE *fp);
```

**Description**

Use this variant of `fopen` if you wish to specify a particular file descriptor `fp` (notably `stdin`, `stdout`, or `stderr`) for the file. If `fp` was associated with another file or stream, `freopen` closes that other file or stream (but ignores any errors while closing it). `file` and `mode` are used just as in `fopen`.

**Returns**

If successful, the result is the same as the argument `fp`. If the file cannot be opened as specified, the result is `NULL`.

**fseek : set file position****Synopsis**

```
#include <stdio.h>
int fseek(FILE *fp, long offset, int whence);
```

## Description

Objects of type FILE can have a "position" that records how much of the file your program has already read. Many of the stdio functions depend on this position, and many change it as a side effect.

You can use fseek to set the position for the file identified by fp. The value of offset determines the new position, in one of three ways selected by the value of whence (defined as macros in `stdio.h`):

SEEK\_SET : offset is the absolute file position (an offset from the beginning of the file) desired. offset must be positive.

SEEK\_CUR : offset is relative to the current file position. offset can meaningfully be either positive or negative.

SEEK\_END : offset is relative to the current end of file. offset can meaningfully be either positive (to increase the size of the file) or negative.

See ftell to determine the current file position.

## Returns

fseek returns 0 when successful. If fseek fails, the result is EOF. The reason for failure is indicated in errno: either ESPIPE (the stream identified by fp doesn't support repositioning) or EINVAL (invalid file position).

## fsetpos : restore position of a stream or file

### Synopsis

```
#include <stdio.h>
int fsetpos(FILE *fp, const fpos_t *pos);
```

### Description

Objects of type FILE can have a "position" that records how much of the file your program has already read. Many of the stdio functions depend on this position, and many change it as a side effect.

You can use fsetpos to return the file identified by fp to a previous position \*pos (after first recording it with fgetpos).

See fseek for a similar facility.

### Returns

fgetpos returns 0 when successful. If fgetpos fails, the result is 1. The reason for failure is indicated in errno: either ESPIPE (the stream identified by fp doesn't support repositioning) or EINVAL (invalid file position).

## ftell : return position in a stream or file

### Synopsis

```
#include <stdio.h>
long ftell(FILE *fp);
```

### Description

Objects of type FILE can have a "position" that records how much of the file your program has already read. Many of the stdio functions depend on this position, and many change it as a side effect.

The result of ftell is the current position for a file identified by fp. If you record this result, you can later use it with fseek to return the file to this position.

In the current implementation, ftell simply uses a character count to represent the file position; this is the same number that would be recorded by fgetpos.

### Returns

ftell returns the file position, if possible. If it cannot do this, it returns -1L. Failure occurs on streams that do not support positioning; the global errno indicates this condition with the value ESPIPE.

**fwrite : write array elements****Synopsis**

```
#include <stdio.h>
size_t fwrite(const void *buf, size_t size, size_t count, FILE *fp);
```

**Description**

fwrite attempts to copy, starting from the memory location buf, count elements (each of size size) into the file or stream identified by fp. fwrite may copy fewer elements than count if an error intervenes.

fwrite also advances the file position indicator (if any) for fp by the number of characters actually written.

**Returns**

If fwrite succeeds in writing all the elements you specify, the result is the same as the argument count. In any event, the result is the number of complete elements that fwrite copied to the file.

**getc : read a character (macro)****Synopsis**

```
#include <stdio.h>
int getc(FILE *fp);
```

**Description**

getc is a macro, defined in stdio.h. You can use getc to get the next single character from the file or stream identified by fp. As a side effect, getc advances the file's current position indicator.

For a subroutine version of this macro, see fgetc.

**Returns**

The next character (read as an unsigned char, and cast to int), unless there is no more data, or the host system reports a read error; in either of these situations, getc returns EOF.

You can distinguish the two situations that cause an EOF result by using the ferror and feof functions.

**getchar : read a character (macro)****Synopsis**

```
#include <stdio.h>
int getchar(void);
int _getchar_r(void *reent);
```

**Description**

getchar is a macro, defined in stdio.h. You can use getchar to get the next single character from the standard input stream. As a side effect, getchar advances the standard input's current position indicator.

The alternate function \_getchar\_r is a reentrant version. The extra argument reent is a pointer to a reentrancy structure.

**Returns**

The next character (read as an unsigned char, and cast to int), unless there is no more data, or the host system reports a read error; in either of these situations, getchar returns EOF.

You can distinguish the two situations that cause an EOF result by using `ferror(stdin)' and `feof(stdin)'.

## gets : get character string (obsolete, use fgets instead)

### Synopsis

```
#include <stdio.h>
char *gets(char *buf); char *_gets_r(void *reent, char *buf);
```

### Description

Reads characters from standard input until a newline is found. The characters up to the newline are stored in buf. The newline is discarded, and the buffer is terminated with a 0.

This is a dangerous function, as it has no way of checking the amount of space available in buf. One of the attacks used by the Internet Worm of 1988 used this to overrun a buffer allocated on the stack of the finger daemon and overwrite the return address, causing the daemon to execute code downloaded into it over the connection.

The alternate function `_gets_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

`gets` returns the buffer passed to it, with the data filled in. If end of file occurs with some data already accumulated, the data is returned with no other indication. If end of file occurs with no data in the buffer, `NULL` is returned.

Supporting OS subroutines required: `close`, `fstat`, `isatty`, `lseek`, `read`, `sbrk`, `write`.

## iprintf : write formatted output (integer only)

### Synopsis

```
#include <stdio.h>
int iprintf(const char *format, ...);
```

### Description

`iprintf` is a restricted version of `printf`: it has the same arguments and behavior, save that it cannot perform any floating-point formatting: the `f`, `g`, `G`, `e`, and `F` type specifiers are not recognized.

### Returns

`iprintf` returns the number of bytes in the output string, save that the concluding `NULL` is not counted. `iprintf` returns when the end of the format string is encountered. If an error occurs, `iprintf` returns `EOF`.

## mktemp, mkstemp : generate unused file name

### Synopsis

```
#include <stdio.h>
char *mktemp(char *path);
int mkstemp(char *path);
char *_mktemp_r(void *reent, char *path);
int *_mkstemp_r(void *reent, char *path);
```

### Description

`mktemp` and `mkstemp` attempt to generate a file name that is not yet in use for any existing file. `mkstemp` creates the file and opens it for reading and writing; `mktemp` simply generates the file name.

You supply a simple pattern for the generated file name, as the string at `path`. The pattern should be a valid filename (including path information if you wish) ending with some number of ``X'` characters. The generated filename will match the leading part of the name you supply, with the trailing ``X'` characters replaced by some combination of digits and letters.

The alternate functions `_mktemp_r` and `_mkstemp_r` are reentrant versions. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

`mktemp` returns the pointer path to the modified string representing an unused filename, unless it could not generate one, or the pattern you provided is not suitable for a filename; in that case, it returns `NULL`.

`mkstemp` returns a file descriptor to the newly created file, unless it could not generate an unused filename, or the pattern you provided is not suitable for a filename; in that case, it returns `-1`.

## perror : print an error message on standard error

### Synopsis

```
#include <stdio.h>
void perror(char *prefix);
void _perror_r(void *reent, char *prefix);
```

### Description

Use `perror` to print (on standard error) an error message corresponding to the current value of the global variable `errno`. Unless you use `NULL` as the value of the argument `prefix`, the error message will begin with the string at `prefix`, followed by a colon and a space (`:` ). The remainder of the error message is one of the strings described for `strerror`.

The alternate function `_perror_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

`perror` returns no result.

## printf, fprintf, sprintf : format output

### Synopsis

```
#include <stdio.h>
int printf(const char *format [, arg, ...]);
int fprintf(FILE *fd, const char *format [, arg, ...]);
int sprintf(char *str, const char *format [, arg, ...]);
```

### Description

`printf` accepts a series of arguments, applies to each a format specifier from `*format`, and writes the formatted data to `stdout`, terminated with a null character. The behavior of `printf` is undefined if there are not enough arguments for the format. `printf` returns when it reaches the end of the format string. If there are more arguments than the format requires, excess arguments are ignored.

`fprintf` and `sprintf` are identical to `printf`, other than the destination of the formatted output: `fprintf` sends the output to a specified file `fd`, while `sprintf` stores the output in the specified char array `str`. For `sprintf`, the behavior is also undefined if the output `*str` overlaps with one of the arguments. `format` is a pointer to a character string containing two types of objects: ordinary characters (other than `%`), which are copied unchanged to the output, and conversion specifications, each of which is introduced by `%`. (To include `%` in the output, use `%%` in the format string.) A conversion specification has the following form:

