

Help

**© Copyright 2011 Robert Bosch Engineering
and Business Solutions Limited**

Contents

Introduction.....	7
What is new?.....	9
General.....	12
Configuration settings in a file.....	12
Trace Window.....	12
Status Bar.....	13
Format Converters.....	13
CAN.....	17
CAN Simulation in BUSMASTER.....	17
CAN Controller Configuration.....	17
Transmit Messages.....	19
Message Window.....	20
Message Window Configuration.....	24
Network Statistics.....	29
Logging.....	30
Replay.....	32
Filters.....	34
Signal Watch.....	35
Signal Generation.....	37
Signal Graph.....	39
CAN Node Simulation.....	47
What is new?.....	47
Node Simulation Configuration.....	48
Function Editor.....	50
API Reference.....	55
Examples.....	61
Test Automation.....	63
Test Setup File.....	63
Test Setup Editor.....	66
Test Suite Executor.....	68
Database Editor.....	69
COM Interface.....	73
BUSMASTER COM interface.....	73
COM Interface API Listing.....	75
J1939.....	83
J1939.....	83
J1939 Node Simulation.....	91
What is new?.....	91
Node Simulation Configuration.....	92
J1939 API Reference.....	95
Examples.....	102
Diagnostics.....	105
Diagnostics Settings.....	105
Diagnostics Main Window.....	106
LIN.....	109
LIN Simulation in BUSMASTER.....	109
LIN Cluster Configuration.....	109
LIN Schedule Table Configuration.....	110
LIN Controller Configuration.....	111
LIN Transmit Window.....	112
Connect and Disconnect.....	113
LIN Message Window.....	113
Message Window Configuration.....	115
Network Statistics.....	120

Signal Watch.....	121
Logging.....	123
Filters.....	126
LIN Node Simulation.....	127
Node Simulation Configuration.....	127
Function Editor.....	130
LIN API Reference.....	135
LIN Node Simulation Examples.....	139
LIN Database Editor.....	140
Introduction.....	140
Overview.....	141
Getting Started.....	144
LDF Elements.....	144
C Library Functions.....	166
Standard Library Functions.....	166
abs : integer absolute value (magnitude).....	166
atexit : request execution of functions at program exit.....	166
atof, atoff : string to double or float.....	166
atoi, atol : string to integer.....	167
bsearch : binary search.....	167
calloc : allocate space for arrays.....	168
div : divide two integers.....	168
ecvt,ecvtf,fcvt,fcvtf : double or float to string.....	168
gvcvt, gcvtf : format double or float as string.....	169
ecvtbuf, fcvtbuf : double or float to string.....	169
exit : end program execution.....	169
getenv : look up environment variable.....	170
labs : long integer absolute value.....	170
ldiv : divide two long integers.....	170
malloc, realloc, free : manage memory.....	171
mbtowc : minimal multibyte to wide char converter.....	171
qsort : sort an array.....	172
rand, srand : pseudo-random numbers.....	172
strtod, strtodf : string to double or float.....	172
strtol : string to long.....	173
strtoul : string to unsigned long.....	174
system : execute command string.....	174
wctomb : minimal wide char to multibyte converter.....	175
Character Type Macros and Functions.....	175
isalnum : alphanumeric character predicate.....	175
isalpha : alphabetic character predicate.....	175
isascii : ASCII character predicate.....	176
iscntrl : control character predicate.....	176
isdigit : decimal digit predicate.....	176
islower : lower-case character predicate.....	176
isprint, isgraph : printable character predicate.....	177
ispunct : punctuation character predicate.....	177
isspace : whitespace character predicate.....	177
isupper : uppercase character predicate.....	178
isxdigit : hexadecimal digit predicate.....	178
toascii : force integers to ASCII range.....	178
tolower : translate characters to lower case.....	179
toupper : translate characters to upper case.....	179
I/O Functions.....	179
clearerr : clear file or stream error indicator.....	180
fclose : close a file.....	180
fdopen : turn open file into a stream.....	180
feof : test for end of file.....	180
ferror : test whether read/write error has occurred.....	181
fflush : flush buffered file output.....	181

fgetc : get a character from a file or stream.....	181
fgetpos : record position in a stream or file.....	182
fgets : get character string from a file or stream.....	182
fprintf : format output to file (integer only).....	182
fopen : open a file.....	182
fputc : write a character on a stream or file.....	183
fputs : write a character string in a file or stream.....	184
fread : read array elements from a file.....	184
freopen : open a file using an existing file descriptor.....	184
fseek : set file position.....	184
fsetpos : restore position of a stream or file.....	185
ftell : return position in a stream or file.....	185
fwrite : write array elements.....	186
getc : read a character (macro).....	186
getchar : read a character (macro).....	186
gets : get character string (obsolete, use fgets instead).....	187
fprintf : write formatted output (integer only).....	187
mktemp, mkstemp : generate unused file name.....	187
perror : print an error message on standard error.....	188
printf, fprintf, sprintf : format output.....	188
putc : write a character (macro).....	190
putchar : write a character (macro).....	190
puts : write a character string.....	190
remove : delete a file's name.....	191
rename : rename a file.....	191
rewind : reinitialize a file or stream.....	191
scanf, fscanf, sscanf : scan and format input.....	192
setbuf : specify full buffering for a file or stream.....	194
setvbuf : specify file or stream buffering.....	194
sprintf : write formatted output (integer only).....	195
tmpfile : create a temporary file.....	195
tmpnam, tempnam : name for a temporary file.....	195
vprintf, vfprintf, vsprintf : format argument list.....	196
String and Memory Functions.....	196
bcmpl : compare two memory areas.....	196
bcopy : copy memory regions.....	197
bzero : initialize memory to zero.....	197
index : search for character in string.....	197
memchr : find character in memory.....	197
memcmp : compare two memory areas.....	198
memcpy : copy memory regions.....	198
memmove : move possibly overlapping memory.....	198
memset : set an area of memory.....	198
rindex : reverse search for character in string.....	199
strcat : concatenate strings.....	199
strchr : search for character in string.....	199
strcmp : character string compare.....	199
strcoll : locale specific character string compare.....	200
strcpy : copy string.....	200
strcspn : count chars not in string.....	200
strerror : convert error number to string.....	200
strlen : character string length.....	202
strlwr : force string to lower case.....	202
strncat : concatenate strings.....	203
strncmp : character string compare.....	203
strncpy : counted copy string.....	203
strpbrk : find chars in string.....	203
strrchr : reverse search for character in string.....	204
strspn : find initial match.....	204
strstr : find string segment.....	204

strtok : get next token from a string.....	205
strupr : force string to uppercase.....	205
strxfrm : transform string.....	205
Time Functions.....	206
asctime : format time as string.....	206
clock : cumulative processor time.....	206
ctime : convert time to local and format as string.....	207
difftime : subtract two times.....	207
gmtime : convert time to UTC traditional form.....	207
localtime : convert time to local representation.....	208
mktime : convert time to arithmetic representation.....	208
strftime : flexible calendar time formatter.....	208
time : get current calendar time (as single number).....	209
C Math Library Functions.....	209
acos, acosf : arc cosine.....	209
acosh, acoshf : inverse hyperbolic cosine.....	210
asin, asinf : arc sine.....	210
asinh, asinhf : inverse hyperbolic sine.....	210
atan, atanf : arc tangent.....	211
atan2, atan2f : arc tangent of y/x.....	211
atanh, atanhf : inverse hyperbolic tangent.....	211
jN,jNf,yN,yNf : Bessel functions.....	211
cbrt, cbtrf : cube root.....	212
copysign, copysignf : sign of y, magnitude of x.....	212
cosh, coshf : hyperbolic cosine.....	212
erf, erff, erfc, erfcf : error function.....	213
exp, expf : exponential.....	213
expm1, expm1f : exponential minus 1.....	213
fabs, fabsf : absolute value (magnitude).....	214
floor, floorf, ceil, ceilf : floor and ceiling.....	214
fmod, fmodf : floating-point remainder (modulo).....	214
frexp, frexpf : split floating-point number.....	214
gamma, gammaf, lgamma, lgammaf, gamma_r, gammaf_r, lgamma_r, lgammaf_r.....	215
hypot, hypotf : distance from origin.....	215
ilogb, ilogbf : get exponent of floating point number.....	216
infinity, infinityf : representation of infinity.....	216
isnan,isnanf,isinf,isinff,finite,finitef : test for exceptional numbers.....	216
ldexp, ldexpf : load exponent.....	217
log, logf : natural logarithms.....	217
log10, log10f : base 10 logarithms.....	217
log1p, log1pf : log of 1 + x.....	217
matherr : modifiable math error handler.....	218
modf, modff : split fractional and integer parts.....	219
nan, nanf : representation of infinity.....	219
nextafter, nextafterf : get next number.....	219
pow, powf : x to the power y.....	219
rint, rintf, remainder, remainderf : round and remainder.....	220
scalbn, scalbnf : scale by integer.....	220
sqrt, sqrtf : positive square root.....	220
sin, sinf, cos, cosf : sine or cosine.....	221
sinh, sinhf : hyperbolic sine.....	221
tan, tanf : tangent.....	221
tanh, tanhf : hyperbolic tangent.....	221
Miscellaneous Macros and Functions.....	222
unctrl : translate characters to upper case.....	222
Variable Argument Lists.....	222
Copyright.....	224
Hot Keys.....	225
Frequently Asked Questions.....	226
Additional Installation.....	229

MinGW Installation using TDM-GCC Installer.....	229
---	-----

Introduction

BUSMASTER Overview

BUSMASTER is a user friendly and cost effective testing and development tool for CAN bus systems that runs on Windows 7 and Windows 10. 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 than 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?

3.2.2

Following features are added:

- ETAS BOA v2.14.0 support
- Removal of CAN FD support from CAN ETAS BOA and Node Simulation.
- Bug Fixes

3.2.1

Following features are added:

- Bug Fixes

3.2.0

Following features are added:

- Windows 10 Support
- CAN ETAS ES582.1 hardware support
- Bug Fixes

3.1.0

Following features are added:

- Ribbon bar support
- Channel Selection dialog enhancements
- Bug Fixes

3.0.0

Following features are added:

- CAN Transmit Windows
 - 1. UI Redesign
 - 2. Message wise raster support
- Node Simulation
 - 1. Big Endian support
 - 2. Message and Signal access is simplified
- Signal watch configuration window is updated with channel wise signal details
- Bug Fixes

2.6.4

Following features are added:

- Advanced log file settings
- Replay optimization for CAN
- Node Simulation UI Improvement
- Toolbar cleanup

2.6.3

Following features are added:

- Support for LIN Kvaser
- Bug Fixes

2.6.2

Following features are added:

- Bug Fixes

2.6.1

Following features are added:

- Support for FlexRay GIGATRONIK flex-i Controller.
- Bug Fixes

2.6.0

Following features are added:

- LIN Database editor (LDF)
- Introduction of CMake for solution/project file generation

2.5.0

Following features are added:

- BLF to LOG Conversion
- Bug Fixes

2.4.0

Following features are added:

- LIN PEAK device support
- LIN Master mode
- LIN Status message reporting
- ISO-TP over CAN support
- UDS support
- Bug Fixes

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

General

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 **Application Button --> New** 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 **Application Button --> 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 (**Application Button > 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 change 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 **Application Button--> 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 (**Application Button > Recent Configuration**).

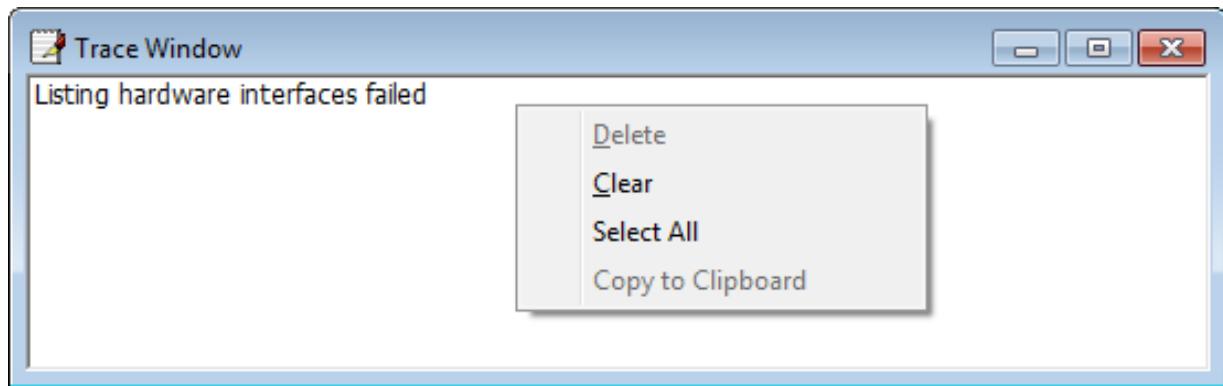
Saving a configuration file with new name

1. Select **Application Button --> 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.

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 **View --> Trace Window**.

Status Bar

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.

Format Converters

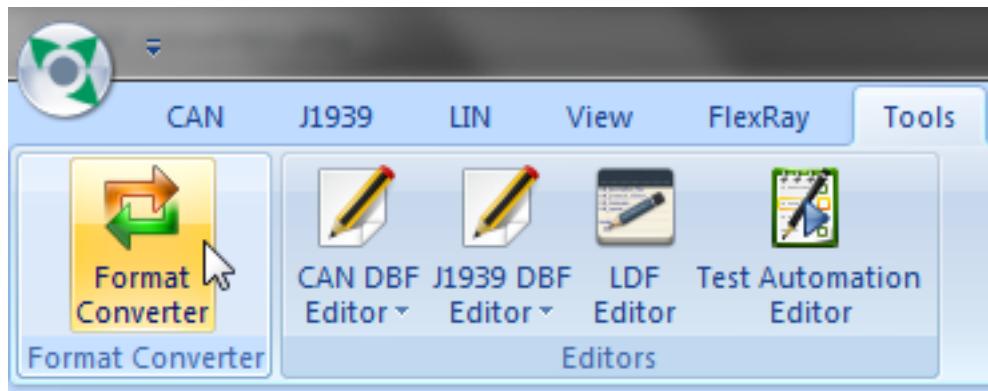
Format Converters:

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
- BLF To LOG Converter: Converts BLF (*.blf) file into BUSMASTER log file (*.log)

Usage:

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



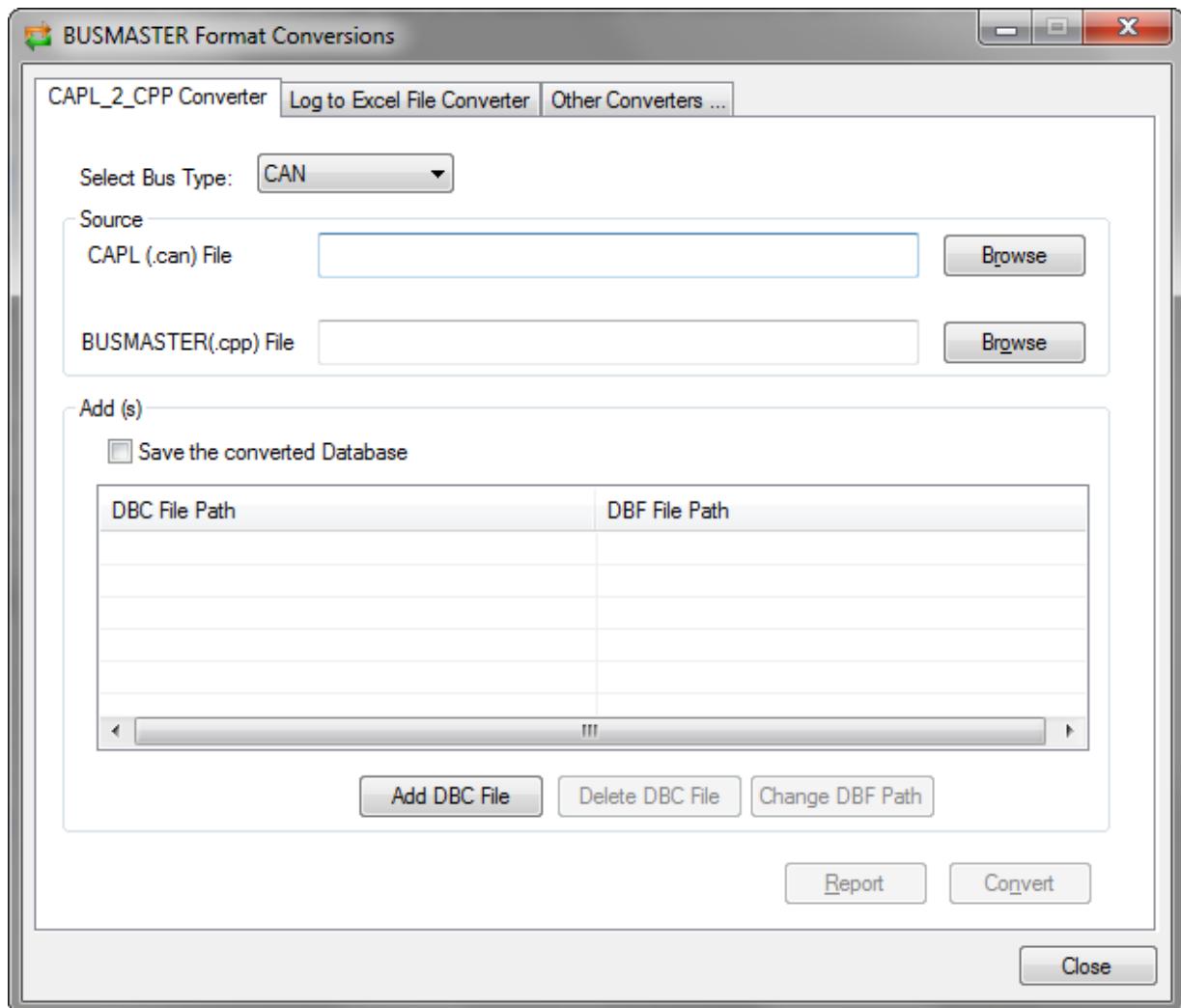
- A window is displayed with 3 tabs in it which caters to various conversions.

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 .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

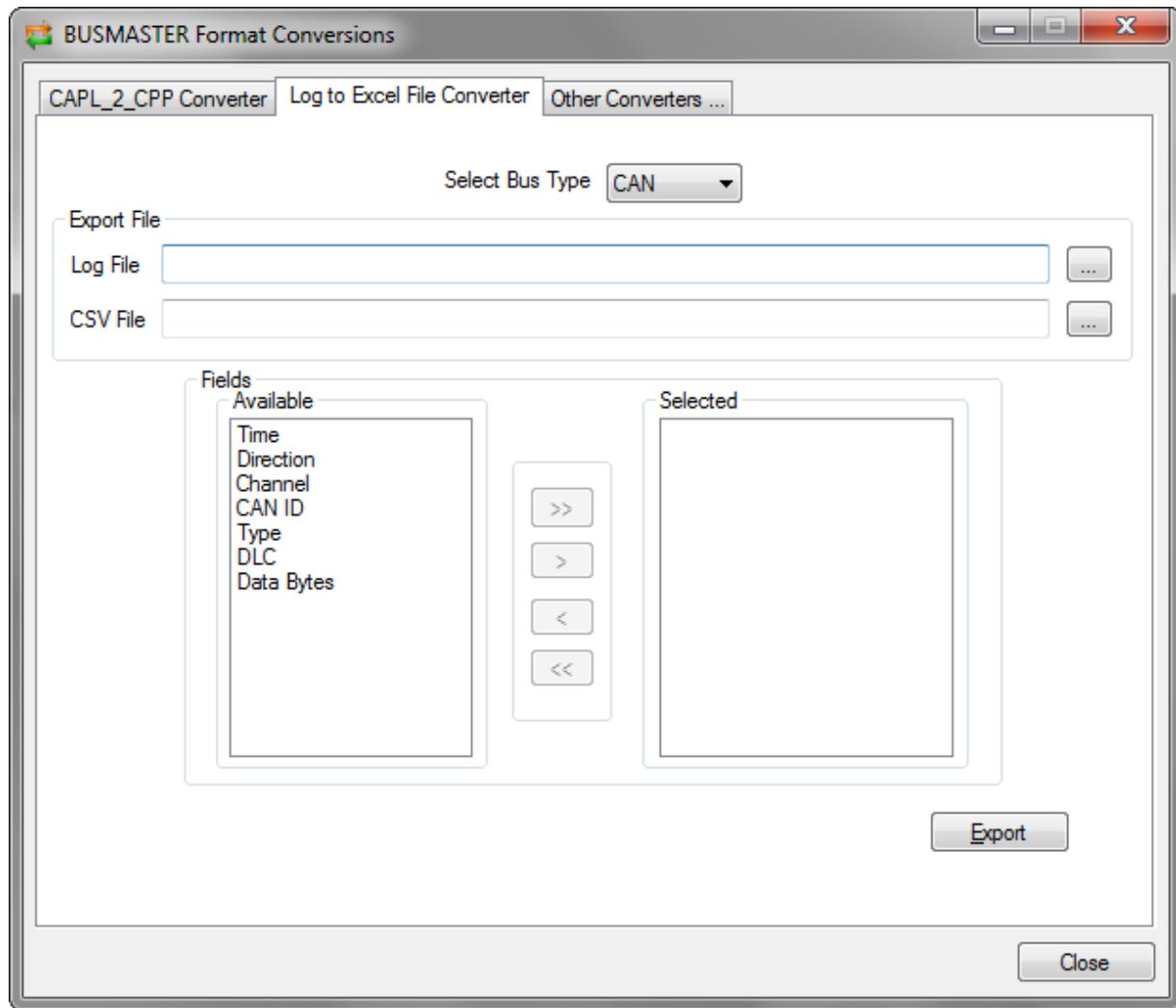


Log To Excel Converter

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

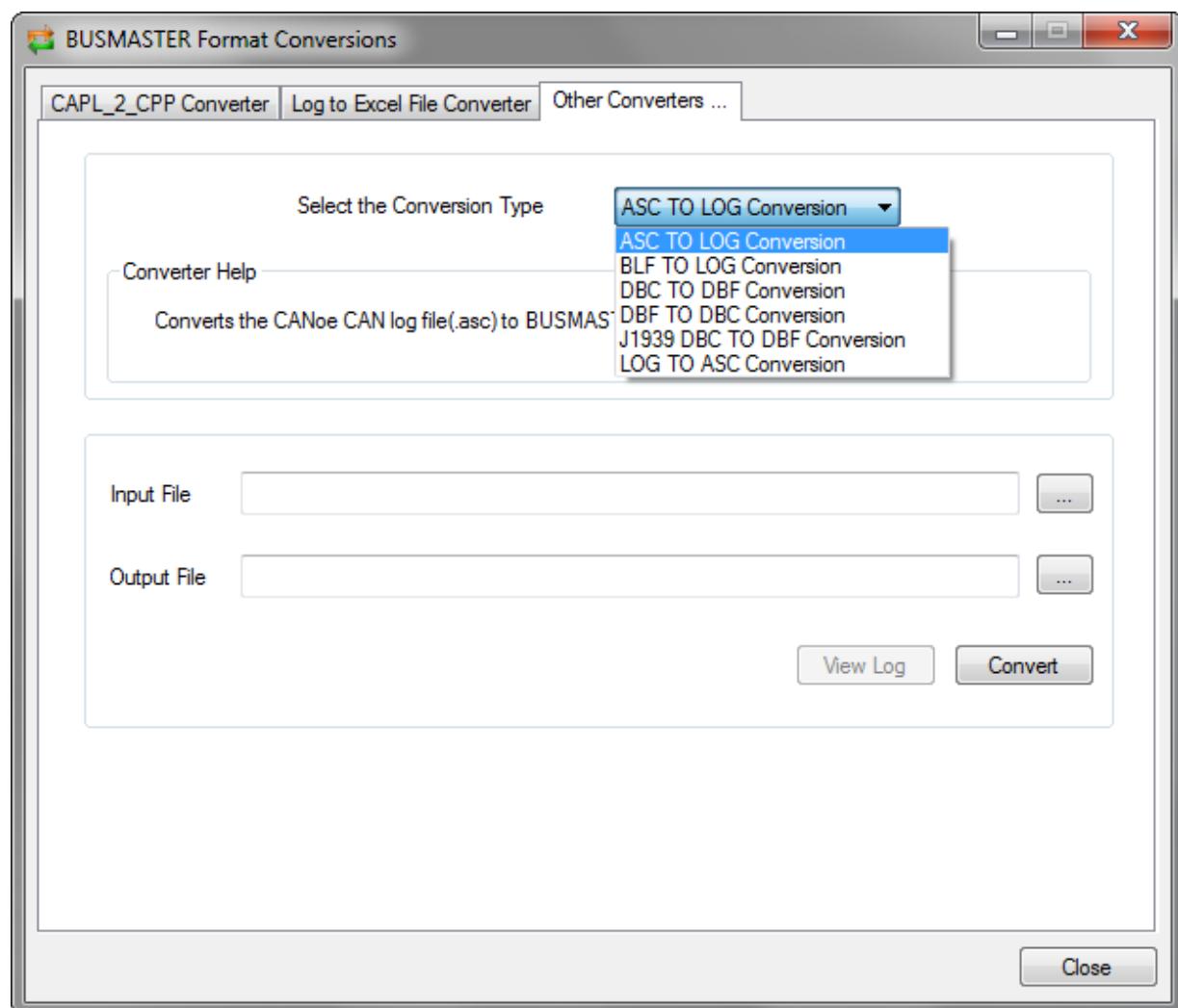


Other Converters

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



CAN

Introduction

CAN Simulation in BUSMASTER

Introduction:

BUSMASTER can be used as master to transmit master requests and as slave to respond to master requests. User can monitor/analyze the LIN messages using BUSMASTER. The following steps are required to Configure the BUSMASTER for transmission of frame headers or transmission/reception of LIN messages.

1. Controller (Driver) Selection:

BUSMASTER can be connected to Physical CAN Network using CAN Controller. Refer [CAN Controller Configuration](#) on page 17 section for more Information.

2. Configuring CAN BUS Parameters:

Once the required driver is selected CAN BUS parameters (like baud rate, BTR0, BTR1, etc..) need to be configured. Refer CAN Channel Configuration section for more information.

3. Database Configuration:

This is an optional step and is required for Message&Signal interpretation of CAN data in BUSMASTER. Refer CAN Database Configuration section for more Information.

4. Connect to Network:

Once the Configuration done, BUSMASTER can be connected to CAN Network using **CAN->Connect**. menu.

5. Monitoring Messages:

BUSMASTER **CAN Message Window** can be used to monitor the CAN messages of CAN Network. Refer [CAN Message Window](#) on page 20 section for more information.

CAN Controller Configuration

Introduction:

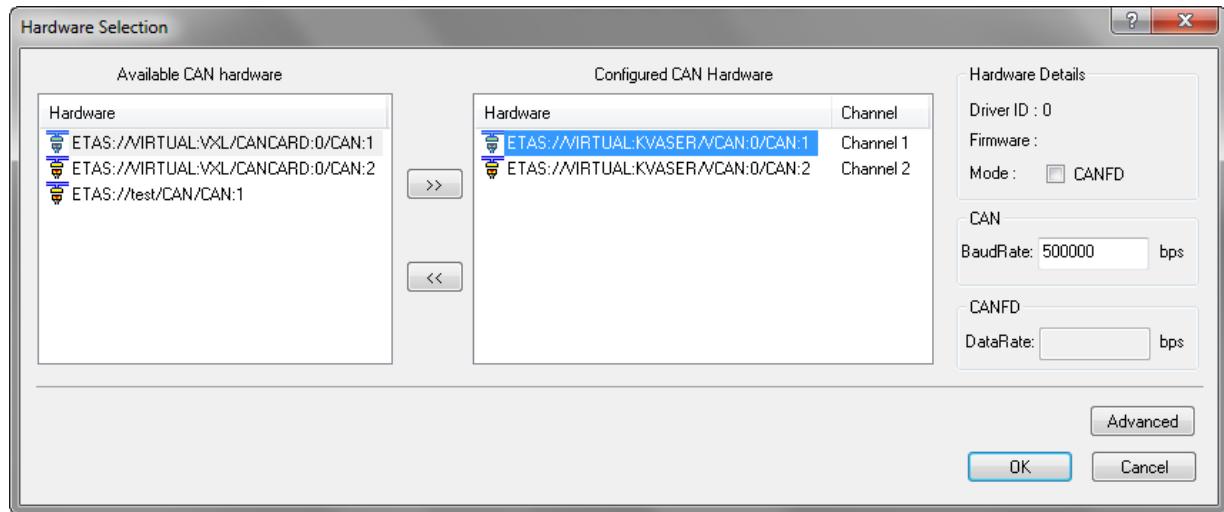
BUSMASTER Can be connected to CAN physical channel using any one of the following CAN Controllers.

- 1. ETAS BOA**
- 2. ETAS ES581.3**
- 3. ETAS ES581.4**
- 4. ETAS ISOLAR-EVE**
- 5. i-VIEW**
- 6. InterprediCS neoVI**
- 7. IXXAT VCI**
- 8. Kvaser CAN**
- 9. MHS Tiny-CAN**
- 10. NSI CAN-API**
- 11. PEAK USB**
- 12. Vector XL**
- 13. VScom CAN-API**

Controller Selection:

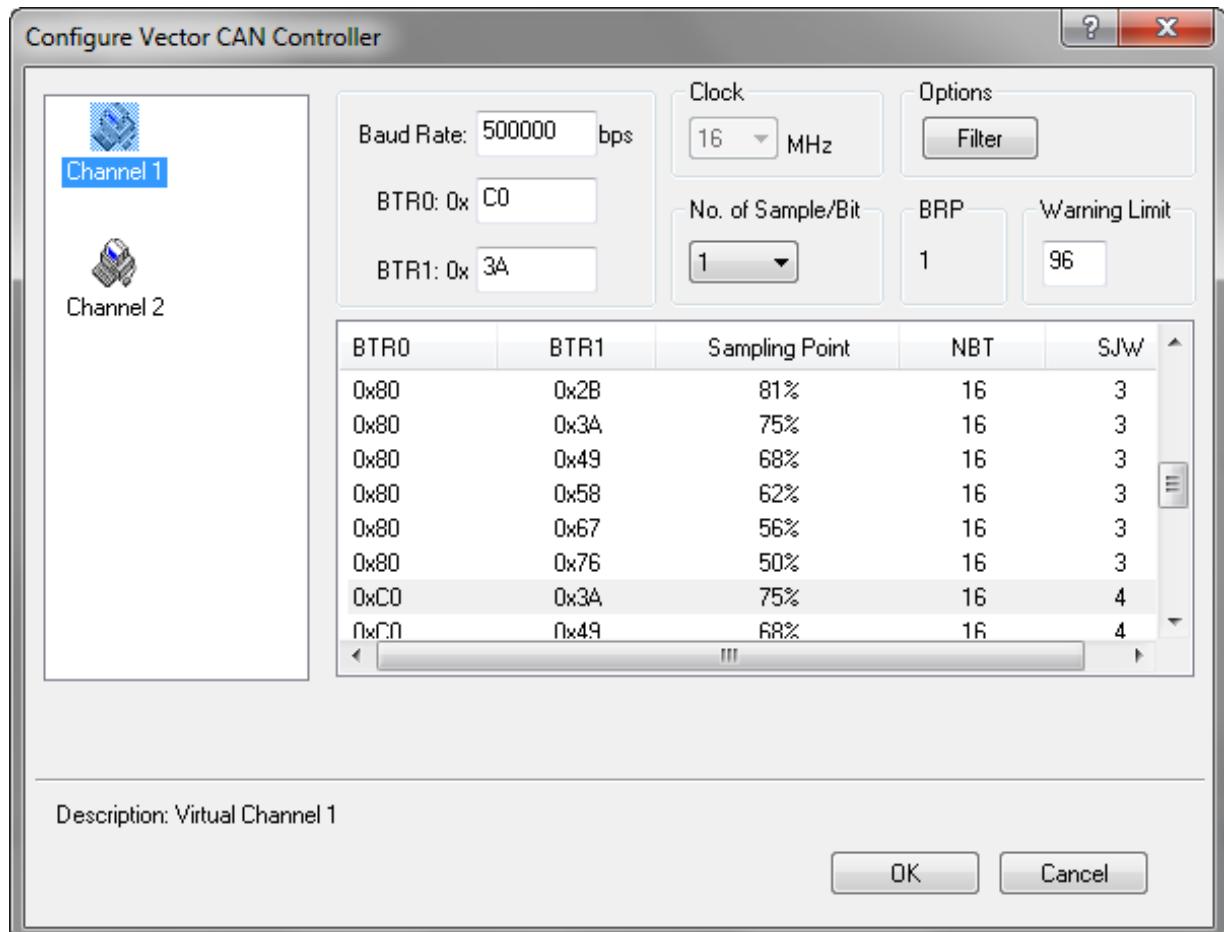
To select controller use CAN->Driver Selection->*{Driver}* For example to select ETAS Devices use **CAN->Driver Selection->ETAS BOA**.

If there are multiple devices connected BUSMASTER will display a Hardware selection dialog as shown below to map the devices and the channels.



CAN Parameter Configuration:

BUSMASTER Will select the open the CAN Channel with 500kbps by default. These default parameters can be changed using CAN channel configuration window. Select **CAN->Channel Configuration** menu. This will invoke the channel configuration dialog depending on the controller selected. The following figure shows the channel configuration window for ETAS BOA Devices.

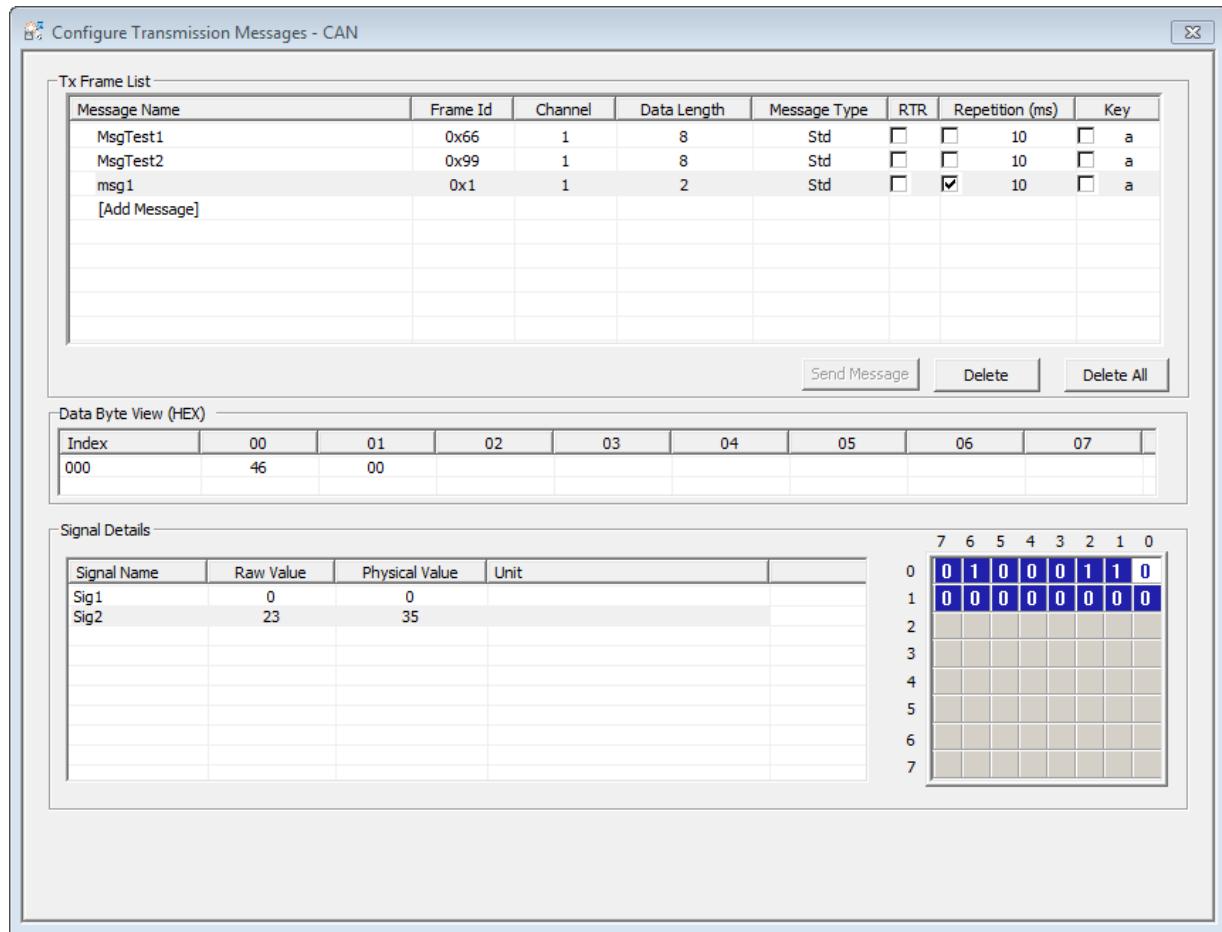


Once the Controller is configured BUSMASTER Can be connected to CAN network using **CAN->Connect** Menu.

Transmit Messages

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

Getting Started



- Configuring Messages:**

Once DBF Files are imported the Messages(DB Messages) in DBF files will be populated in **Tx Frame list** column. Double Click on **[Add Message]** to select data base message. It is also possible to add Non-db Messages by typing Message id.

- If the Message ID/Name from a database is selected 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 check box
- Signal Matrix will show the bit pattern of the data bytes.

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 will start automatically once the BUSMASTER is connected to BUS and stops on disconnect.

Transmission on Event:

The Messages can be sent to the network on pressing key. Each message in Tx Frame List can be assigned an alpha-numeric key.

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

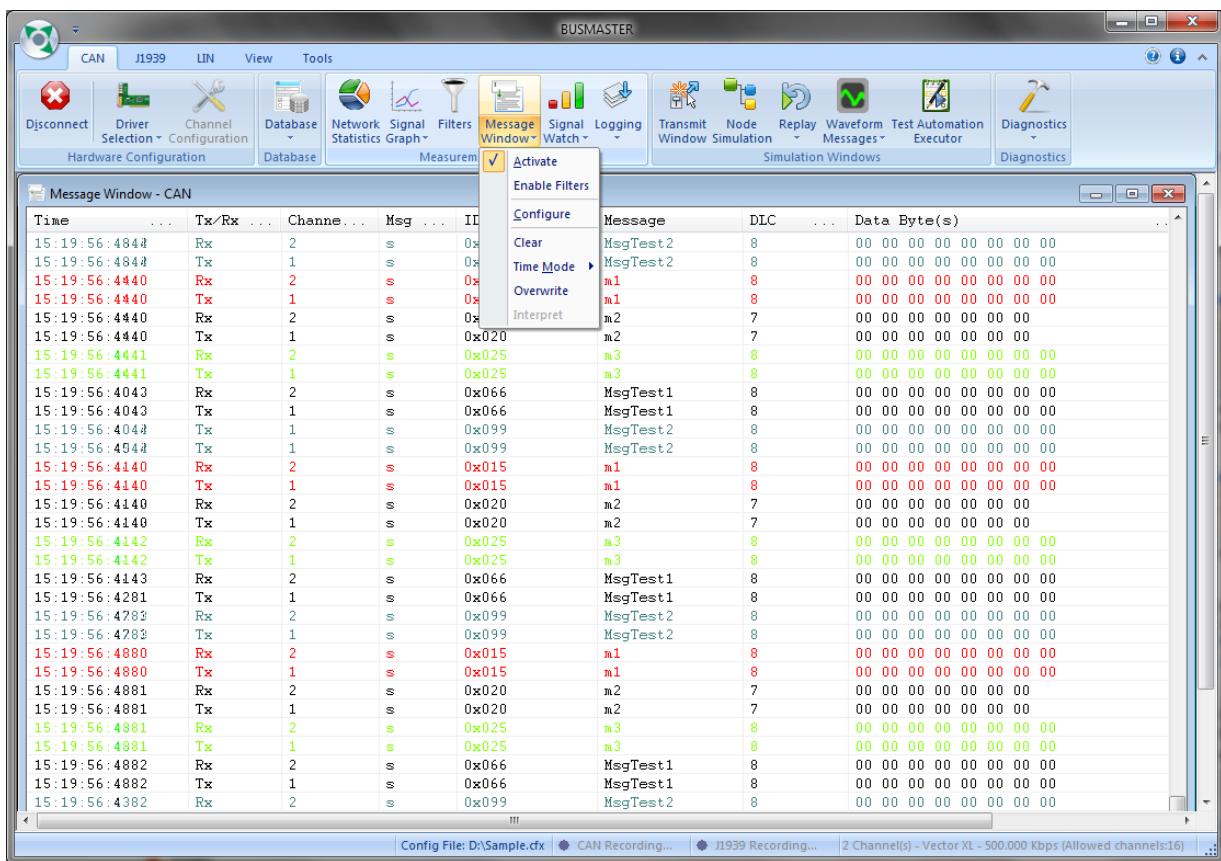
Each message is displayed in a separate line, which consists of the following five fields listed below respectively

- 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

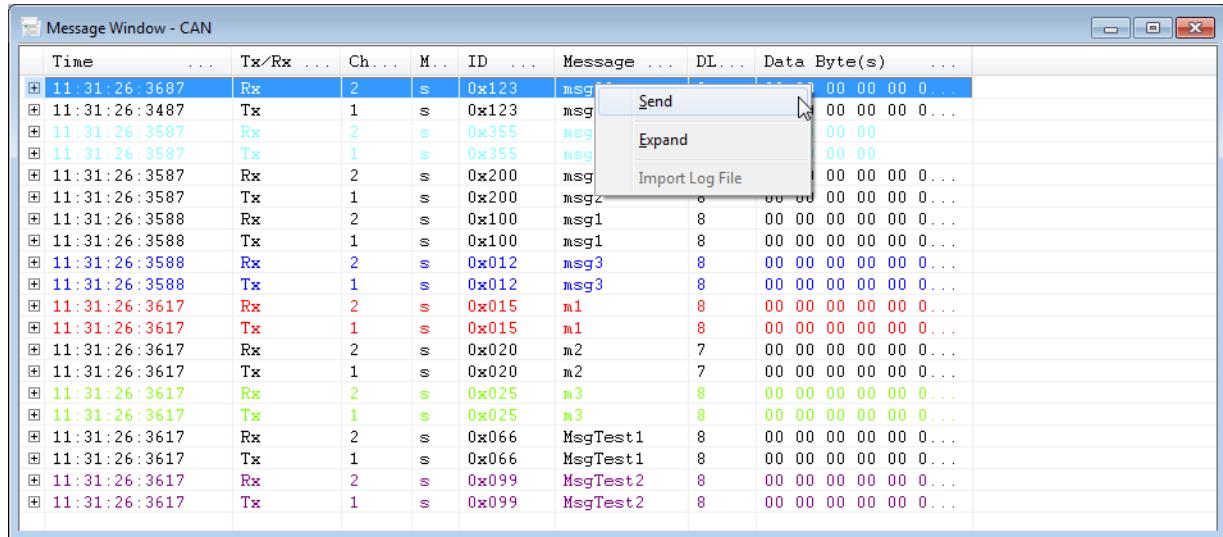
This is a toggle tool bar button. This button is used either to enable or disable message on-line interpretation. This button is enabled only in message overwrite mode. If on-line interpretation of message is enabled, a message entry will be followed by a textual description of the received message.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

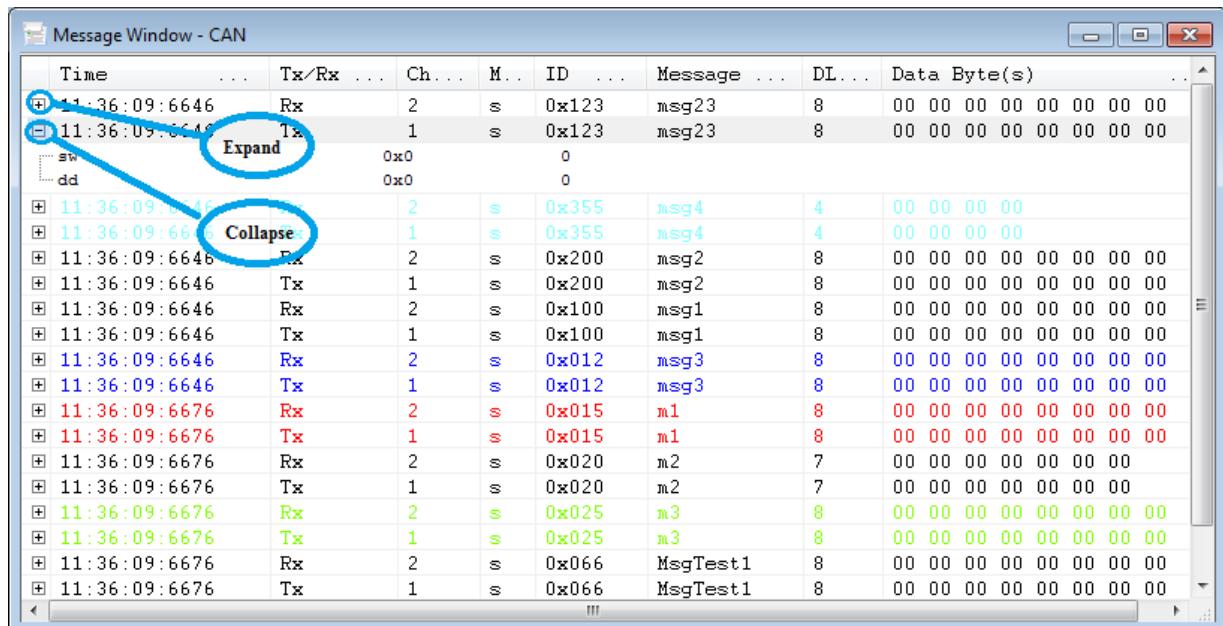
Message interpretation can be obtained by double clicking on the message.

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.

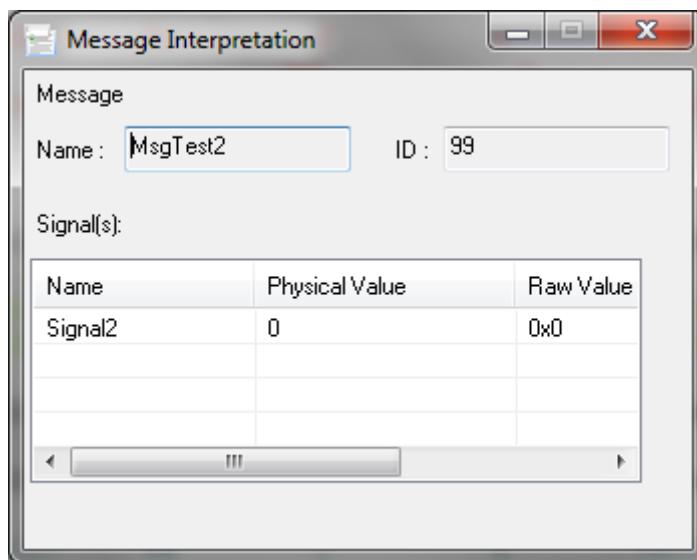


Select Expand to expand the message entry with its signal value. Signal values will be displayed in terms Raw and Physical values. The expanded entries can be closed by right clicking on that entry and selecting Collapse. The expanded entries can be closed by right clicking on that entry and selecting 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.



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.



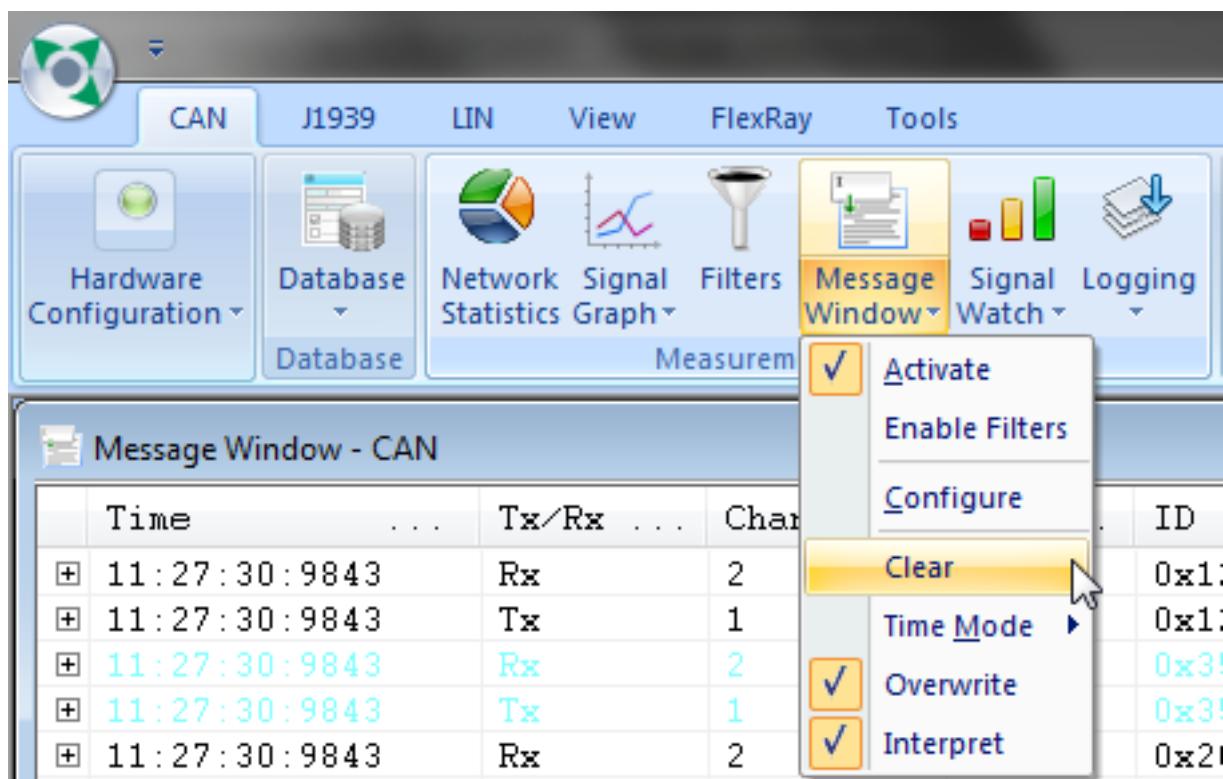
Left clicking on the message entry will change the message selection.

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.

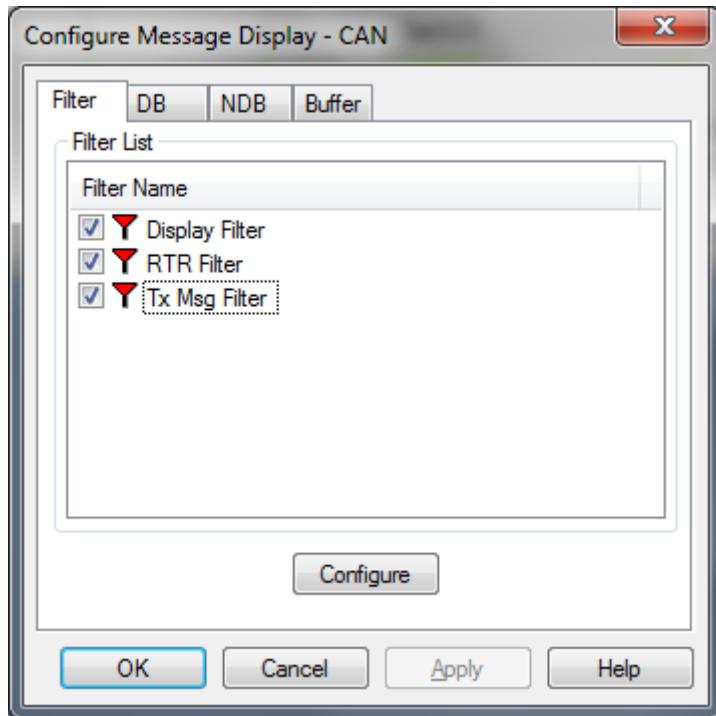
These column ordering and visibility are saved along with configuration.

Time	...	Tx/Rx	Channel	Msg	ID	Message	DLC	...	Data Byte(s)	...
15:20:34:6324		Rx	2	s	0x015	<input checked="" type="checkbox"/> Time	8		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6324		Tx	1	s	0x015	<input checked="" type="checkbox"/> Tx/Rx	8		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6325		Rx	2	s	0x020	<input checked="" type="checkbox"/> Channel	7		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6325		Tx	1	s	0x020	<input checked="" type="checkbox"/> Msg Type	7		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6326		Rx	2	s	0x025	<input checked="" type="checkbox"/> ID	8		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6326		Tx	1	s	0x025	<input checked="" type="checkbox"/> Message	8		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6326		Rx	2	s	0x066	<input checked="" type="checkbox"/> DLC	8		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6326		Tx	1	s	0x066	<input checked="" type="checkbox"/> Data Byte(s)	8		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6327		Rx	2	s	0x099		8		00 00 00 00 00 00 00 00 00 00 00	
15:20:34:6327		Tx	1	s	0x099		8		00 00 00 00 00 00 00 00 00 00 00	

Message Window Configuration

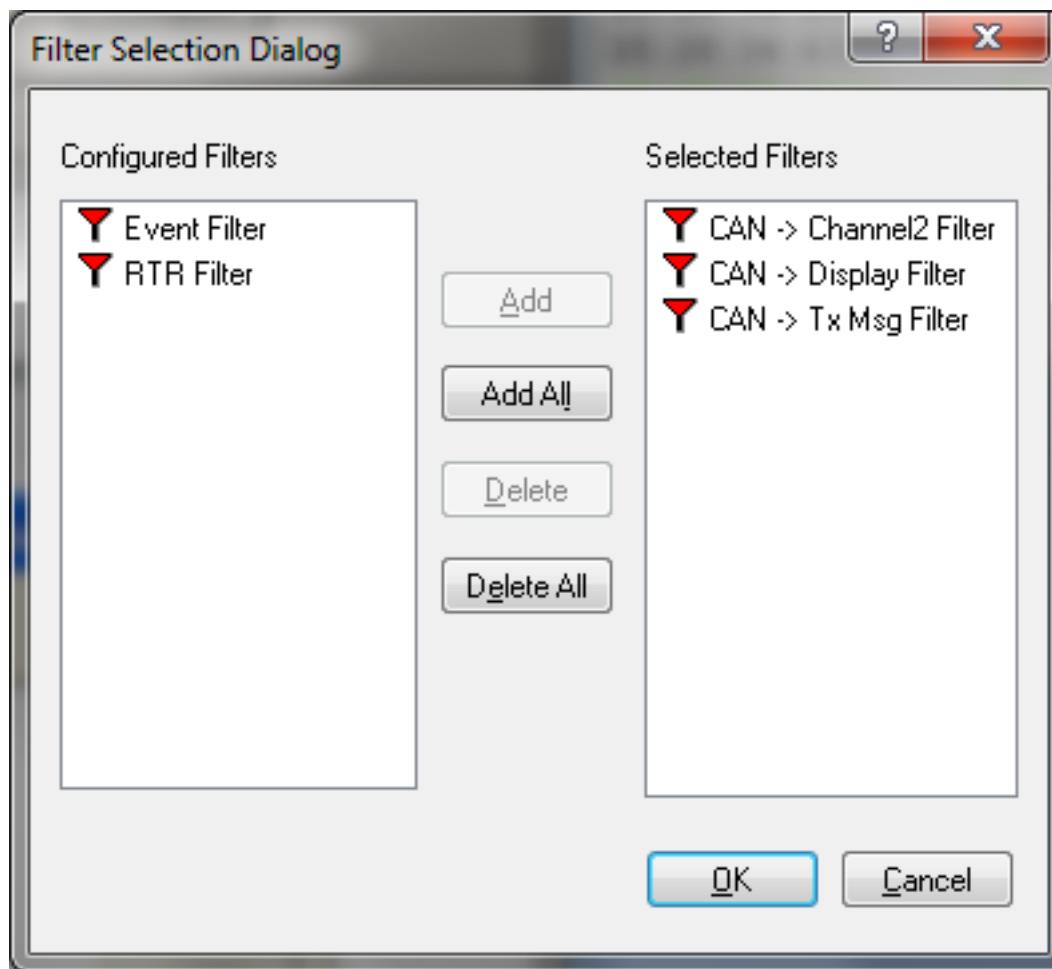
Message Filter

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

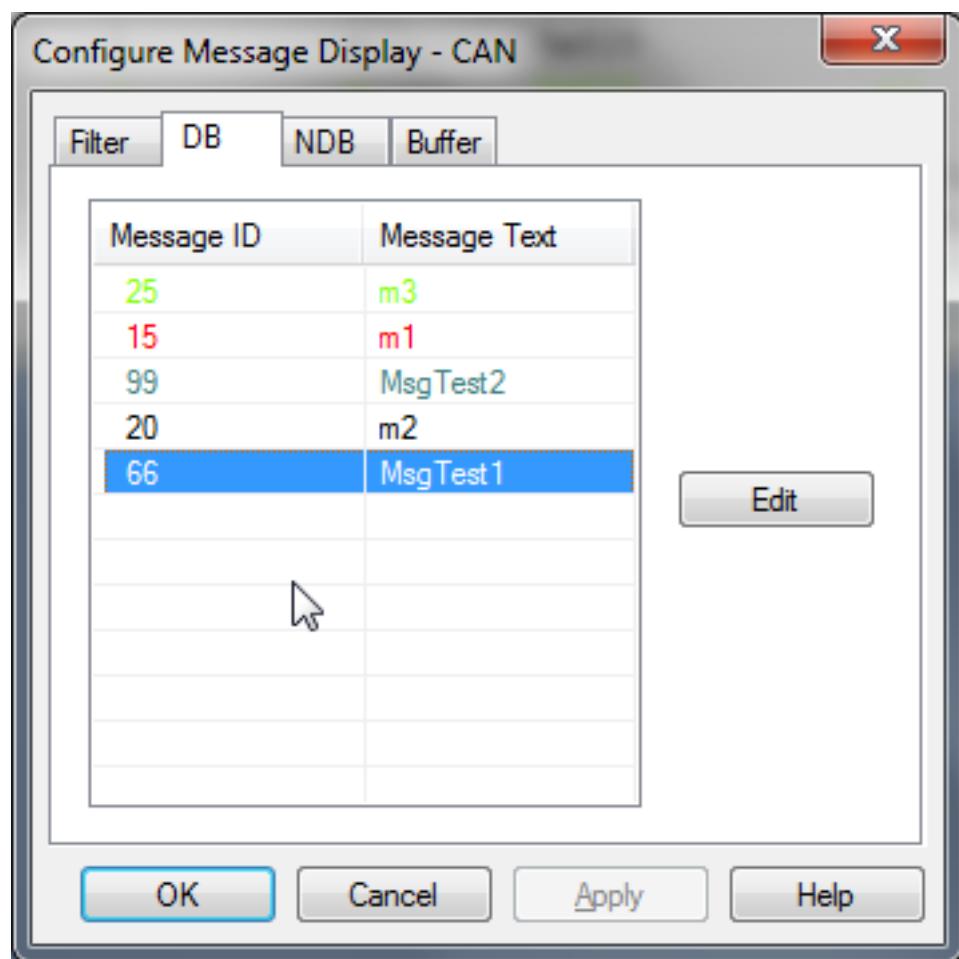
To configure display filter list select Configure button which will list available filters and selected filters.

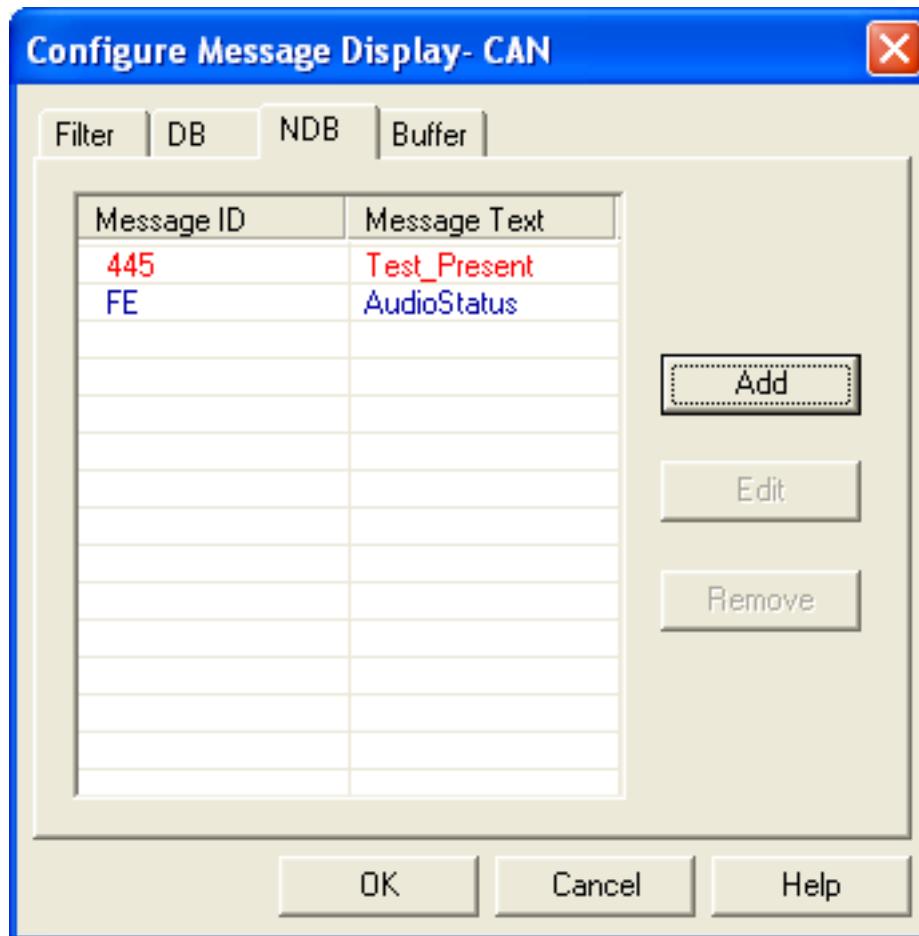


Message Coloring

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.

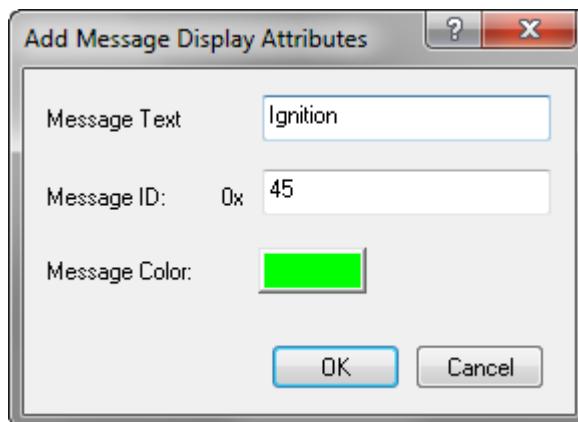




Adding message attribute

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

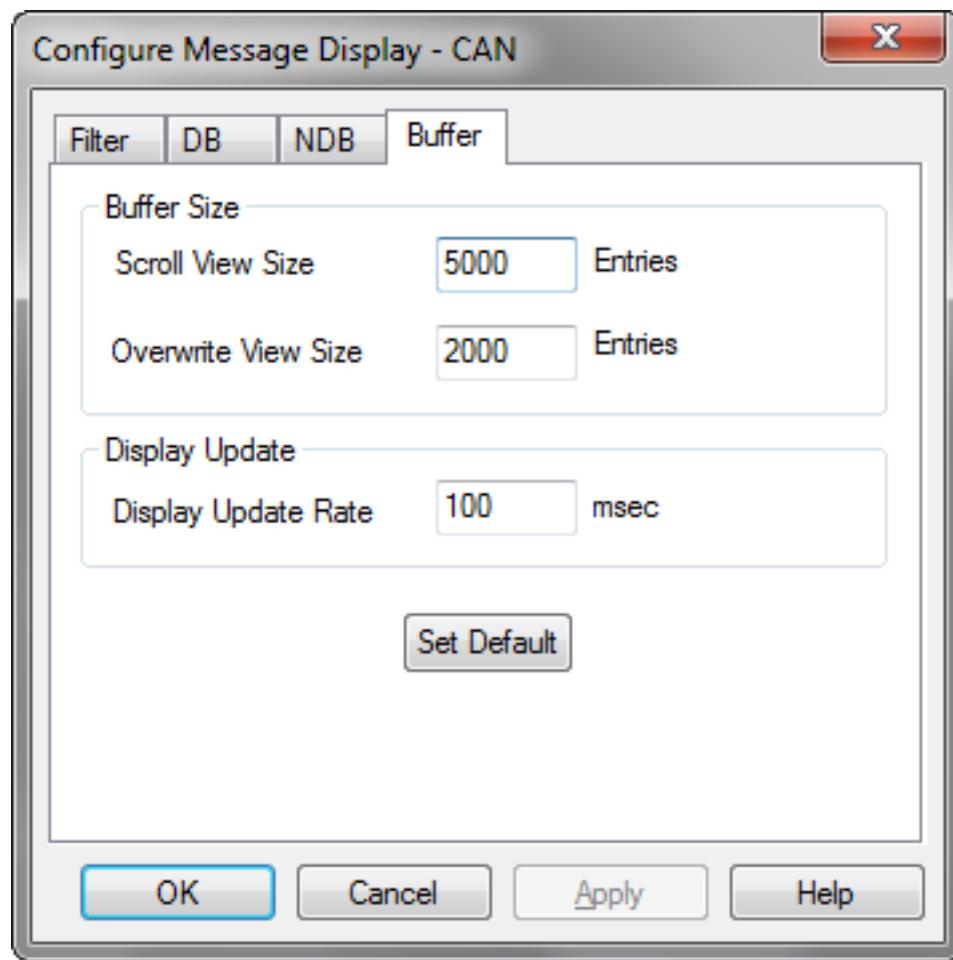
1. Select **CAN --> Message Window --> Configure**.
2. A dialog box will pop up. Select the message entry to be deleted from the message entry list.
3. Click on Remove button. A delete confirmation message box will be displayed.
4. Select Yes to confirm deletion.
5. Select OK button to confirm the modification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



Note:

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

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.

Network Statistics

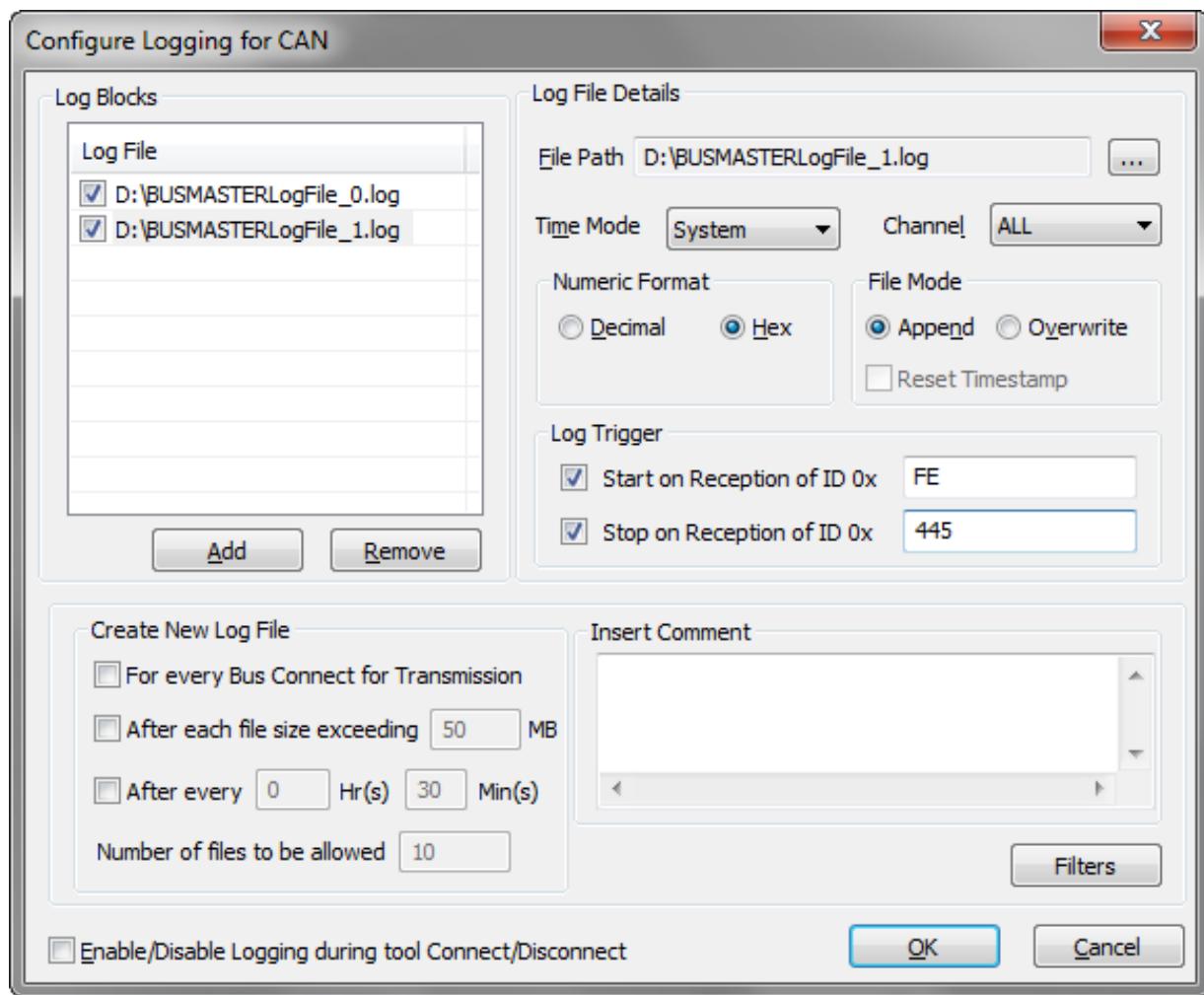
Parameter	Channel 1	Channel 2
Messages [Total]	1044	0
Messages [Msg/s]	9	0
Errors [Total]	0	0
Errors [Err/s]	0.00	0.00
Load	0.25 %	0.00 %
Peak Load	0.28 %	0.00 %
Average Load	0.25 %	0.00 %
Transmitted		
Total	1044	0
Standard [Total]	1044	0
Standard [Msg/s]	10.00	0.00
Extended [Total]	0	0
Extended [Msg/s]	0.00	0.00
Standard RTR	0	0
Extended RTR	0	0
Errors [Total]	0	0
Error [Err/s]	0.00	0.00
Received		
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
Status		
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 **CAN --> Network Statistics**.

Logging

Description:

BUSMASTER CAN Logging feature can be used to log the CAN network into a file for offline analysis. User can configure log file setting using **CAN --> Logging --> Configure** menu. This will show log file configuration dialog as shown below.



- Log Blocks:** 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:** This section will show the configuration details 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 Time stamp 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.

- **Create New Log File:**
- **1. For Every Bus Connect for Transmission:** New Log file can be created for every Bus Connect. The new log file will have a file name. Eg: BusmasterLogFile_CAN_ *Mn*.log where 'n' is the count, and 'M' indicates logging is 'Measurement' based.
- **2. After each file size exceeding:** New Log file can be created with log file exceeding certain file size. The new log file will have a file name. Eg: BusmasterLogFile_CAN_ *Sn*.log where 'n' is the count, and 'S' indicates logging is 'Size' based.
- **3. After specified time:** New Log file can be created for certain interval of time. The new log file will have a file name. Eg: BusmasterLogFile_CAN_ *Tn*.log where 'n' is the count, and 'T' indicates logging is 'Time' based.
- **Comment:** User defined Comments can be inserted to the header of the log file.
- **Filters:** Filters can be added for logging.

Activating Logging:

Logging can be activated in two ways.

1. **Auto Start:** Enable the check box **Enable/Disable Logging on Tool Connect/Disconnect** in Log Configuration window to activate\deactivate logging automatically when the tool is connected.
2. **Manual Start:** use **CAN->Logging->Activate** menu to start\stop Logging Manually

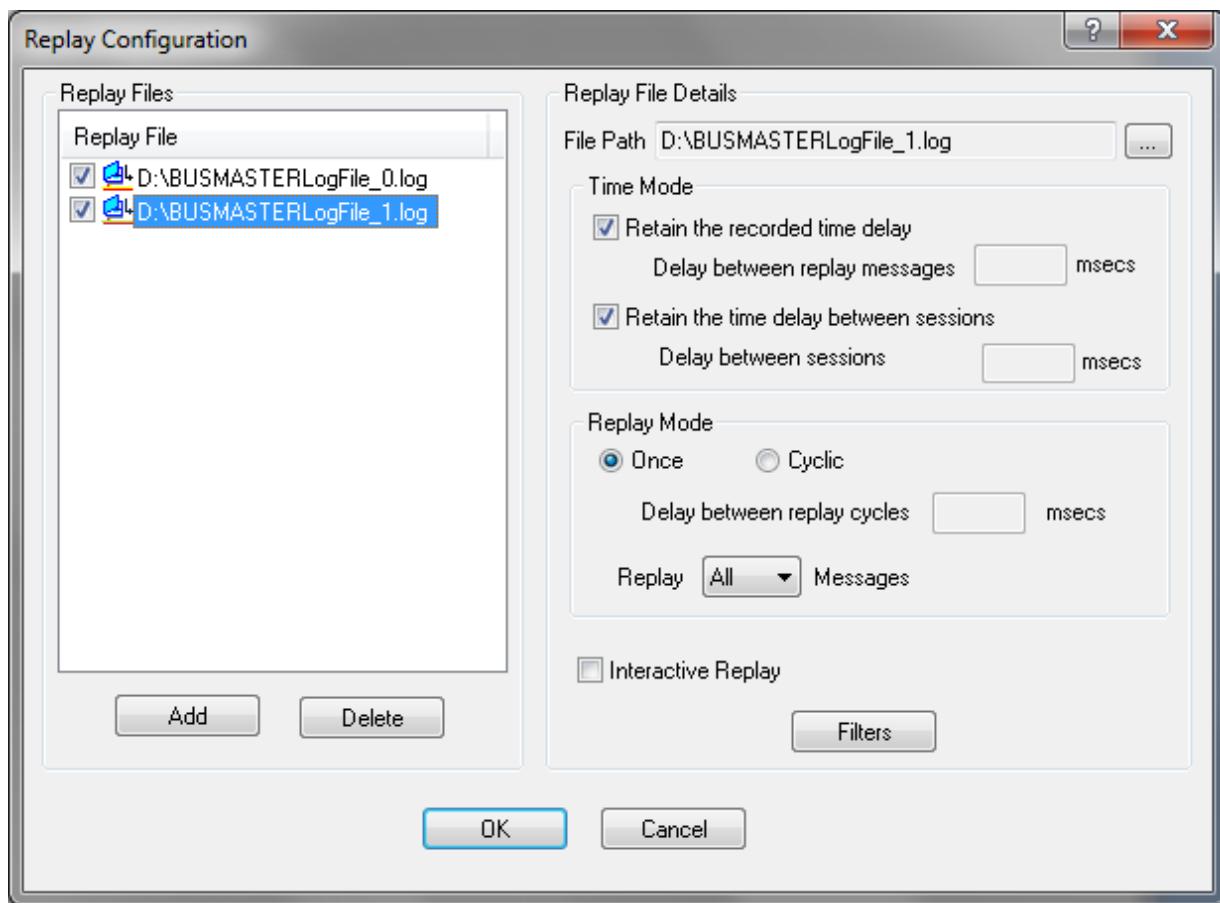
Logging Indication:

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 blinking icon will be shown in the status bar till the logging is stopped.

Replay

Description:

CAN Replay feature can be used to replay the CAN log data to the network. 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 Configuration:

Replaying of file can be configured using the three parameters mentioned below

- Time Mode
- Replay Delay

1. Replay Mode:

There are two modes of Replay

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

2. Time Mode:

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.

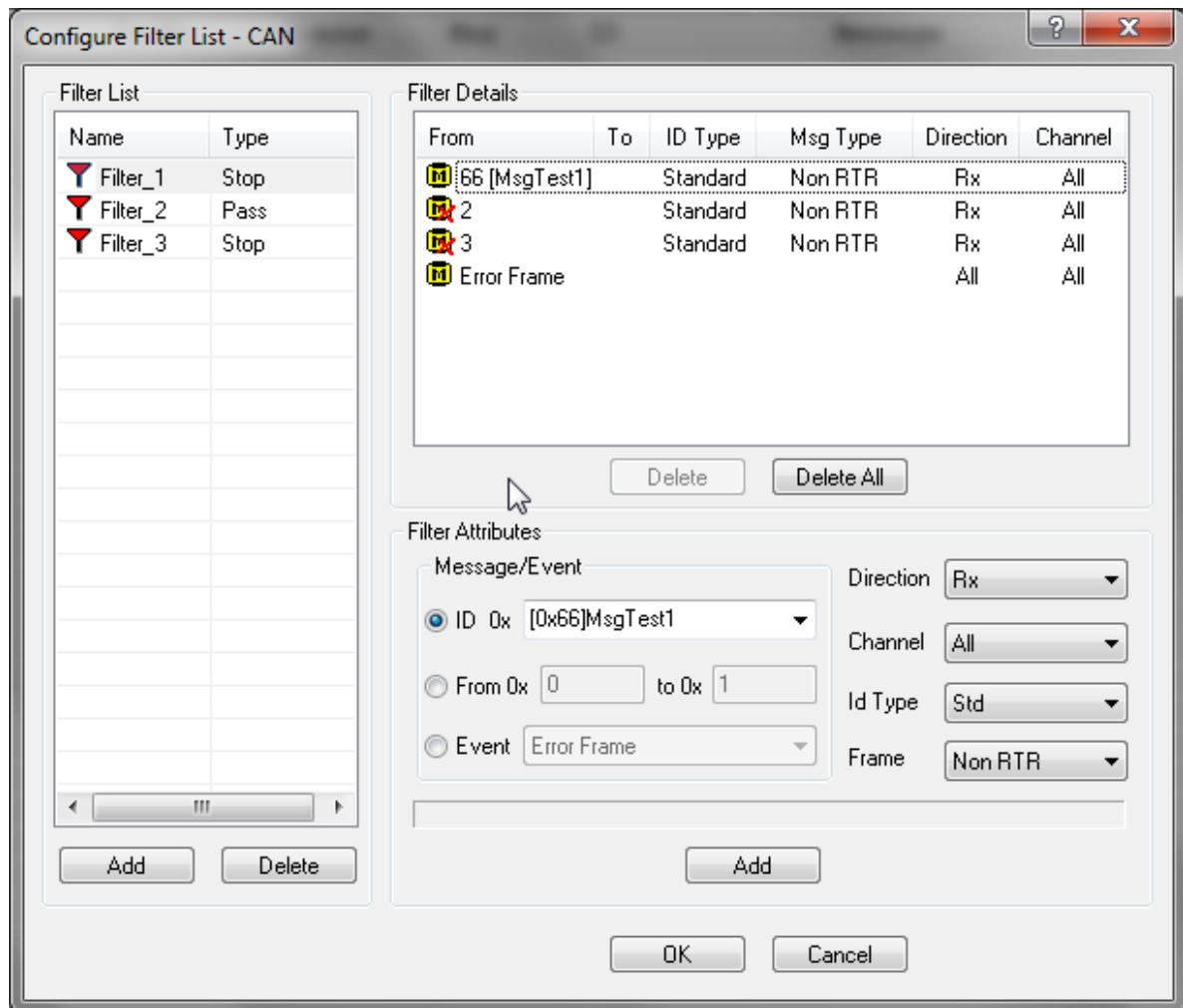
On clicking the OK button a Message Replay Window will be displayed. This will contain all messages in the replay file. By default first message in the replay window will be selected. Please see section Replay a File for further details.

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.

Filters

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

- Select CAN --> Filters.
- 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. 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 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. 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 enabled.

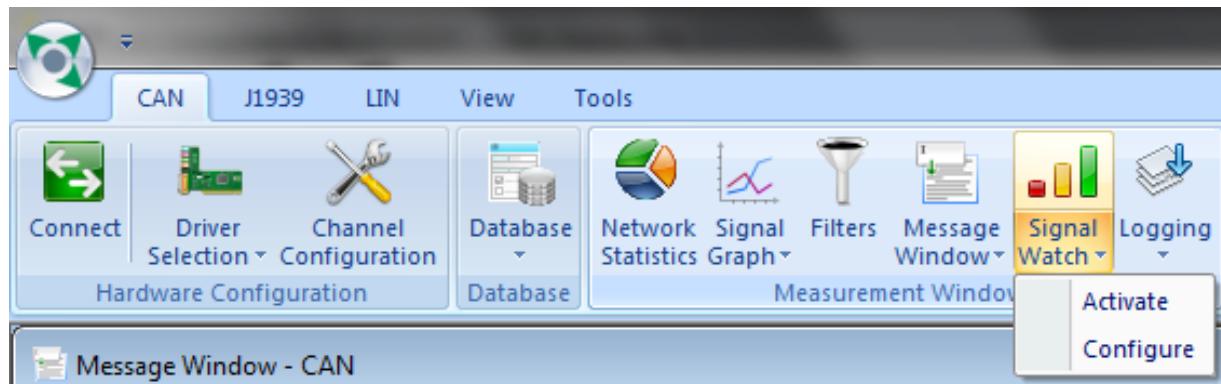
The Add button in the Filter Attributes section will add configured filter in to the selected named filter list. This button will be disabled in case of invalid parameter entered by the user and appropriate error message will be displayed in the status bar.

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.

Signal Watch

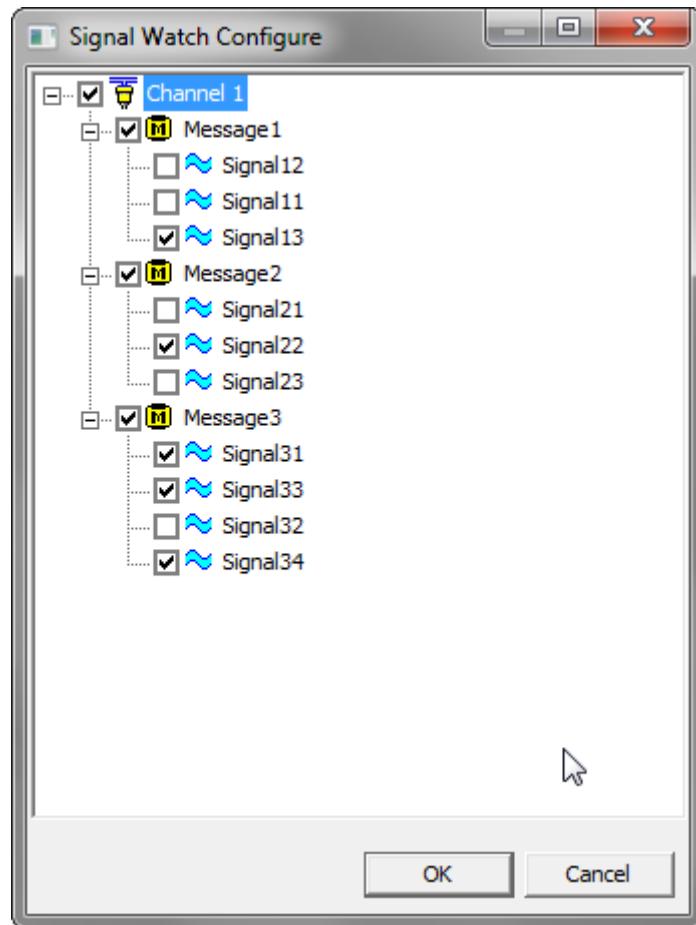
User can watch the value of a signal using the signal watch window as and when a message having that signal is received. The Physical and Raw values will be listed and updated as and when the message arrives. Click on the tool bar button shown below to display the signal watch window.