```
%[flags][width][.prec][size][type]
```

The fields of the conversion specification have the following meanings:

- `flags` an optional sequence of characters which control output justification, numeric signs, decimal points, trailing zeroes, and octal and hex prefixes. The flag characters are minus (`-`), plus (`+`), space (), zero (`0`), and sharp (`#`). They can appear in any combination.
  - The result of the conversion is left justified, and the right is padded with blanks. If you do not use this flag, the result is right justified, and padded on the left.



- + The result of a signed conversion (as determined by type) will always begin with a plus or minus sign. (If you do not use this flag, positive values do not begin with a plus sign.)
- " " (space) If the first character of a signed conversion specification is not a sign, or if a signed conversion results in no characters, the result will begin with a space. If the space ( ) flag and the plus (+) flag both appear, the space flag is ignored.
- 0 If the type character is d, i, o, u, x, X, e, E, f, g, or G: leading zeroes, are used to pad the field width (following any indication of sign or base); no spaces are used for padding. If the zero (0) and minus (-) flags both appear, the zero (0) flag will be ignored. For d, i, o, u, x, and X conversions, if a precision prec is specified, the zero (0) flag is ignored. Note that 0 is interpreted as a flag, not as the beginning of a field width.
- # The result is to be converted to an alternative form, according to the next character:
  - 0 increases precision to force the first digit of the result to be a zero.
  - x a non-zero result will have a 0x prefix.
  - X a non-zero result will have a 0X prefix.
  - e, E or f The result will always contain a decimal point even if no digits follow the point. (Normally, a decimal point appears only if a digit follows it.) Trailing zeroes are removed.
  - g or G same as e or E, but trailing zeroes are not removed.
  - all others undefined.
- width width is an optional minimum field width. You can either specify it directly as a decimal integer, or indirectly by using instead an asterisk (\*), in which case an int argument is used as the field width. Negative field widths are not supported; if you attempt to specify a negative field width, it is interpreted as a minus (-) flag followed by a positive field width.
- prec an optional field; if present, it is introduced with '.' (a period). This field gives the maximum number of characters to print in a conversion; the minimum number of digits of an integer to print, for conversions with type d, i, o, u, x, and X; the maximum number of significant digits, for the g and G conversions; or the number of digits to print after the decimal point, for e, E, and f conversions. You can specify the precision either directly as a decimal integer or indirectly by using an asterisk (\*), in which case an int argument is used as the precision. Supplying a negative precision is equivalent to omitting the precision. If only a period is specified the precision is zero. If a precision appears with any other conversion type than those listed here, the behavior is undefined.
- size h, l, and L are optional size characters which override the default way that printf interprets the data type of the corresponding argument. h forces the following d, i, o, u, x or X conversion type to apply to a short or unsigned short. h also forces a following n type to apply to a pointer to a short. Similarly, an l forces the following d, i, o, u, x or X conversion type to apply to a long or unsigned long. l also forces a following n type to apply to a pointer to a long. If an h or an l appears with another conversion specifier, the behavior is undefined. L forces a following e, E, f, g or G conversion type to apply to a long double argument. If L appears with any other conversion type, the behavior is undefined.
- type type specifies what kind of conversion printf performs. Here is a table of these:
  - % prints the percent character (%)
  - c prints arg as single character
  - s prints characters until precision is reached or a null terminator is encountered; takes a string pointer
  - d prints a signed decimal integer; takes an int (same as i)
  - i prints a signed decimal integer; takes an int (same as d)
  - o prints a signed octal integer; takes an int
  - u prints an unsigned decimal integer; takes an int
  - x prints an unsigned hexadecimal integer (using abcdef as digits beyond 9); takes an int
  - X prints an unsigned hexadecimal integer (using ABCDEF as digits beyond 9); takes an int
  - f prints a signed value of the form [-]9999.9999; takes a floating point number
  - e prints a signed value of the form [-]9.9999e[+|-]999; takes a floating point number
  - E prints the same way as e, but using E to introduce the exponent; takes a floating point number
  - g prints a signed value in either f or e form, based on given value and precision--trailing zeros and the decimal point are printed only if necessary; takes a floating point number
  - G prints the same way as g, but using E for the exponent if an exponent is needed; takes a floating point number
  - n stores (in the same object) a count of the characters written; takes a pointer to int

- p prints a pointer in an implementation-defined format. This implementation treats the pointer as an unsigned long (same as Lu).

### Returns

sprintf returns the number of bytes in the output string, save that the concluding NULL is not counted. printf and fprintf return the number of characters transmitted. If an error occurs, printf and fprintf return EOF. No error returns occur for sprintf.

## putc : write a character (macro)

### Synopsis

```
#include <stdio.h>
int putc(int ch, FILE *fp);
```

### Description

putc is a macro, defined in stdio.h. putc writes the argument ch to the file or stream identified by fp, after converting it from an int to an unsigned char.

If the file was opened with append mode (or if the stream cannot support positioning), then the new character goes at the end of the file or stream. Otherwise, the new character is written at the current value of the position indicator, and the position indicator advances by one.

For a subroutine version of this macro, see fputc.

### Returns

If successful, putc returns its argument ch. If an error intervenes, the result is EOF. You can use `ferror(fp)' to query for errors.

## putchar : write a character (macro)

### Synopsis

```
#include <stdio.h>
int putchar(int ch);
int _putchar_r(void *reent, int ch);
```

### Description

putchar is a macro, defined in stdio.h. putchar writes its argument to the standard output stream, after converting it from an int to an unsigned char.

The alternate function \_putchar\_r is a reentrant version. The extra argument reent is a pointer to a reentrancy structure.

### Returns

If successful, putchar returns its argument ch. If an error intervenes, the result is EOF. You can use `ferror(stdin)' to query for errors.

## puts : write a character string

### Synopsis

```
#include <stdio.h>
int puts(const char *s);
int _puts_r(void *reent, const char *s);
```

### Description

puts writes the string at s (followed by a newline, instead of the trailing null) to the standard output stream.

The alternate function `_puts_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

If successful, the result is a nonnegative integer; otherwise, the result is EOF.

## remove : delete a file's name

### Synopsis

```
#include <stdio.h>
int remove(char *filename);
int _remove_r(void *reent, char *filename);
```

### Description

Use `remove` to dissolve the association between a particular filename (the string at `filename`) and the file it represents. After calling `remove` with a particular filename, you will no longer be able to open the file by that name.

In this implementation, you may use `remove` on an open file without error; existing file descriptors for the file will continue to access the file's data until the program using them closes the file.

The alternate function `_remove_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

`remove` returns 0 if it succeeds, -1 if it fails.

## rename : rename a file

### Synopsis

```
#include <stdio.h>
int rename(const char *old, const char *new);
int _rename_r(void *reent, const char *old, const char *new);
```

### Description

Use `rename` to establish a new name (the string at `new`) for a file now known by the string at `old`. After a successful rename, the file is no longer accessible by the string at `old`.

If `rename` fails, the file named `*old` is unaffected. The conditions for failure depend on the host operating system.

The alternate function `_rename_r` is a reentrant version. The extra argument `reent` is a pointer to a reentrancy structure.

### Returns

The result is either 0 (when successful) or -1 (when the file could not be renamed).

## rewind : reinitialize a file or stream

### Synopsis

```
#include <stdio.h>
void rewind(FILE *fp);
```

### Description

`rewind` returns the file position indicator (if any) for the file or stream identified by `fp` to the beginning of the file. It also clears any error indicator and flushes any pending output.

## Returns

rewind does not return a result.

## scanf, fscanf, sscanf : scan and format input

### Synopsis

```
#include <stdio.h>
int scanf(const char *format [, arg, ...]);
int fscanf(FILE *fd, const char *format [, arg, ...]);
int sscanf(const char *str, const char *format [, arg, ...]);
```

### Description

scanf scans a series of input fields from standard input, one character at a time. Each field is interpreted according to a format specifier passed to scanf in the format string at \*format. scanf stores the interpreted input from each field at the address passed to it as the corresponding argument following format. You must supply the same number of format specifiers and address arguments as there are input fields.

There must be sufficient address arguments for the given format specifiers; if not the results are unpredictable and likely disastrous. Excess address arguments are merely ignored.

scanf often produces unexpected results if the input diverges from an expected pattern. Since the combination of gets or fgets followed by sscanf is safe and easy, that is the preferred way to be certain that a program is synchronized with input at the end of a line.

fscanf and sscanf are identical to scanf, other than the source of input: fscanf reads from a file, and sscanf from a string.

The string at \*format is a character sequence composed of zero or more directives. Directives are composed of one or more whitespace characters, non-whitespace characters, and format specifications.

Whitespace characters are blank ( ), tab (\t), or newline (\n). When scanf encounters a whitespace character in the format string it will read (but not store) all consecutive whitespace characters up to the next non-whitespace character in the input.

Non-whitespace characters are all other ASCII characters except the percent sign (%). When scanf encounters a non-whitespace character in the format string it will read, but not store a matching non-whitespace character.

Format specifications tell scanf to read and convert characters from the input field into specific types of values, and store them in the locations specified by the address arguments.

Trailing whitespace is left unread unless explicitly matched in the format string. The format specifiers must begin with a percent sign (%) and have the following form:

%[\*][width][size]type

Each format specification begins with the percent character (%). The other fields are:

- \* an optional marker; if present, it suppresses interpretation and assignment of this input field.
- width an optional maximum field width: a decimal integer, which controls the maximum number of characters that will be read before converting the current input field. If the input field has fewer than width characters, scanf reads all the characters in the field, and then proceeds with the next field and its format specification. If a whitespace or a non-convertible character occurs before width character are read, the characters up to that character are read, converted, and stored. Then scanf proceeds to the next format specification.
- size h, l, and L are optional size characters which override the default way that scanf interprets the data type of the corresponding argument. Modifier Type(s) h d, i, o, u, x convert input to short, store in short object h D, I, O, U, X no effect e, f, c, s, n, p l d, i, o, u, x convert input to long, store in long object l e, f, g convert input to double store in a double object l D, I, O, U, X no effect c, s, n, p L d, i, o, u, x convert to long double, store in long double L all others no effect
- type A character to specify what kind of conversion scanf performs. Here is a table of the conversion characters:
- % No conversion is done; the percent character (%) is stored.
- c Scans one character. Corresponding arg: (char \*arg).
- s Reads a character string into the array supplied. Corresponding arg: (char arg[]).

- [pattern] Reads a non-empty character string into memory starting at arg. This area must be large enough to accept the sequence and a terminating null character which will be added automatically. (pattern is discussed in the paragraph following this table). Corresponding arg: (char \*arg).
- d Reads a decimal integer into the corresponding arg: (int \*arg).
- D Reads a decimal integer into the corresponding arg: (long \*arg).
- o Reads an octal integer into the corresponding arg: (int \*arg).
- O Reads an octal integer into the corresponding arg: (long \*arg).
- u Reads an unsigned decimal integer into the corresponding arg: (unsigned int \*arg).
- U Reads an unsigned decimal integer into the corresponding arg: (unsigned long \*arg).
- x,X Read a hexadecimal integer into the corresponding arg: (int \*arg).
- e, f, g Read a floating point number into the corresponding arg: (float \*arg).
- E, F, G Read a floating point number into the corresponding arg: (double \*arg).
- i Reads a decimal, octal or hexadecimal integer into the corresponding arg: (int \*arg).
- I Reads a decimal, octal or hexadecimal integer into the corresponding arg: (long \*arg).
- n Stores the number of characters read in the corresponding arg: (int \*arg).
- p Stores a scanned pointer. ANSI C leaves the details to each implementation; this implementation treats %p exactly the same as %U. Corresponding arg: (void \*\*arg).

A pattern of characters surrounded by square brackets can be used instead of the s type character. pattern is a set of characters which define a search set of possible characters making up the scanf input field. If the first character in the brackets is a caret (^), the search set is inverted to include all ASCII characters except those between the brackets. There is also a range facility which you can use as a shortcut. %[0-9] matches all decimal digits. The hyphen must not be the first or last character in the set. The character prior to the hyphen must be lexically less than the character after it. Here are some pattern examples:

- %[abcd] matches strings containing only a, b, c, and d.
- %[^abcd] matches strings containing any characters except a, b, c, or d
- %[A-DW-Z] matches strings containing A, B, C, D, W, X, Y, Z
- %[z-a] matches the characters z, -, and a

Floating point numbers (for field types e, f, g, E, F, G) must correspond to the following general form: [+/-] dddd[.ddd [E|e[+/-]ddd] where objects inclosed in square brackets are optional, and ddd represents decimal, octal, or hexadecimal digits.

## Returns

scanf returns the number of input fields successfully scanned, converted and stored; the return value does not include scanned fields which were not stored.

If scanf attempts to read at end-of-file, the return value is EOF.

If no fields were stored, the return value is 0.

scanf might stop scanning a particular field before reaching the normal field end character, or may terminate entirely.

scanf stops scanning and storing the current field and moves to the next input field (if any) in any of the following situations:

- The assignment suppressing character (\*) appears after the % in the format specification; the current input field is scanned but not stored.
- width characters have been read (width is a width specification, a positive decimal integer).
- The next character read cannot be converted under the the current format (for example, if a Z is read when the format is decimal).
- The next character in the input field does not appear in the search set (or does appear in the inverted search set).

When scanf stops scanning the current input field for one of these reasons, the next character is considered unread and used as the first character of the following input field, or the first character in a subsequent read operation on the input.

scanf will terminate under the following circumstances:

- The next character in the input field conflicts with a corresponding non-whitespace character in the format string.
- The next character in the input field is EOF.
- The format string has been exhausted.

When the format string contains a character sequence that is not part of a format specification, the same character sequence must appear in the input; `scanf` will scan but not store the matched characters. If a conflict occurs, the first conflicting character remains in the input as if it had never been read.

## setbuf : specify full buffering for a file or stream

### Synopsis