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 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
- Uncheck the signal to delete it from the signal watch.
- 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

To pop up signal watch window, select the tool-bar button explained in the previous section or the menu **CAN->Signal Watch->Activate**. This will show the Signal Watch Window.

Message	Signal	Physical Value	Raw Value
Message1	Signal11	58.1234	29
Message2	Signal12	1	1

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 Generation

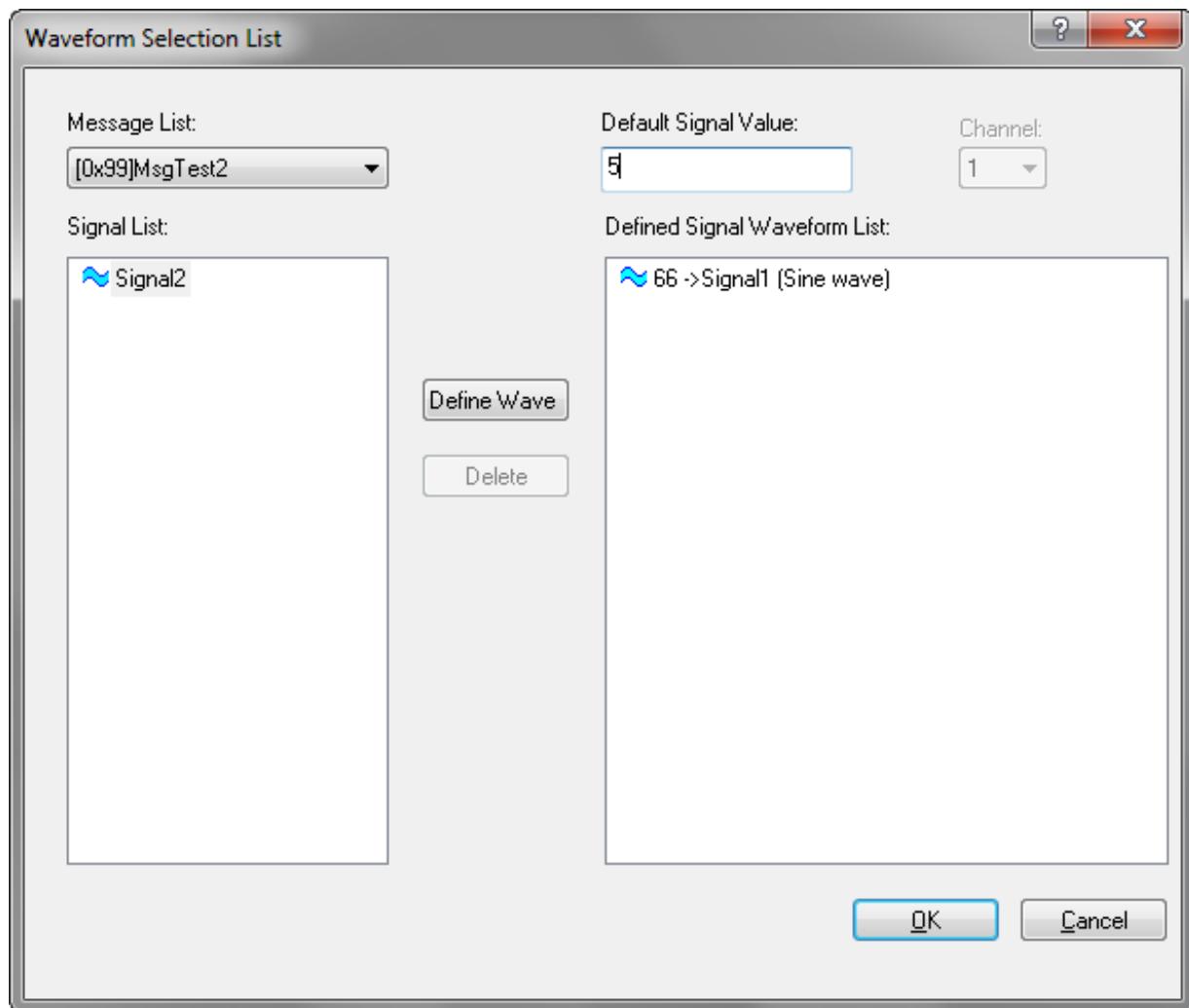
Signal Generation allows the user to configure each signal in database messages with particular waveform and send the messages with these signal values at a particular sampling time period..

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.

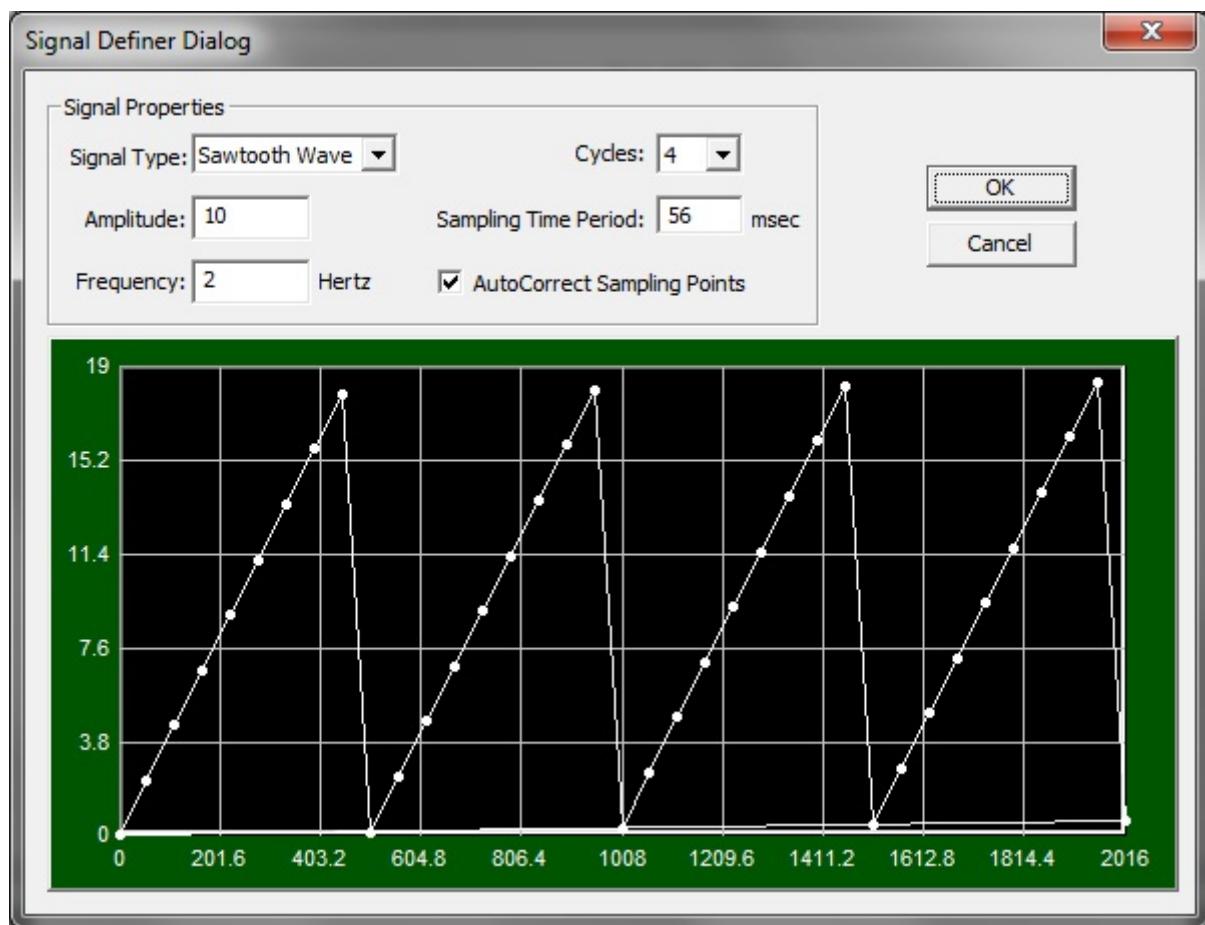
“Signal List” List control shows the signals in currently selected message in combo box which are not defined with any waveform.

“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.

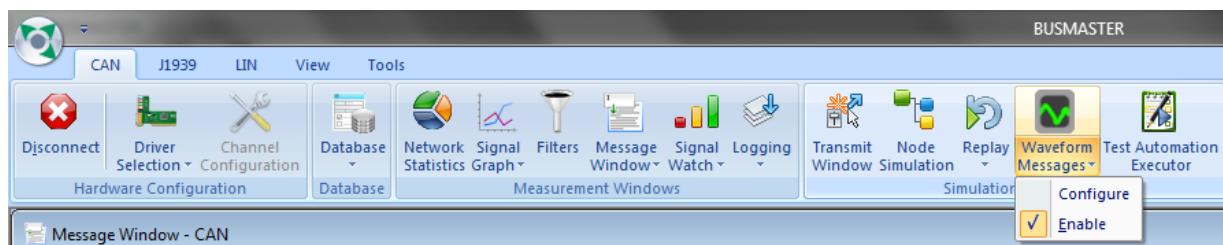
The sampling Time Period which is last modified will be applicable to all the signals. For example, if for first signals you choose the sampling time period as 125 and for the second signal, you choose the sampling time period as 100. Then the sampling time period applicable is 100 for first and second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

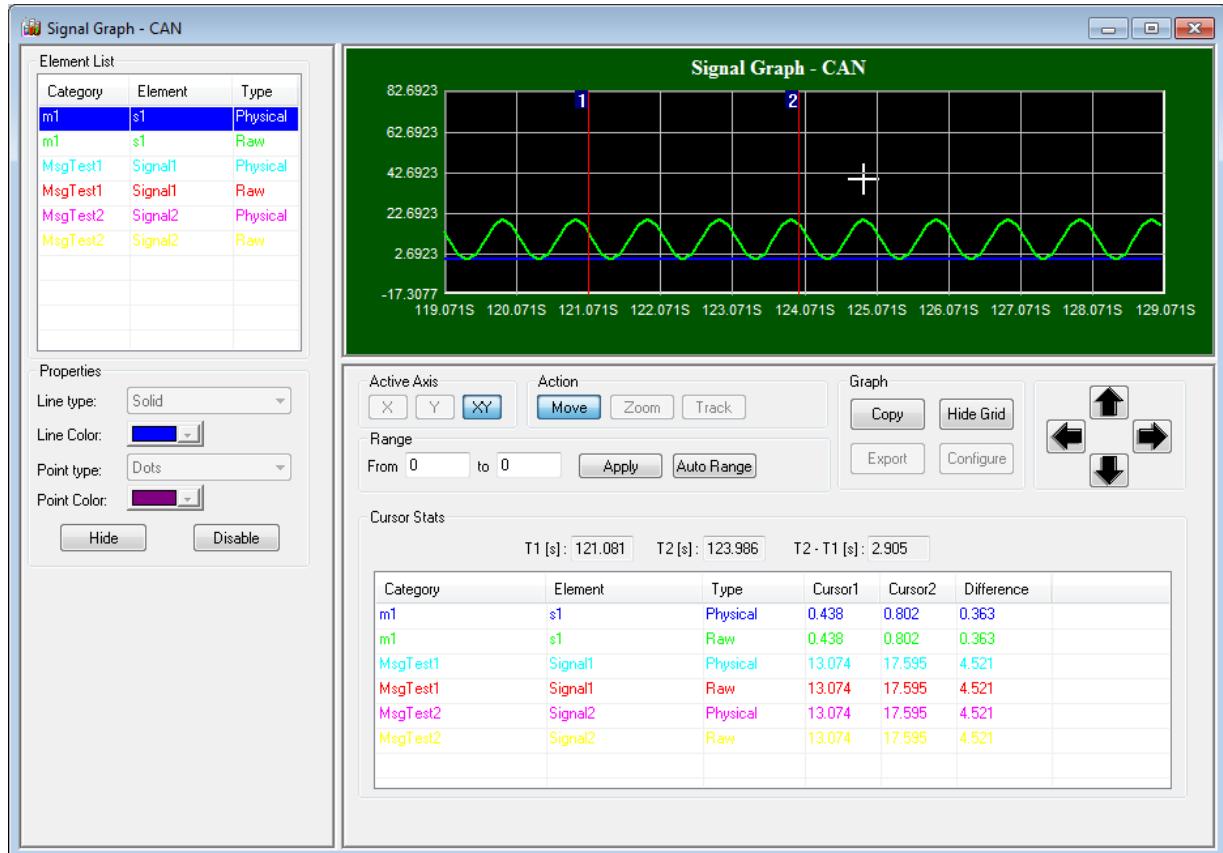
The Waveform Signals defined are saved along with configuration.

Signal 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

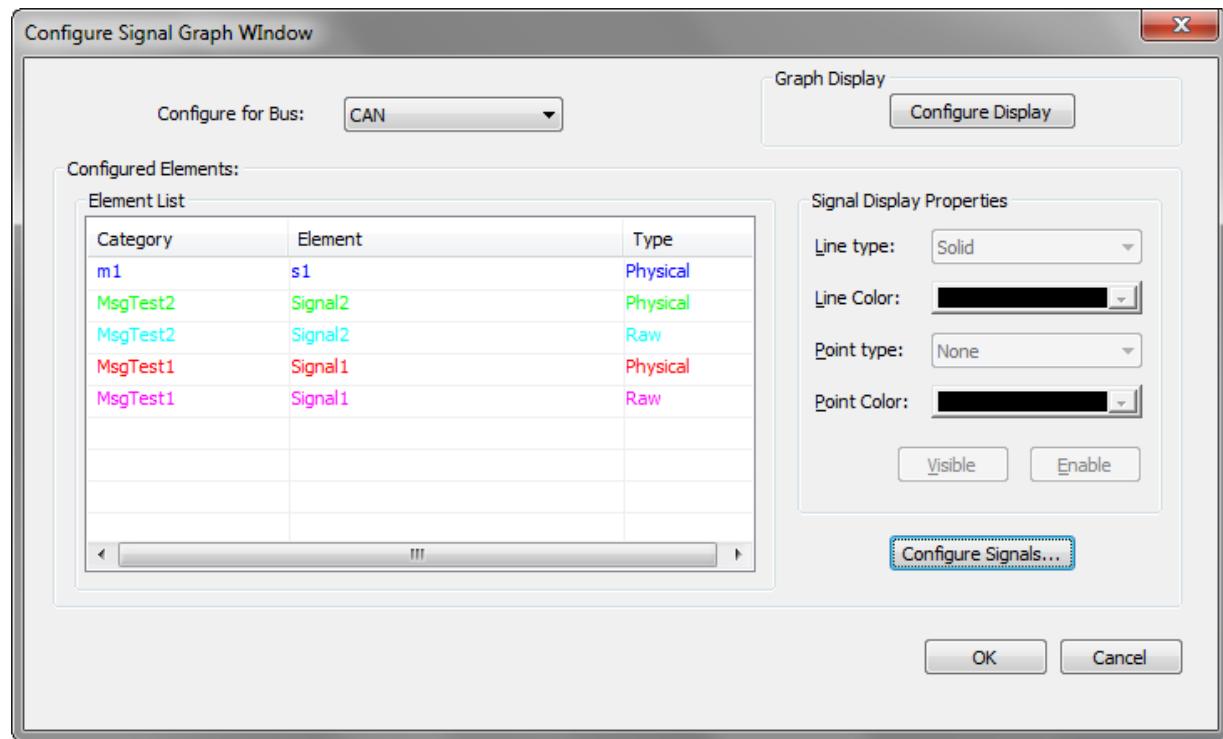
like setting scale values automatically, setting all graph elements one below another and setting manual range. For easy navigation directional navigation keys are provided which will move the graph in the selected direction by one grid position.

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.

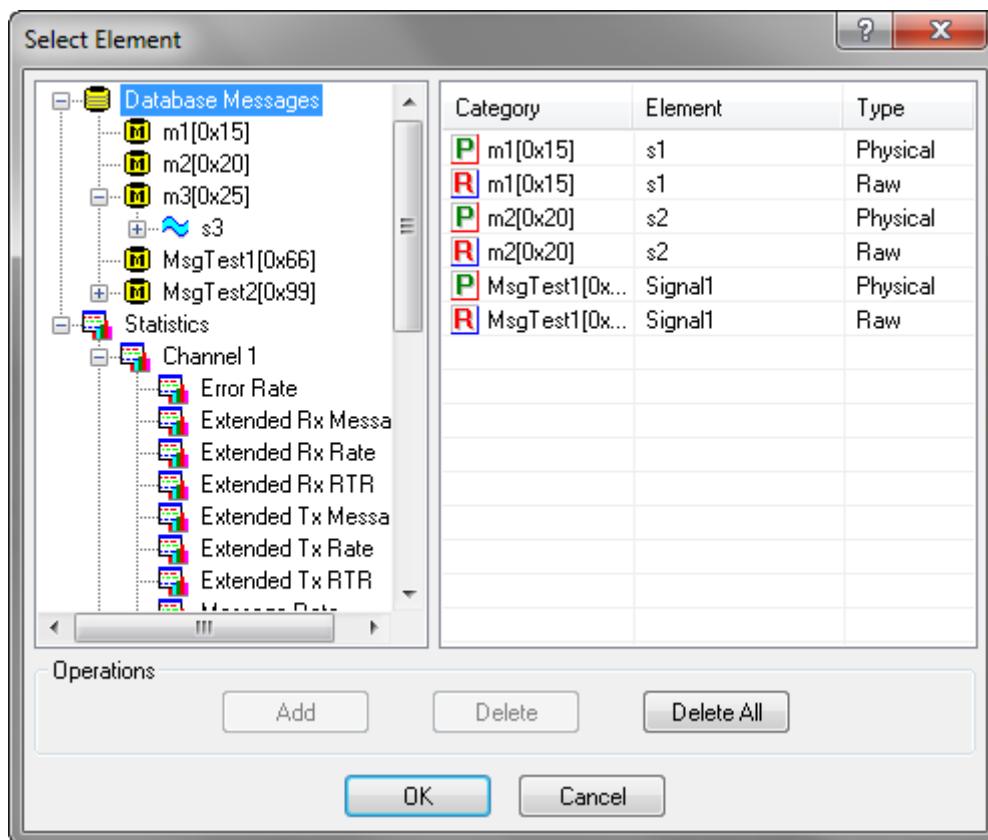
Configuring Graph

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 pop up 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 the 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 from 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 a 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

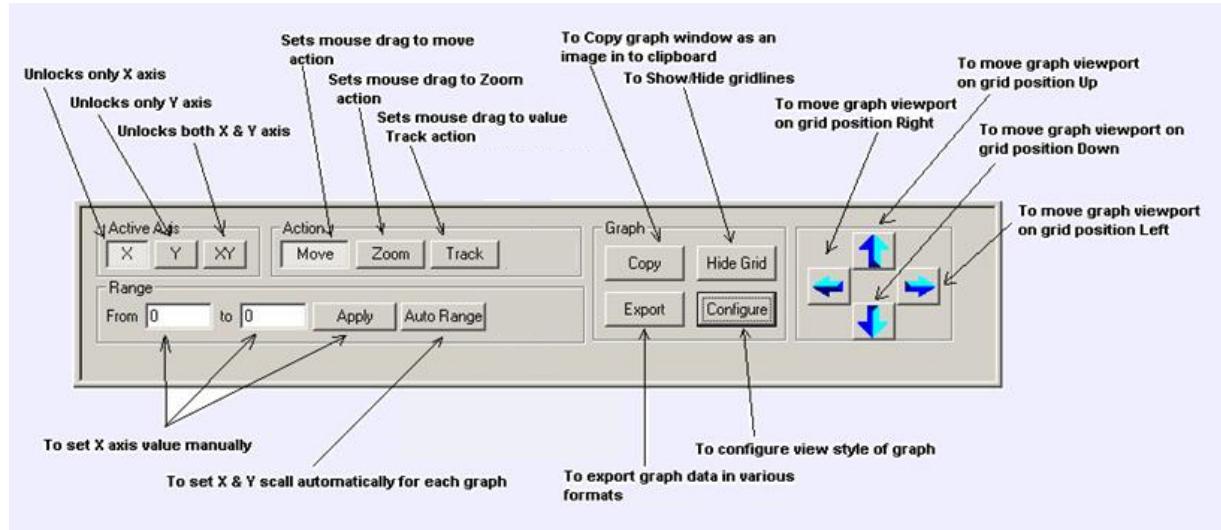
This is to enable or disable a graph element from receiving sample values. If a graph is disabled it will not receive any update for message/signals or statistics parameters. This is to avoid a graph getting samples from message/signals or statistics parameters. If the tool is connected and a graph element 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)

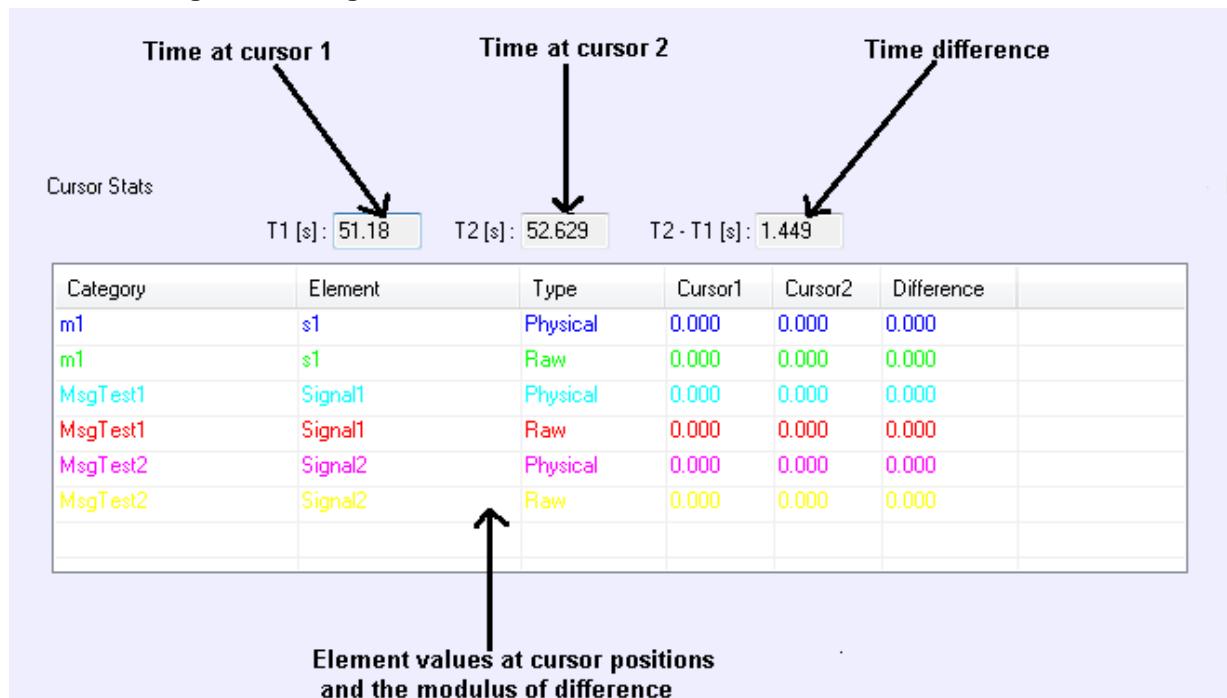
Auto Range

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.

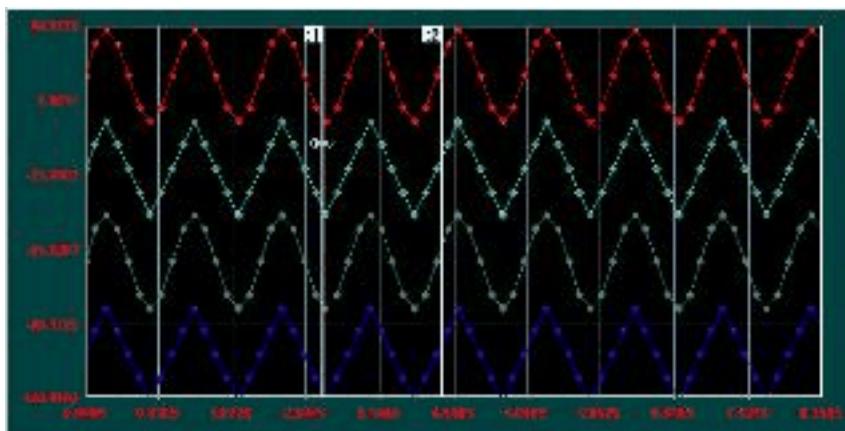
The time values at cursors are shown in a read only edit boxes. The list box shown in the above figure presents the interpolated element values at both the cursor positions and the modulus of difference between both the values.

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.

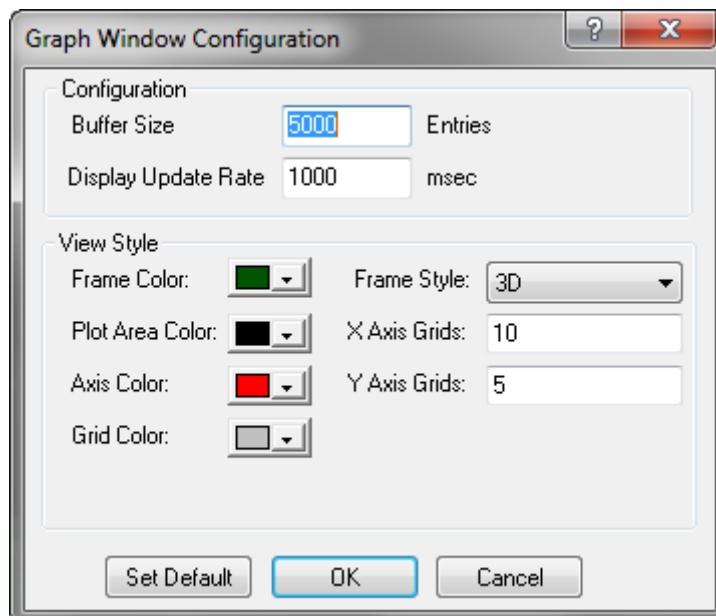
The image below shows the dragging of cursor to new time value.



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.



CAN Node Simulation

What is new?

Node Simulation v1.2 changes

- STCAN_MSG in node simulation is updated to ease accessing message attributes, signal values and to support Big Endian signals as given below

```
• class STCAN_MSG
{
    unsigned int      id;
    bool              isExtended;
    bool              isRtr;
    unsigned char     dlc;
    unsigned char     cluster;
    unsigned char     data[64];
    unsigned long     timeStamp;
    bool              isCanfd;

    // To set data
    bool byteAt(int index, unsigned char val);
    bool wordAt(int index, unsigned short val);
    bool longAt(int index, unsigned long val);

    // To get data
    unsigned char byteAt(int index);
    unsigned short wordAt(int index);
    unsigned long longAt(int index);
};
```

- Following functions are supported to access/update Signal values

```
• To set signal rawvalue or physicalvalue
  1. rawvalue(int x); // Type 'int' will vary as per the signal type
  2. physicalvalue(double x);
```

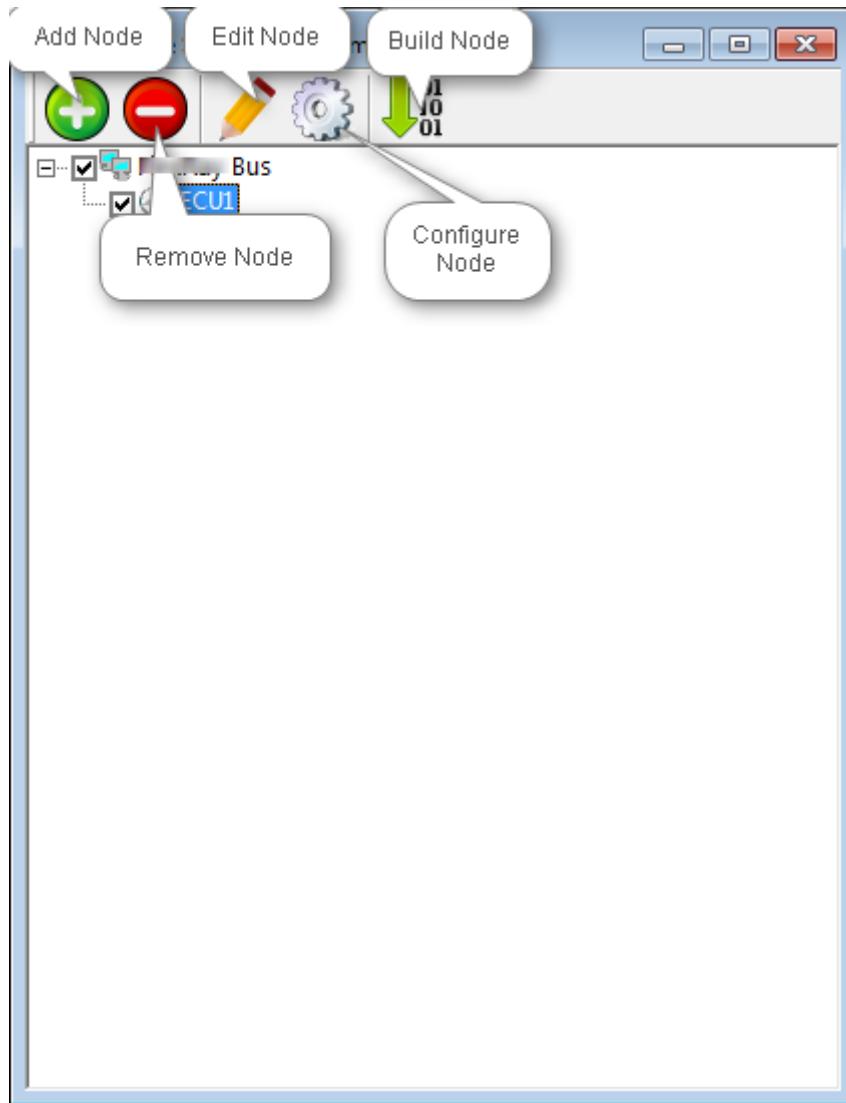
```
To get signal rawvalue or physicalvalue
  1. rawvalue(); // returns signal rawvalue
  2. physicalvalue(); // returns signal physicalvalue
```

For more details, refer 'Examples' section under 'CAN->Node Simulation'

- On importing Node Simulation .cpp file of version 1.1, .cpp file will be automatically updated with version 1.2 changes and a backup file will be created in the same path (.bak file)
- CAN CAPL to Cpp conversion is updated as per Node Simulation 1.2 structures

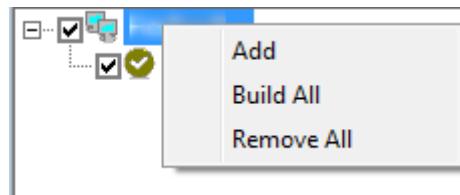
Node Simulation Configuration

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



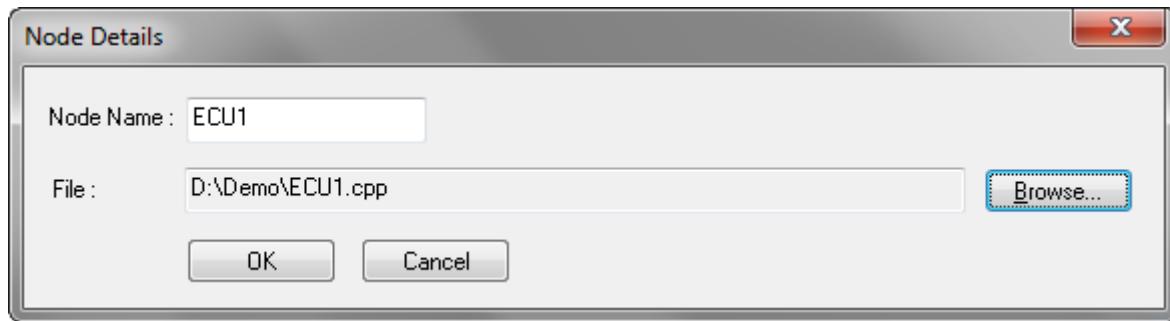
Add Node

This is used to add .cpp/.dll files to Node Simulation. Add Node can be done by following ways:



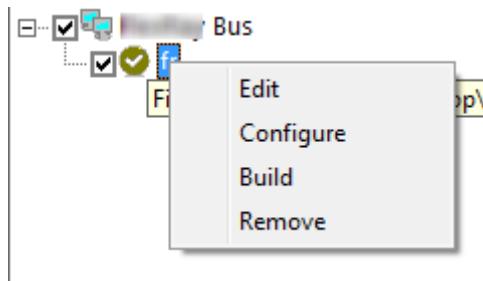
1. Right click the Root Node(<Protocol> Bus) and select "Add".
2. Click Add Node in the toolbar.
3. Pressing "Insert" key in the keyboard.

Then "Node Details" dialog box appears as shown below. Add unique Node name and add existing .cpp/.dll or provide new File name to create new .cpp file.



Edit Node

This is used to edit the .cpp file attached to a Node. Editing can be done by following ways:



1. Select the Node then Right click and select "Edit".
2. Select the Node and click "Edit Node" in the toolbar.
3. Select the Node and press "Enter" key in the keyboard.

Then "Function Editor" window appears in which the required editing can be done.

Remove Node

This is used remove selected node all the nodes in the Simulated system. Removing a Node can be done by following ways:

1. Select the Node then Right click and select "Remove". To Remove All Nodes select Root Node(<Protocol> Bus) and select "Remove All".
2. Select the Node and click "Remove Node" in the toolbar. To Remove All Nodes select Root Node(<Protocol> Bus) and select "Remove Node" in the toolbar.
3. Select the Node and press "Delete" key in the keyboard. To Remove All Nodes select Root Node(<Protocol> Bus) and press "Delete" key.

Configure Node

This is used change the name of the Node or change/add .cpp/.dll associated with a Node. Configuring a Node can be done by following ways:

1. Select the Node then Right click and select "Configure".
2. Select the Node and click "Configure Node" in the toolbar.
3. If no .cpp/.dll files are associated with the node previously, then by pressing "Enter" key in the keyboard.

Build Node

This is used build the .cpp files associated with selected Node or all the nodes in the Simulated System. Building a Node can be done by following ways:

1. Select the Node then Right click and select "Build". To Build All Nodes select Root Node(<Protocol> Bus) and select "Build All".
2. Select the Node and click "Build Node" in the toolbar. To Build All Nodes select Root Node(<Protocol> Bus) and select "Build All" in the toolbar.

Enable/Disable Node

This used to active/deactivate selected Node or all the Nodes in the Simulated System. Enabling/Disabling can be done by following ways:

1. Check/Uncheck the checkbox associated with the Node will Enable/Disable the Node respectively. To Enable/Disable all the Nodes Check/Uncheck the Root Node(<Protocol> Bus) respectively.
2. "Spacebar" key can be used as keyboard shortcut to Check/Uncheck the Node(s).



Note:

1. Node(s) can't be Added/Removed/Configured/Enabled/Disabled while the network is connected.
2. A Node can be edited while the network is connected. But the file must be built again to see the changes.

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.

The screenshot shows the ECU1.cpp function editor interface. The left pane displays a hierarchical tree of function prototypes and global variables. The right pane shows the source code of a function, with specific lines highlighted and annotated:

- PANE 1:** Displays Function prototypes, global variables etc.
- PANE 2:** Displays contents of C file and is non-editable. It highlights lines 80 through 92 of the code.
- PANE 3:** Editable view that displays the function body. It highlights the entire code block from line 78 to 91.

```

    /* TODO */
78: }/* End BUSMASTER generated function - OnDLL_Unload */
79: /* Start BUSMASTER generated function - OnKey_a */
80: void OnKey_a(unsigned char KeyValue)
81: {
82:     STCAN_MSG sMsg; // Initialise message structure
83:     sMsg.id = 0x100; // Message ID
84:     sMsg.isExtended = false; // Standard message type
85:     sMsg.isRtr = false; // Not RTR type
86:     sMsg.dlc = 8; // Length is 8 Bytes
87:     sMsg.data[0] = 10; // Byte Data
88:     sMsg.data[1] = 20;
89:     sMsg.wordAt(1, 30); // Word data
90:     sMsg.cluster = 1; // First CAN channel
91:     // Send the message SendMsg(sMsg);
92: }/* End BUSMASTER generated function - OnKey_a */

```

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

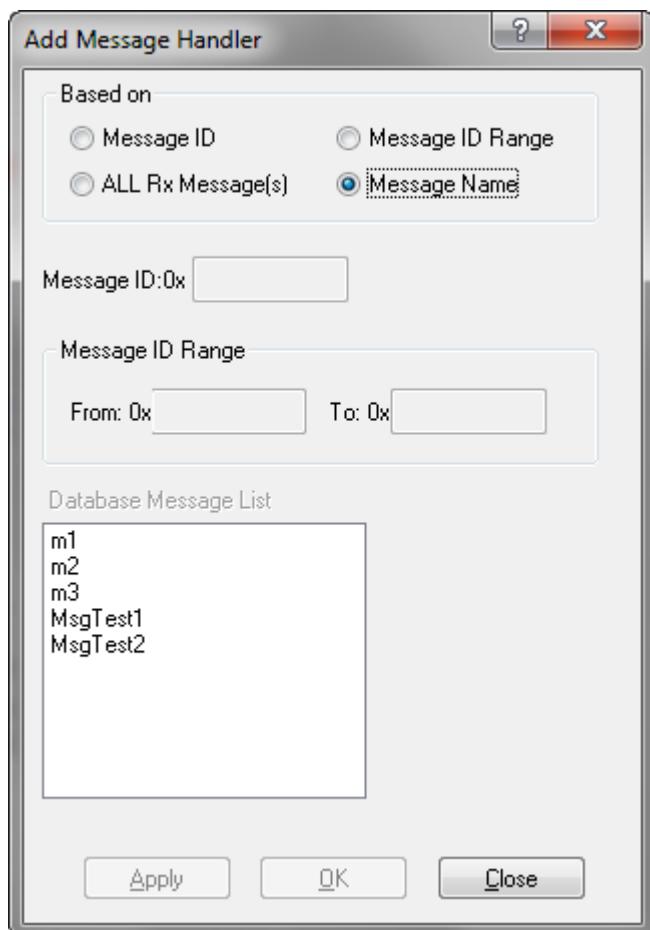
User can delete Header files, Message Handlers, Timer Handlers, Key Handlers, Error handlers, DLL handlers and Utility Functions in source file opened for editing, to do so follow the steps given below:

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.



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.



- 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.

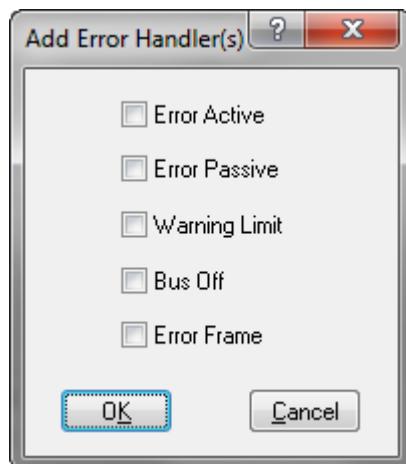
Add Key Handler

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.

API Reference

STCAN_MSG Structure

STCAN_MSG is the CAN message structure which accepts CAN parameters and data.

```
class STCAN_MSG
{
    unsigned int      id;
    bool             isExtended;
    bool             isRtr;
    unsigned char    dlc;
    unsigned char    cluster;
    unsigned char    data[64];
    unsigned long    timeStamp;
    bool             isCanfd;

    // To set data
    bool byteAt(int index, unsigned char val);
    bool wordAt(int index, unsigned short val);
    bool longAt(int index, unsigned long val);

    // To get data
    unsigned char    byteAt(int index);
    unsigned short   wordAt(int index);
    unsigned long    longAt(int index);
};
```

Member	Description
id	CAN message identifier is a unsigned integer in decimal or hexadecimal (0x) to identify the message

isExtended	true for extended message. Possible values: true, false
isRtr	true for Remote Transmission Request. Possible values: true, false
dlc	Data Length in bytes. [0-8] for CAN messages, [0-64] for CANFD messages
cluster	channel on which the frame is received or to be transmitted
data[64]	Message data. [0-7] bytes for CAN, [0-63] bytes for CANFD messages
isCanfd	true for CANFD message. Possible values: true, false
timeStamp	Received frame absolute timestamp in 100's of microseconds
bool byteAt (int index, unsigned char val)	To set data byte (8 bit). Possible index: [0-7]. Example: byteAt(0, 10); '0' is index, 10 is value
bool wordAt (int index, unsigned short val)	To set data word (16 bit). Possible index: [0-3]. Example: wordAt(0, 10); '0' is index, 10 is value.
bool longAt (int index, unsigned long val)	To set data word (32 bit). Possible index: [0-1]. Example: longAt(0, 10); '0' is index, 10 is value.