```
#include <stdio.h>
void setbuf(FILE *fp, char *buf);
```

### Description

`setbuf` specifies that output to the file or stream identified by `fp` should be fully buffered. All output for this file will go to a buffer (of size `BUFSIZ`, specified in `stdio.h`). Output will be passed on to the host system only when the buffer is full, or when an input operation intervenes.

You may, if you wish, supply your own buffer by passing a pointer to it as the argument `buf`. It must have size `BUFSIZ`. You can also use `NULL` as the value of `buf`, to signal that the `setbuf` function is to allocate the buffer.

### Warnings

You may only use `setbuf` before performing any file operation other than opening the file.

If you supply a non-null `buf`, you must ensure that the associated storage continues to be available until you close the stream identified by `fp`.

### Returns

`setbuf` does not return a result.

## setvbuf : specify file or stream buffering

### Synopsis

```
#include <stdio.h>
int setvbuf(FILE *fp, char *buf, int mode, size_t size);
```

### Description

Use `setvbuf` to specify what kind of buffering you want for the file or stream identified by `fp`, by using one of the following values (from `stdio.h`) as the mode argument:

`_IONBF` Do not use a buffer: send output directly to the host system for the file or stream identified by `fp`.

`_IOFBF` Use full output buffering: output will be passed on to the host system only when the buffer is full, or when an input operation intervenes.

`_IOLBF` Use line buffering: pass on output to the host system at every newline, as well as when the buffer is full, or when an input operation intervenes.

Use the size argument to specify how large a buffer you wish. You can supply the buffer itself, if you wish, by passing a pointer to a suitable area of memory as `buf`. Otherwise, you may pass `NULL` as the `buf` argument, and `setvbuf` will allocate the buffer.

### Warnings

You may only use `setvbuf` before performing any file operation other than opening the file.

If you supply a non-null `buf`, you must ensure that the associated storage continues to be available until you close the stream identified by `fp`.

**Returns**

A 0 result indicates success, EOF failure (invalid mode or size can cause failure).

**sprintf : write formatted output (integer only)****Synopsis**

```
#include <stdio.h>
int sprintf(char *str, const char *format [, arg, ...]);
```

**Description**

sprintf is a restricted version of printf: it has the same arguments and behavior, save that it cannot perform any floating-point formatting: the f, g, G, e, and E type specifiers are not recognized.

**Returns**

sprintf returns the number of bytes in the output string, save that the concluding NULL is not counted. sprintf returns when the end of the format string is encountered.

**tmpfile : create a temporary file****Synopsis**

```
#include <stdio.h>
FILE *tmpfile(void);
FILE *_tmpfile_r(void *reent);
```

**Description**

Create a temporary file (a file which will be deleted automatically), using a name generated by tmpnam. The temporary file is opened with the mode "wb+", permitting you to read and write anywhere in it as a binary file (without any data transformations the host system may perform for text files).

The alternate function \_tmpfile\_r is a reentrant version. The argument reent is a pointer to a reentrancy structure.

**Returns**

tmpfile normally returns a pointer to the temporary file. If no temporary file could be created, the result is NULL, and errno records the reason for failure.

**tmpnam, tmpnam : name for a temporary file****Synopsis**

```
#include <stdio.h>
char *tmpnam(char *s);
char *tmpnam(char *dir, char *pfx);
char *_tmpnam_r(void *reent, char *s);
char *_tmpnam_r(void *reent, char *dir, char *pfx);
```

**Description**

Use either of these functions to generate a name for a temporary file. The generated name is guaranteed to avoid collision with other files (for up to TMP\_MAX calls of either function).

tmpnam generates file names with the value of P\_tmpdir (defined in `stdio.h') as the leading directory component of the path.

You can use the tmpnam argument s to specify a suitable area of memory for the generated filename; otherwise, you can call tmpnam(NULL) to use an internal static buffer.

tmpnam allows you more control over the generated filename: you can use the argument dir to specify the path to a directory for temporary files, and you can use the argument pfx to specify a prefix for the base filename.

If `dir` is `NULL`, `tempnam` will attempt to use the value of environment variable `TMPDIR` instead; if there is no such value, `tempnam` uses the value of `P_tmpdir` (defined in ``stdio.h'`).

If you don't need any particular prefix to the basename of temporary files, you can pass `NULL` as the `pfx` argument to `tempnam`.

`_tmpnam_r` and `_tempnam_r` are reentrant versions of `tmpnam` and `tempnam` respectively. The extra argument `reent` is a pointer to a reentrancy structure.

#### Warnings

The generated filenames are suitable for temporary files, but do not in themselves make files temporary. Files with these names must still be explicitly removed when you no longer want them.

If you supply your own data area `s` for `tmpnam`, you must ensure that it has room for at least `L_tmpnam` elements of type `char`.

#### Returns

Both `tmpnam` and `tempnam` return a pointer to the newly generated filename.

## **vprintf, vfprintf, vsprintf : format argument list**

#### Synopsis

```
#include <stdio.h>
#include <stdarg.h>
int vprintf(const char *fmt, va_list list);
int vfprintf(FILE *fp, const char *fmt, va_list list);
int vsprintf(char *str, const char *fmt, va_list list);
int _vprintf_r(void *reent, const char *fmt, va_list list);
int _vfprintf_r(void *reent, FILE *fp, const char *fmt, va_list list);
int _vsprintf_r(void *reent, char *str, const char *fmt, va_list list);
```

#### Description

`vprintf`, `vfprintf`, and `vsprintf` are (respectively) variants of `printf`, `fprintf`, and `sprintf`. They differ only in allowing their caller to pass the variable argument list as a `va_list` object (initialized by `va_start`) rather than directly accepting a variable number of arguments.

#### Returns

The return values are consistent with the corresponding functions: `vsprintf` returns the number of bytes in the output string, save that the concluding `NULL` is not counted. `vprintf` and `vfprintf` return the number of characters transmitted. If an error occurs, `vprintf` and `vfprintf` return `EOF`. No error returns occur for `vsprintf`.

## **String and Memory Functions**

---

**String and Memory Functions** This chapter describes string-handling functions and functions for managing areas of memory. The corresponding declarations are in ``string.h'`.

### **bcmp : compare two memory areas**

#### Synopsis

```
#include <string.h>
int bcmp(const char *s1, const char *s2, size_t n);
```

#### Description

This function compares not more than `n` characters of the object pointed to by `s1` with the object pointed to by `s2`.

This function is identical to `memcmp`.



**Returns**

The function returns an integer greater than, equal to or less than zero according to whether the object pointed to by s1 is greater than, equal to or less than the object pointed to by s2.

**bcopy : copy memory regions****Synopsis**

```
#include <string.h>
void bcopy(const char *in, char *out, size_t n);
```

**Description**

This function copies n bytes from the memory region pointed to by in to the memory region pointed to by out.

This function is implemented in term of memmove.

**bzero : initialize memory to zero****Synopsis**

```
#include <string.h>
void bzero(char *b, size_t length);
```

**Description**

bzero initializes length bytes of memory, starting at address b, to zero.

**Returns**

bzero does not return a result.

**index : search for character in string****Synopsis**

```
#include <string.h>
char * index(const char *string, int c);
```

**Description**

This function finds the first occurrence of c (converted to a char) in the string pointed to by string (including the terminating null character).

This function is identical to strchr.

**Returns**

Returns a pointer to the located character, or a null pointer if c does not occur in string.

**memchr : find character in memory****Synopsis**

```
#include <string.h>
void *memchr(const void *src, int c, size_t length);
```

**Description**

This function searches memory starting at \*src for the character c. The search only ends with the first occurrence of c, or after length characters; in particular, NULL does not terminate the search.

**Returns**

If the character `c` is found within `length` characters of `*src`, a pointer to the character is returned. If `c` is not found, then `NULL` is returned.

**memcmp : compare two memory areas****Synopsis**

```
#include <string.h>
int memcmp(const void *s1, const void *s2, size_t n);
```

**Description**

This function compares not more than `n` characters of the object pointed to by `s1` with the object pointed to by `s2`.

**Returns**

The function returns an integer greater than, equal to or less than zero according to whether the object pointed to by `s1` is greater than, equal to or less than the object pointed to by `s2`.

**memcpy : copy memory regions****Synopsis**

```
#include <string.h>
void* memcpy(void *out, const void *in, size_t n);
```

**Description**

This function copies `n` bytes from the memory region pointed to by `in` to the memory region pointed to by `out`.

If the regions overlap, the behavior is undefined.

**Returns**

`memcpy` returns a pointer to the first byte of the `out` region.

**memmove : move possibly overlapping memory****Synopsis**

```
#include <string.h>
void *memmove(void *dst, const void *src, size_t length);
```

**Description**

This function moves `length` characters from the block of memory starting at `*src` to the memory starting at `*dst`. `memmove` reproduces the characters correctly at `*dst` even if the two areas overlap.

**Returns**

The function returns `dst` as passed.

**memset : set an area of memory****Synopsis**

```
#include <string.h>
void *memset(const void *dst, int c, size_t length);
```

**Description**

This function converts the argument `c` into an unsigned char and fills the first `length` characters of the array pointed to by `dst` to the value.

**Returns**

memset returns the value of m.

**rindex : reverse search for character in string****Synopsis**

```
#include <string.h>
char * rindex(const char *string, int c);
```

**Description**

This function finds the last occurrence of c (converted to a char) in the string pointed to by string (including the terminating null character).

This function is identical to strrchr.

**Returns**

Returns a pointer to the located character, or a null pointer if c does not occur in string.

**strcat : concatenate strings****Synopsis**

```
#include <string.h>
char *strcat(char *dst, const char *src);
```

**Description**

strcat appends a copy of the string pointed to by src (including the terminating null character) to the end of the string pointed to by dst. The initial character of src overwrites the null character at the end of dst.

**Returns**

This function returns the initial value of dst

**strchr : search for character in string****Synopsis**

```
#include <string.h>
char * strchr(const char *string, int c);
```

**Description**

This function finds the first occurrence of c (converted to a char) in the string pointed to by string (including the terminating null character).

**Returns**

Returns a pointer to the located character, or a null pointer if c does not occur in string.

**strcmp : character string compare****Synopsis**

```
#include <string.h>
int strcmp(const char *a, const char *b);
```

**Description**

strcmp compares the string at a to the string at b.

**Returns**

If \*a sorts lexicographically after \*b, strcmp returns a number greater than zero. If the two strings match, strcmp returns zero. If \*a sorts lexicographically before \*b, strcmp returns a number less than zero.

**strcoll : locale specific character string compare****Synopsis**

```
#include <string.h>
int strcoll(const char *stra, const char * strb);
```

**Description**

strcoll compares the string pointed to by stra to the string pointed to by strb, using an interpretation appropriate to the current LC\_COLLATE state.

**Returns**

If the first string is greater than the second string, strcoll returns a number greater than zero. If the two strings are equivalent, strcoll returns zero. If the first string is less than the second string, strcoll returns a number less than zero.

**strcpy : copy string****Synopsis**

```
#include <string.h>
char *strcpy(char *dst, const char *src);
```

**Description**

strcpy copies the string pointed to by src (including the terminating null character) to the array pointed to by dst.

**Returns**

This function returns the initial value of dst.

**strcspn : count chars not in string****Synopsis**

```
size_t strcspn(const char *s1, const char *s2);
```

**Description**

This function computes the length of the initial part of the string pointed to by s1 which consists entirely of characters NOT from the string pointed to by s2 (excluding the terminating null character).

**Returns**

strcspn returns the length of the substring found.

**strerror : convert error number to string****Synopsis**

```
#include <string.h>
char *strerror(int errnum);
```

**Description**

strerror converts the error number errnum into a string. The value of errnum is usually a copy of errno. If errnum is not a known error number, the result points to an empty string.

This implementation of `strerror` prints out the following strings for each of the values defined in `errno.h`:

E2BIG Arg list too long  
EACCES Permission denied  
EADV Advertise error  
EAGAIN No more processes  
EBADF Bad file number  
EBADMSG Bad message  
EBUSY Device or resource busy  
ECHILD No children  
ECOMM Communication error  
EDEADLK Deadlock  
EEXIST File exists  
EDOM Math argument  
EFAULT Bad address  
EFBIG File too large  
EIDRM Identifier removed  
EINTR Interrupted system call  
EINVAL Invalid argument  
EIO I/O error  
EISDIR Is a directory  
ELIBACC Cannot access a needed shared library  
ELIBBAD Accessing a corrupted shared library  
ELIBEXEC Cannot exec a shared library directly  
ELIBMAX Attempting to link in more shared libraries than system limit  
ELIBSCN .lib section in a.out corrupted  
EMFILE Too many open files  
EMLINK Too many links  
EMULTIHOP Multihop attempted  
ENAMETOOLONG File or path name too long  
ENFILE Too many open files in system  
ENODEV No such device  
ENOENT No such file or directory  
ENOEXEC Exec format error  
ENOLCK No lock  
ENOLINK Virtual circuit is gone  
ENOMEM Not enough space  
ENOMSG No message of desired type  
ENONET Machine is not on the network  
ENOPKG No package  
ENOSPC No space left on device

ENOSR No stream resources  
ENOSTR Not a stream  
ENOSYS Function not implemented  
ENOTBLK Block device required  
ENOTDIR Not a directory  
ENOTEMPTY Directory not empty  
ENOTTY Not a character device  
ENXIO No such device or address  
EPERM Not owner  
EPIPE Broken pipe  
EPROTO Protocol error  
ERANGE Result too large  
EREMOTE Resource is remote  
EROFS Read-only file system  
ESPIPE Illegal seek  
ESRCH No such process  
ESRMNT Srmount error  
ETIME Stream ioctl timeout  
ETXTBSY Text file busy  
EXDEV Cross-device link

### Returns

This function returns a pointer to a string. Your application must not modify that string.

## strlen : character string length

### Synopsis

```
#include <string.h>
size_t strlen(const char *str);
```

### Description

The strlen function works out the length of the string starting at \*str by counting characters until it reaches a NULL character.

### Returns

strlen returns the character count.

## strlwr : force string to lower case

### Synopsis

```
#include <string.h>
char *strlwr(char *a);
```

### Description

strlwr converts each characters in the string at a to lower case.

**Returns**

strlwr returns its argument, a.

**strncat : concatenate strings****Synopsis**

```
#include <string.h>
char *strncat(char *dst, const char *src, size_t length);
```

**Description**

strncat appends not more than length characters from the string pointed to by src (including the terminating null character) to the end of the string pointed to by dst. The initial character of src overwrites the null character at the end of dst. A terminating null character is always appended to the result

**Warnings**

Note that a null is always appended, so that if the copy is limited by the length argument, the number of characters appended to dst is  $n + 1$ .

**Returns**

This function returns the initial value of dst

**strncmp : character string compare****Synopsis**

```
#include <string.h>
int strncmp(const char *a, const char * b, size_t length);
```

**Description**

strncmp compares up to length characters from the string at a to the string at b.

**Returns**

If \*a sorts lexicographically after \*b, strncmp returns a number greater than zero. If the two strings are equivalent, strncmp returns zero. If \*a sorts lexicographically before \*b, strncmp returns a number less than zero.

**strncpy : counted copy string****Synopsis**

```
#include <string.h>
char *strncpy(char *dst, const char *src, size_t length);
```

**Description**

strncpy copies not more than length characters from the the string pointed to by src (including the terminating null character) to the array pointed to by dst. If the string pointed to by src is shorter than length characters, null characters are appended to the destination array until a total of length characters have been written.

**Returns**

This function returns the initial value of dst.

**strpbrk : find chars in string****Synopsis**

```
#include <string.h>
```

```
char *strpbrk(const char *s1, const char *s2);
```

### Description

This function locates the first occurrence in the string pointed to by s1 of any character in string pointed to by s2 (excluding the terminating null character).

### Returns

strpbrk returns a pointer to the character found in s1, or a null pointer if no character from s2 occurs in s1.

## strrchr : reverse search for character in string

### Synopsis

```
#include <string.h>
char * strrchr(const char *string, int c);
```

### Description

This function finds the last occurrence of c (converted to a char) in the string pointed to by string (including the terminating null character).

### Returns

Returns a pointer to the located character, or a null pointer if c does not occur in string.

## strspn : find initial match

### Synopsis

```
#include <string.h>
size_t strspn(const char *s1, const char *s2);
```

### Description

This function computes the length of the initial segment of the string pointed to by s1 which consists entirely of characters from the string pointed to by s2 (excluding the terminating null character).

### Returns

strspn returns the length of the segment found.

## strstr : find string segment

### Synopsis

```
#include <string.h>
char *strstr(const char *s1, const char *s2);
```

### Description

Locates the first occurrence in the string pointed to by s1 of the sequence of characters in the string pointed to by s2 (excluding the terminating null character).

### Returns

Returns a pointer to the located string segment, or a null pointer if the string s2 is not found. If s2 points to a string with zero length, the s1 is returned.



## strtok : get next token from a string

### Synopsis