SCAN_ERR

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
};
```

Member	Description
m_ucTxError	Tx Error counter value
m_ucRxError	Rx Error counter value
m_ucChannel	Channel on which error frame is received

Example:

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

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

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

```
UINT WriteToFile ( 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

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

Examples

Non database message transmission:

```
STCAN_MSG sMsg;

// Initialise message structure
sMsg.id = 0x100;           // Message ID
sMsg.isExtended = false;    // Standard Message type
sMsg.isRtr = false;        // Not RTR type
sMsg.dlc = 8;              // Length is 8 Bytes
sMsg.data[0] = 10;          // Byte Data
sMsg.data[1] = 20;
sMsg.wordAt(1, 30);        // Word data
sMsg.cluster = 1;           // First CAN channel

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

Database message transmission:

```
// Message Declaration
CAN_Request sMsgStruct; // CAN_Request is a database message

// Use signal member
// Sig1
sMsgStruct.Sig_1 = 10; // for setting signal raw value
// Sig2
sMsgStruct.Sig_2 = 20;
// Sig3
sMsgStruct.Sig_3 = 30;
// Send the message now
SendMsg(sMsgStruct));
```

Accessing signal values:

```
// Message Declaration
CAN_Request sMsgStruct;

// Use signal member
```

```

// Sig1
int sig1Value = sMsgStruct..Sig_1;    // Type 'int' to be changed as per
// signal type
// Sig2
int sig2Value = sMsgStruct.Sig_2;
// Sig3
int sig3Value = sMsgStruct.Sig_3;

(OR)

int sig1Rawvalue = sMsgStruct.sig1.rawvalue();

(OR)

double sig1PhyValue = sMsgStruct.sig1.physicalvalue();

```

Updating 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;

// Use signal member
// Sig1
sMsgStruct.Sig_1 = 10;
// Sig2
sMsgStruct.Sig_2 = 20;
// Sig3
sMsgStruct.Sig_3 = 30;

(OR)

sMsgStruct.sig1.rawvalue(10);

(OR)

sMsgStruct.sig1.physicalvalue(12.4);

```

Updating message data bytes:

```

STCAN_MSG sMsg;

// Initialise message structure here
sMsg.id = 0x100;           // Message ID
sMsg.isExtended = false;    // Standard Message type
sMsg.isRtr = false;        // Not RTR type
sMsg.dlc = 8;              // Length is 8 Bytes
sMsg.cluster = 1;           // First CAN channel

sMsg.data[0] = 10;          // Byte Data
sMsg.data[1] = 20;

(OR)

sMsg.byteAt(0, 10);
sMsg.byteAt(1, 20);

// Send the message
SendMsg(sMsg);

```

**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.
- Messages and Signals of a database can be used in Node Simulation if database is associated/imported in BusMaster

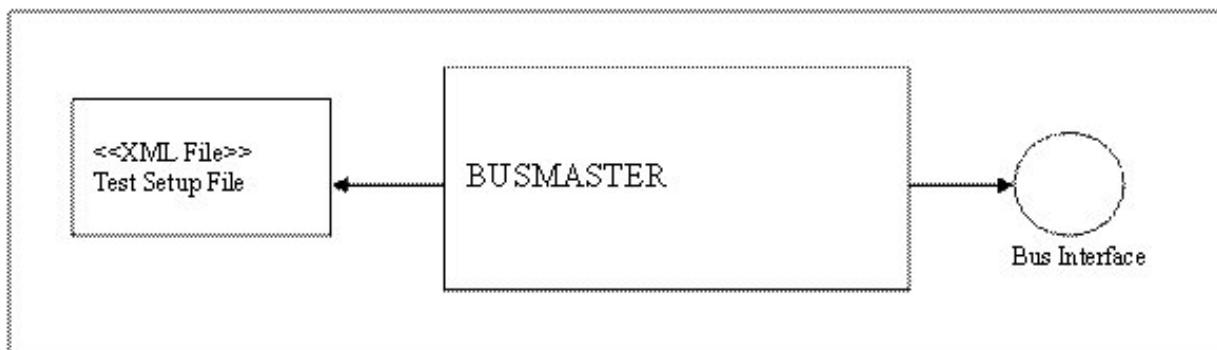
Test Automation

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 >= 1
- Test case := {test step 1, test step 2, ..., test step N}, N >= 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) with in 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 <= 10) && (x >= 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	SYS	Warning

Section (tag)	Description	Assumed value if absent	Error condition if absent
	(relative) and ABS (absolute)		
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
Transmission (send)	Collection of the messages to be transmitted.	-	No error
Transmittion 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.

Section (tag)	Description	Assumed value if absent	Error condition if absent
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.

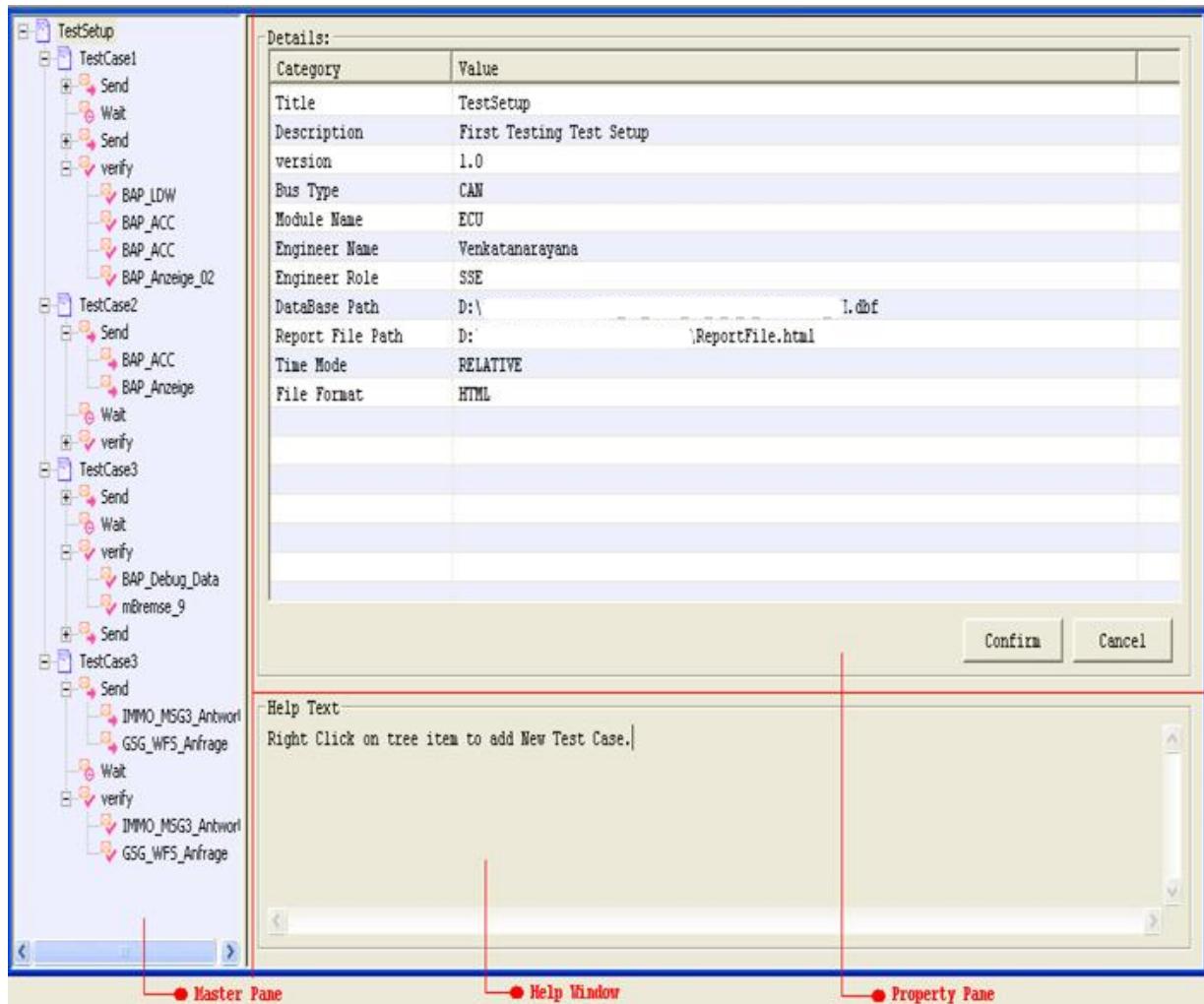
Features provided by test setup editor

- 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 **Tools->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.

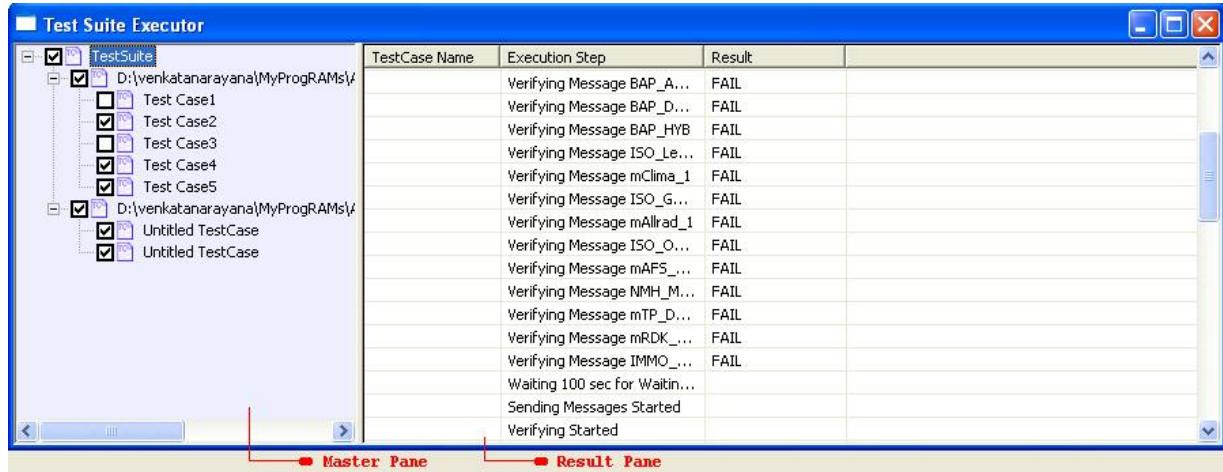
Features provided by test suite Executor

- 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 nor 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.

Database Editor

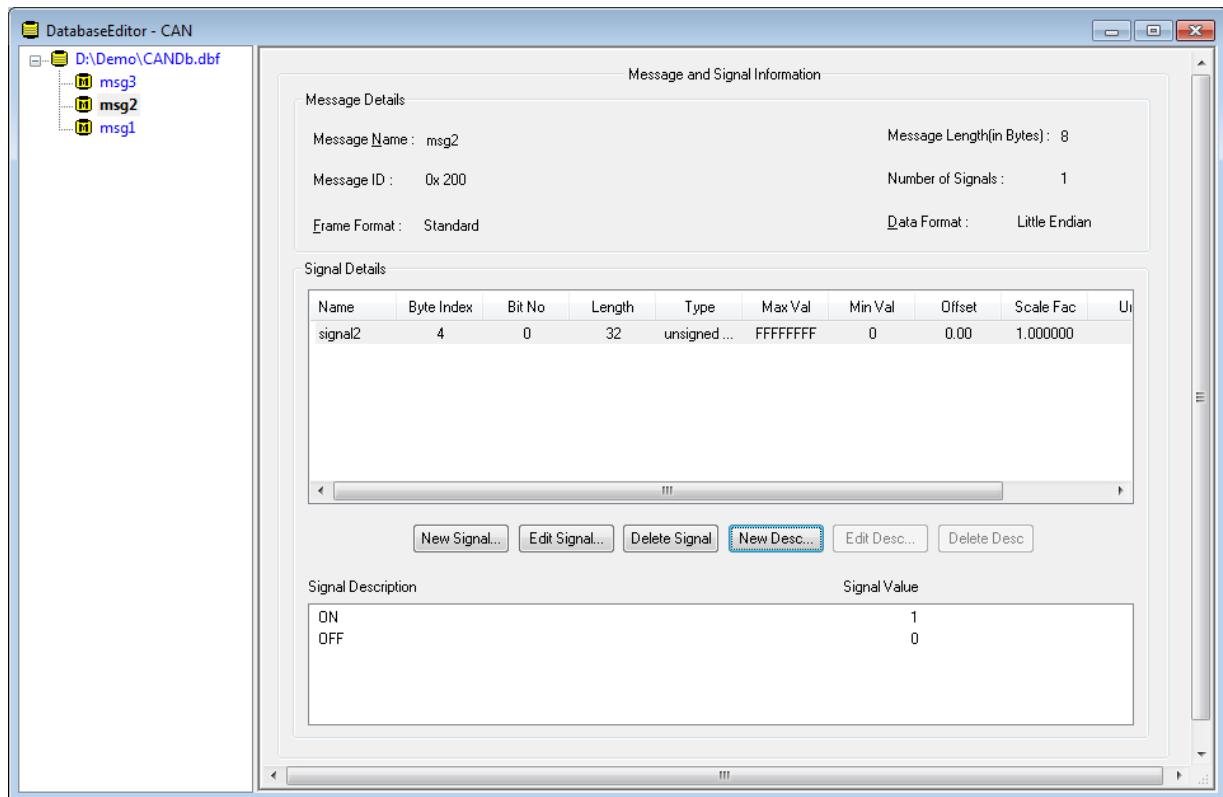
BUSMASTER database consists of information about expected message. You can create a database of messages to be transmitted or received over CAN bus. Each message has a unique ID and name. Each message has upto eight bytes of data. You can define the length of message in bytes. Each message can consist 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 **Tools-> CAN DBF Editor--> 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 **Tools-> CAN DBF Editor--> 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

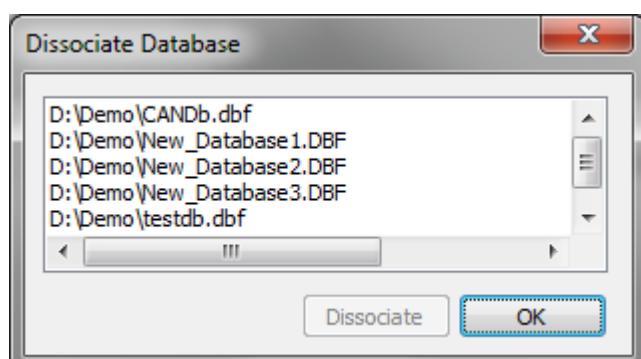
User can select any number of BUSMASTER generated database and make them as active databases.

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

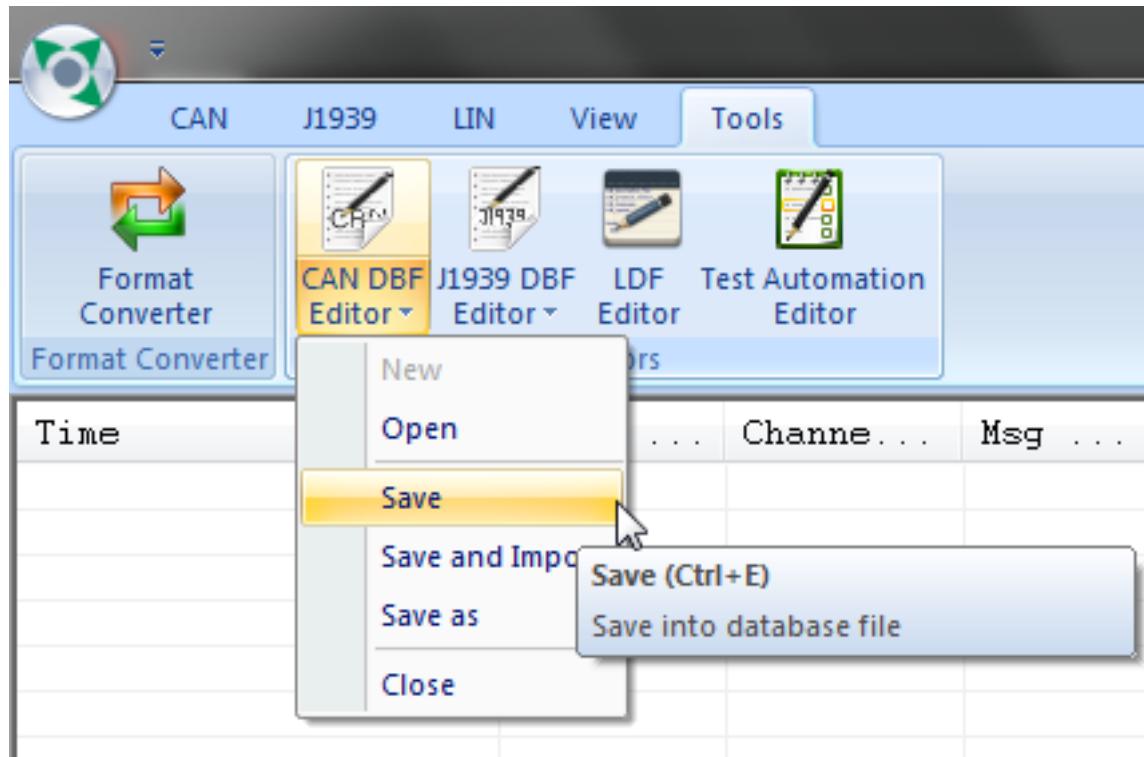
User can delete Signal description and Signal value by following the steps given below

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

COM Interface

BUSMASTER COM interface

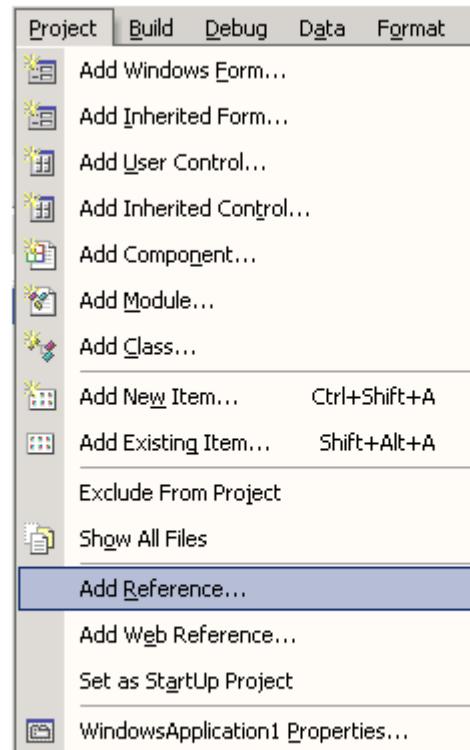
Using BUSMASTER Automation Object:

User can use all the APIs exposed by BUSMASTER, as COM interface functions in his own application by following ways:

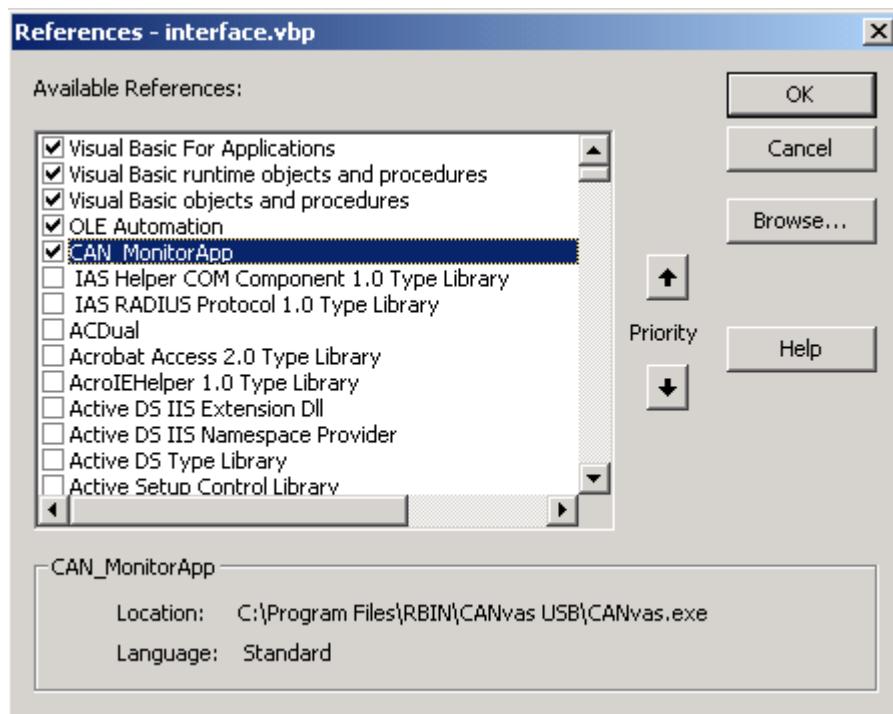
FROM VB:

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

Synopsis

```
HRESULT Connect(BOOL bConnect);
```

Description

This function connects / disconnects BUSMASTER to the bus.

Inputs

BOOL bConnect: TRUE - connect, FALSE - Disconnect

Cause of failure

NA

GetMsgInfo : Retrieves the message parameters from the loaded database, given the message name

Synopsis

```
HRESULT GetMsgInfo(BSTR MsgName,sMESSAGESTRUCT *sMsgStruct);
```

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**Synopsis**

```
HRESULT GetNetworkStatistics(int nChannel, sBUSSTATISTICS_USR *sStat);
```

Description

This function will provide the channel's statistics.

Inputs

```
Channel number and Pointer to the structuresCHANNELSTATISTICS { 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_fDLCCount; 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

GetErrorCounter : Getter for both Rx and Tx error, given the channel number**Synopsis**

```
HRESULT GetErrorCounter(UCHAR *Tx, UCHAR *Rx, INT nChannel);
```

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

ImportDatabase : To import a database file in BUSMASTER**Synopsis**

```
HRESULT ImportDatabase(BSTR DBFilePath);
```

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**Synopsis**

```
HRESULT LoadConfiguration(BSTR FileName);
```

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**Synopsis**

```
HRESULT SaveConfiguration();
```

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**Synopsis**

```
HRESULT SaveConfigurationAs(BSTR ConfigPath);
```

Description

To save current configuration in a particular configuration file.

Inputs

BSTR ConfigPath - Configuration file path.

Cause of failure

NA

RegisterClientForRx : To register Client for receiving messages**Synopsis**

```
HRESULT RegisterClientForRx([in] USHORT usUniqueID, [out] BSTR* pEventName, [out] BSTR* pPIPEName);
```

Description

This function registers a client for receiving messages.

Inputs

[in]usUniqueId - The unique Id the Client needs to provide while registering.

[out]pEventName - The event which gets notified on reception of a message. Client needs to wait on this event.

[out]pPIPEName - The Buffer on which the Rx messages will be written for the client.

Usage in COM Client

```
BSTR* pEventName;
```

```
BSTR* pPIPEName;
```

```
HRESULT hResult = m_IApplication->RegisterClientForRx(1,pEventName,pPipeName);
```

/*If HRESULT is S_OK the Client is registered with a client id of 1*/

Cause of failure

NA

UnRegisterClient : To Unregister a Client**Synopsis**

```
HRESULT UnRegisterClient([in] USHORT usUniqueID);
```

Description

This function unregisters the registered Client

Inputs

usUniqueID - Client Id.

Usage in COM Client

```
HRESULT hResult = m_IApplication->UnRegisterClient(1); //Unregisters Client with id 1;
```

Cause of failure

NA

SendCANMSg : To send a CAN message**Synopsis**

```
HRESULT SendCANMSg(CAN_MSGS *sMsg)
```

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

GetApplication : Gets pointer to BUSMASTER Application**Description**

Gets the pointer to BUSMASTER Application using which various operation in BUSMASTER is performed.

Synopsis

```
HRESULT GetApplication([out] IBusMasterApp** pApplication)
```

Inputs

[out] IBusMasterApp** pApplication - gets the pointer to BUSMASTER Application.

Usage in COM Client

```
IBusMasterApp** pApplication;
```

```
HRESULT hResult = GetApplication(pApplication);
```

Cause of failure

NA

StopLogging : To stop logging**Synopsis**

```
HRESULT StopLogging()
```

Description

This function disables logging.

Inputs

NA

Cause of failure

NA

StartLogging : To start logging**Synopsis**

```
HRESULT StartLogging();
```

Description

This function enables logging.

Inputs

NA

Cause of failure

Log file absent in configuration

AddLoggingBlock : To Add a Logging Block**Synopsis**

```
HRESULT AddLoggingBlock(SLOGGINGBLOCK_USR* psLoggingBlock);
```

Description

This function is used to add a logging block.

Inputs

SLOGGINGBLOCK_USR* psLoggingBlock - pointer to logging block

Usage in COM Client

```
SLOGGINGBLOCK_USR* psLoggingBlock = new SLOGGINGBLOCK_USR();
m_IApplication->AddLoggingBlock(psLoggingBlock);
```

Cause of failure

NA

GetLoggingBlock : To get a particular Logging Block**Synopsis**

```
HRESULT GetLoggingBlock([in] USHORT BlockIndex, [out] SLOGGINGBLOCK_USR* psLoggingBlock);
```

Description

This function gets a particular logging block

Inputs

[in] USHORT BlockIndex - The zero based logging block index.

[out] SLOGGINGBLOCK_USR* psLoggingBlock - return pointer to Logging block.

Usage in COM Client

```
SLOGGINGBLOCK_USR* psLoggingBlock
```

```
HRESULT hResult = m_IApplication->GetLoggingBlock(0,psLoggingBlock)//Gets pointer to first logging
block.
```

Cause of failure

NA

RemoveLoggingBlock : To remove a particular logging block**Synopsis**

```
HRESULT RemoveLoggingBlock([in] USHORT BlockIndex);
```

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.

GetLoggingBlockCount : Getter for total number of logging blocks**Synopsis**

```
HRESULT GetLoggingBlockCount([out] USHORT* BlockCount)
```

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

ClearLoggingBlockList : To Clear Logging block list**Synopsis**

```
HRESULT ClearLoggingBlockList(void);
```

Description

This function clears the logging block list.

Inputs

void

Cause of failure

NA

WriteToFile : Writes a text in the log file currently open**Synopsis**

```
HRESULT WriteToFile(USHORT BlockIndex, BSTR pcStr);
```

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

```
BSTR bstr;  
bstr = SysAllocString(L"In CanSendMsg1 : ");  
m_IApplication->WriteToFile(0, bstr);  
SysFreeString(bstr);
```

J1939

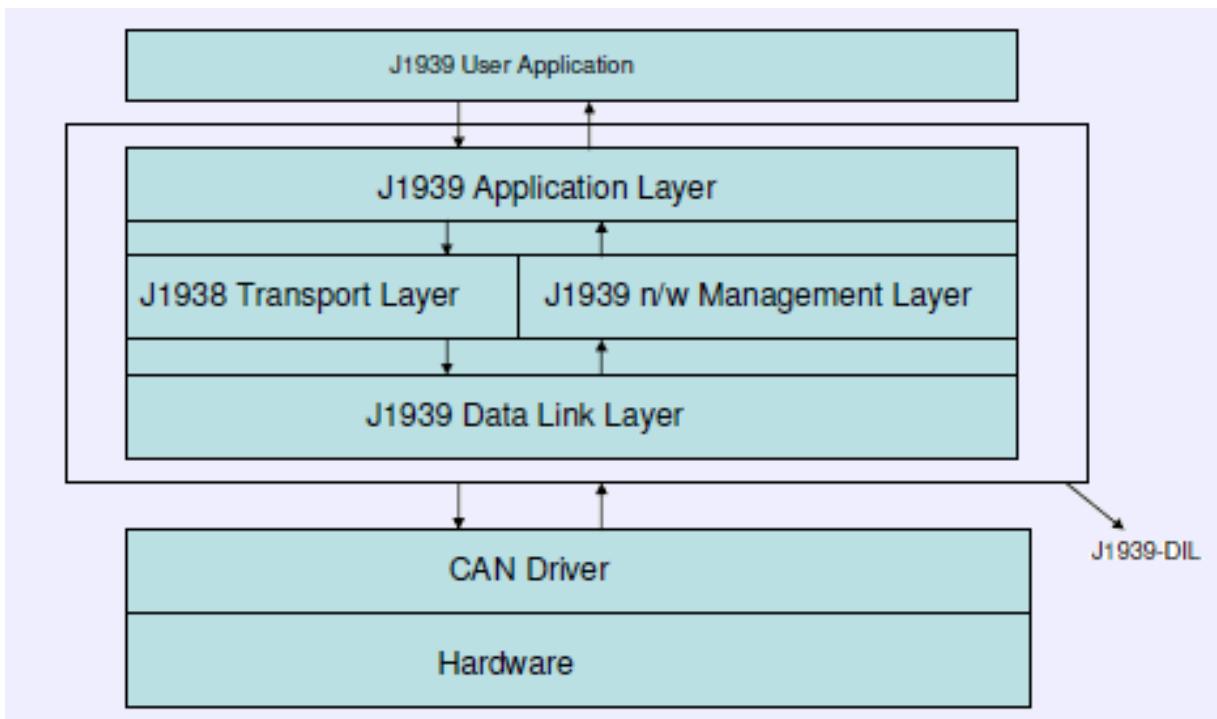
Introduction

J1939

Introduction

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

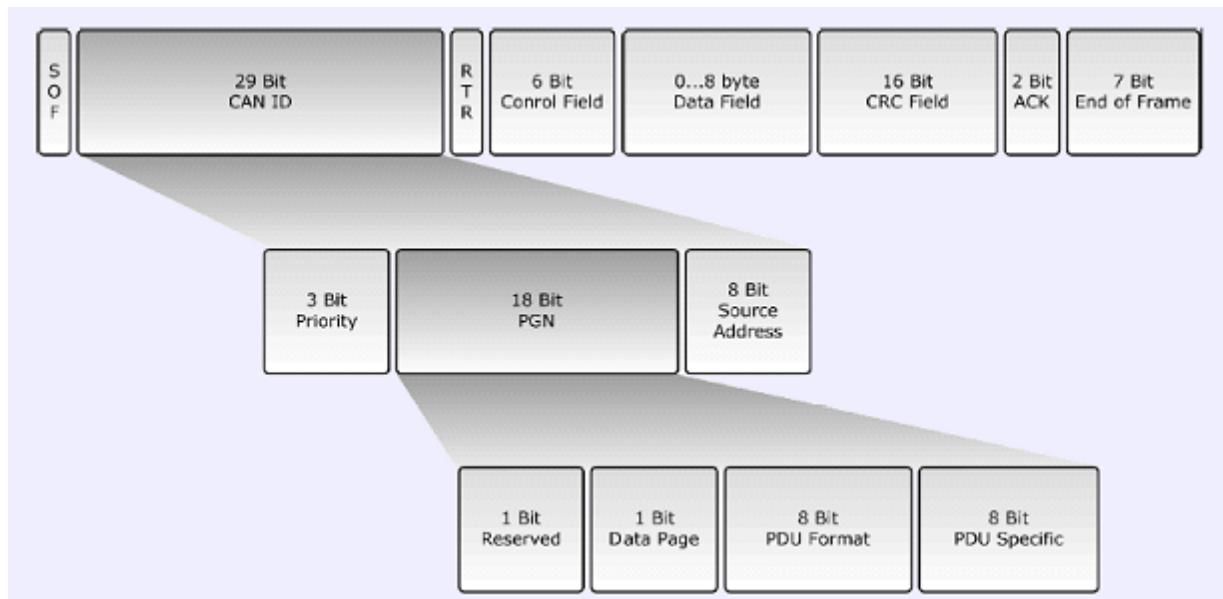
- 29 bit extended CAN identifier.
- Point-to-point and broadcast communication.
- Transmission up to 1785 bytes.



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

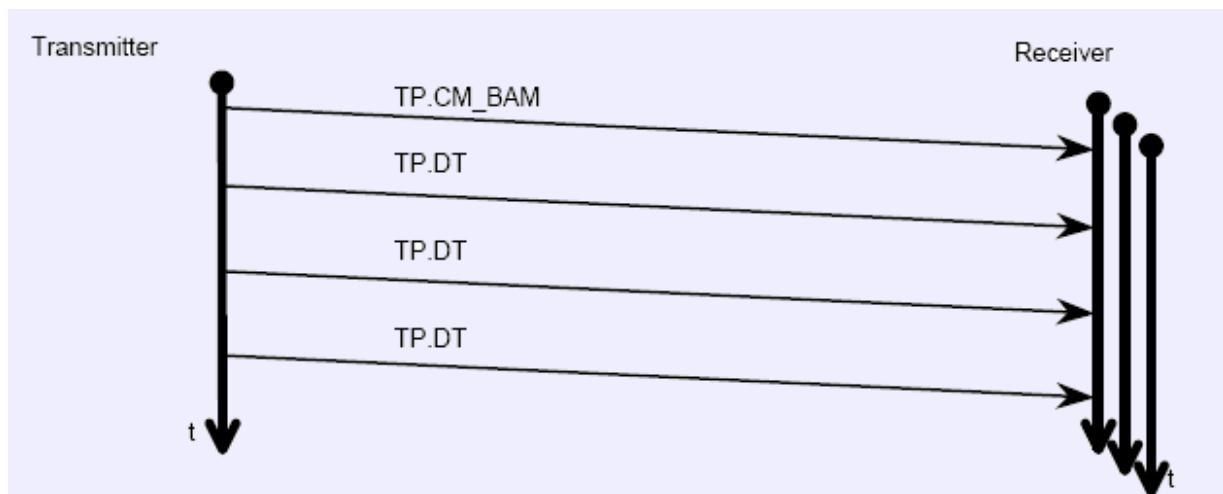
Transport protocol functions are mainly used for transmission and reception of multi-packet messages which can extend upto 1785 bytes. Function involves packaging into sequence of 8 byte size messages during transmission, re-assemble of such data at the receiver side.

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

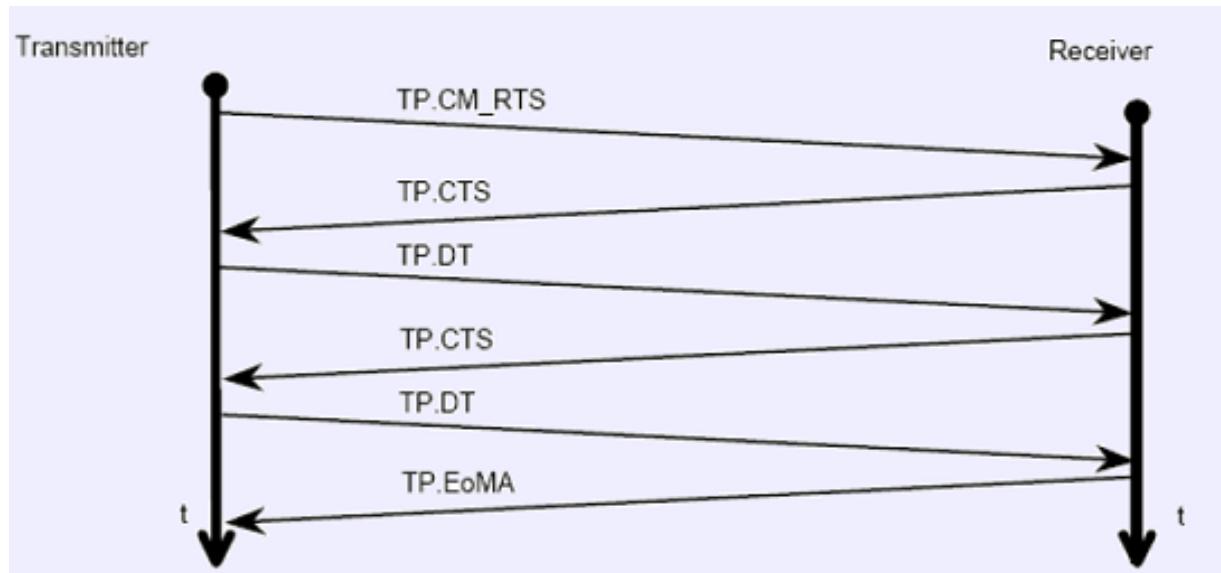
2. Multi-packet peer-to-peer

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.

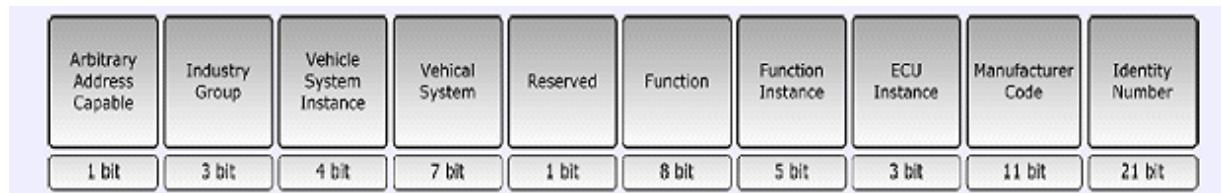


Multi-packet peer-to-peer data transfer

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 claim 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

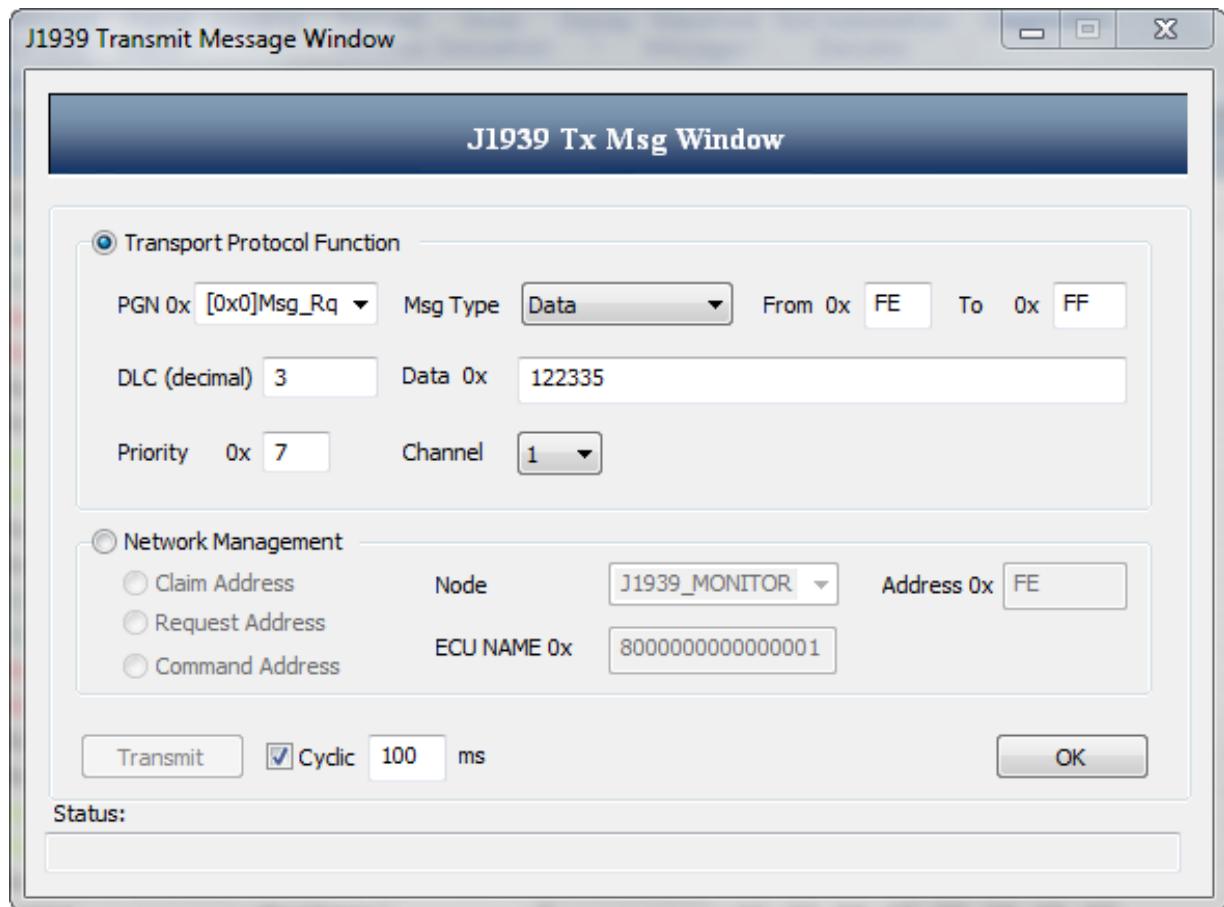
This invokes the logging configuration dialog box whose layout and the configuration procedure is exactly same as that of CAN. Only difference is that for J1939 a message is identified not by CAN identifier, but by its PGN number.

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 cyclic mode.



J1939 Transmit Message Window

Logging

By selecting the associated menu item or clicking on the toolbar icon, the user can start the logging process. This has the characteristics of a toggle switch and hence using the same, ongoing logging process can be stopped too.

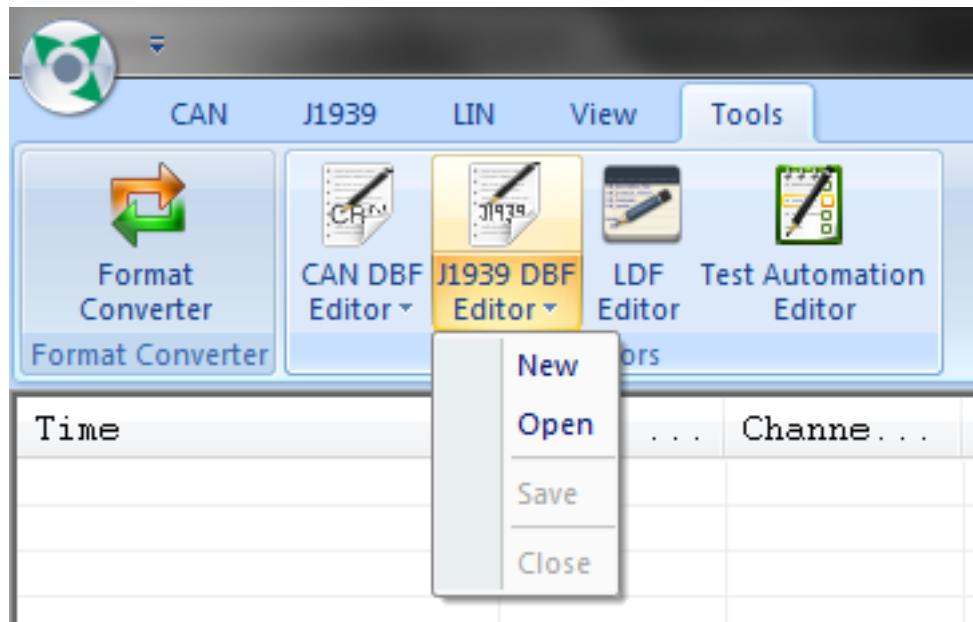
```
***<Time><Channel><CAN ID><PGN><Type> <Src><Dest><Priority><Tx/Rx><DLC><DataBytes>***
25:24:14:6112 1 18beeff00 00EE00 ACL      00 FF 006 Tx 8 01 00 00 00 00 00 00 00 80
25:24:14:6124 1 18beeff00 00EE00 ACL      00 FF 006 Rx 8 01 00 00 00 00 00 00 00 80
22:16:26:5893 2 18beeff00 00EE00 ACL      00 FF 006 Rx 8 01 00 00 00 00 00 00 00 80
22:16:26:5905 2 18beeff00 00EE00 ACL      00 FF 006 Tx 8 01 00 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 00 80
25:24:18:2355 1 1ceefffe 00EE00 ACL      FE FF 007 Tx 8 01 00 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 00 80
25:24:18:2367 1 1ceefffe 00EE00 ACL      FE FF 007 Rx 8 01 00 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 1cecffffe 00EC00 BAM     FE FF 007 Tx 8 20 09 00 02 FF 00 EE 00
22:16:32:1336 2 1cecffffe 00EC00 BAM     FE FF 007 Rx 8 20 09 00 02 FF 00 EE 00
22:16:32:1347 2 1cecffffe 00EC00 BAM     FE FF 007 Tx 8 20 09 00 02 FF 00 EE 00
25:24:20:1565 1 1cecffffe 00EC00 BAM     FE FF 007 Rx 8 20 09 00 02 FF 00 EE 00
22:16:32:2337 2 1cebffffe 00EB00 TPDT    FE FF 007 Rx 8 01 01 00 00 00 00 00 00 00
22:16:32:2349 2 1cebffffe 00EB00 TPDT    FE FF 007 Tx 8 01 01 00 00 00 00 00 00 00
25:24:20:2555 1 1cebffffe 00EB00 TPDT    FE FF 007 Tx 8 01 01 00 00 00 00 00 00 00
25:24:20:2567 1 1cebffffe 00EB00 TPDT    FE FF 007 Rx 8 01 01 00 00 00 00 00 00 00
22:16:32:3342 2 1cebffffe 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 00 80 FE
```

J1939 Log File

Message Database

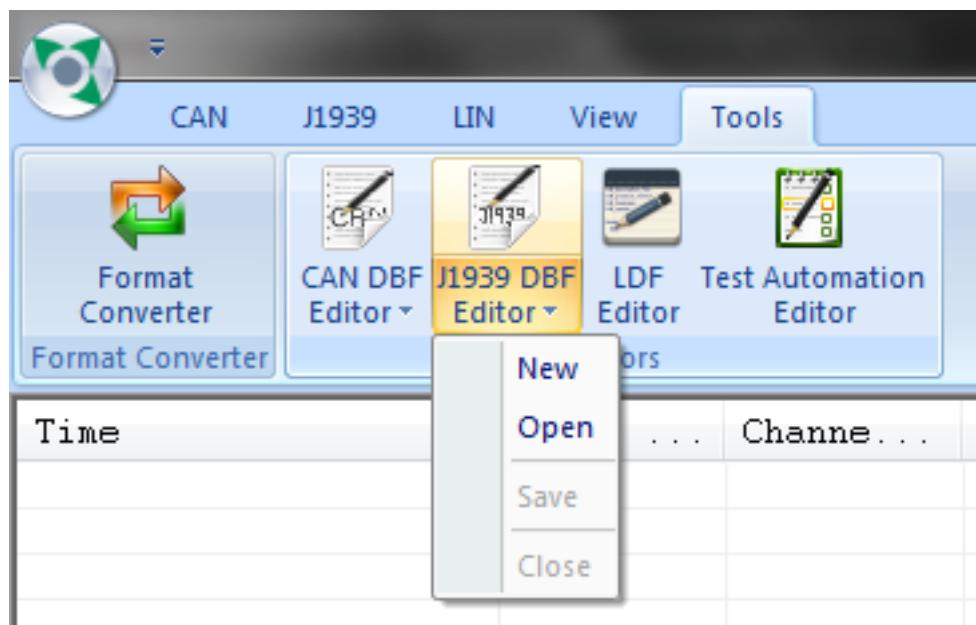
1. Database Editor:

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.

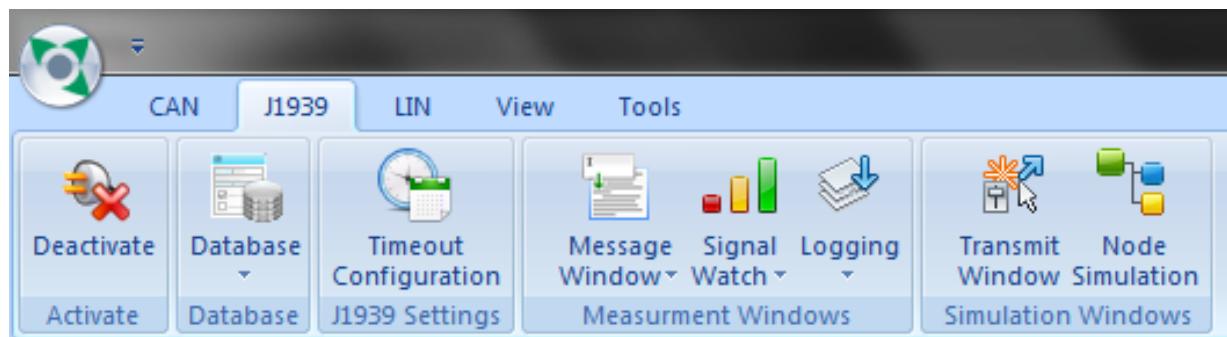


2. Database Function:

User can associate/dissociate J1939 database files.



J1939 features can be accessed from the below options.

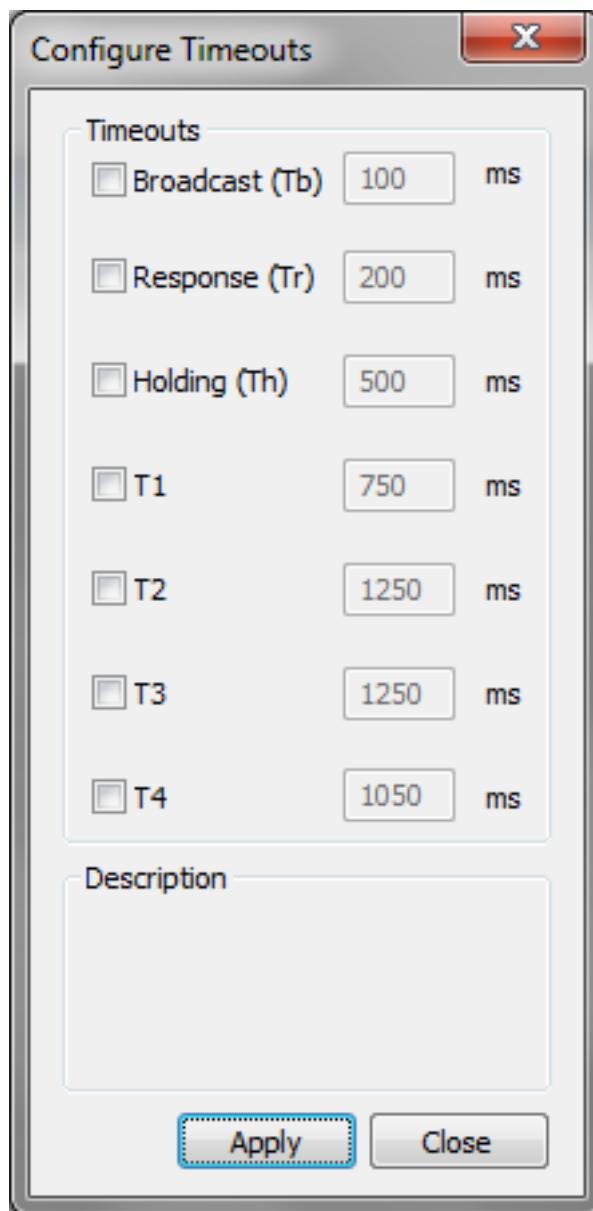


Configure Timeouts

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

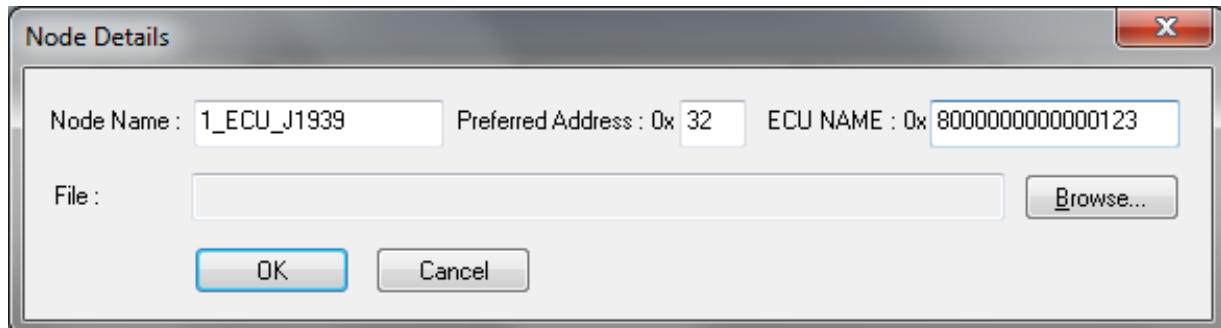
J1939 signal watch window is similar to CAN signal watch window. User can add SPNs(Signals) of the PGN defined in database.

Node Programming

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

- Node Name
- Preferred Address
- 64 bit ECU name



- 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);
```