```
#include <string.h>
char *strtok(char *source, const char *delimiters)
char *strtok_r(char *source, const char *delimiters, char **lasts)
```

### Description

The strtok function is used to isolate sequential tokens in a null-terminated string, \*source. These tokens are delimited in the string by at least one of the characters in \*delimiters. The first time that strtok is called, \*source should be specified; subsequent calls, wishing to obtain further tokens from the same string, should pass a null pointer instead. The separator string, \*delimiters, must be supplied each time, and may change between calls.

The strtok function returns a pointer to the beginning of each subsequent token in the string, after replacing the separator character itself with a NUL character. When no more tokens remain, a null pointer is returned.

The strtok\_r function has the same behavior as strtok, except a pointer to placeholder \*[lasts> must be supplied by the caller.

### Returns

strtok returns a pointer to the next token, or NULL if no more tokens can be found.

## strupr : force string to uppercase

### Synopsis

```
#include <string.h>
char *strupr(char *a);
```

### Description

strupr converts each characters in the string at a to upper case.

### Returns

strupr returns its argument, a.

## strxfrm : transform string

### Synopsis

```
#include <string.h>
size_t strxfrm(char *s1, const char *s2, size_t n);
```

### Description

This function transforms the string pointed to by s2 and places the resulting string into the array pointed to by s1. The transformation is such that if the strcmp function is applied to the two transformed strings, it returns a value greater than, equal to, or less than zero, corresponding to the result of a strcoll function applied to the same two original strings.

No more than n characters are placed into the resulting array pointed to by s1, including the terminating null character. If n is zero, s1 may be a null pointer. If copying takes place between objects that overlap, the behavior is undefined.

With a C locale, this function just copies.

### Returns

The strxfrm function returns the length of the transformed string (not including the terminating null character). If the value returned is n or more, the contents of the array pointed to by s1 are indeterminate.

## Time Functions

---

This chapter groups functions used either for reporting on time (elapsed, current, or compute time) or to perform calculations based on time.

The header file 'time.h' defines three types. `clock_t` and `time_t` are both used for representations of time particularly suitable for arithmetic. (In this implementation, quantities of type `clock_t` have the highest resolution possible on your machine, and quantities of type `time_t` resolve to seconds.) `size_t` is also defined if necessary for quantities representing sizes. 'time.h' also defines the structure `tm` for the traditional representation of Gregorian calendar time as a series of numbers, with the following fields:

**tm\_sec**

Seconds.

**tm\_min**

Minutes.

**tm\_hour**

Hours.

**tm\_mday**

Day.

**tm\_mon**

Month.

**tm\_year**

Year (since 1900).

**tm\_wday**

Day of week: the number of days since Sunday.

**tm\_yday**

Number of days elapsed since last January 1.

**tm\_isdst**

Daylight Savings Time flag: positive means DST in effect, zero means DST not in effect, negative means no information about DST is available.

### asctime : format time as string

#### Synopsis

```
#include <time.h>
char *asctime(const struct tm *clock);
char *asctime_r(const struct tm *clock, char *buf);
```

#### Description

Format the time value at `clock` into a string of the form `Wed Jun 15 11:38:07 1988`

The string is generated in a static buffer; each call to `asctime` overwrites the string generated by previous calls.

#### Returns

A pointer to the string containing a formatted timestamp.

### clock : cumulative processor time

#### Synopsis

```
#include <time.h>
clock_t clock(void);
```

**Description**

Calculates the best available approximation of the cumulative amount of time used by your program since it started. To convert the result into seconds, divide by the macro `CLOCKS_PER_SEC`.

**Returns**

The amount of processor time used so far by your program, in units defined by the machine-dependent macro `CLOCKS_PER_SEC`. If no measurement is available, the result is -1.

**ctime : convert time to local and format as string****Synopsis**

```
#include <time.h>
char *ctime(time_t clock);
char *ctime_r(time_t clock, char *buf);
```

**Description**

Convert the time value at `clock` to local time (like `localtime`) and format it into a string of the form `Wed Jun 15 11:38:07 1988` (like `asctime`).

**Returns**

A pointer to the string containing a formatted timestamp.

**difftime : subtract two times****Synopsis**

```
#include <time.h>
double difftime(time_t tim1, time_t tim2);
```

**Description**

Subtracts the two times in the arguments: ``tim1 - tim2'`.

**Returns**

The difference (in seconds) between `tim2` and `tim1`, as a double.

**gmtime : convert time to UTC traditional form****Synopsis**

```
#include <time.h>
struct tm *gmtime(const time_t *clock);
struct tm *gmtime_r(const time_t *clock, struct tm *res);
```

**Description**

`gmtime` assumes the time at `clock` represents a local time. `gmtime` converts it to UTC (Universal Coordinated Time, also known in some countries as GMT, Greenwich Mean time), then converts the representation from the arithmetic representation to the traditional representation defined by `struct tm`.

`gmtime` constructs the traditional time representation in static storage; each call to `gmtime` or `localtime` will overwrite the information generated by previous calls to either function.

**Returns**

A pointer to the traditional time representation (`struct tm`).

## localtime : convert time to local representation

### Synopsis

```
#include <time.h>
struct tm *localtime(time_t *clock);
struct tm *localtime_r(time_t *clock, struct tm *res);
```

### Description

localtime converts the time at clock into local time, then converts its representation from the arithmetic representation to the traditional representation defined by struct tm.

localtime constructs the traditional time representation in static storage; each call to gmtime or localtime will overwrite the information generated by previous calls to either function.

mktime is the inverse of localtime.

### Returns

A pointer to the traditional time representation (struct tm).

## mktime : convert time to arithmetic representation

### Synopsis

```
#include <time.h>
time_t mktime(struct tm *timp);
```

### Description

mktime assumes the time at timp is a local time, and converts its representation from the traditional representation defined by struct tm into a representation suitable for arithmetic.

localtime is the inverse of mktime.

### Returns

If the contents of the structure at timp do not form a valid calendar time representation, the result is -1. Otherwise, the result is the time, converted to a time\_t value.

## strftime : flexible calendar time formatter

### Synopsis

```
#include <time.h>
size_t strftime(char *s, size_t maxsize, const char *format, const struct tm
*timp);
```

### Description

strftime converts a struct tm representation of the time (at timp) into a string, starting at s and occupying no more than maxsize characters.

You control the format of the output using the string at format. \*format can contain two kinds of specifications: text to be copied literally into the formatted string, and time conversion specifications. Time conversion specifications are two-character sequences beginning with '%' (use `%%' to include a percent sign in the output). Each defined conversion specification selects a field of calendar time data from \*timp, and converts it to a string in one of the following ways:

- %a An abbreviation for the day of the week.
- %A The full name for the day of the week.
- %b An abbreviation for the month name.
- %B The full name of the month.

- %c A string representing the complete date and time, in the form Mon Apr 01 13:13:13 1992
- %d The day of the month, formatted with two digits.
- %H The hour (on a 24-hour clock), formatted with two digits.
- %I The hour (on a 12-hour clock), formatted with two digits.
- %j The count of days in the year, formatted with three digits (from `001' to `366').
- %m The month number, formatted with two digits.
- %M The minute, formatted with two digits.
- %p Either `AM' or `PM' as appropriate.
- %S The second, formatted with two digits.
- %U The week number, formatted with two digits (from `00' to `53'; week number 1 is taken as beginning with the first Sunday in a year). See also %W.
- %w A single digit representing the day of the week: Sunday is day 0.
- %W Another version of the week number: like `%U', but counting week 1 as beginning with the first Monday in a year.
- %x A string representing the complete date, in a format like Mon Apr 01 1992
- %X A string representing the full time of day (hours, minutes, and seconds), in a format like 13:13:13
- %y The last two digits of the year.
- %Y The full year, formatted with four digits to include the century.
- %Z Defined by ANSI C as eliciting the time zone if available; it is not available in this implementation (which accepts `%Z' but generates no output for it).
- %% A single character, `%'.

### Returns

When the formatted time takes up no more than maxsize characters, the result is the length of the formatted string. Otherwise, if the formatting operation was abandoned due to lack of room, the result is 0, and the string starting at s corresponds to just those parts of \*format that could be completely filled in within the maxsize limit.

## time : get current calendar time (as single number)

### Synopsis

```
#include <time.h>
time_t time(time_t *t);
```

### Description

time looks up the best available representation of the current time and returns it, encoded as a time\_t. It stores the same value at t unless the argument is NULL.

### Returns

A -1 result means the current time is not available; otherwise the result represents the current time.

## C Math Library Functions

---

### acos, acosf : arc cosine

#### Synopsis

```
#include <math.h>
double acos(double x);
float acosf(float x);
```

#### Description

acos computes the inverse cosine (arc cosine) of the input value. Arguments to acos must be in the range -1 to 1. acosf is identical to acos, except that it performs its calculations on floats.

**Returns**

If  $x$  is not between -1 and 1, the returned value is NaN (not a number) the global variable `errno` is set to `EDOM`, and a `DOMAIN` error message is sent as standard error output.

You can modify error handling for these functions using `matherr`.

**acosh, acoshf : inverse hyperbolic cosine****Synopsis**

```
#include <math.h>
double acosh(double x);
float acoshf(float x);
```

**Description**

`acosh` calculates the inverse hyperbolic cosine of  $x$ . `acosh` is defined as  $x$  must be a number greater than or equal to 1. `acoshf` is identical, other than taking and returning floats.

**Returns**

`acosh` and `acoshf` return the calculated value. If  $x$  less than 1, the return value is NaN and `errno` is set to `EDOM`. You can change the error-handling behavior with the non-ANSI `matherr` function.

**asin, asinf : arc sine****Synopsis**

```
#include <math.h>
double asin(double x);
float asinf(float x);
```

**Description**

`asin` computes the inverse sine (arc sine) of the argument  $x$ . Arguments to `asin` must be in the range -1 to 1. `asinf` is identical to `asin`, other than taking and returning floats. You can modify error handling for these routines using `matherr`.

**Returns**

If  $x$  is not in the range -1 to 1, `asin` and `asinf` return NaN (not a number), set the global variable `errno` to `EDOM`, and issue a `DOMAIN` error message. You can change this error treatment using `matherr`.

**asinh, asinhf : inverse hyperbolic sine****Synopsis**

```
#include <math.h>
double asinh(double x);
float asinhf(float x);
```

**Description**

`asinh` calculates the inverse hyperbolic sine of  $x$ . `asinh` is defined as `asinhf` is identical, other than taking and returning floats.

**Returns**

`asinh` and `asinhf` return the calculated value.

**atan, atanf : arc tangent****Synopsis**

```
#include <math.h>
double atan(double x);
float atanf(float x);
```

**Description**

atan computes the inverse tangent (arc tangent) of the input value. atanf is identical to atan, save that it operates on floats.

**Returns**

atan and atanf return the calculated value

**atan2, atan2f : arc tangent of y/x****Synopsis**

```
#include <math.h>
double atan2(double y, double x);
float atan2f(float y, float x);
```

**Description**

atan2 computes the inverse tangent (arc tangent) of y/x. atan2 produces the correct result even for angles near (that is, when x is near 0). atan2f is identical to atan2, save that it takes and returns float.

**Returns**

atan2 and atan2f return a value in radians. If both x and y are 0.0, atan2 causes a DOMAIN error. You can modify error handling for these functions using matherr.

**atanh, atanhf : inverse hyperbolic tangent****Synopsis**

```
#include <math.h>
double atanh(double x);
float atanhf(float x);
```

**Description**

atanh calculates the inverse hyperbolic tangent of x. atanhf is identical, other than taking and returning float values.

**Returns**

atanh and atanhf return the calculated value. If is greater than 1, the global errno is set to EDOM and the result is a NaN. A DOMAIN error is reported. If is 1, the global errno is set to EDOM; and the result is infinity with the same sign as x. A SING error is reported. You can modify the error handling for these routines using matherr.

**jN,jNf,yN,yNf : Bessel functions****Synopsis**

```
#include <math.h>
double j0(double x);
float j0f(float x);
double j1(double x);
float j1f(float x);
```

```
double jn(int n, double x);
float jnf(int n, float x);
double y0(double x);
float y0f(float x);
double y1(double x);
float y1f(float x);
double yn(int n, double x);
float ynf(int n, float x);
```

### Description

The Bessel functions are a family of functions that solve the differential equation. These functions have many applications in engineering and physics. `jn` calculates the Bessel function of the first kind of order `n`. `j0` and `j1` are special cases for order 0 and order 1 respectively. Similarly, `yn` calculates the Bessel function of the second kind of order `n`, and `y0` and `y1` are special cases for order 0 and 1. `jnf`, `j0f`, `j1f`, `ynf`, `y0f`, and `y1f` perform the same calculations, but on float rather than double values.

### Returns

The value of each Bessel function at `x` is returned.

## cbirt, cbirtf : cube root

### Synopsis

```
#include <math.h>
double cbirt(double x);
float cbirtf(float x);
```

### Description

`cbirt` computes the cube root of the argument.

### Returns

The cube root is returned.

## copysign, copysignf : sign of y, magnitude of x

### Synopsis

```
#include <math.h>
double copysign (double x, double y);
float copysignf (float x, float y);
```

### Description

`copysign` constructs a number with the magnitude (absolute value) of its first argument, `x`, and the sign of its second argument, `y`. `copysignf` does the same thing; the two functions differ only in the type of their arguments and result.

### Returns

`copysign` returns a double with the magnitude of `x` and the sign of `y`. `copysignf` returns a float with the magnitude of `x` and the sign of `y`.

## cosh, coshf : hyperbolic cosine

### Synopsis

```
#include <math.h>
double cosh(double x);
float coshf(float x);
```



**Description**

cosh computes the hyperbolic cosine of the argument  $x$ .  $\cosh(x)$  is defined as  $\frac{e^x + e^{-x}}{2}$ . Angles are specified in radians.  $\coshf$  is identical, save that it takes and returns float.

**Returns**

The computed value is returned. When the correct value would create an overflow,  $\cosh$  returns the value  $HUGE\_VAL$  with the appropriate sign, and the global value  $errno$  is set to  $ERANGE$ . You can modify error handling for these functions using the function  $\mathit{matherr}$ .

**erf, erff, erfc, erfcf : error function****Synopsis**

```
#include <math.h>
double erf(double x);
float erff(float x);
double erfc(double x);
float erfcf(float x);
```

**Description**

$\mathit{erf}$  calculates an approximation to the "error function", which estimates the probability that an observation will fall within  $x$  standard deviations of the mean (assuming a normal distribution).  $\mathit{erfc}$  calculates the complementary probability; that is,  $\mathit{erfc}(x)$  is  $1 - \mathit{erf}(x)$ .  $\mathit{erfc}$  is computed directly, so that you can use it to avoid the loss of precision that would result from subtracting large probabilities (on large  $x$ ) from 1.  $\mathit{erff}$  and  $\mathit{erfcf}$  differ from  $\mathit{erf}$  and  $\mathit{erfc}$  only in the argument and result types.

**Returns**

For positive arguments,  $\mathit{erf}$  and all its variants return a probability--a number between 0 and 1.

**exp, expf : exponential****Synopsis**

```
#include <math.h>
double exp(double x);
float expf(float x);
```

**Description**

$\mathit{exp}$  and  $\mathit{expf}$  calculate the exponential of  $x$ , that is,  $e^x$ , the base of the natural system of logarithms, approximately 2.71828). You can use the (non-ANSI) function  $\mathit{matherr}$  to specify error handling for these functions.

**Returns**

On success,  $\mathit{exp}$  and  $\mathit{expf}$  return the calculated value. If the result underflows, the returned value is 0. If the result overflows, the returned value is  $HUGE\_VAL$ . In either case,  $errno$  is set to  $ERANGE$ .

**expm1, expm1f : exponential minus 1****Synopsis**

```
#include <math.h>
double expm1(double x);
float expm1f(float x);
```

**Description**

$\mathit{expm1}$  and  $\mathit{expm1f}$  calculate the exponential of  $x$  and subtract 1, that is,  $e^x - 1$ , the base of the natural system of logarithms, approximately 2.71828). The result is accurate even for small values of  $x$ , where using  $\mathit{exp}(x) - 1$  would lose many significant digits.

**Returns**

e raised to the power x, minus 1.

**fabs, fabsf : absolute value (magnitude)****Synopsis**

```
#include <math.h>
double fabs(double x);
float fabsf(float x);
```

**Description**

fabs and fabsf calculate the absolute value (magnitude) of the argument x, by direct manipulation of the bit representation of x.

**Returns**

The calculated value is returned. No errors are detected.

**floor, floorf, ceil, ceilf : floor and ceiling****Synopsis**

```
#include <math.h>
double floor(double x);
float floorf(float x);
double ceil(double x);
float ceilf(float x);
```

**Description**

floor and floorf find the nearest integer less than or equal to x. ceil and ceilf find the nearest integer greater than or equal to x.

**Returns**

floor and ceil return the integer result as a double. floorf and ceilf return the integer result as a float.

**fmod, fmodf : floating-point remainder (modulo)****Synopsis**

```
#include <math.h>
double fmod(double x, double y)
float fmodf(float x, float y)
```

**Description**

The fmod and fmodf functions compute the floating-point remainder of x/y (x modulo y).

**Returns**

The fmod function returns the value for the largest integer i such that, if y is nonzero, the result has the same sign as x and magnitude less than the magnitude of y. fmod(x,0) returns NaN, and sets errno to EDOM. You can modify error treatment for these functions using matherr.

**frexp, frexpf : split floating-point number****Synopsis**

```
#include <math.h>
double frexp(double val, int *exp);
float frexpf(float val, int *exp);
```

## Description

All non zero, normal numbers can be described as  $m * 2^p$ . `frexp` represents the double `val` as a mantissa `m` and a power of two `p`. The resulting mantissa will always be greater than or equal to 0.5, and less than 1.0 (as long as `val` is nonzero). The power of two will be stored in `*exp`. `frexpf` is identical, other than taking and returning floats rather than doubles.

## Returns

`frexp` returns the mantissa `m`. If `val` is 0, infinity, or Nan, `frexp` will set `*exp` to 0 and return `val`.

## gamma, gammaf, lgamma, lgammaf, gamma\_r, gammaf\_r, lgamma\_r, lgammaf\_r

### Synopsis

```
#include <math.h>
double gamma(double x);
float gammaf(float x);
double lgamma(double x);
float lgammaf(float x);
double gamma_r(double x, int *signgam);
float gammaf_r(float x, int *signgam);
double lgamma_r(double x, int *signgam);
float lgammaf_r(float x, int *signgam);
```

### Description

`gamma` calculates the natural logarithm of the gamma function of `x`. The gamma function ( $\exp(\text{gamma}(x))$ ) is a generalization of factorial, and retains the property that Accordingly, the results of the gamma function itself grow very quickly. `gamma` is defined as to extend the useful range of results representable.

The sign of the result is returned in the global variable `signgam`, which is declared in `math.h`. `gammaf` performs the same calculation as `gamma`, but uses and returns float values. `lgamma` and `lgammaf` are alternate names for `gamma` and `gammaf`. The use of `lgamma` instead of `gamma` is a reminder that these functions compute the log of the gamma function, rather than the gamma function itself.

The functions `gamma_r`, `gammaf_r`, `lgamma_r`, and `lgammaf_r` are just like `gamma`, `gammaf`, `lgamma`, and `lgammaf`, respectively, but take an additional argument. This additional argument is a pointer to an integer. This additional argument is used to return the sign of the result, and the global variable `signgam` is not used. These functions may be used for reentrant calls (but they will still set the global variable `errno` if an error occurs).

### Returns

Normally, the computed result is returned. When `x` is a nonpositive integer, `gamma` returns `HUGE_VAL` and `errno` is set to `EDOM`. If the result overflows, `gamma` returns `HUGE_VAL` and `errno` is set to `ERANGE`. You can modify this error treatment using `matherr`.

## hypot, hypotf : distance from origin

### Synopsis