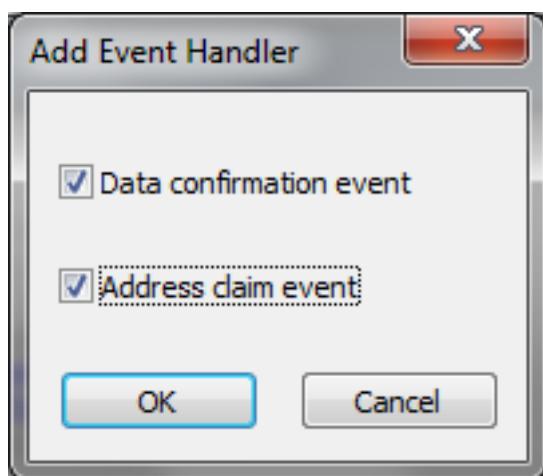
unPGN - PGN of the message transmitted. **bySrc** - Source node. **byDest** - Destination node. **bSuccess** - Result of transmission. (TRUE-success, FALSE-failure)

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

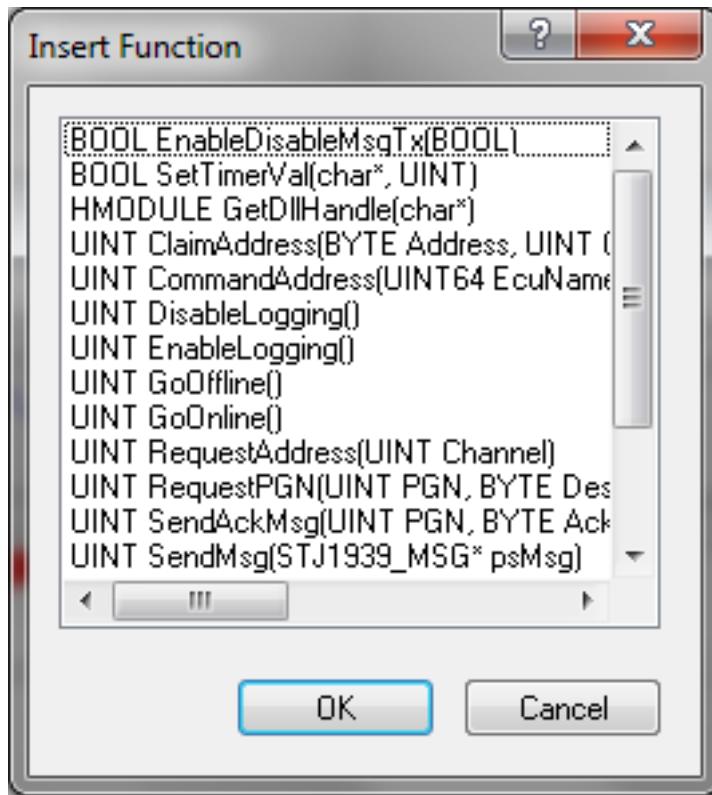
```
void OnEvent_AddressClaim(BYTE byAddress) ;
```

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

Note: These event handlers are always enabled once added.



- 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.



J1939 Node Simulation

What is new?

Node Simulation v1.2 changes

- J1939_MSG in node simulation is updated to ease accessing message attributes, signal values and to support Big Endian signals as given below

```
• class J1939_MSG
{
    unsigned __int64          timeStamp;
    unsigned char              cluster;
    EJ1939_MSG_TYPE          msgType;
    enum EDIRECTION           direction;
    J1939Id                  id;
    unsigned int               dlc;
    unsigned char[1785]         data;

    // To set data
    bool byteAt(int index, unsigned char val);
    bool wordAt(int index, unsigned short val);
    bool longAt(int index, unsigned long val);

    // To get data
    unsigned char   byteAt(int index);
    unsigned short  wordAt(int index);
    unsigned long   longAt(int index);
};

class J1939Id
{
    unsigned int      extendedId;

    // Setters
    void setId(unsigned int _extendedId);
    void setSourceAddress(unsigned char _sourceAddress)
```

```

void setPGN(unsigned int _pgn);
void setPDUFormat(unsigned char _pduFormat)
void setDataPage(unsigned char _dataPage);
void setPriority(unsigned char _priority);
void setPDUSpecific(unsigned char _pduSpecific);

// Getters
unsigned char getSourceAddress();
unsigned char getPDUFormat();
unsigned int getPGN();
unsigned char getDataPage();
unsigned char getPriority();
unsigned char getPDUSpecific();
} ;

```

- Following functions are supported to access/update Signal values
- To **set** signal rawvalue or physicalvalue
 1. rawvalue(int x); // Type 'int' will vary as per the signal type
 2. physicalvalue(double x);

To **get** signal rawvalue or physicalvalue

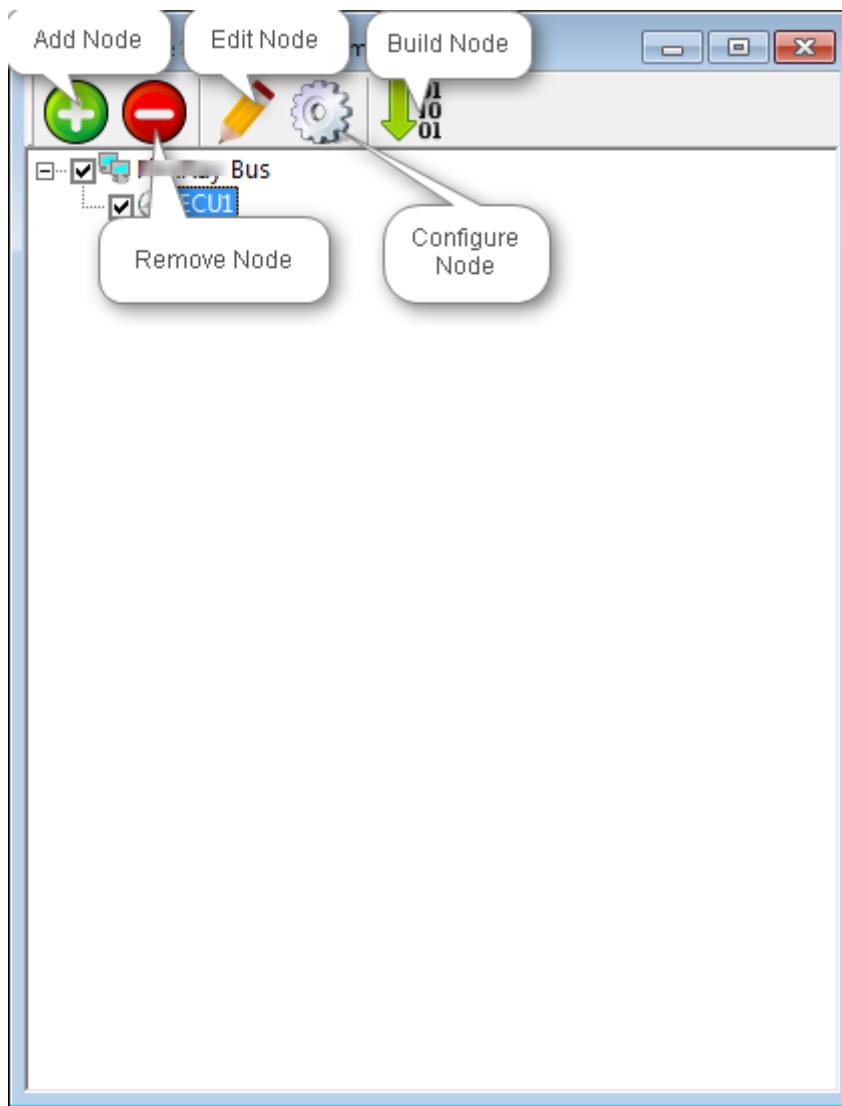
1. rawvalue(); // returns signal rawvalue
2. physicalvalue(); // returns signal physicalvalue

For more details, refer 'Examples' section under 'J1939->Node Simulation'

- For more details, refer 'BMJ1939Defines.h' in installation folder under 'SimulatedSystems\include'

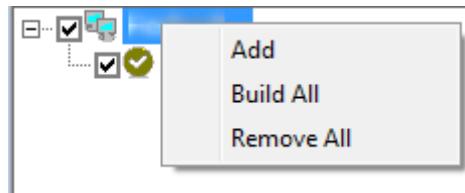
Node Simulation Configuration

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



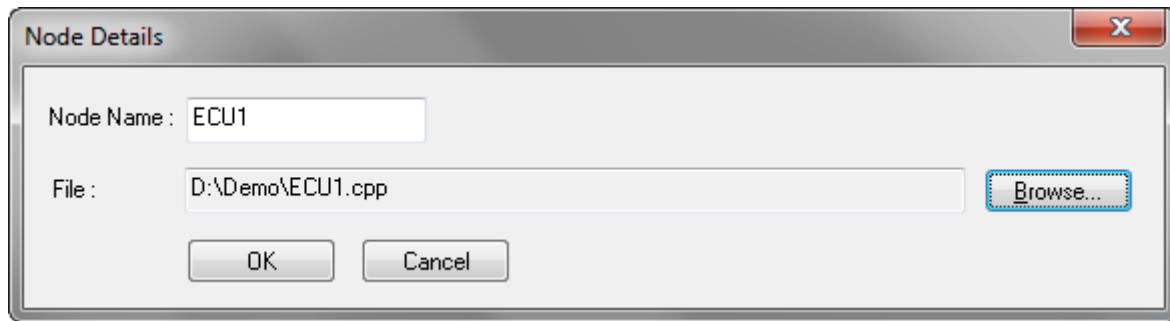
Add Node

This is used to added .cpp/.dll files to Node Simulation. Add Node can be done by following ways:



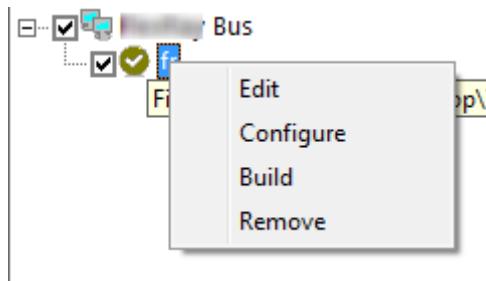
1. Right click the Root Node(<Protocol> Bus) and select "Add".
2. Click Add Node in the toolbar.
3. Pressing "Insert" key in the keyboard.

Then "Node Details" dialog box appears as shown below. Add unique Node name and add existing .cpp/.dll or provide new File name to create new .cpp file.



Edit Node

This is used to edit the .cpp file attached to a Node. Editing can be done by following ways:



1. Select the Node then Right click and select "Edit".
2. Select the Node and click "Edit Node" in the toolbar.
3. Select the Node and press "Enter" key in the keyboard.

Then "Function Editor" window appears in which the required editing can be done.

Remove Node

This is used remove selected node all the nodes in the Simulated system. Removing a Node can be done by following ways:

1. Select the Node then Right click and select "Remove". To Remove All Nodes select Root Node(<Protocol> Bus) and select "Remove All".
2. Select the Node and click "Remove Node" in the toolbar. To Remove All Nodes select Root Node(<Protocol> Bus) and select "Remove Node" in the toolbar.
3. Select the Node and press "Delete" key in the keyboard. To Remove All Nodes select Root Node(<Protocol> Bus) and press "Delete" key.

Configure Node

This is used change the name of the Node or change/add .cpp/.dll associated with a Node. Configuring a Node can be done by following ways:

1. Select the Node then Right click and select "Configure".
2. Select the Node and click "Configure Node" in the toolbar.
3. If no .cpp/.dll files are associated with the node previously, then by pressing "Enter" key in the keyboard.

Build Node

This is used build the .cpp files associated with selected Node or all the nodes in the Simulated System. Building a Node can be done by following ways:

1. Select the Node then Right click and select "Build". To Build All Nodes select Root Node(<Protocol> Bus) and select "Build All".
2. Select the Node and click "Build Node" in the toolbar. To Build All Nodes select Root Node(<Protocol> Bus) and select "Build All" in the toolbar.

Enable/Disable Node

This used to active/deactivate selected Node or all the Nodes in the Simulated System. Enabling/Disabling can be done by following ways:

1. Check/Uncheck the checkbox associated with the Node will Enable/Disable the Node respectively. To Enable/Disable all the Nodes Check/Uncheck the Root Node(<Protocol> Bus) respectively.
2. "Spacebar" key can be used as keyboard shortcut to Check/Uncheck the Node(s).

 **Note:**

1. Node(s) can't be Added/Removed/Configured/Enabled/Disabled while the network is connected.
2. A Node can be edited while the network is connected. But the file must be built again to see the changes.

J1939 API Reference

J1939 Structures

J1939_MSG is the message structure which accepts J1939 parameters and data.

Example:

J1939_MSG objMsg;

Member s of J1939_MSG	Description
id	Extended CAN identifier used for J1939 message identification. Contains PGN, Priority, PDU Format, Pdu Specific and Source Address. Example: To set identifier, objMsg.id =0x1cfefefe . To get identifier, unsigned int nId = id;
dlc	Data Length in bytes [0-1784]
cluster	channel on which the frame is received or to be transmitted
data[1785]	Message data
timeStamp	Received frame timestamp in 100 microseconds
bool byteAt (int index, unsigned char val)	To set data byte (8 bit). Possible index: [0-7]. Example: <code>byteAt(0, 10); '0' is index, 10 is value</code>
bool wordAt (int index, unsigned short val)	To set data word (16 bit). Possible index: [0-3]. Example: <code>wordAt(0, 10); '0' is index, 10 is value.</code>
bool longAt (int index, unsigned long val)	To set data word (32 bit). Possible index: [0-1]. Example: <code>longAt(0, 10); '0' is index, 10 is value.</code>

Accessing J1939 specific parameters:

Parameter	Description
extendedId	Extended CAN identifier used for J1939 message identification. Example: <code>id.extendedId = 0x1cfefefe</code>
void setId (unsigned int _extendedId)	To set extended identifier. Example: <code>id.setId(0x1cfefefe);</code>
void setPGN (unsigned int _pgn)	To set Parameter Group Number. Example: <code>id.setPGN(0xfefe);</code>
void setPriority (unsigned char _priority)	To set Priority parameter in PGN. Example: <code>id.setPriority(1);</code>

<code>void setPDUFormat(unsigned char _pduFormat)</code>	To set PDU Format in PGN. Example: id.setPDUFormat(0xfe);
<code>void setPDUSpecific(unsigned char _pduSpecific)</code>	To set PDU Specific in PGN. Example: id.setPDUSpecific(0xfe);
<code>void setDataPage(unsigned char _dataPage)</code>	To set data Page in PGN
<code>void setSourceAddress(unsigned char _sourceAddress)</code>	To set Source Address. Example: id.setSourceAddress(0xfe);
<code>unsigned int getPGN()</code>	To get PGN of J1939 message. Example: unsigned int pgn = id.getPGN();
<code>unsigned char getPriority()</code>	To get Priority. Example: unsigned char priority = id.getPriority();
<code>unsigned char getPDUFormat()</code>	To get Pdu Format. Example: unsigned char pduFormat = id.getPDUFormat();
<code>unsigned char getPDUSpecific()</code>	To get Pdu Specific. Example: unsigned char pduSpecific = id.getPDUSpecific();
<code>unsigned char getDataPage()</code>	To get data page. Example: unsigned char dataPage = id.getDataPage();
<code>unsigned char getSourceAddress()</code>	To get Source Address. Example: unsigned char nPduSpecific = id.getSourceAddress();

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

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

```
UINT WriteToFile ( 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

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 acknowledgement 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

Examples**Message Transmission:**

```
J1939_MSG objMsg;
objMsg.id = 0x1cfefefe;
objMsg.dlc = 215;
for(int i =0; i < objMsg.dlc; i++)
{
    objMsg.byteAt(i, i*2);
}
SendMsg(objMsg);
```

Database message transmission:

```
// Message Declaration
DBMsg sMsgStruct; // DBMsg is a database message

// Use signal member
// Sig1
sMsgStruct.Sig_1 = 10; // for setting signal raw value
// Sig2
sMsgStruct.Sig_2 = 20;
// Sig3
sMsgStruct.Sig_3 = 30;
// Send the message now
SendMsg(sMsgStruct);
```

Setting J1939 Specific parameters:

```
J1939_MSG objMsg;
objMsg.id.setPGN(0xfefe);
objMsg.id.setSourceAddress(0xfe);
objMsg.id.setPriority(7);
objMsg.dlc = 215;
for(int i =0; i < objMsg.dlc; i++)
{
    objMsg.byteAt(i, i*2);
}
SendMsg(objMsg);
```

Accessing J1939 Specific Parameters:

```
J1939_MSG objMsg;
unsigned int nPGN = objMsg.id.getPGN();
char nPduSpecific = objMsg.id.getSourceAddress();
unsigned char dataPage = id.getDataPage();
objMsg.id.getPriority();
```

Accessing signal values:

```
// Message Declaration
DBMsg sMsgStruct;

// Use signal member
// Sig1
int sig1Value = sMsgStruct.Sig_1; // Type 'int' to be changed as per
// signal type
// Sig2
int sig2Value = sMsgStruct.Sig_2;
// Sig3
int sig3Value = sMsgStruct.Sig_3;

(OR)

int sig1Rawvalue = sMsgStruct.sig1.rawvalue();

(OR)

double sig1PhyValue = sMsgStruct.sig1.physicalvalue();
```

Updating 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.

DBMsg 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
DBMsg sMsgStruct;

// Use signal member
// Sig1
sMsgStruct..Sig_1 = 10;
// Sig2
sMsgStruct.Sig_2 = 20;
// Sig3
sMsgStruct.Sig_3 = 30;

(OR)

sMsgStruct.sig1.rawvalue(10);

(OR)

sMsgStruct.sig1.physicalvalue(12.4);
```



Note:

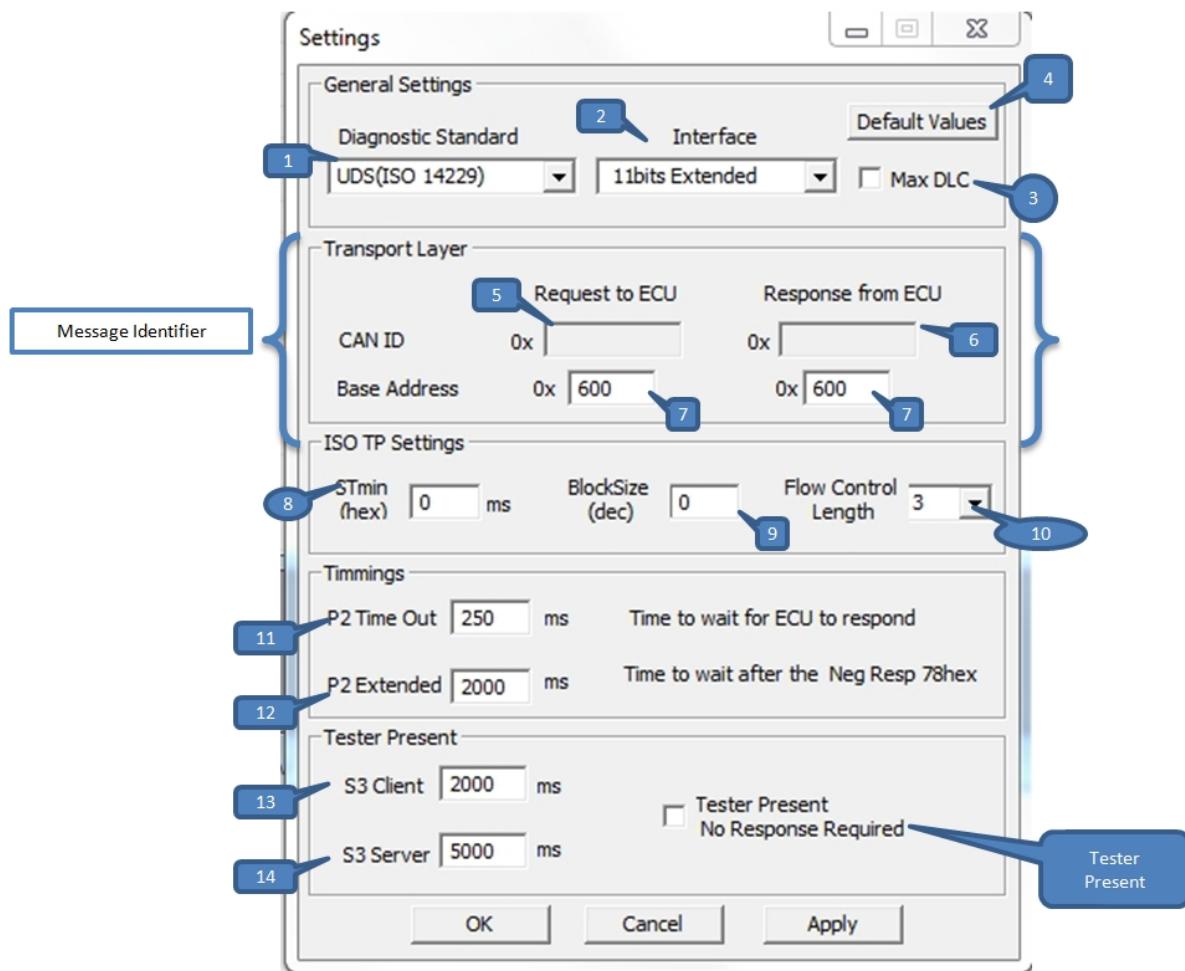
- Right click on edit area of function editor. Select "Insert Message" or "Insert Signal" option to insert message structure or signal structure. Select the option "Yes, I want to declare selected message structure variable" option in the "Message and Signal List" to initialise message with its struct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

Diagnostics

Diagnostics Settings

Diagnostics settings window is used to set the settings for transmitting diagnostics requests and for receiving diagnostics response messages.

To configure diagnostic settings use CAN->Diagnostics->Settings menu. This will display the Window as shown below.



1. Diagnostics Standard

To select diagnostics standard UDS (ISO 14229) or ISO 14230

2. Interface

To select the type of the interface 11 bit or 29 bit interface

3. Max DLC

If checked, the data length of the messages transmitted will be set to 8 bytes even if the data length of the message is less than 8 bytes

4. Default Values

To reset to default settings

5. CAN ID (Request to ECU)

To set the identifier of the diagnostic request message that is to be transmitted

6. CAN ID (Response from ECU)

To set the identifier of the diagnostic response message that is to be received

7. Base address

Indicates the base of the 11 bit message identifier. Enabled only if the interface selected is 11 bit Extended interface

8. STmin

Indicates the time delay between transmission of two consecutive frames

9. Block Size

Maximum number of consecutive frames that a sender can send before waiting for the flow control

10. Flow Control Length

Length of the flow control to be transmitted

11. P2 Time Out

Indicates the time that the tool should wait for the ECU to respond

12. P2 Extended

Indicates the time to wait after the Negative response received

13. S3 Client

Indicates the time delay between tester present messages to be transmitted

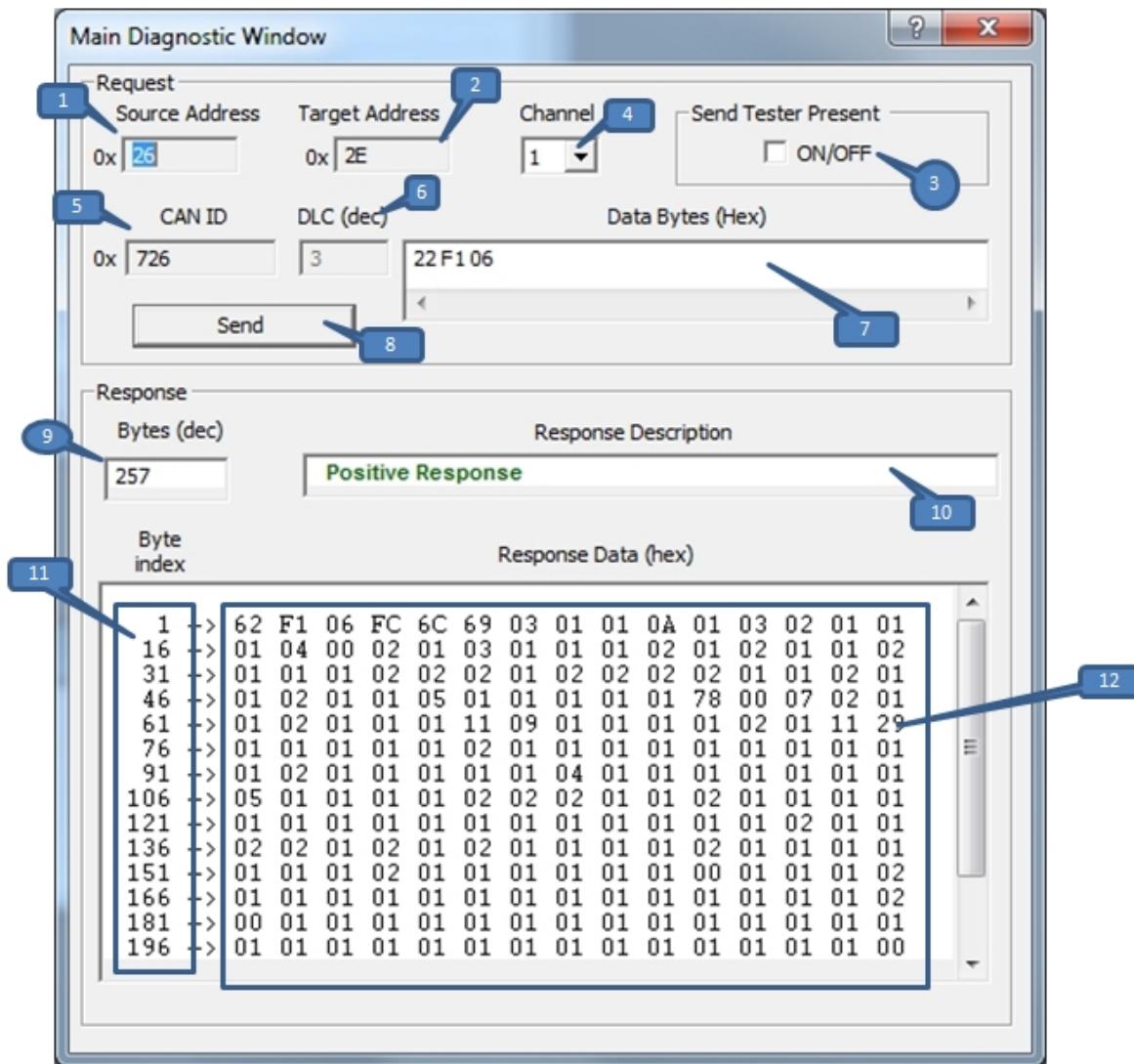
Diagnostics Main Window

Introduction:

Diagnostics Main Window is used to transmit diagnostics requests and to monitor the diagnostics responses received from the ECU

Configuration:

To configure diagnostic requests for transmission or to monitor diagnostic response use **CAN->Diagnostics->Transmit Window** menu. This will display the Window as shown below.



Displayed Fields:

1. Source Address

To specify the Source Address if the interface is selected as 29 bit interface

If the interface is selected as 11 bit interface, the source address will be taken from **CAN ID Request** to ECU field in the **Settings** window

2. Target Address

To specify the Target address if the interface is selected as 29 bit interface

If the interface is selected as 11 bit interface, the source address will be taken from **CAN ID Response** from ECU field in the **Settings** window

3. Send Tester Present

Checked to transmit tester present message

4. Max DLC

If checked, the data length of the messages transmitted will be set to 8 bytes even if the data length of the message is less than 8 bytes

5. Channel

Channel number on which the message to be transmitted

6. CAN ID

Indicates the message identifier

7. DLC

Displays the data length of the message based on the bytes inserted in the Data Bytes field

8. Data Bytes

Data bytes to be transmitted

9. Send

Transmits the configured message

10. Bytes

Number of data bytes received as response to the request sent

11. Response Description

Description of the response received

12. Byte Index

Index or position of the data bytes

13. Response Data

Data bytes received as response to the request sent

LIN

Introduction

LIN Simulation in BUSMASTER

Introduction:

BUSMASTER can be used as master to transmit master requests and as slave to respond to master requests. User can monitor/analyze the LIN messages using BUSMASTER. The following steps are required to Configure the BUSMASTER for transmission of frame headers or transmission/reception of LIN messages.

1. Cluster Configuration:

1. To Transmit|Receive the LIN Messages BUSMASTER has to be configured with LIN Baud Rate and Version. Refer [LIN Cluster Configuration](#) on page 109 Section for more Information.
2. To enable master mode for LIN channel for transmitting frame headers, check the **Enable Master Mode** check box under [LIN Network Settings](#)

2. Schedule Table Configuration:

Configure Schedule Table window can be used to select schedule table/frame headers for transmission imported from the loaded LDF file if BUSMASTER is used as master. Refer [LIN Schedule Table Configuration](#) on page 110 for more information.

3. Controller (Driver) Selection:

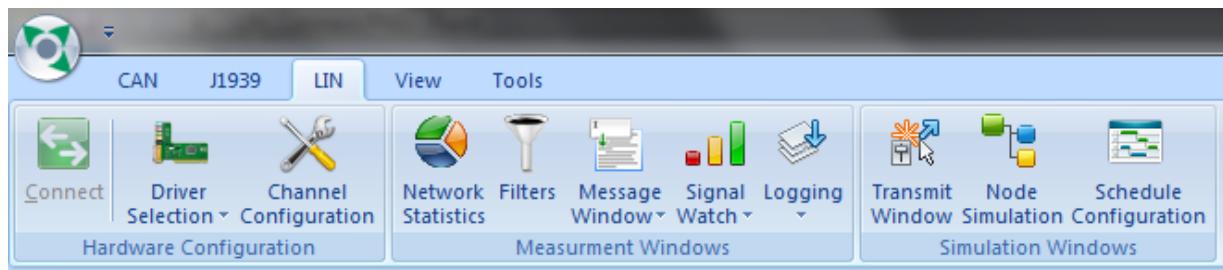
BUSMASTER can be connected to Physical LIN Network using LIN Controller. Refer [LIN Controller Configuration](#) on page 111 section for more Information.

4. Transmit Messages:

LIN Slave Messages or LIN Master requests Can be transmitted over LIN network using LIN Tx Window. Refer [LIN Transmit Window](#) on page 112 Section for more information.

5. 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.



6. Monitoring Messages:

BUSMASTER Message Window can be used to monitor the LIN messages of LIN Network. Refer [LIN Message Window](#) on page 113 section for more information.

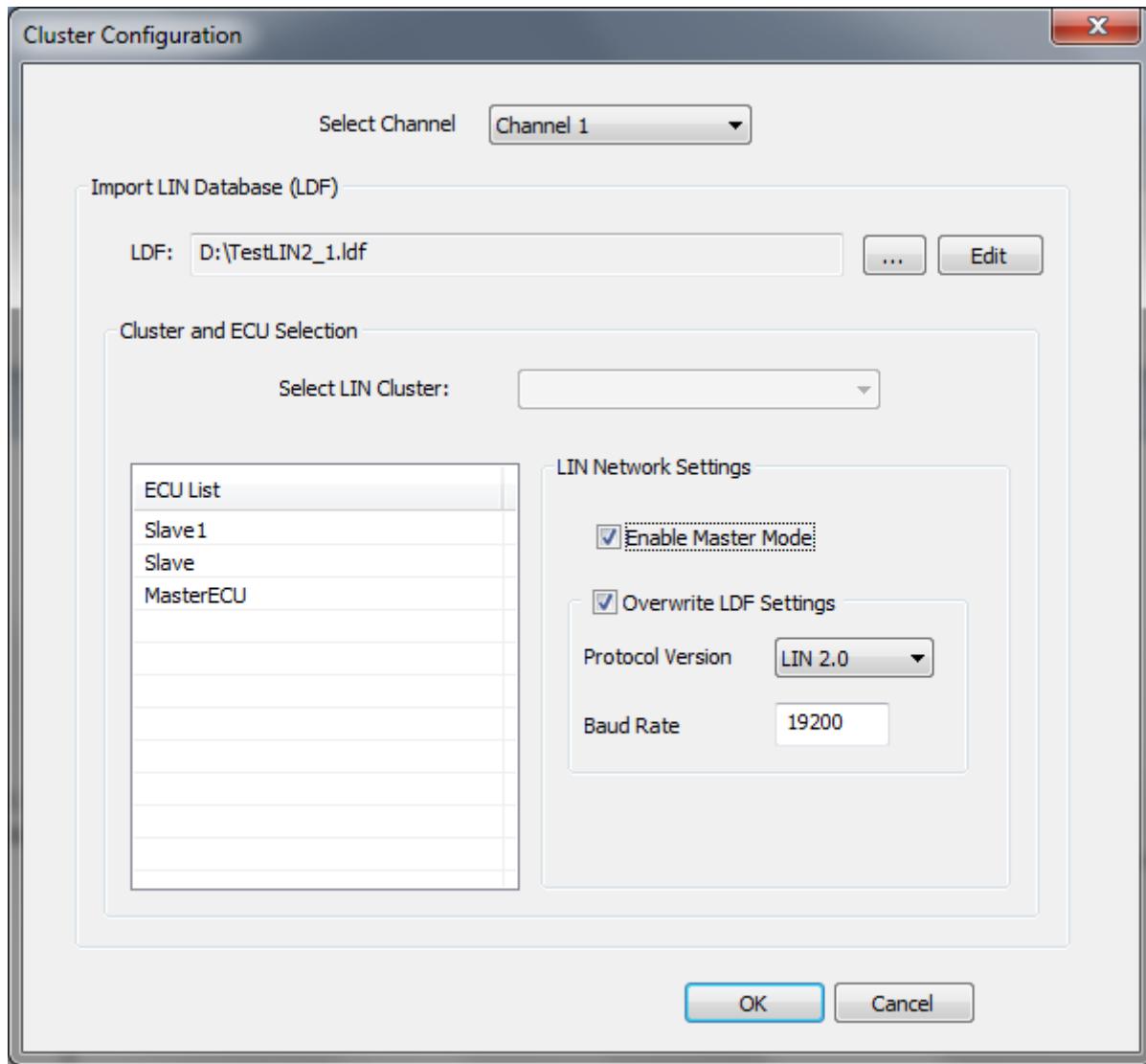
LIN Cluster Configuration

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->Channel Configuration** menu. This will display the Window as shown in following Figure.

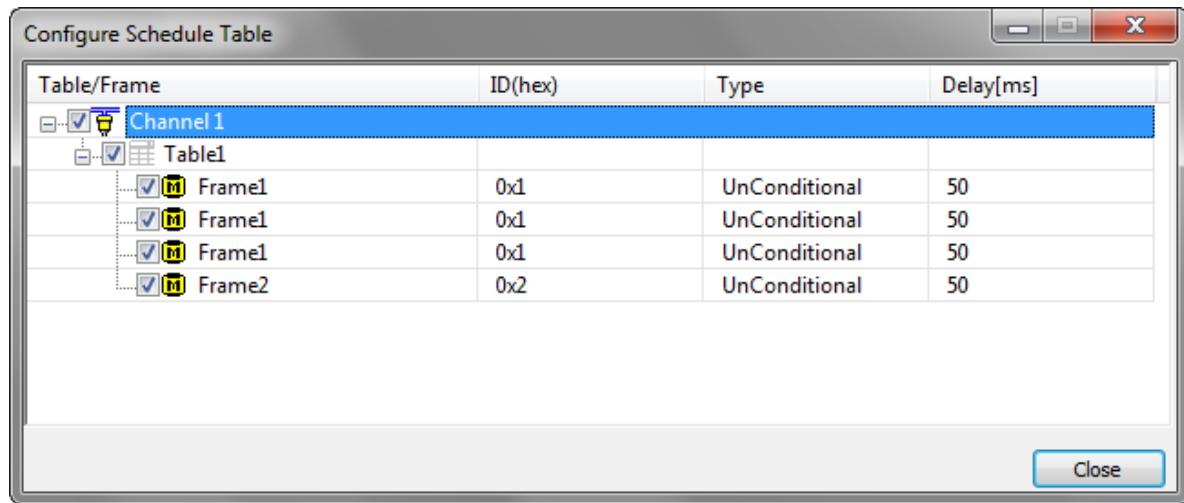


1. To enable master mode for LIN channel for transmitting frame headers, check the **Enable Master Mode** check box under **LIN Network Settings**
2. LIN baud rate & Protocol version can be set either by loading the LDF file or can be set explicitly by using **LIN Network Settings** section by Enabling **Overwrite LDF Settings** as shown in above figure.

LIN Schedule Table Configuration

LIN Schedule Table Configuration can be used to configure schedule tables imported from LDF file to transmit master requests by following the below steps.

1. To configure Schedule Table use **LIN->Schedule Configuration** menu which displays **Configure Schedule Table** dialog as shown below.



2. Configure Schedule Table window displays the Schedule Tables channel wise.
3. Frames will be listed under respective Schedule table.

Displayed Columns

- **Table/Frame**

Schedule Table name or Frame name

- **ID(hex)**

Frame Identifier displayed in hex mode

- **Type**

Frame type or Command name

- **Delay**

Frame delay time in ms

4. To select the Schedule Table from the list, mark the respective Schedule Table as checked. By which all the frames part of Schedule Table will be selected
5. User can select/de-select the frame(s) by marking the frame as check/un-check.
6. Master request(s) shall be sent only for the selected frame(s) at pre-configured time interval as specified in the Schedule table.
7. Schedule Tables and Frames can be selected/de-selected during runtime.
8. The check status of Schedule Table and the frames will be stored in the configuration file and retained on importing configuration file.



Note:

- Schedule Tables and frames from the **Configure Schedule Table** window will be considered when BUSMASTER simulates the LIN Master node of a LIN network
- From the LDF file imported, only unconditional frames in the Schedule Table will be considered for the configuration and execution.

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 LDF file needs to be associated)
2. ETAS ISOLAR-EVE
3. PEAK USB
4. Vector XL
5. Kvaser LIN

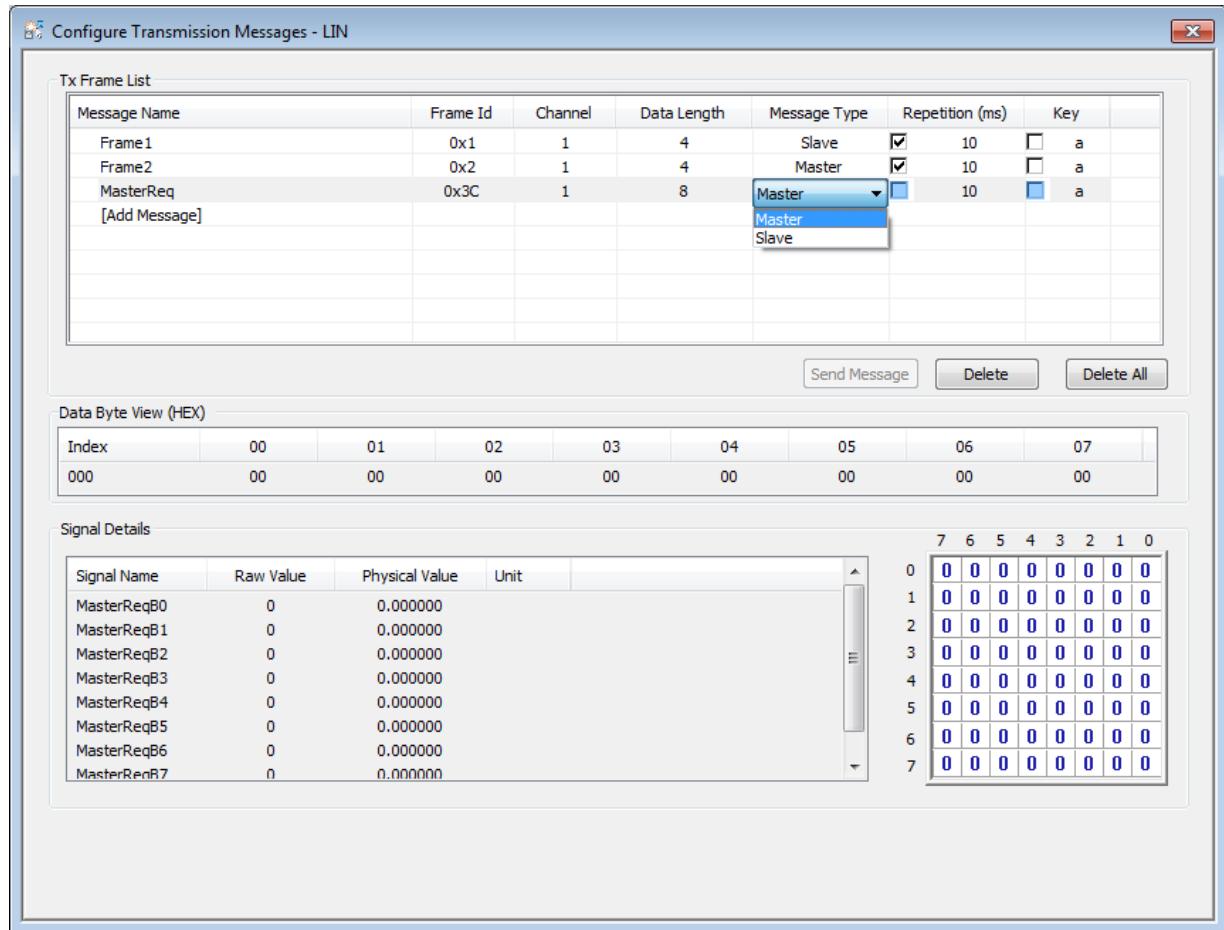
Selecting Controller:

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.

LIN Transmit Window

BUSMASTER LIN Transmit Window (Tx Window) can be used to transmit frame headers (If BUSMASTER is configured as Master. Check section [LIN Cluster Configuration](#) for more information)and Slave data. Use **LIN --> Transmit Window** menu option, to open the LIN Transmission Window.



Configuring Messages:

Once a LDF File is imported the Messages(DB Messages) in LDF file will be populated in **Tx Frame list** column.Double Click on **[Add Message]** to select data base message.It is also possible to add Non-db Messages by typing Message id.

Configure Master Requests:

- Select the frame type as **Header** from the Type group
- Dlc and data byte values will not be editable for frame Header

Configure Slave Responses:

- Select the frame type as **Response** from the Type group
- The DLC and data byte values can be changed using DLC and Data Bytes edit box windows.

Updating Signal Values:

- 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.

Signal Details							
Signal Name	Raw Value	Physical Value	Unit				
SlaveRespB0	C	12.000000					
SlaveRespB1	0	0.000000					
SlaveRespB2	0	0.000000					
SlaveRespB3	0	0.000000					
SlaveRespB4	0	0.000000					
SlaveRespB5	0	0.000000					
SlaveRespB6	0	0.000000					
SlaveRespB7	0	0.000000					

7	6	5	4	3	2	1	0
0	0	0	0	1	1	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0

Cyclic Transmission of Message:

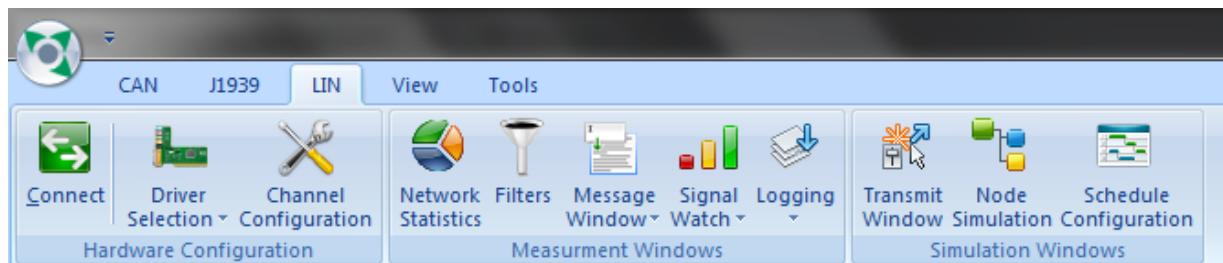
The message/frame header can be transmitted periodically by Enabling Repetition.Cyclic Transmission will be useful to transmit the message with different data bytes periodically.

Transmission on Event:

The Message/frame header can be sent to the controller on pressing key.Each message in Tx Frame List 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.

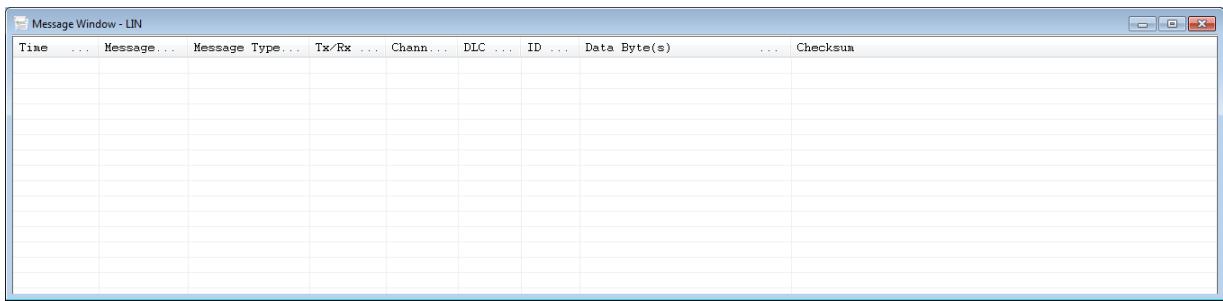
LIN Message Window

Introduction:

On-line LIN Network Monitoring can be done using LIN Message window.

Activation:

Use **LIN->Message Window->Activate** menu to Activate the Message window.This will display Message Window as shown in following figure.



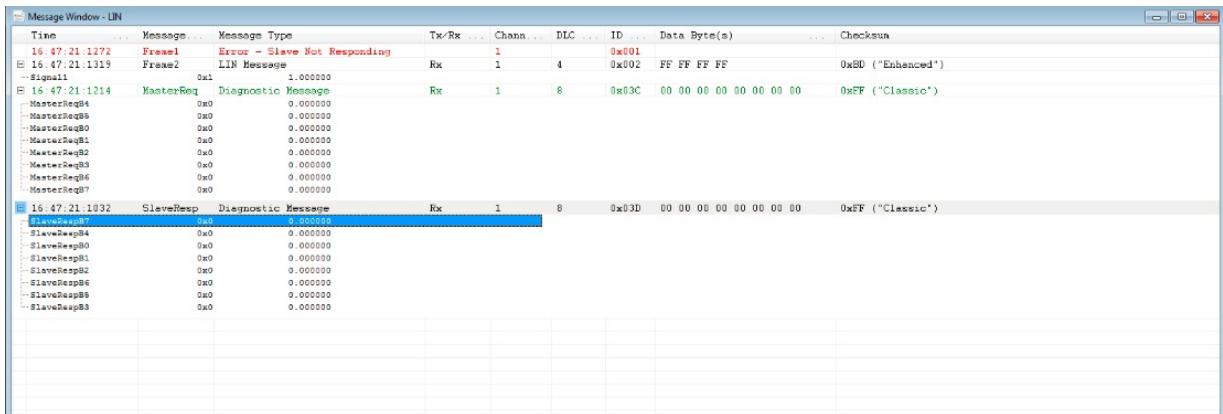
Once the BUSMASTER is connected to LIN Network the Message window will display all the Messages Transmitted on the network. Also the Message window will display the LIN Error Messages & other LIN Events. Currently the following Error or Event messages were supported.

- 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.



The Following section will explain the Columns Displayed in Message window with explanation.

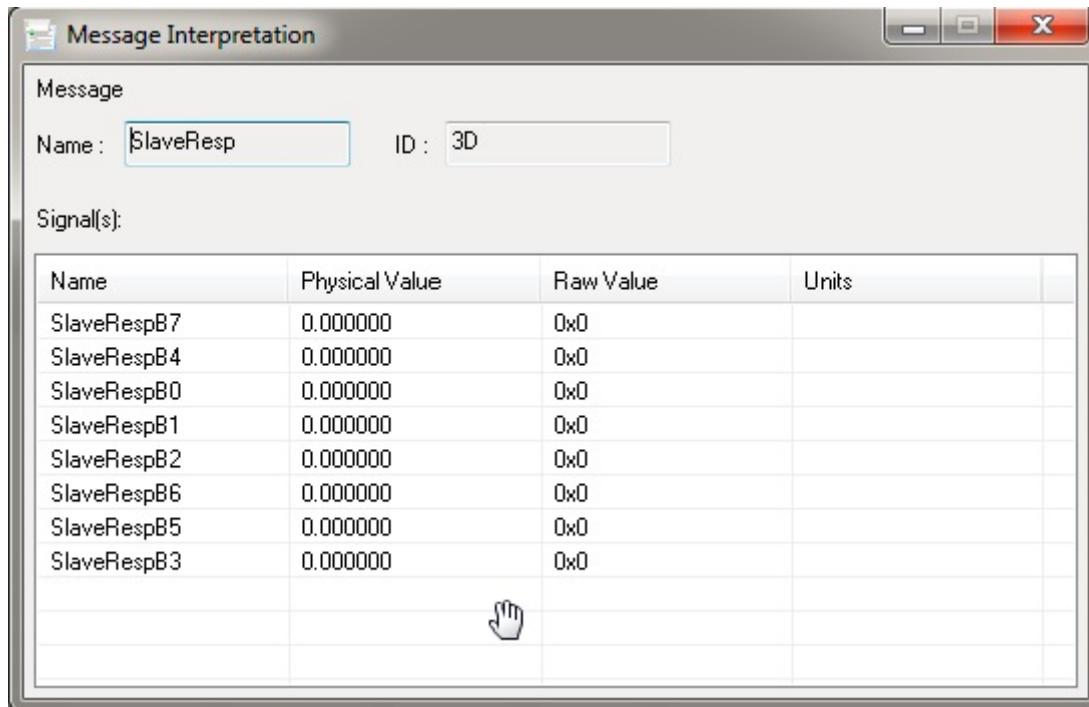
Table 1:

Column	Explanation
Time	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 LIN->Message Window->Time Mode menu
Tx/Rx	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
Message	Displays the Name of message if available in LDF file

Column	Explanation
Message Type	This Column will tell the Frame type. The following are the Frame types displayed in this column. <ul style="list-style-type: none"> • LIN Frame • Error - Slave No Response • Error - CRC Error • Event - Sleep • Event - Wakeup
ID	Displays the LIN Message ID.
Checksum	This column will give the Checksum value and Checksum type.
Channel	This column will display on which channel (A, B or AB) the message was received.
DLC	This column will display the Length of Frame in Bytes.
Data Byte (s)	This column will display the Data Bytes received\Transmitted of the Frame

Message Interpretation window:

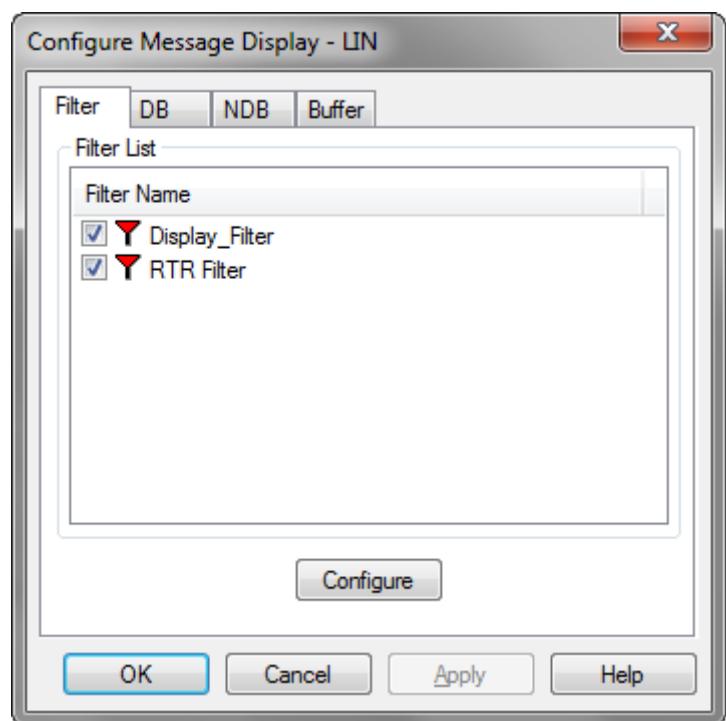
It is possible to Monitor the interpretation of a single message in separate window called **Message Interpretation**. Double click on any message in Message window to Activate the Message Interpretation window. An Instance of this window is shown in following figure.



Message Window Configuration

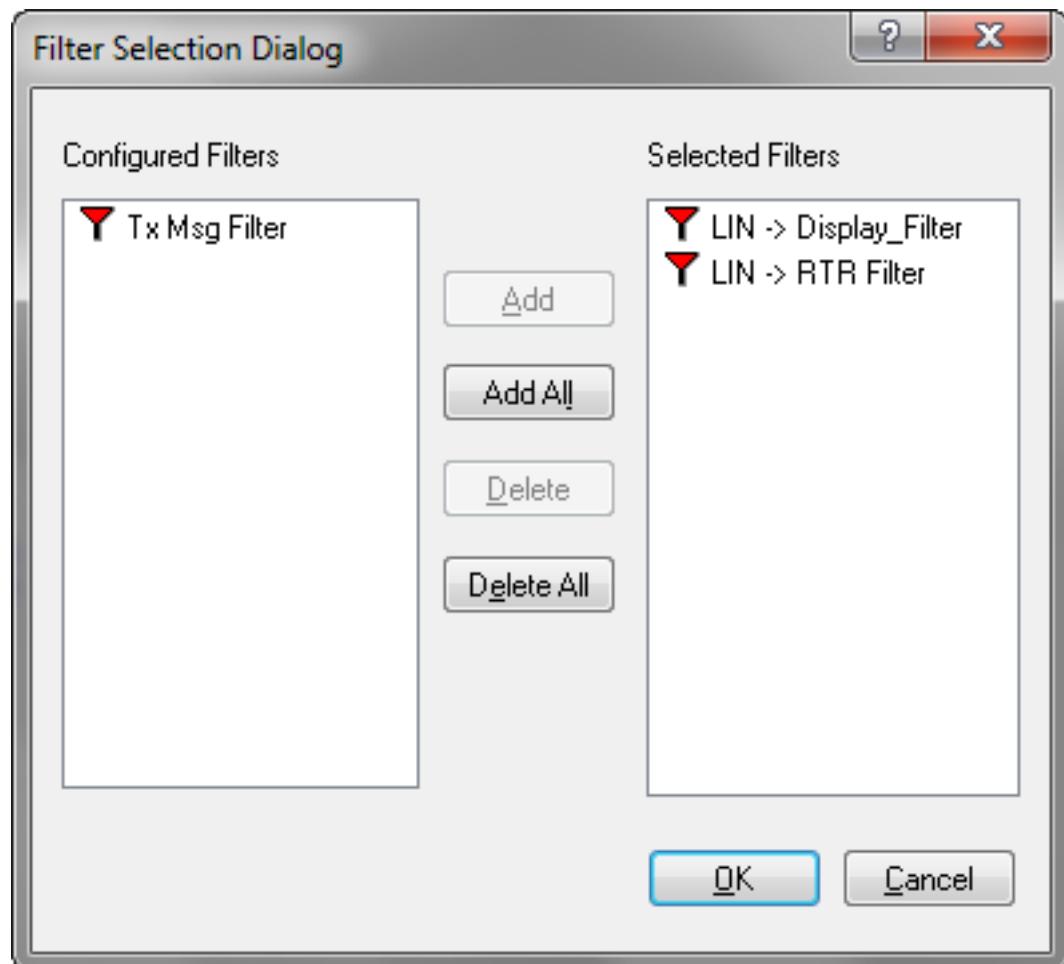
Message Filter

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

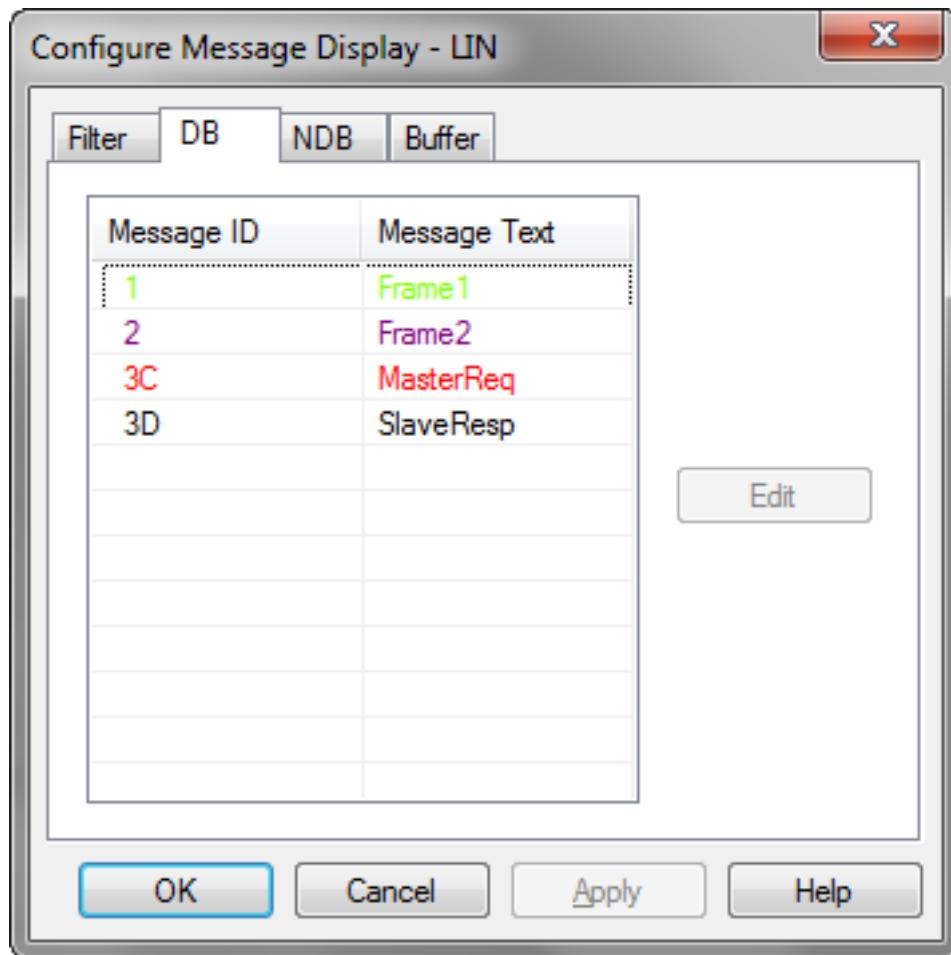
To configure display filter list select Configure button which will list available filters and selected filters.

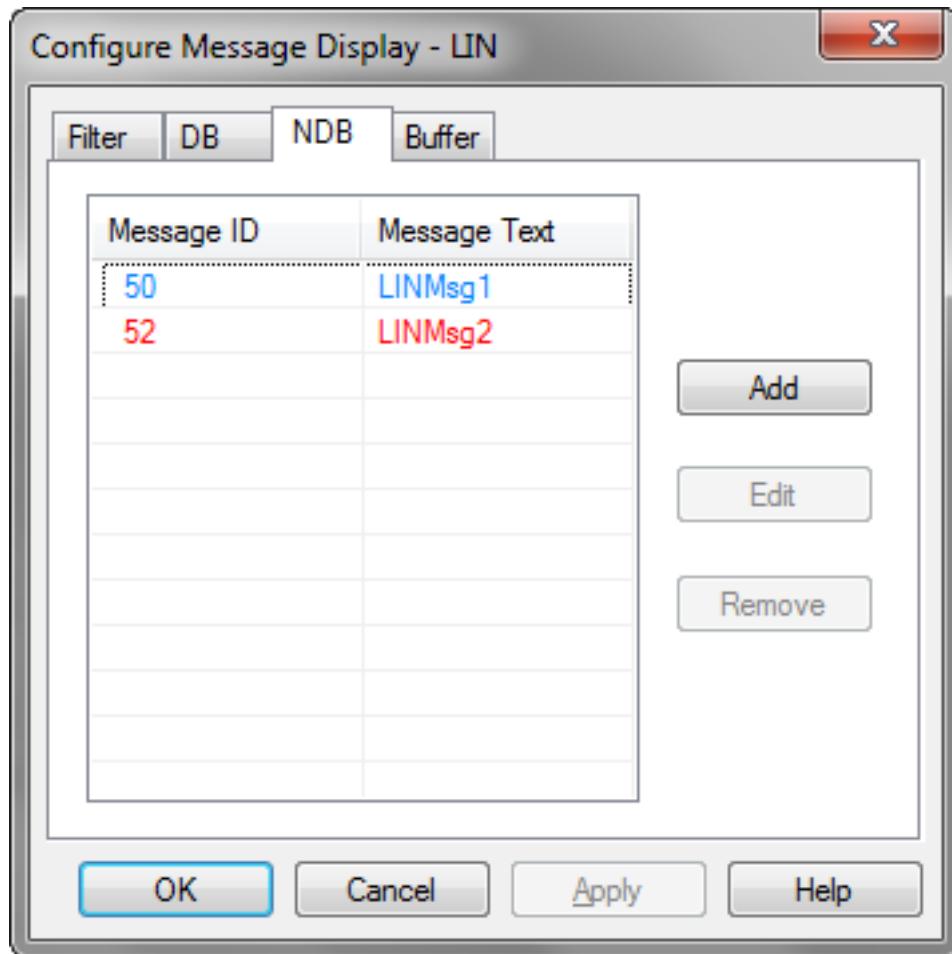


Message Coloring

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.

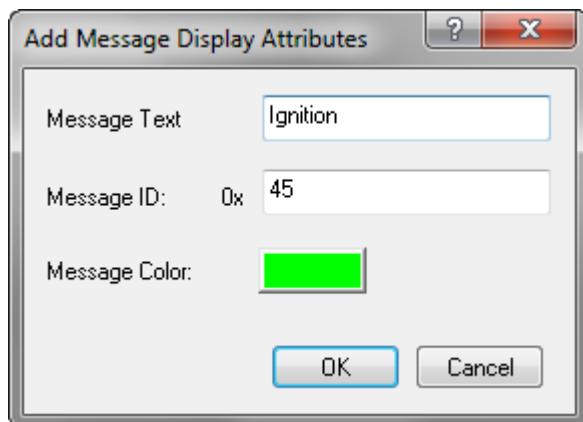




Adding message attribute

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

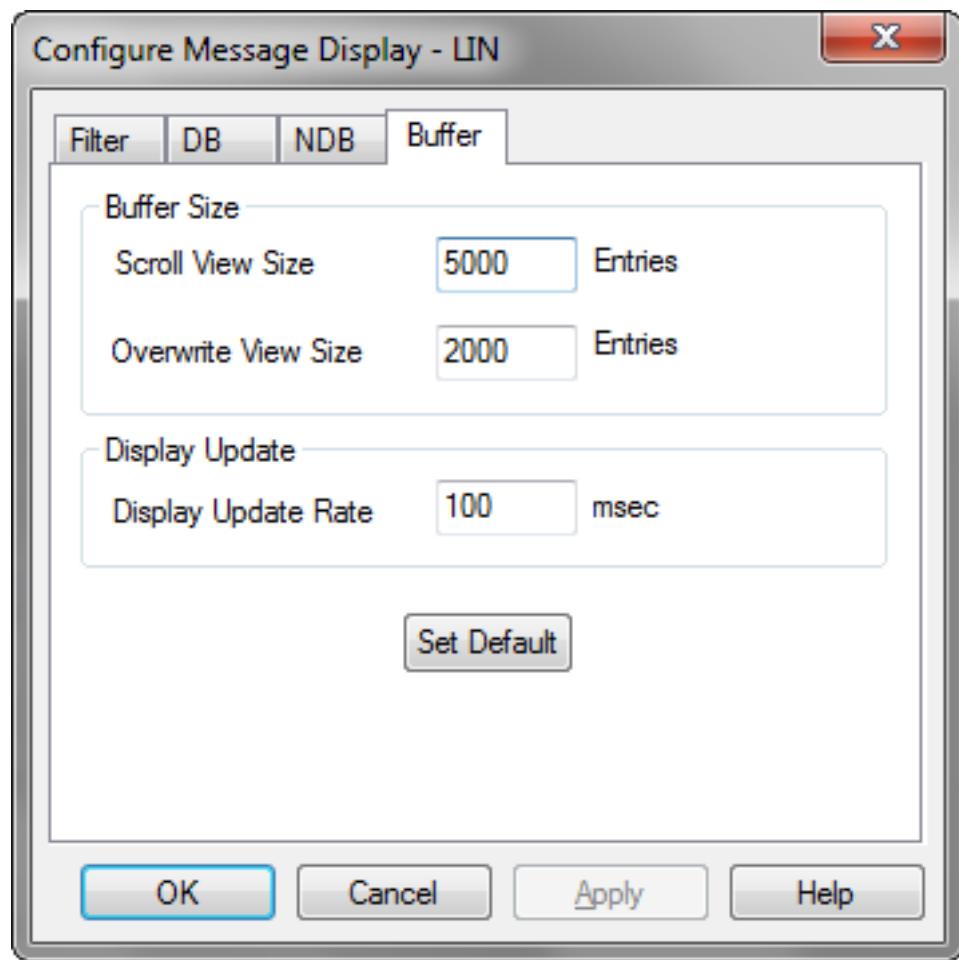
1. Select **LIN --> Message Window --> Configure**.
2. A dialog box will pop up. Select the message entry to be deleted from the message entry list.
3. Click on Remove button. A delete confirmation message box will be displayed.
4. Select Yes to confirm deletion.
5. Select OK button to confirm the modification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



Note:

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

Network Statistics

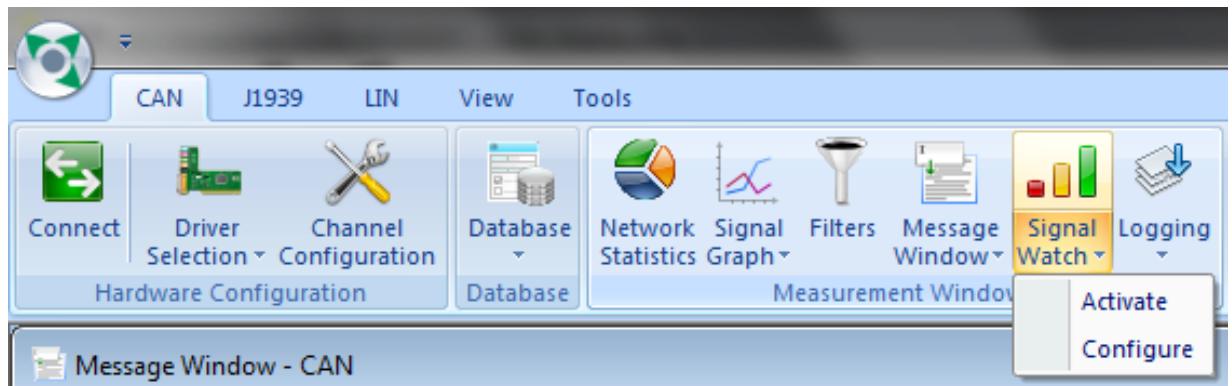
Network statistics dialog gives details about the messages transmitted and received on the bus. This information includes the number of Data Frames and Error messages transmitted and received by BUSMASTER and current rate of these parameters. Also information related to the total Wakeups and its rate 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.

Network Statistics		
CAN	LIN	X
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 %	
Transmission Statistics		
Total Tx Frames	0	
TransErr [Total]	0	
TransErr [Err/s]	0.00	
Reception Statistics		
Total Rx Frames	9383	
RecErr [Total]	0	
RecErr [Err/s]	0.00	
Status		
Controller	Active	
WAKEUPS [fr/s]	0.00	
WAKEUPS [Total]	0	

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

Signal Watch

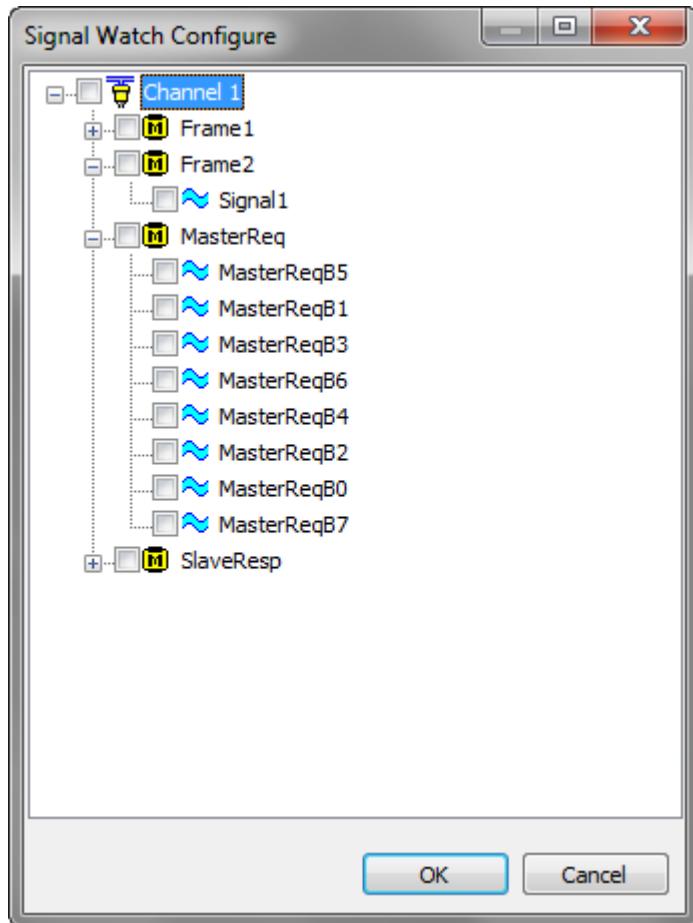
User can watch the value of a signal using the signal watch window as and when a message having that signal is received. The Physical and Raw values will be listed and updated as and when the message arrives. Click on the tool bar button shown below to display the signal watch window.



Add/ Delete Signals

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

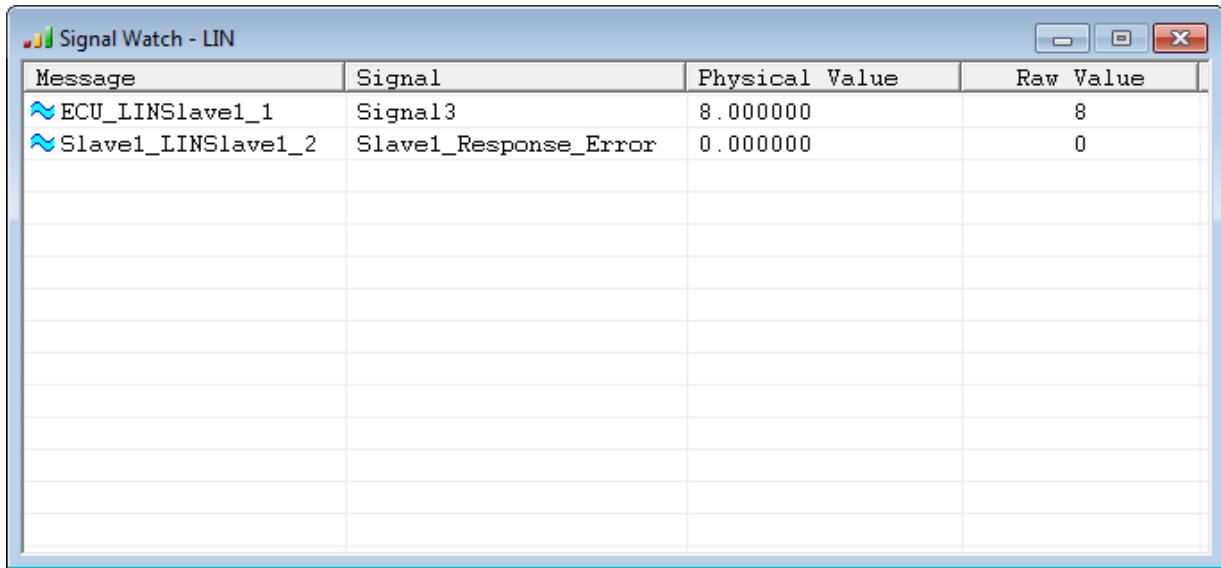
- Click on **LIN** --> **Signal Watch** --> **Activate**.
- A dialog box will be displayed then do right click and select **Configure Signals** from the menu. This will show the signal configuration Window.
-



- 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.
- Uncheck the signal to delete it from the signal watch.
- 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

To pop up signal watch window, select the tool-bar button explained in the previous section or the menu **CAN->Signal Watch->Activate**. This will show the Signal Watch Window.



Message	Signal	Physical Value	Raw Value
ECU_LINSlave1_1	Signal3	8.000000	8
Slave1_LINSlave1_2	Slave1_Response_Error	0.000000	0

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.

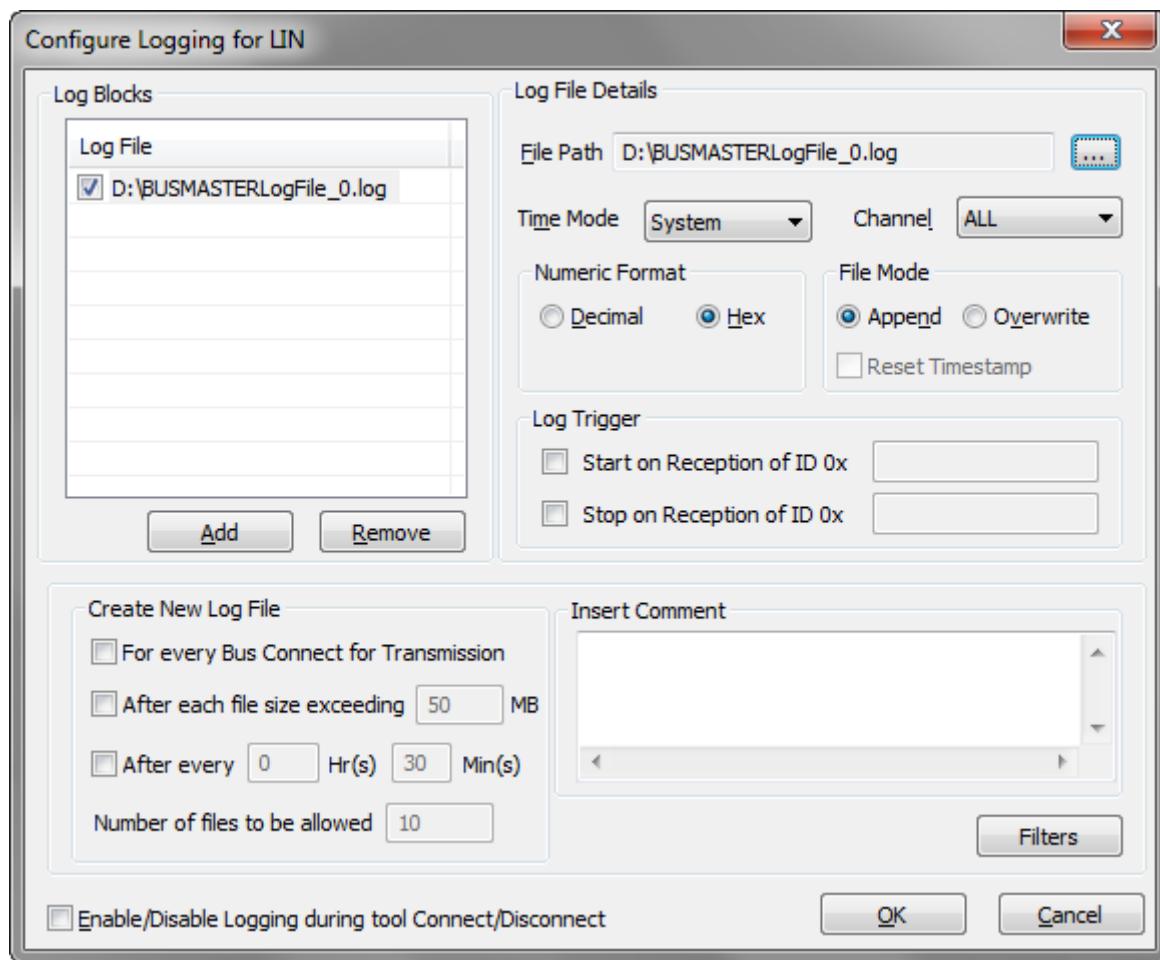
OR

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.