```
#include <math.h>
double hypot(double x, double y);
float hypotf(float x, float y);
```

### Description

`hypot` calculates the Euclidean distance between the origin (0,0) and a point represented by the Cartesian coordinates (x,y). `hypotf` differs only in the type of its arguments and result.

### Returns

Normally, the distance value is returned. On overflow, `hypot` returns `HUGE_VAL` and sets `errno` to `ERANGE`. You can change the error treatment with `matherr`.

## ilogb, ilogbf : get exponent of floating point number

### Synopsis

```
#include <math.h>
int ilogb(double val);
int ilogbf(float val);
```

### Description

All non zero, normal numbers can be described as  $m * 2^p$ . `ilogb` and `ilogbf` examine the argument `val`, and return `p`. The functions `frexp` and `frexpf` are similar to `ilogb` and `ilogbf`, but also return `m`.

### Returns

`ilogb` and `ilogbf` return the power of two used to form the floating point argument. If `val` is 0, they return -`INT_MAX` (`INT_MAX` is defined in `limits.h`). If `val` is infinite, or NaN, they return `INT_MAX`.

## infinity, infinityf : representation of infinity

### Synopsis

```
#include <math.h>
double infinity(void);
float infinityf(void);
```

### Description

`infinity` and `infinityf` return the special number IEEE infinity in double and single precision arithmetic respectively.

## isnan, isnanf, isinf, isinff, finite, finitf : test for exceptional numbers

### Synopsis

```
#include <ieeefp.h>
int isnan(double arg);
int isinf(double arg);
int finite(double arg);
int isnanf(float arg);
int isinff(float arg);
int finitf(float arg);
```

### Description

These functions provide information on the floating point argument supplied. There are five major number formats -

zero a number which contains all zero bits.

subnormal Is used to represent number with a zero exponent, but a non zero fraction.

normal A number with an exponent, and a fraction

infinity A number with an all 1's exponent and a zero fraction.

NAN A number with an all 1's exponent and a non zero fraction.

### Returns

`isnan` returns 1 if the argument is a nan. `isinf` returns 1 if the argument is infinity. `finite` returns 1 if the argument is zero, subnormal or normal. The `isnanf`, `isinff` and `finitf` perform the same operations as their `isnan`, `isinf` and `finite` counterparts, but on single precision floating point numbers.

## ldexp, ldexpf : load exponent

### Synopsis

```
#include <math.h>
double ldexp(double val, int exp);
float ldexpf(float val, int exp);
```

### Description

ldexp calculates the value ldexpf is identical, save that it takes and returns float rather than double values.

### Returns

ldexp returns the calculated value. Underflow and overflow both set errno to ERANGE. On underflow, ldexp and ldexpf return 0.0. On overflow, ldexp returns plus or minus HUGE\_VAL.

## log, logf : natural logarithms

### Synopsis

```
#include <math.h>
double log(double x);
float logf(float x);
```

### Description

Return the natural logarithm of x, that is, its logarithm base e (where e is the base of the natural system of logarithms, 2.71828...). log and logf are identical save for the return and argument types. You can use the (non-ANSI) function matherr to specify error handling for these functions.

### Returns

Normally, returns the calculated value. When x is zero, the returned value is -HUGE\_VAL and errno is set to ERANGE. When x is negative, the returned value is -HUGE\_VAL and errno is set to EDOM. You can control the error behavior via matherr.

## log10, log10f : base 10 logarithms

### Synopsis

```
#include <math.h>
double log10(double x);
float log10f(float x);
```

### Description

log10 returns the base 10 logarithm of x. It is implemented as  $\log(x) / \log(10)$ . log10f is identical, save that it takes and returns float values.

### Returns

log10 and log10f return the calculated value. See the description of log for information on errors.

## log1p, log1pf : log of 1 + x

### Synopsis

```
#include <math.h>
double log1p(double x);
float log1pf(float x);
```

## Description

log1p calculates the natural logarithm of 1+x. You can use log1p rather than 'log(1+x)' for greater precision when x is very small. log1pf calculates the same thing, but accepts and returns float values rather than double.

## Returns

log1p returns a double, the natural log of 1+x. log1pf returns a float, the natural log of 1+x.

## matherr : modifiable math error handler

### Synopsis

```
#include <math.h>
int matherr(struct exception *e);
```

### Description

matherr is called whenever a math library function generates an error. You can replace matherr by your own subroutine to customize error treatment. The customized matherr must return 0 if it fails to resolve the error, and non-zero if the error is resolved.

When matherr returns a nonzero value, no error message is printed and the value of errno is not modified. You can accomplish either or both of these things in your own matherr using the information passed in the structure \*e.

This is the exception structure (defined in 'math.h'):

```
struct exception {
    int type;
    char *name;
    double arg1, arg2, retval;
    int err;
};
```

The members of the exception structure have the following meanings:

type The type of mathematical error that occurred; macros encoding error types are also defined in 'math.h'.

name a pointer to a null-terminated string holding the name of the math library function where the error occurred.

arg1, arg2 The arguments which caused the error.

retval The error return value (what the calling function will return).

err If set to be non-zero, this is the new value assigned to errno.

The error types defined in 'math.h' represent possible mathematical errors as follows:

DOMAIN An argument was not in the domain of the function; e.g. log(-1.0).

SING The requested calculation would result in a singularity; e.g. pow(0.0,-2.0)

OVERFLOW A calculation would produce a result too large to represent; e.g. exp(1000.0).

UNDERFLOW A calculation would produce a result too small to represent; e.g. exp(-1000.0).

TLOSS Total loss of precision. The result would have no significant digits; e.g. sin(10e70).

PLOSS Partial loss of precision.

## Returns

The library definition for matherr returns 0 in all cases. You can change the calling function's result from a customized matherr by modifying e->retval, which propagates back to the caller.

If matherr returns 0 (indicating that it was not able to resolve the error) the caller sets errno to an appropriate value, and prints an error message.

## modf, modff : split fractional and integer parts

### Synopsis

```
#include <math.h>
double modf(double val, double *ipart);
float modff(float val, float *ipart);
```

### Description

modf splits the double val apart into an integer part and a fractional part, returning the fractional part and storing the integer part in \*ipart. No rounding whatsoever is done; the sum of the integer and fractional parts is guaranteed to be exactly equal to val. That is, if `realpart = modf(val, &intpart)`; then `realpart+intpart` is the same as val. modff is identical, save that it takes and returns float rather than double values.

### Returns

The fractional part is returned. Each result has the same sign as the supplied argument val.

## nan, nanf : representation of infinity

### Synopsis

```
#include <math.h>
double nan(void);
float nanf(void);
```

### Description

nan and nanf return an IEEE NaN (Not a Number) in double and single precision arithmetic respectively.

## nextafter, nextafterf : get next number

### Synopsis

```
#include <math.h>
double nextafter(double val, double dir);
float nextafterf(float val, float dir);
```

### Description

nextafter returns the double precision floating point number closest to val in the direction toward dir. nextafterf performs the same operation in single precision. For example, `nextafter(0.0,1.0)` returns the smallest positive number which is representable in double precision.

### Returns

Returns the next closest number to val in the direction toward dir.

## pow, powf : x to the power y

### Synopsis

```
#include <math.h>
double pow(double x, double y);
float powf(float x, float y);
```

### Description

pow and powf calculate x raised to the power y.

**Returns**

On success, `pow` and `powf` return the value calculated.

When the argument values would produce overflow, `pow` returns `HUGE_VAL` and set `errno` to `ERANGE`. If the argument `x` passed to `pow` or `powf` is a negative noninteger, and `y` is also not an integer, then `errno` is set to `EDOM`. If `x` and `y` are both 0, then `pow` and `powf` return 1. You can modify error handling for these functions using `matherr`.

**rint, rintf, remainder, remainderf : round and remainder****Synopsis**

```
#include <math.h>
double rint(double x);
float rintf(float x);
double remainder(double x, double y);
float remainderf(float x, float y);
```

**Description**

`rint` and `rintf` returns their argument rounded to the nearest integer. `remainder` and `remainderf` find the remainder of `x/y`; this value is in the range  $-y/2 .. +y/2$ .

**Returns**

`rint` and `remainder` return the integer result as a double.

**scalbn, scalbnf : scale by integer****Synopsis**

```
#include <math.h>
double scalbn(double x, int y);
float scalbnf(float x, int y);
```

**Description**

`scalbn` and `scalbnf` scale `x` by `n`, returning `x` times 2 to the power `n`. The result is computed by manipulating the exponent, rather than by actually performing an exponentiation or multiplication.

**Returns**

`x` times 2 to the power `n`.

**sqrt, sqrtf : positive square root****Synopsis**

```
#include <math.h>
double sqrt(double x);
float sqrtf(float x);
```

**Description**

`sqrt` computes the positive square root of the argument. You can modify error handling for this function with `matherr`.

**Returns**

On success, the square root is returned. If `x` is real and positive, then the result is positive. If `x` is real and negative, the global value `errno` is set to `EDOM` (domain error).



**sin, sinf, cos, cosf : sine or cosine****Synopsis**

```
#include <math.h>
double sin(double x);
float  sinf(float x);
double cos(double x);
float  cosf(float x);
```

**Description**

sin and cos compute (respectively) the sine and cosine of the argument x. Angles are specified in radians. sinf and cosf are identical, save that they take and return float values.

**Returns**

The sine or cosine of x is returned.

**sinh, sinh : hyperbolic sine****Synopsis**