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

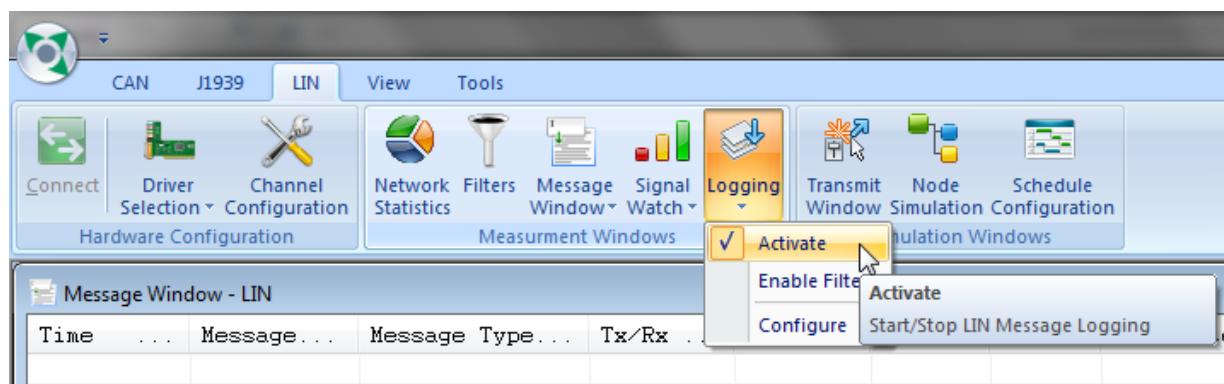
If the log file name is abc.log for the first time, then for the next time the log file name will be abc0.log.

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.



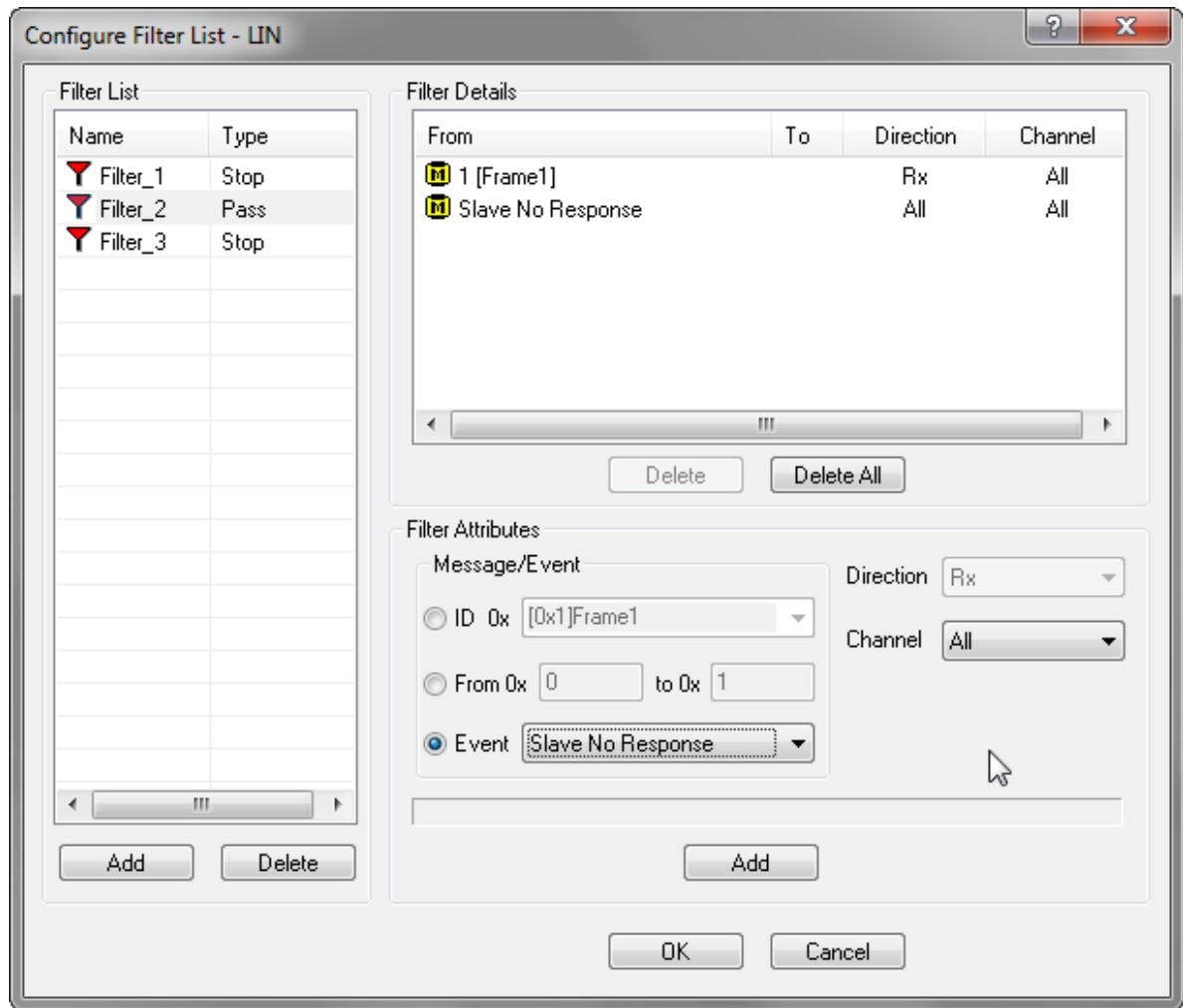
Note:

- 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.

Filters

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

- Select **LIN --> Filters**.
- 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 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 updated. 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.

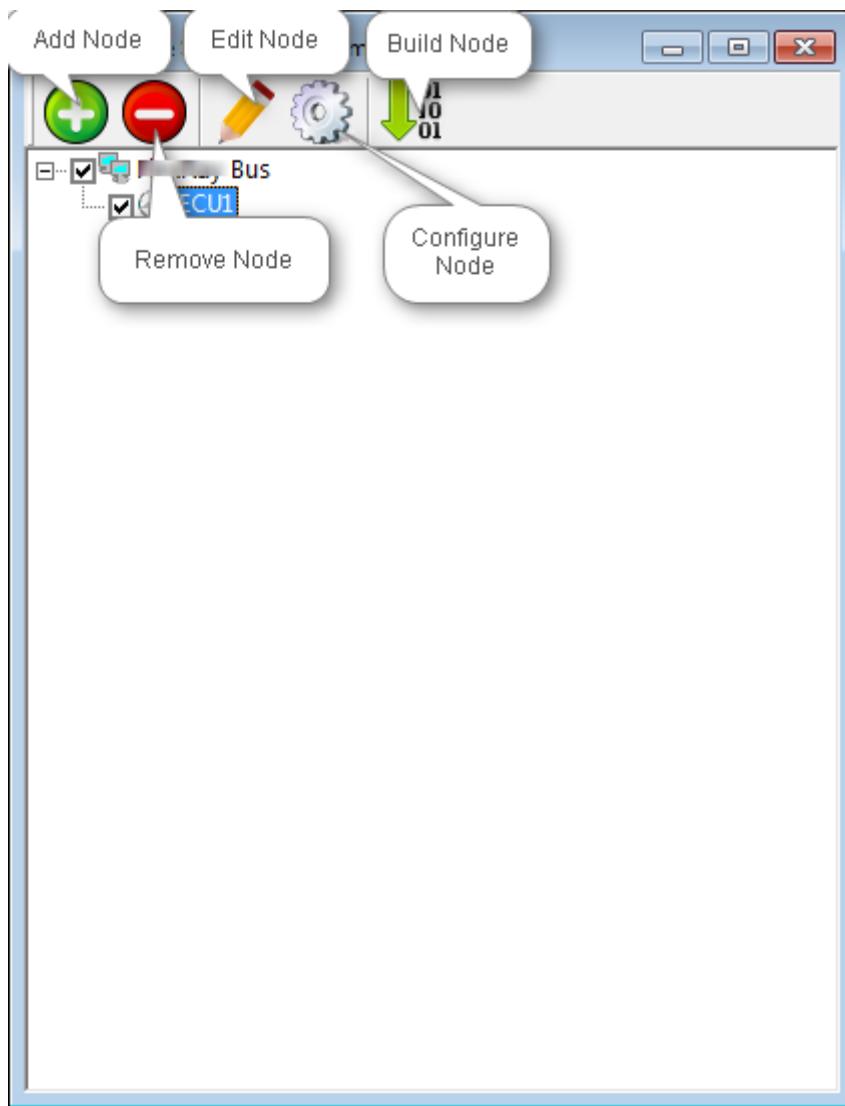
Once the filter is added in to the Filter List then the name of the filter will appear in the Filter Configuration List to select. Any modification on these filter will immediately reflect in the all modules that are using these filters.

Filter list will be saved in configuration file and will be updated while loading a configuration file.

LIN Node Simulation

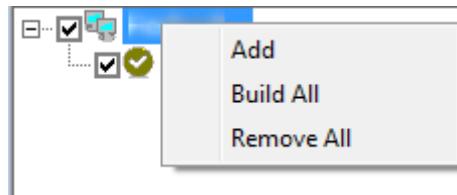
Node Simulation Configuration

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



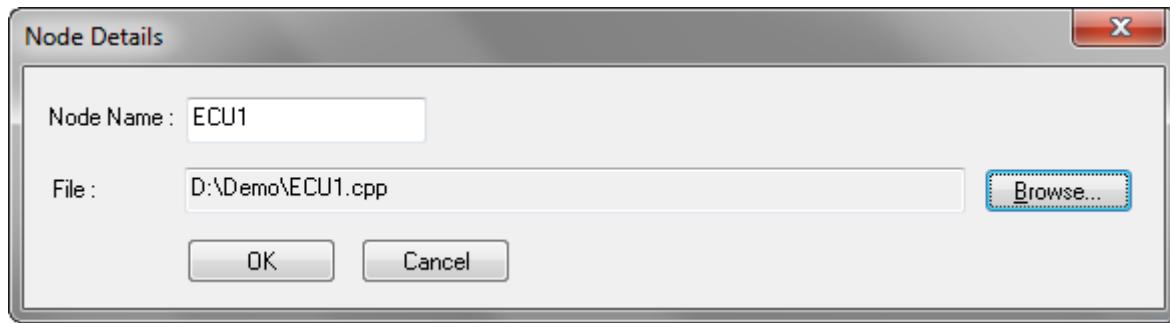
Add Node

This is used to added .cpp/.dll files to Node Simulation. Add Node can be done by following ways:



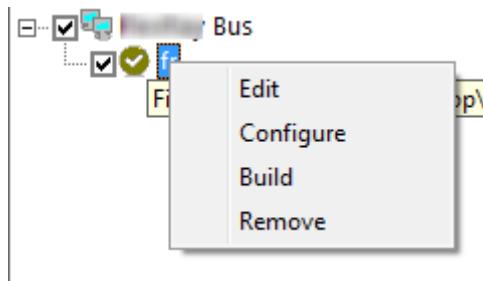
1. Right click the Root Node(<Protocol> Bus) and select "Add".
2. Click Add Node in the toolbar.
3. Pressing "Insert" key in the keyboard.

Then "Node Details" dialog box appears as shown below. Add unique Node name and add existing .cpp/.dll or provide new File name to create new .cpp file.



Edit Node

This is used to edit the .cpp file attached to a Node. Editing can be done by following ways:



1. Select the Node then Right click and select "Edit".
2. Select the Node and click "Edit Node" in the toolbar.
3. Select the Node and press "Enter" key in the keyboard.

Then "Function Editor" window appears in which the required editing can be done.

Remove Node

This is used remove selected node all the nodes in the Simulated system. Removing a Node can be done by following ways:

1. Select the Node then Right click and select "Remove". To Remove All Nodes select Root Node(<Protocol> Bus) and select "Remove All".
2. Select the Node and click "Remove Node" in the toolbar. To Remove All Nodes select Root Node(<Protocol> Bus) and select "Remove Node" in the toolbar.
3. Select the Node and press "Delete" key in the keyboard. To Remove All Nodes select Root Node(<Protocol> Bus) and press "Delete" key.

Configure Node

This is used change the name of the Node or change/add .cpp/.dll associated with a Node. Configuring a Node can be done by following ways:

1. Select the Node then Right click and select "Configure".
2. Select the Node and click "Configure Node" in the toolbar.
3. If no .cpp/.dll files are associated with the node previously, then by pressing "Enter" key in the keyboard.

Build Node

This is used build the .cpp files associated with selected Node or all the nodes in the Simulated System. Building a Node can be done by following ways:

1. Select the Node then Right click and select "Build". To Build All Nodes select Root Node(<Protocol> Bus) and select "Build All".
2. Select the Node and click "Build Node" in the toolbar. To Build All Nodes select Root Node(<Protocol> Bus) and select "Build All" in the toolbar.

Enable/Disable Node

This used to active/deactivate selected Node or all the Nodes in the Simulated System. Enabling/Disabling can be done by following ways:

1. Check/Uncheck the checkbox associated with the Node will Enable/Disable the Node respectively. To Enable/Disable all the Nodes Check/Uncheck the Root Node(<Protocol> Bus) respectively.
2. "Spacebar" key can be used as keyboard shortcut to Check/Uncheck the Node(s).



Note:

1. Node(s) can't be Added/Removed/Configured/Enabled/Disabled while the network is connected.
2. A Node can be edited while the network is connected. But the file must be built again to see the changes.

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

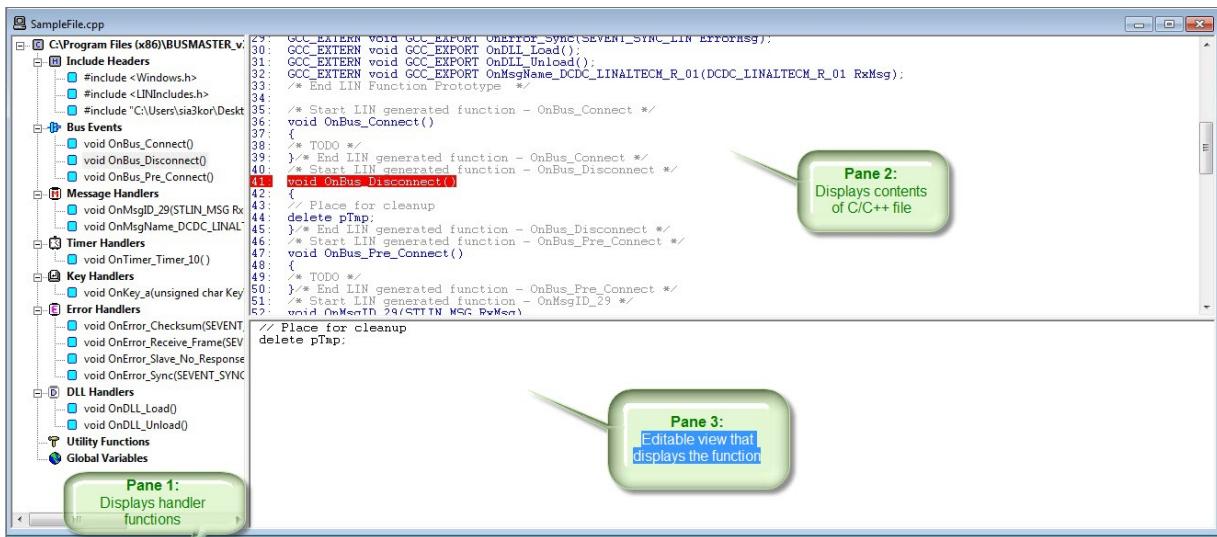
- Bus connect and disconnect
- Receipt of a Message.
- Elapse of a time interval.
- Press of a Key
- Detection of error or change in error state
- Loading / unloading of DLL.

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

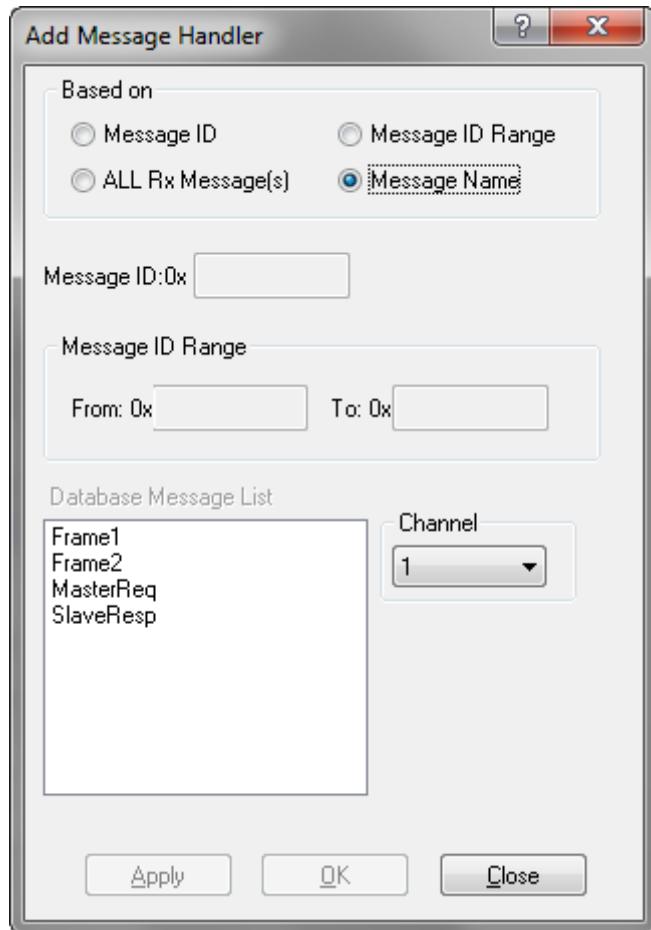
User can delete Header files, Message Handlers, Timer Handlers, Key Handlers, Error handlers, DLL handlers and Utility Functions in source file opened for editing, to do so follow the steps given below:

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.

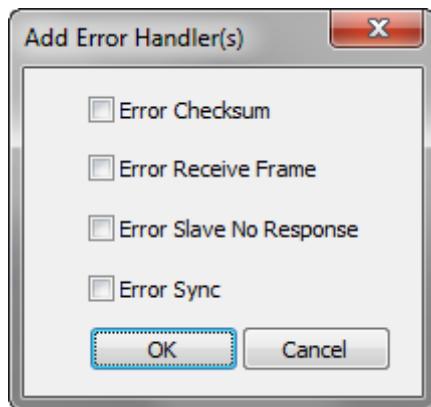
Add Key Handler

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 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.

LIN API Reference

STLIN_MSG Structure

STLIN_MSG Structure Definition

```
class STLIN_MSG
{
    unsigned char messagetype;           // Header - 0, Slave Response - 1
    unsigned char checksumtype;          // Checksum Type (0 - Classical / 1 -
Enhanced)
    unsigned char dlc;                  // Data length (0..8)
    unsigned char id;                   // LIN Identifier

    unsigned char data[8];              // Data access member
    unsigned long timeStamp;            // Channel Number
    unsigned char cluster;              // Cluster Identifier
    unsigned char crc;                 // Checksum - Read Only

} STLIN_MSG;
```

Required Include header file is LINIncludes.h

Table 2:

Member	Description
messagetype	To configure frame as Master request or Slave. 0 - Master request/header
checksumtype	To set checksum type as Classic or Enhanced. 0 - Classic 1-Enhanced
dlc	Data Length in bytes. Possible values [0-8]
id	LIN message identifier is a unsigned integer in decimal or hexadecimal (0x) to identify the message
data[8]	Message data. [0-7] bytes

timeStamp	Received frame absolute timestamp in 100's of microseconds
cluster	channel on which the frame is received or to be transmitted
crc	Checksum value of the received message

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

LIN 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 the controller from the bus**Synopsis**

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

Description

This function will disconnect the tool from correponding protocol 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 controller to the bus**Synopsis**

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

Description

This function will connect the tool to corresponding protocol 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

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

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

WriteToFile : To send string to log file

Synopsis

```
UINT WriteToFile ( 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.

LIN Node Simulation Examples

Master Request Transmission:

To send the Master request (or Header), the header ID should be configured in Node simulation Pre Connect Event.

Example code:

The following example shows how to send the master request with an identifier 0x4, for every 10ms.

```
void OnBus_Pre_Connect()
{
    STLIN_MSG sMsg;

    sMsg.messageType = 0;      // Master Response
    sMsg.checksumType = 0;     // Classic
    sMsg.id = 0x4;            // Message Identifier
    sMsg.cluster = 1;          // channel 1

    // Register the header frame.
    SendMsg(sMsg);
}

//Called For Every 10ms.
```

```

void OnTimer_TimerFor10ms_10()
{
    STLIN_MSG sMsg;

    sMsg.messageType = 0; // Master Response
    sMsg.checksumType = 0; // Classic
    sMsg.id = 0x4; // Message Identifier
    sMsg.cluster = 1;

    // Send the header frame
    SendMsg(sMsg);
}

```

Responding to Master Request

To respond to the master request, slave response of the particular identifier needs to be configured in Node simulation Pre Connect Event. Once the configuration is done, The data can be changed in any other Node simulation handlers.

Example code:

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.messageType = 1; // Slave Response
    sMsg.checksumType = 0; // Classic
    sMsg.dlc = 8;
    sMsg.id = 0x4; // Message Identifier
    sMsg.data[0] = 10; // Lower 4 Bytes
    sMsg.data[1] = 20; // Upper 4 Bytes
    sMsg.cluster = 1;

    // Register Slave response
    SendMsg(sMsg);
}

//changing data in key handlers.
void OnKey_A()
{
STLIN_MSG sMsg;

    sMsg.messageType = 1; // Slave Response
    sMsg.checksumType = 0; // Classic
    sMsg.dlc = 8;
    sMsg.id = 0x4; // Message Identifier
    sMsg.data[0] = 20; // Lower 4 Bytes
    sMsg.data[1] = 30; // Upper 4 Bytes
    sMsg.cluster = 1;

    // Send the message
    SendMsg(sMsg);
}

```

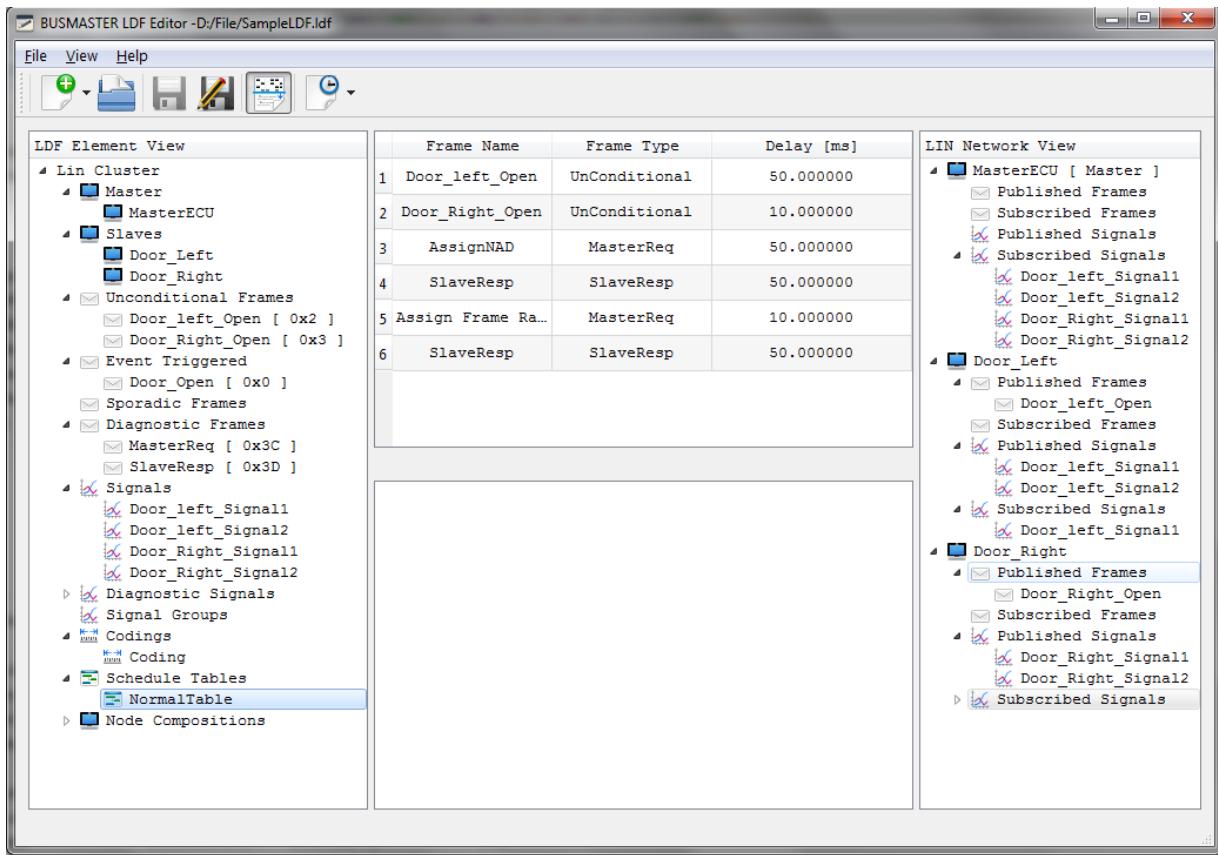
LIN Database Editor

Introduction

LIN Database Editor Overview

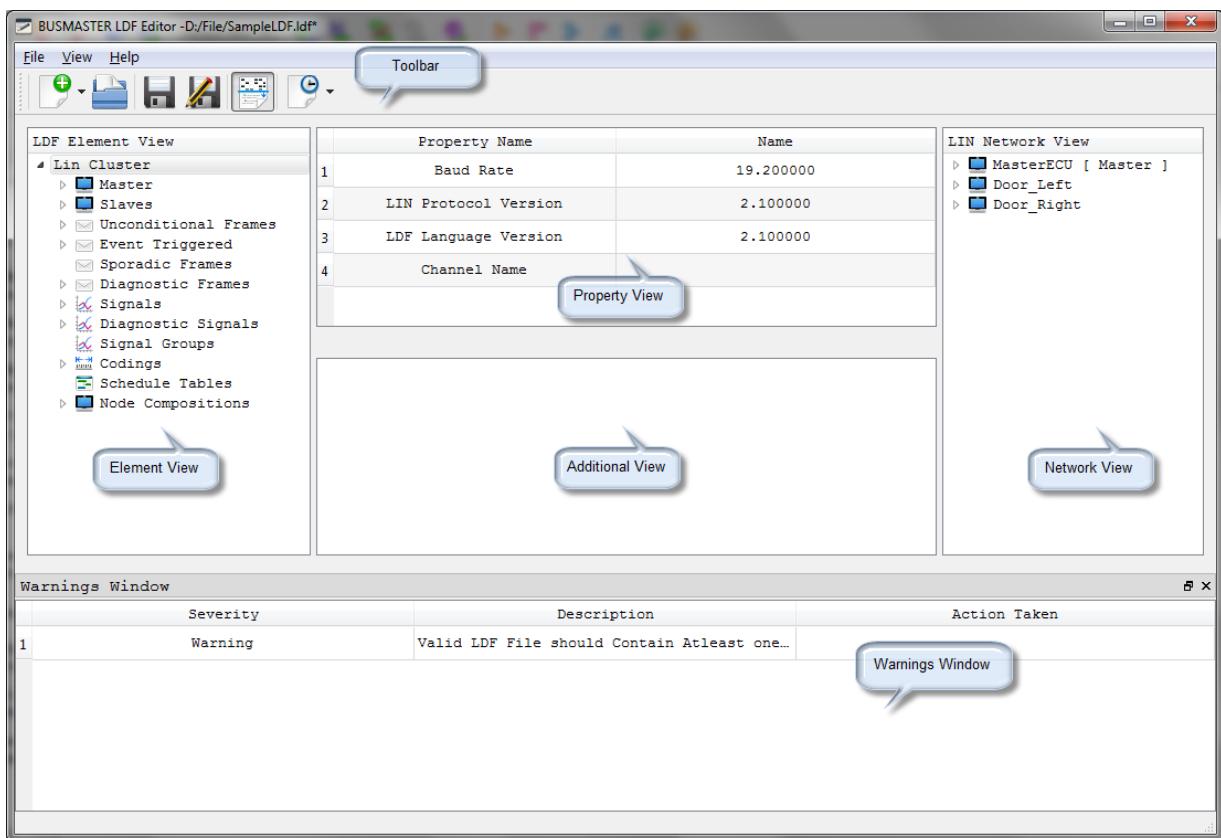
BUSMASTER LIN Database Editor is a user friendly tool to create, edit and view LIN Description Files(LDF). LIN Database Editor supports LDF versions 1.3, 2.0 and 2.1.

Using LIN Database Editor user can create LIN Description files without knowing the details of LIN Description file format



Overview

LIN Database Editor main window is as shown below:

**Menu bar:**• **File Menu**

1. File->New->LIN 1.3

Creates LIN 1.3 LDF file. Default elements will get created.

2. File->New->LIN 2.0

Creates LIN 2.0 LDF file. Default elements will get created.

3. File->New->LIN 2.1

Creates LIN 2.1 LDF file. Default elements will get created.

4. File->Open

To Open an existing LDF file of versions 1.3, 2.0 and 2.1.

5. File->Save

To Save the changes to the current loaded LDF file.

6. File->Save As

To Save changes to a new LDF file.

7. File->Recent Files

Displays 5 recently viewed LDF files. Click on the file to load the LDF file.

• **View Menu**

1. View->Hex

Select/DeSelect Hex to toggle between numeric modes Hex/Dec.

2. View->Preview LDF File

Opens the current LDF file in LDF file editor.

3. View->Warnings Window

Populates the Warning Window, which displays the list of warnings with description and action taken if any.

Toolbar:

Toolbar can be used for creating, loading, saving LDF files and also to set the numeric mode (hex/dec).



Element View:

Element view displays the LIN Cluster elements by which user can create or edit elements.

To Create a new element, right click on the element in the element view and select the pop up menu 'New'.

To Edit a element, right click on the element in the element view and select the pop up menu 'Edit'

To Delete a element, right click on the element in the element view and select the pop up menu 'Delete'. Confirmation message is displayed before deleting the element.

The following LIN Cluster elements are displayed in Element View.

- Lin Cluster Settings
- Master
- Slaves
- Unconditional Frames
- Event Triggered Frames
- Sporadic Frames (Displayed for LDF version 2.0 and 2.1)
- Diagnostic Frames
- Signals
- Diagnostic Signals
- Signal Groups
- Codings
- Schedule Tables
- Node Compositions (Displayed for LDF version 2.0 and 2.1)

On selecting an element in the element view, Property view and additional view will be updated with selected element properties.

Property View:

Property view displays the properties of the element selected in the element view. Properties are populated based on the type of element selected in the element view.

Additional View:

Additional view displays the additional properties of the element selected in the element view. Properties displayed in the additional view will vary based on the type of element selected in the element view.

Table 3:

Selected Element	Properties displayed
Node (Master/Slave)	<ul style="list-style-type: none"> 1. Node Attributes 2. List of published frames
Frame (Unconditional, Event Triggered, Sporadic and Diagnostic frames)	<ul style="list-style-type: none"> 1. Frame Attributes 2. List of published signals
Signals (Normal and Diagnostic Signals)	<ul style="list-style-type: none"> 1. Signal Attributes 2. List of Codings mapped to the signal
Codings	<ul style="list-style-type: none"> 1. Coding Attributes
Schedule Table	<ul style="list-style-type: none"> 1. Schedule Table Items 2. Schedule Table attributes populated based on the type of the frame selected

Signal Groups	<ul style="list-style-type: none"> 1. Signal Group properties 2. Signals mapped to the Signal group
Node Compositions	<ul style="list-style-type: none"> 1. List of Composite nodes mapped to the Node Configuration

Network View:

Network view displays the Master and Slave nodes. Published, subscribed frames and signals will be displayed under respective node.

On Selecting an element in the network view respective element in the element view is selected and elements properties are displayed in the Property view and Additional view.

Warning Window:

On Save or Load LDF file, warning will be displayed in the Warnings window if exists any with description and action taken is specified if any action is performed to correct the warning.

Getting Started

1. Creating LDF File Using LDF Editor:

Currently LDF Editor supports creation of LDF 1.3, 2.0 and 2.1 versions.

Recommended work flow to create a LDF file:

1. Create LDF File using File->New->LDF <version>.LDF Editor will create a Master and a Slave node with default parameters.
2. Create slaves if required. (Refer section : [Slave](#) on page 145)
3. Create signal and provide its Publisher and subscribers (Refer section:[Signals](#) on page 156)
4. Create unconditional Frames and map publisher and signals. (Refer section:[Unconditional Frame](#) on page 148)
5. Create Event triggered and sporadic frames if required (Refer sections:[Event Triggered Frame](#) on page 151 and [Sporadic Frame](#) on page 153)
6. Add Diagnostic Messages and signals if required (Refer section:[Diagnostic Support](#) on page 155)
7. Create schedule table(s) and define slots (Refer section:[Schedule Table](#) on page 162)
8. Create codings and associate to signals (Refer section:[Signals](#) on page 156)
9. Create signal groups if required.Signal groups are depreciated from LDF 2.x (Refer section:[Signal Group](#) on page 158)
10. Create Node compositions if Required (Refer section:[Node Composition](#) on page 163)

2. Importing|Editing LDF File:

Use File->Open to import the existing LDF file.If any errors found tool will report the same and file not be loaded.If any warnings are found tool will display the same in warnings window with the description, action point if any and imports LDF File

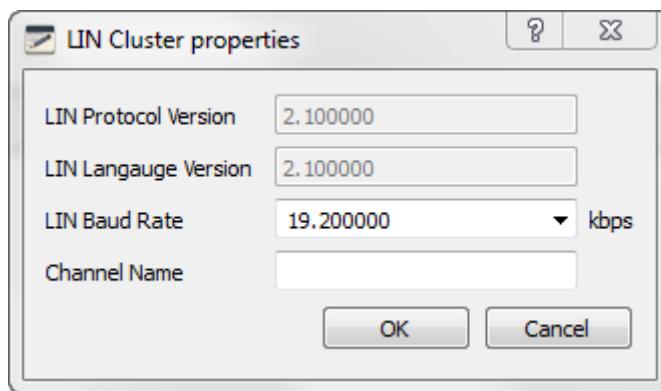
3. Preview LDF File:

To preview the current LDF File use View->Preview File menu.

LDF Elements

Cluster Properties

The LIN Cluster parameters can be edited by Right clicking the LIN Cluster Element in Element View and click on pop up menu 'Edit'.A dialog Box as Shown in below image will be displayed.



1. Lin protocol and Language versions are read only sections.
2. Baud rate of the Lin cluster can be defined in the LIN Baud rate Section.
3. Channel Name can be provided in **Channel Name** section. This field is available from LDF2.1 version.

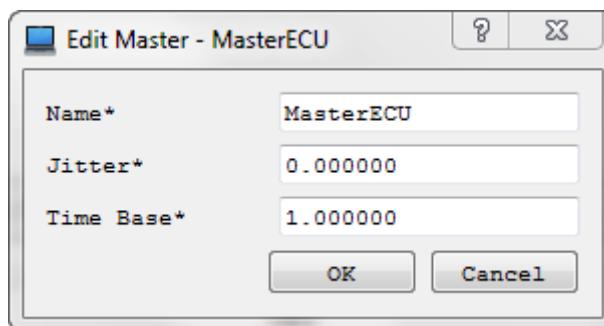
Master

Creating Master ECU:

When a new LDF File is created with LDF Editor a master node will with default values will be created automatically

Editing Master ECU Properties:

To edit the properties of master ECU right click on the Master node item in the Element view and click on 'Edit'. A dialog will be displayed as shown below.



To save the changes click on 'OK' button. Errors are displayed if validation fails.

The following validations are performed:

- ECU name will be checked for its uniqueness

To discard the changes click on 'Cancel' button.

Deleting Coding:

Master Node can not be deleted.

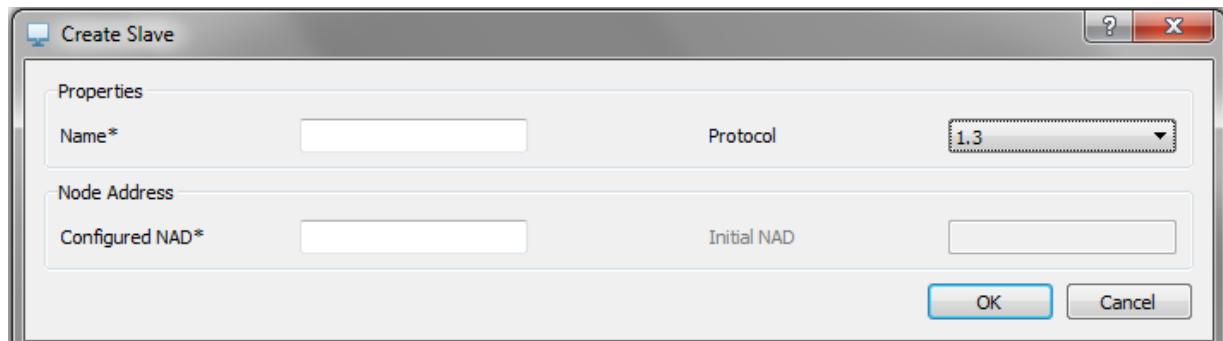
Slave

Creating Slave:

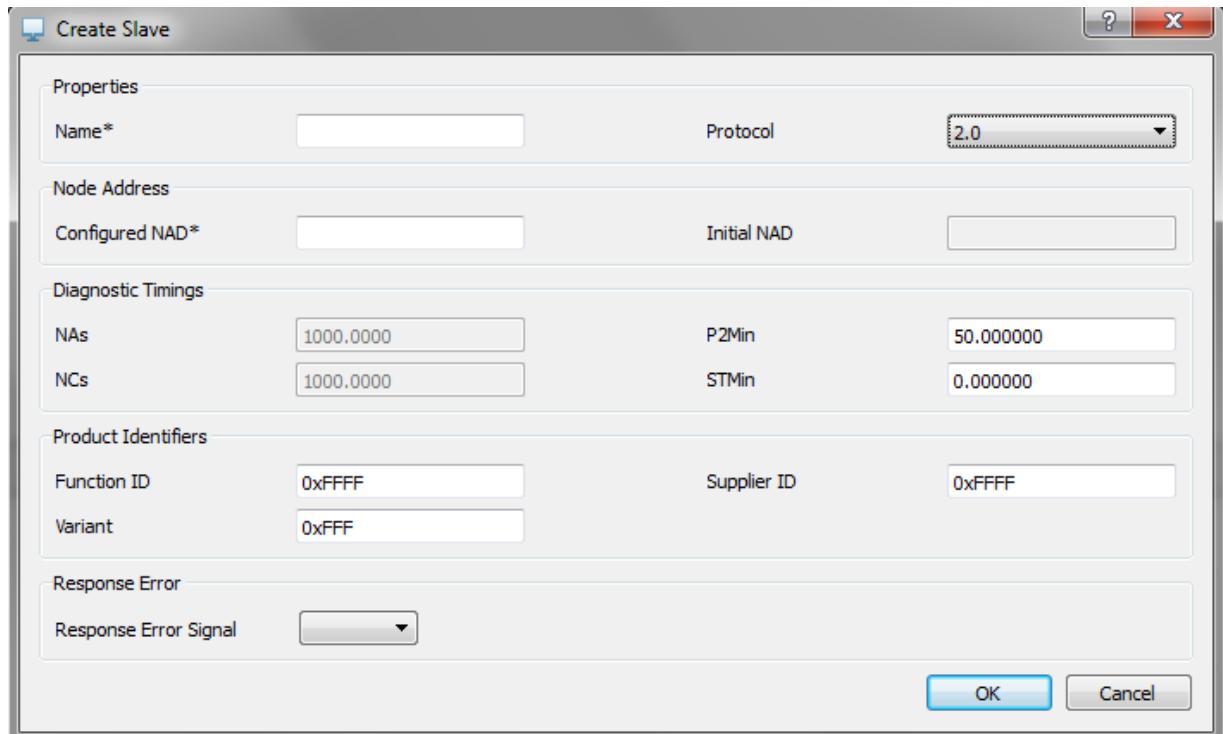
To create or edit slave nodes right click on the 'Slaves' element in the Element View. By default one slave will be created on creating new LDF file. 'Create Slave Dialog' is as shown below.