```
#include <math.h>
double sinh(double x);
float  sinh(float x);
```

**Description**

sinh computes the hyperbolic sine of the argument x. Angles are specified in radians. sinh(x) is defined as sinhf is identical, save that it takes and returns float values.

**Returns**

The hyperbolic sine of x is returned.

When the correct result is too large to be representable (an overflow), sinh returns HUGE\_VAL with the appropriate sign, and sets the global value errno to ERANGE. You can modify error handling for these functions with matherr.

**tan, tanf : tangent****Synopsis**

```
#include <math.h>
double tan(double x);
float  tanf(float x);
```

**Description**

tan computes the tangent of the argument x. Angles are specified in radians. tanf is identical, save that it takes and returns float values.

**Returns**

The tangent of x is returned.

**tanh, tanhf : hyperbolic tangent****Synopsis**

```
#include <math.h>
double tanh(double x);
float  tanhf(float x);
```

**Description**

$\tanh$  computes the hyperbolic tangent of the argument  $x$ . Angles are specified in radians.  $\tanh(x)$  is defined as  $\sinh(x) / \cosh(x)$

$\tanhf$  is identical, save that it takes and returns float values.

**Returns**

The hyperbolic tangent of  $x$  is returned.

## Miscellaneous Macros and Functions

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This chapter describes miscellaneous routines not covered elsewhere.

### **unctrl : translate characters to upper case**

**Synopsis**

```
#include <unctrl.h>
char *unctrl(int c);
int unctrlllen(int c);
```

**Description**

`unctrl` is a macro which returns the printable representation of `c` as a string. `unctrlllen` is a macro which returns the length of the printable representation of `c`.

**Returns**

`unctrl` returns a string of the printable representation of `c`. `unctrlllen` returns the length of the string which is the printable representation of `c`.

### **Variable Argument Lists**

The `printf` family of functions is defined to accept a variable number of arguments, rather than a fixed argument list. You can define your own functions with a variable argument list, by using macro definitions from either ``stdarg.h'` (for compatibility with ANSI C) or from ``varargs.h'` (for compatibility with a popular convention prior to ANSI C).

**ANSI-standard macros, `stdarg.h'**

In ANSI C, a function has a variable number of arguments when its parameter list ends in an ellipsis (...). The parameter list must also include at least one explicitly named argument; that argument is used to initialize the variable list data structure.

ANSI C defines three macros (`va_start`, `va_arg`, and `va_end`) to operate on variable argument lists. ``stdarg.h'` also defines a special type to represent variable argument lists: this type is called `va_list`.

**Initialize variable argument list****Synopsis**

```
#include <stdarg.h>
void va_start(va_list ap, rightmost);
```

**Description**

Use `va_start` to initialize the variable argument list `ap`, so that `va_arg` can extract values from it. `rightmost` is the name of the last explicit argument in the parameter list (the argument immediately preceding the ellipsis ``...'` that flags variable arguments in an ANSI C function header). You can only use `va_start` in a function declared using this ellipsis notation (not, for example, in one of its subfunctions).

**Returns**

`va_start` does not return a result.

**Extract a value from argument list****Synopsis**

```
#include <stdarg.h>
type va_arg(va_list ap, type);
```

**Description**

`va_arg` returns the next unprocessed value from a variable argument list `ap` (which you must previously create with `va_start`). Specify the type for the value as the second parameter to the macro, `type`.

You may pass a `va_list` object `ap` to a subfunction, and use `va_arg` from the subfunction rather than from the function actually declared with an ellipsis in the header; however, in that case you may only use `va_arg` from the subfunction. ANSI C does not permit extracting successive values from a single variable-argument list from different levels of the calling stack.

There is no mechanism for testing whether there is actually a next argument available; you might instead pass an argument count (or some other data that implies an argument count) as one of the fixed arguments in your function call.

**Returns**

`va_arg` returns the next argument, an object of type `type`.

**Abandon a variable argument list****Synopsis**

```
#include <stdarg.h>
void va_end(va_list ap);
```

**Description**

Use `va_end` to declare that your program will not use the variable argument list `ap` any further.

**Returns**

`va_end` does not return a result.

**Traditional macros, ``varargs.h'`**

If your C compiler predates ANSI C, you may still be able to use variable argument lists using the macros from the ``varargs.h'` header file. These macros resemble their ANSI counterparts, but have important differences in usage. In particular, since traditional C has no declaration mechanism for variable argument lists, two additional macros are provided simply for the purpose of defining functions with variable argument lists.

As with ``stdarg.h'`, the type `va_list` is used to hold a data structure representing a variable argument list.

**Declare variable arguments****Synopsis**

```
#include <varargs.h>
function(va_alist) va_dcl
```

**Description**

To use the ``varargs.h'` version of variable argument lists, you must declare your function with a call to the macro `va_alist` as its argument list, and use `va_dcl` as the declaration. Do not use a semicolon after `va_dcl`.

**Returns**

These macros cannot be used in a context where a return is syntactically possible.

**Initialize variable argument list****Synopsis**

```
#include <varargs.h>
va_list ap; va_start(ap);
```

**Description**

With the ``varargs.h'` macros, use `va_start` to initialize a data structure `ap` to permit manipulating a variable argument list. `ap` must have the type `va_alist`.

**Returns**

`va_start` does not return a result.

**Extract a value from argument list****Synopsis**

```
#include <varargs.h>
type va_arg(va_list ap, type);
```

**Description**

`va_arg` returns the next unprocessed value from a variable argument list `ap` (which you must previously create with `va_start`). Specify the type for the value as the second parameter to the macro, `type`.

**Returns**

`va_arg` returns the next argument, an object of type `type`.

**Abandon a variable argument list****Synopsis**

```
#include <varargs.h>
va_end(va_list ap);
```

**Description**

Use `va_end` to declare that your program will not use the variable argument list `ap` any further.

**Returns**

`va_end` does not return a result.

## Copyright

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C Library functions help is taken from GCC help content and it is from

The Cygnus C Support Library

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## Hot Keys

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Hot keys are available for most frequently used operations. Following are the hot keys implemented.

Hot key	Operation
CTRL + ALT + C	Clear Message Window
CTRL + ALT + I	Toggle between Activate/Deactivate message interpretation mode.
CTRL + ALT + O	Toggle between Append/Overwrite display mode.
CTRL + ALT + R	Reset Message Window column header positions to default.
CTRL + ALT + H	Toggle between Hex/Dec display format.
CTRL + ALT + S	Toggle between Start/Stop sending messages cyclically.
CTRL + ALT + L	Toggle between Enable/Disable logging of messages.

## Frequently Asked Questions

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**Question: I can log CAN Bus messages, and it looks like I can transmit them, but the Tester does not see the messages I transmit.**

Answer: Follow the steps below

1. Disconnect the BUSMASTER application. Then click "option -> controller mode" if active mode is not selected please select it.
2. If baud rate is  $\geq 500$  Kbps use 120 ohm terminating resistors between CANH and CANL at both end of cable between USB hardware and ECU (Tester).

**Question: BUSMASTER is able to receive messages but when message is transmitted application gives error?**

Answer: Follow the steps below

1. Measure the voltage between Pin 2 and 3 and Pin 7 and 3 of the SUB-D connector Pins of the PCAN-USB when system is idle.
2. If voltage is not around 2.5v then CAN Transceiver (Philips PCA82C251T) has got damaged.

**Question: BUSMASTER throws up an error saying BUSMASTER\_Interface.h missing while compiling. Why?**

Answer:

Rebuilding the solution will solve the problem. When rebuild is selected, the visual studio will compile BUSMASTER.idl file and will generate BUSMASTER\_Interface.h and BUSMASTER\_Interface.c files.

**Question: Why Toolbar replay buttons are not active after changing the active window?** Answer: This is the intended behavior of the toolbar replay button.

This is because of the following functionality :

1. Add more than one log file for replay in Replay Configuration window
2. Select interactive replay
3. Connect to the network. Multiple replay windows will be displayed corresponding to the number of log files added for replay. If 2 log files are added then 2 interactive replay windows will be displayed on connect.
4. The replay toolbar functionality works based on the active interactive window. So making it general will not work.

Hence the tool bar is disabled.

**Question: After the Message Replay Window is closed, there is no way to have it back.** Answer:

In interactive replay method, the functionality of close button is basically stopping the replay. Hence the window will be closed and immediately the replay will be stopped. To get back the replay window, just disconnect and connect to the network again. No restart of application is required. Make sure, Interactive Replay Window option is selected in the Replay configuration window.

**Question: The files union.h are created each time BUSMASTER starts. Due to this, any previous manual changes in these files are lost.**

Answer:

Unions.h file generated is intended to use with BUSMASTER only. So any manual modification will not be retained. If any additional changes or definitions are required then the same can be achieved by creating a new header file and referring it in the cpp file or modifying in the database file itself.

**Question: In Message window, close window does not work**

Answer:

This is the intended behavior. Message window will always be kept open. If the window has to be hidden then uncheck the View --> Message Window menu option

**Question:Error launching BUSMASTER. When BUSMASTER is installed and launched, error message "The application cannot be started because the application config is not correct" is displayed**

Answer:

Install .Net framework 3.5 or above and try again. BUSMASTER has dependency with .Net Framework.

## Unused chapters

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### Message Logging

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User can configure the name of the log file to which the messages will be logged by following the steps given below

- Select **Configure > Log**
- Select log file name. You can also navigate to any folder to select the log file. If an existing file is selected it will be overwritten if Over Write Mode. Otherwise it will append the same log file for each new logging session. If a new file name is entered, you will be prompted to confirm the new file creation.
- Specify a message ID or select a message name, on reception of which, logging gets triggered

### Connection Details

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The connection to the CAN bus is via the 9 pole SUB-D-plug according to CiA Recommendation DS 102-1. Minimal configurations are the PINs 2 and 7 (CAN-L, CAN-H)

Pin Connection

1. User-defined +12V / +5V / not connected.
2. CAN-L
3. User-defined CAN-GND / not connected.
4. Not Connected.
5. Not Connected.
6. User-defined CAN-GND / not connected.
7. CAN-H
8. Not Connected.
9. User-defined +12V / +5V / not connected.