Slave can be created with the following Slave Protocol versions, Properties displayed will vary based on the protocol version selected

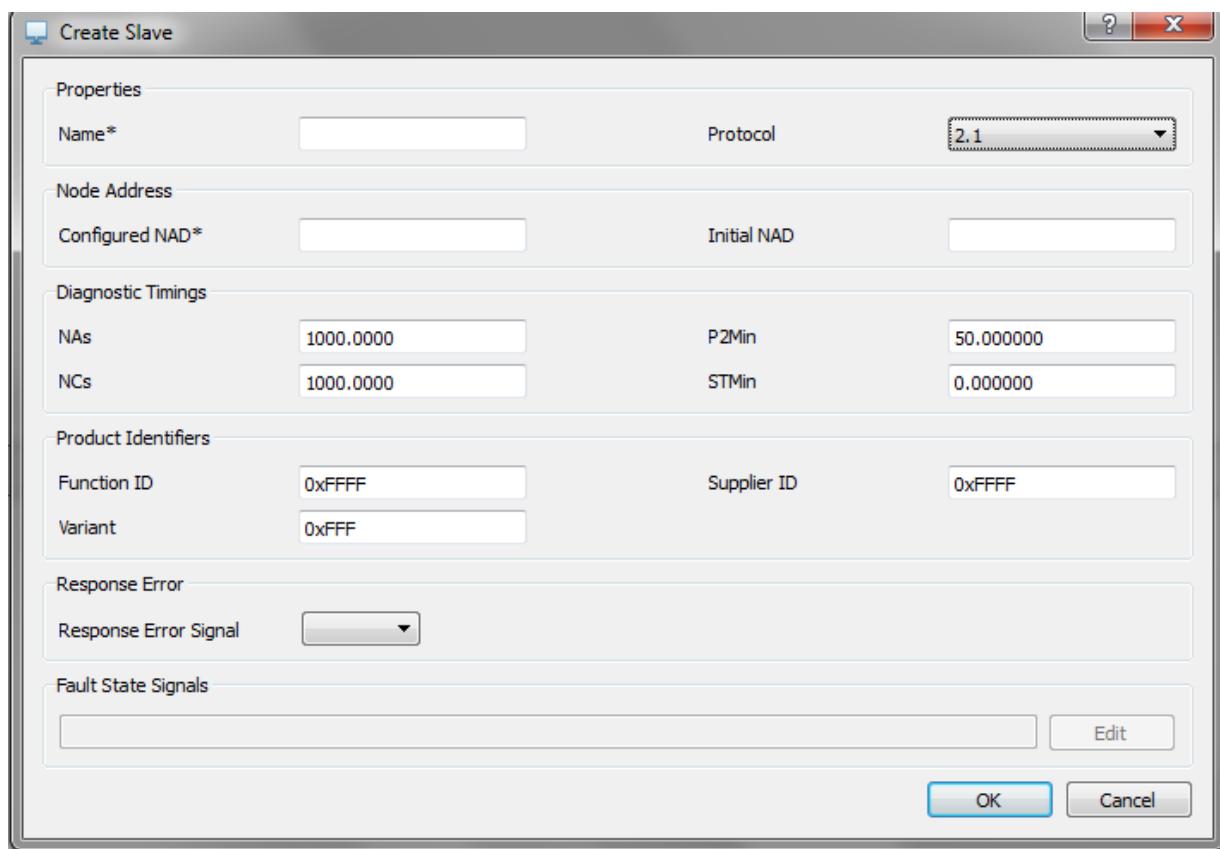
- Slave created with the protocol version 1.3 is as shown below



- Slave created with the protocol version 2.0 is as shown below

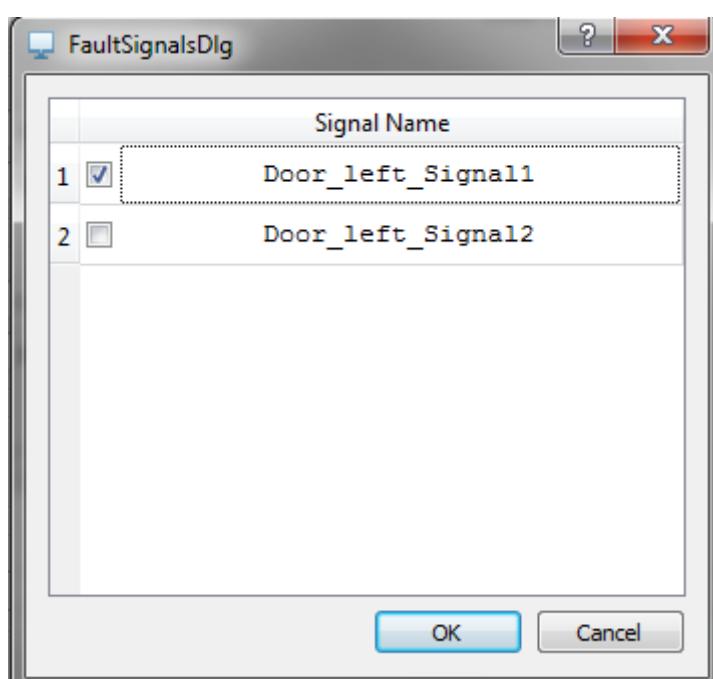


- Slave created with the protocol version 2.1 is as shown below



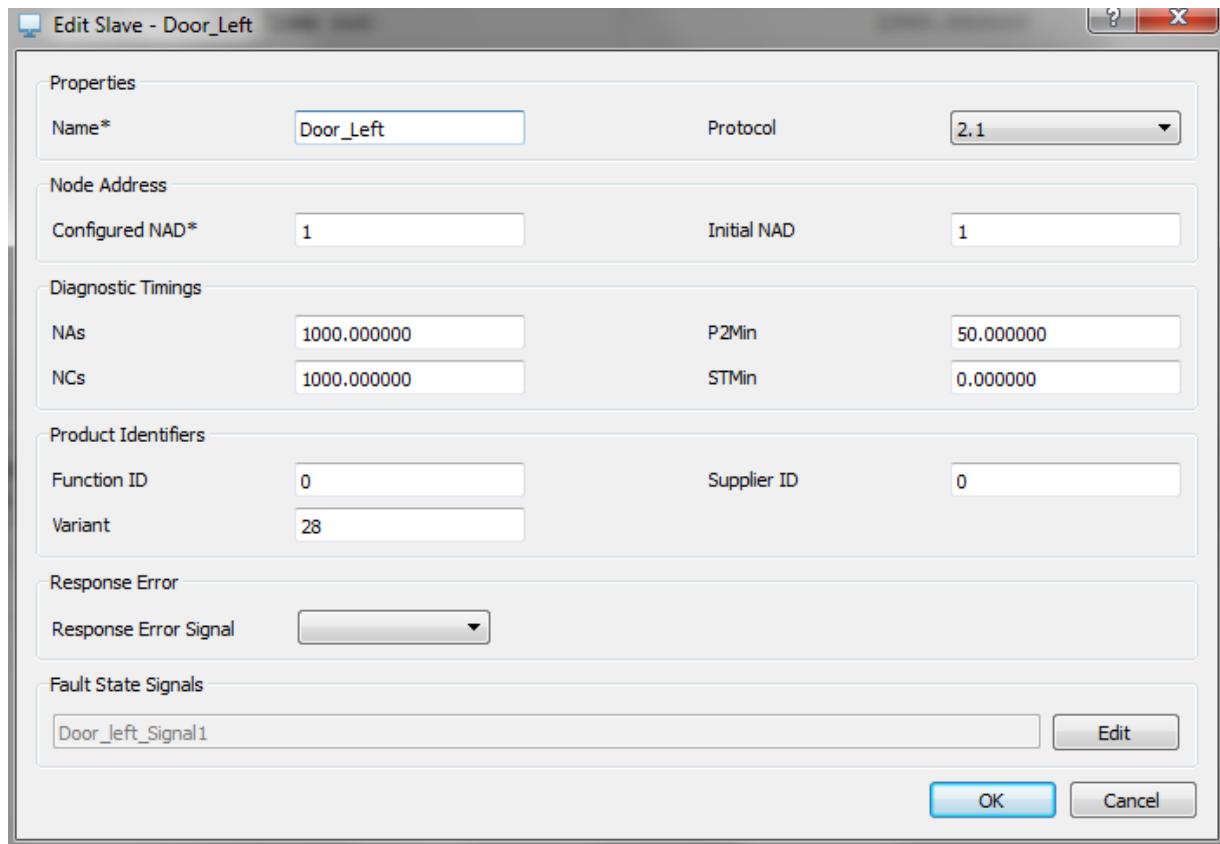
General Properties:

- **Name:** Name of the Slave which should follow C identifier rules and should be unique.
- **Protocol Version:**
 1. For LDF Version 2.1, Protocol version drop down will be populated with 1.3,2.0 and 2.1
 2. For LDF Version 2.0, Protocol version drop down will be populated with 1.3 and 2.0
 3. For LDF Version 1.3, Protocol version drop down will be populated with 1.3
- **Response Error Signal:** Response Error Signal drop down will be populated with the list of signals existing in the configuration. Response Error Signal is displayed if the Slave protocol versions 2.0 and 2.1
- **Fault State Signals:** To specify fault state signals, click on 'Edit' button which displays



Editing Slave:

To Edit the existing Slave node, right click on the Slave in the Element View and select popup menu 'Edit' which displays



Deleting Slave:

To delete Slave node, right click on the Slave node in the Element View and select pop up menu 'Delete'. Confirmation message will be displayed before deleting the Node.

On deleting node, all the frames and signals published by the node will also be deleted.

To save the changes click on 'OK' button. Errors are displayed if validation fails.

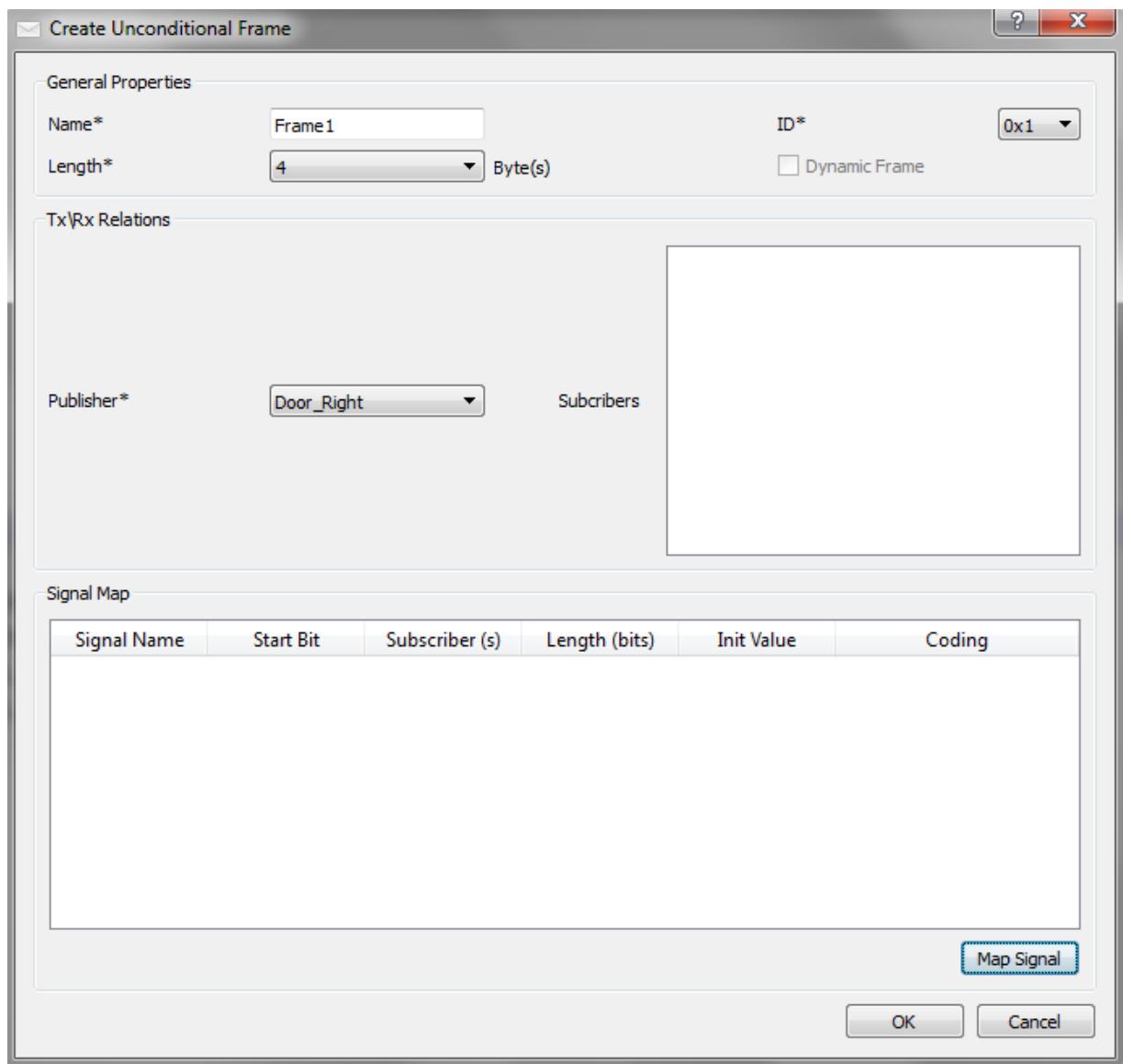
The following validations are performed:

- Slave name will be checked for its uniqueness
- On delete, checks if at least one Slave node is available. If not tool will give error.

Unconditional Frame

Creating Unconditional Frames:

To create Unconditional frame right click on the Unconditional Frame element in the element view and click on popup menu 'New'. 'Create Unconditional Frame' dialog is shown as below.



1. General Properties:

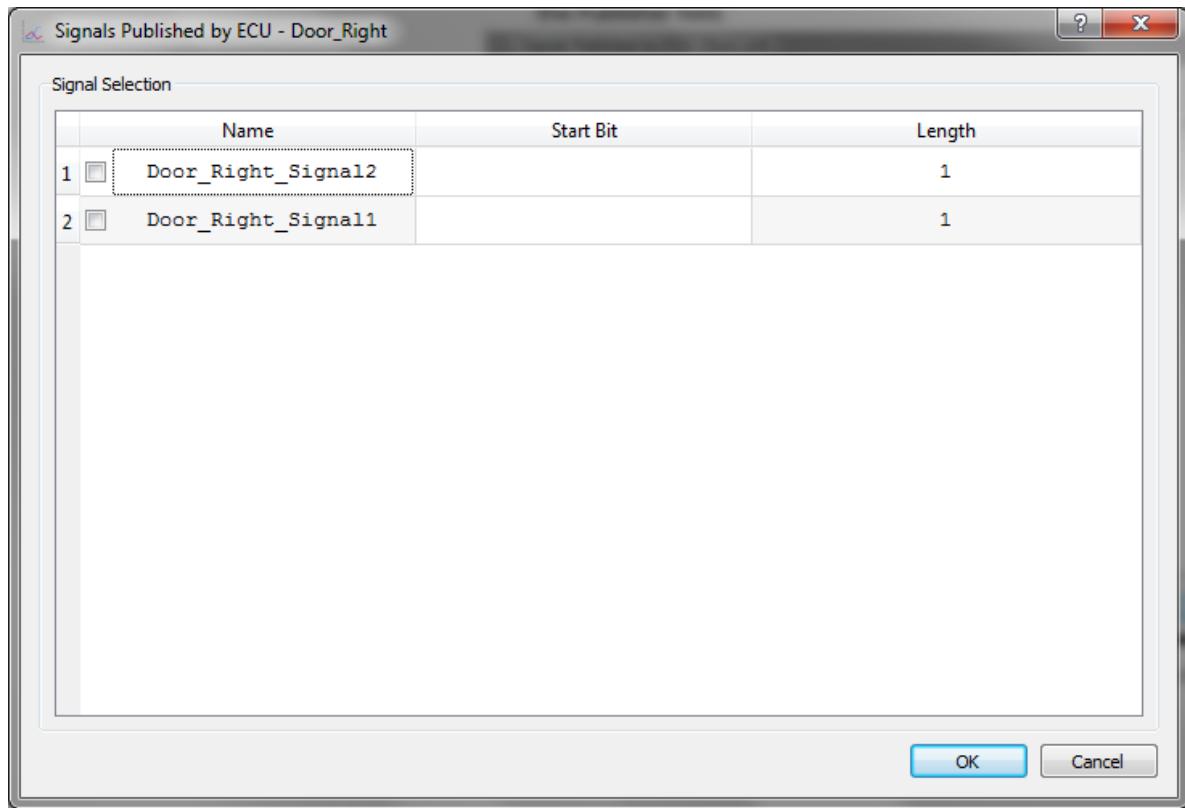
- **Name:** Name of the frame should follow C identifier rules and should be unique.
- **ID:** Identifier of the frame [0-59]
- **Length:** Length of the frame [1-8] in bytes
- **Dynamic Frame:** If dynamic frame, the 'Dynamic Frame' check box should be checked. More than one Unconditional frame can exist with the same Id and it is introduced from LDF version 2.0.

2. Publisher and Subscribers:

- Frame publisher can be selected from the Publisher drop down which lists Master and Slave nodes
- Subscribers list is read only and will get populated on mapping signals using 'Map Signal' button

3. Signal Mapping:

- To map signals to the frame click on 'Map Signal' button. Map Signal dialog is displayed as shown below with lists signals that belong to the publisher selected in the Publisher field.



To save the changes click on 'OK' button. Errors are displayed if validation fails.

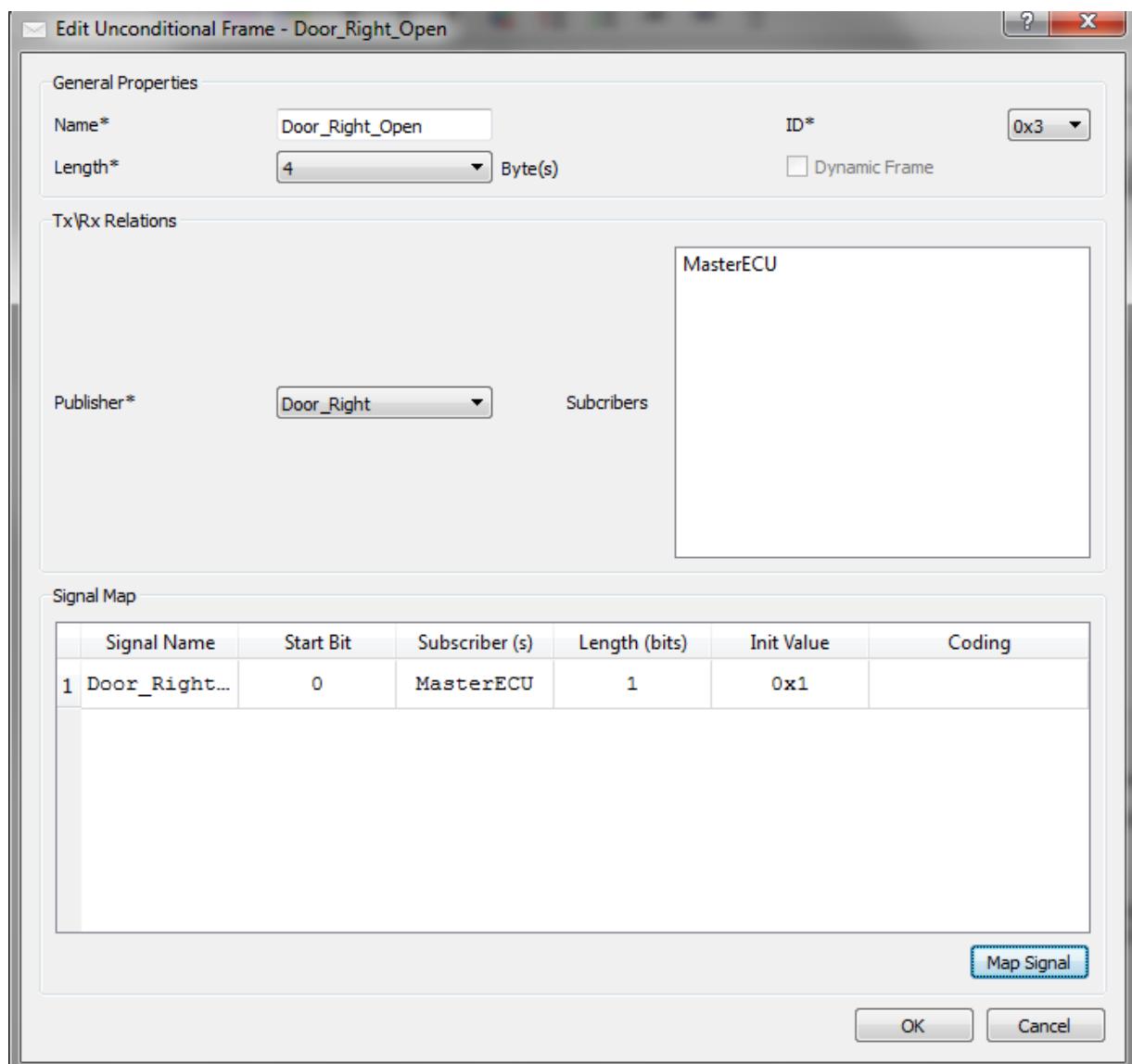
The following validations are performed:

- Frame name will be checked for its uniqueness
- If the frame is not dynamic frame, Frame Id will be checked for uniqueness

To discard the changes click on 'Cancel' button.

Editing Unconditional Frames:

To edit existing Unconditional Frame right click on the Unconditional frame item in the Element view and click on 'Edit'. 'Edit Unconditional Frame' dialog is displayed as shown below.



Deleting Unconditional Frame:

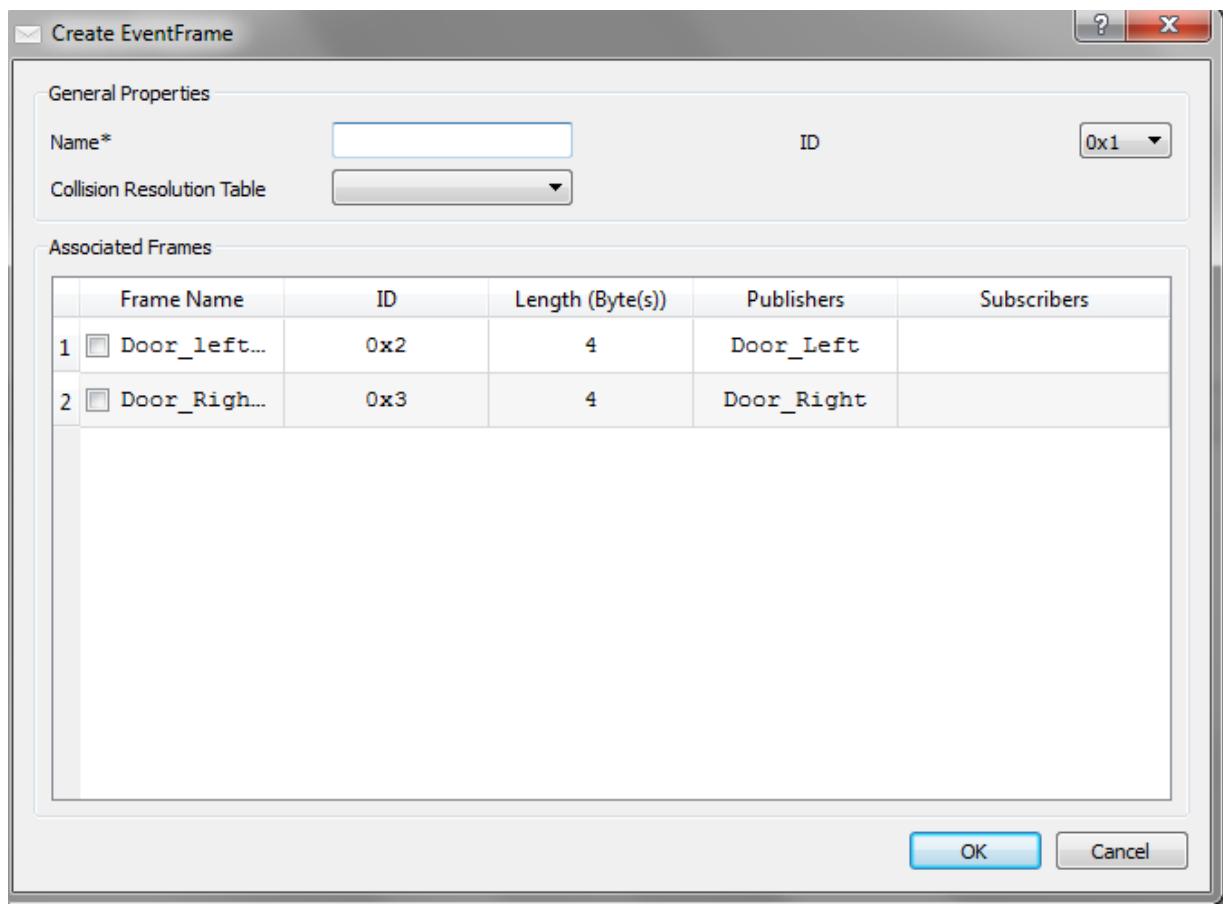
To delete Unconditional Frame, right click on the Unconditional frame item in the Element view and click on the popup menu 'Delete'. A confirmation message will be displayed before deleting the frame.

On deletion, deleted Unconditional frame will be unmapped from the Publisher and the Subscribers.

Event Triggered Frame

Creating Event Triggered Frames:

To create Event Triggered frame right click on the Event Triggered Frame element in the element view and click on popup menu 'New'. Create Event Triggered Frame dialog is as shown below.



1. General Properties:

- **Name:** Name of the frame which should follow C identifier rules and should be unique.
- **ID:** Identifier of the frame [0-59]
- **Collision Resolution Table:** Using drop down select the Schedule table to be referred in case of Collision.

2. Associating Frames:

- Check the Unconditional frames to be mapped to the Event Triggered frame from the Associated Frames list.

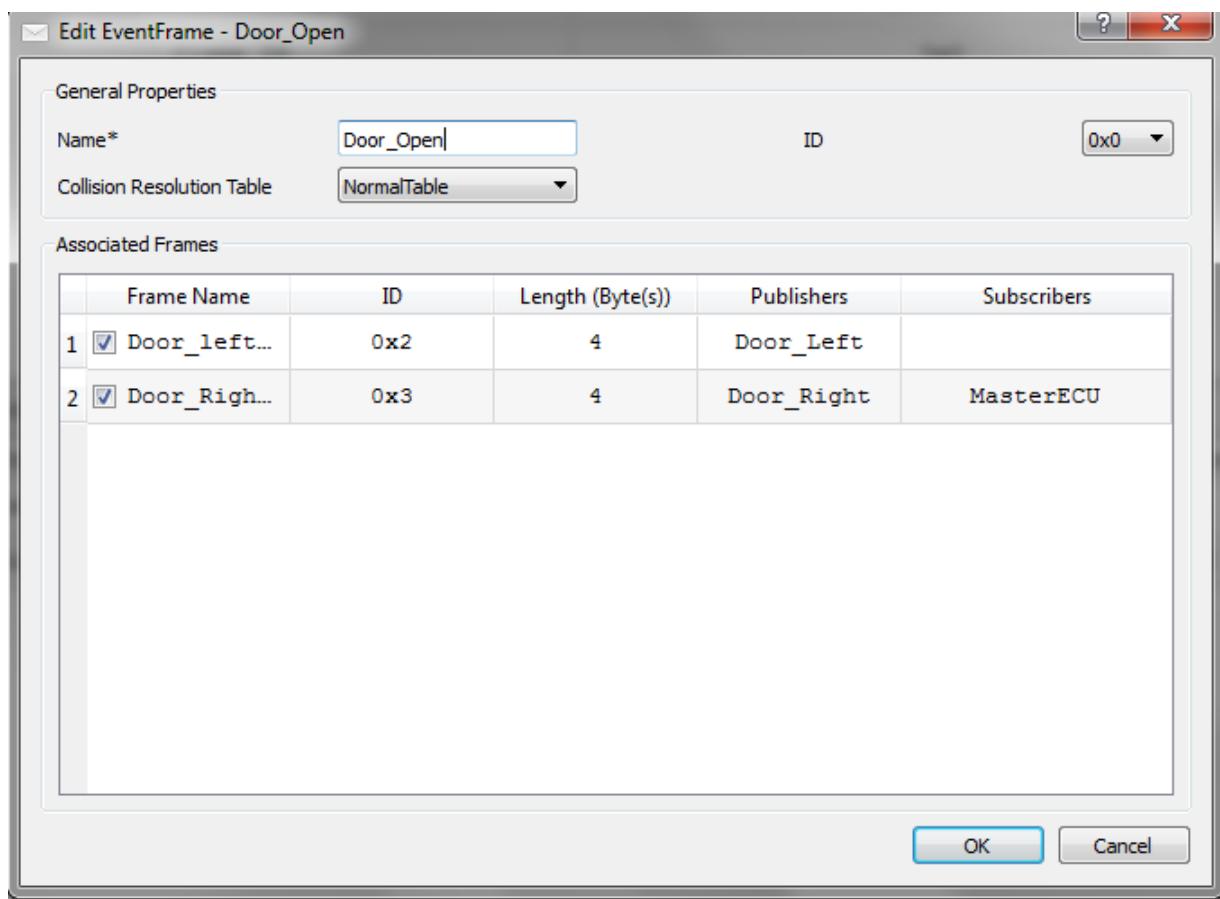
The following validations are performed:

- Frame name will be checked for its uniqueness
- Frame Id will be checked for its uniqueness
- Checked if selected Associated frames belong to the Collision resolving table

To discard the changes click on 'Cancel' button.

Editing Event Triggered Frames:

To edit existing Event Triggered Frame right click on the Event Triggered frame item in the Element view and click on 'Edit'. 'Edit Event Triggered Frame' dialog is displayed as shown below.



Deleting Event Triggered Frame:

To delete Event Triggered Frame, right click on the Event Triggered frame item in the Element view and click on the pop up menu 'Delete'. A confirmation message will be displayed before deleting the frame.

To save the changes click on 'OK' button. Errors are displayed if validation fails.

The following validations are performed:

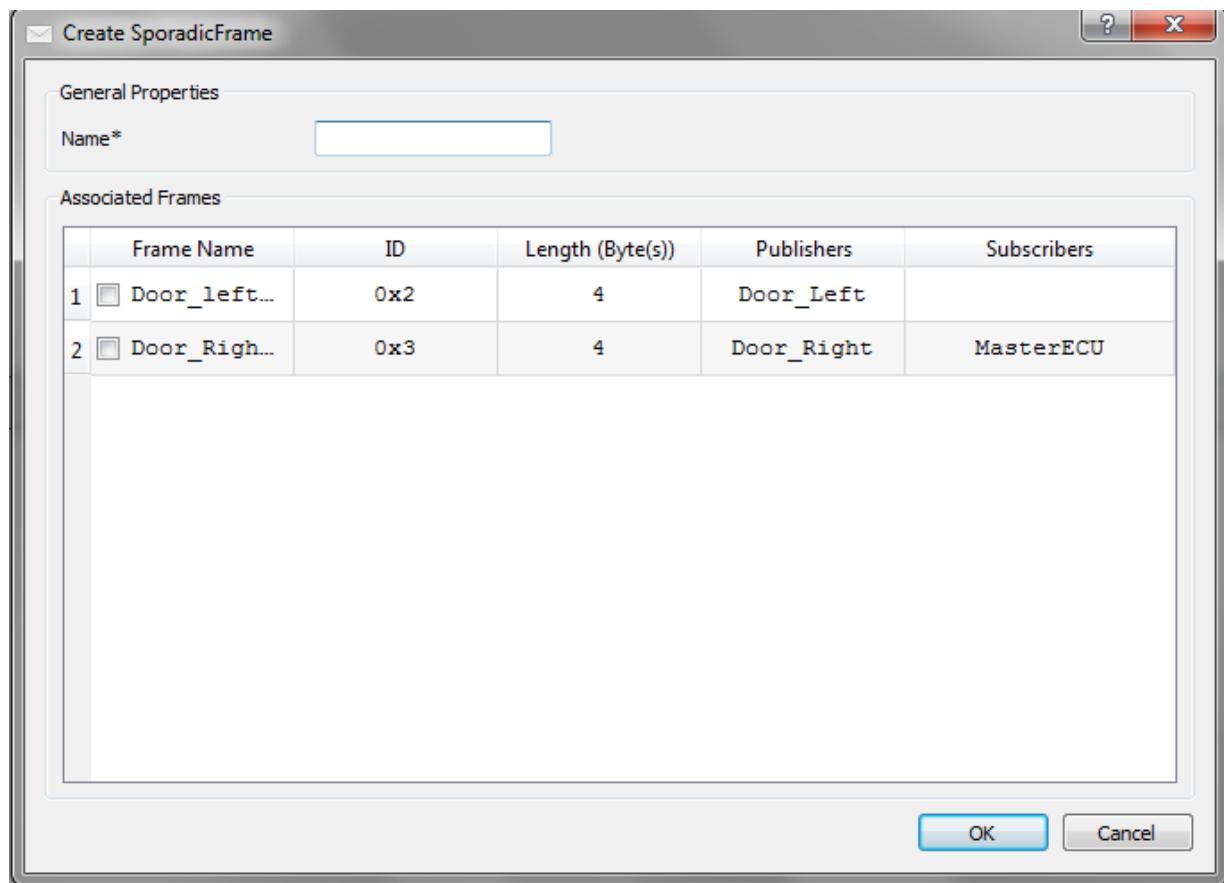
- Frame name will be checked for its uniqueness
- Frame Id will be checked for its uniqueness
- Checked if selected Associated frames belong to the Collision resolving table

To discard the changes click on 'Cancel' button.

Sporadic Frame

Creating Sporadic Frames:

To create Sporadic frame right click on the Sporadic Frame element in the element view and click on popup menu 'New'. 'Create Sporadic Frame' dialog is as shown below.



1. General Properties:

- **Name:** Name of the frame which should follow C identifier rules and should be unique.

2. Associating Frames:

- Check the Unconditional frames to be mapped to the Sporadic frame from the Associated Frames list.

To save the changes click on 'OK' button. Errors are displayed if validation fails.

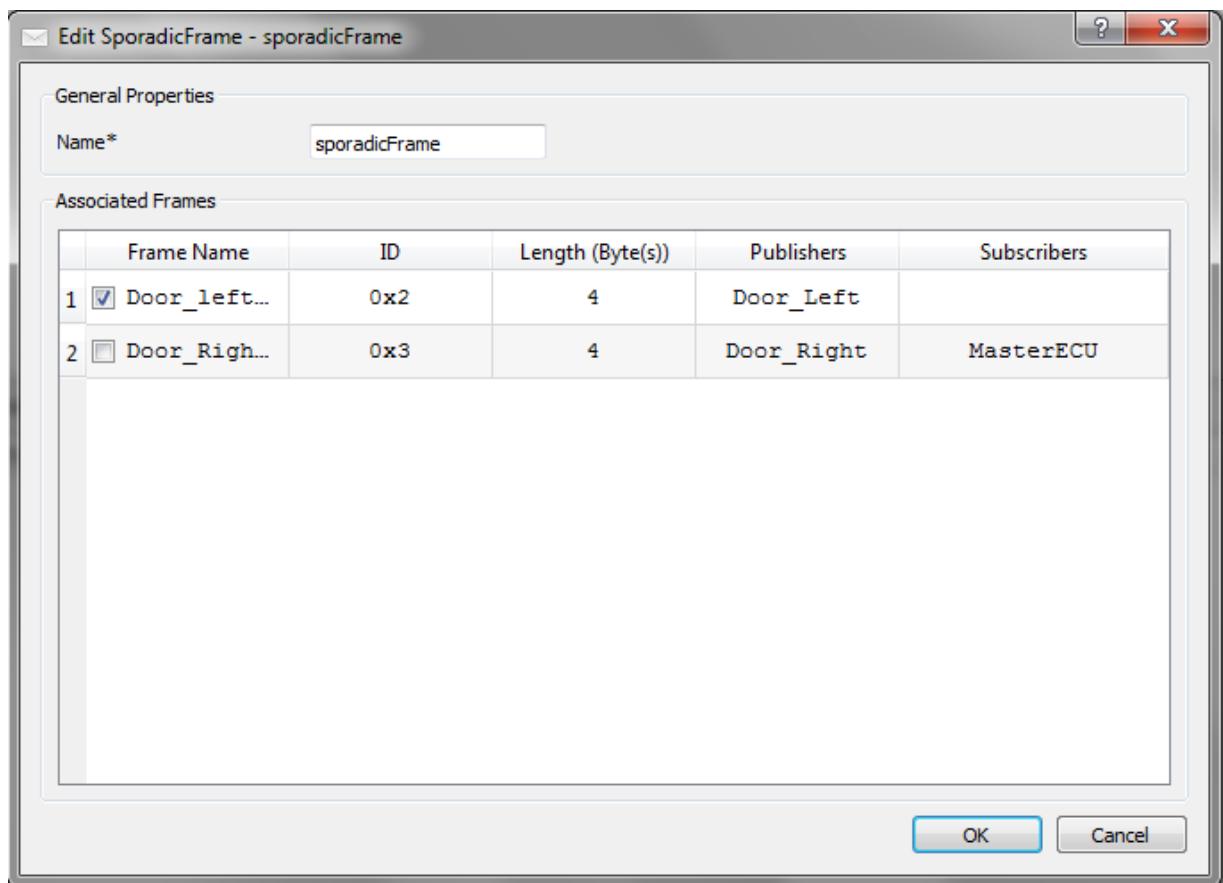
The following validations are performed:

- Frame name will be checked for its uniqueness

To discard the changes click on 'Cancel' button.

Editing Sporadic Frames:

To edit existing Sporadic Frame right click on the Sporadic frame item in the Element view and click on 'Edit'. 'Edit Sporadic Frame' dialog is displayed as shown below.



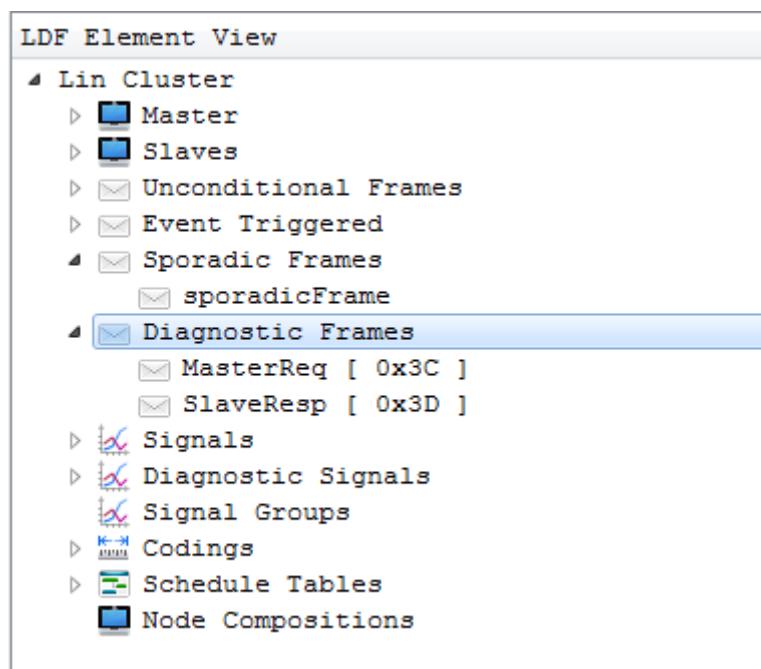
Deleting Sporadic Frame:

To delete Sporadic Frame, right click on the Sporadic item in the Element view and click on the popup menu 'Delete'. A confirmation message will be displayed before deleting the frame.

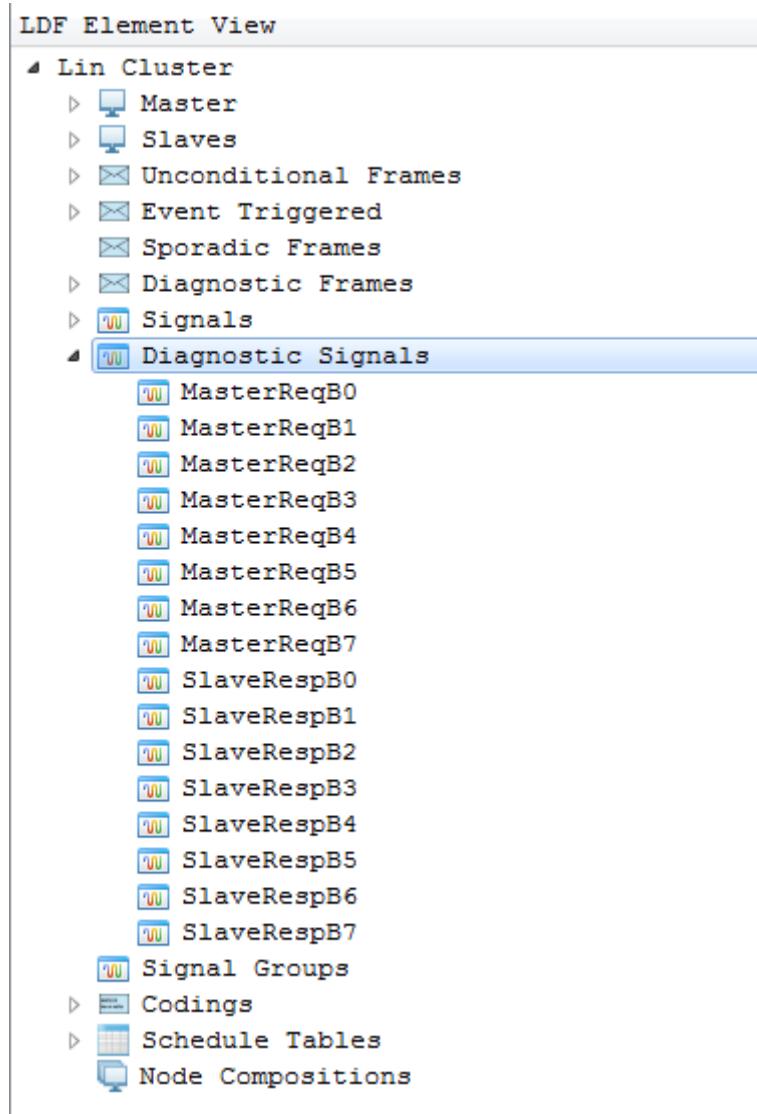
Diagnostic Support

Adding Diagnostic Support:

To create diagnostic frames, right click on the 'Diagnostic Frames' element in the Element view. By default 'MasterReq' and 'SlaveResp' diagnostic frames will get created as shown below.



On Adding diagnostic support for Frame, Diagnostic Signals will get automatically created for Master and Slave under 'Diagnostic Signals' in the Element View as shown below.



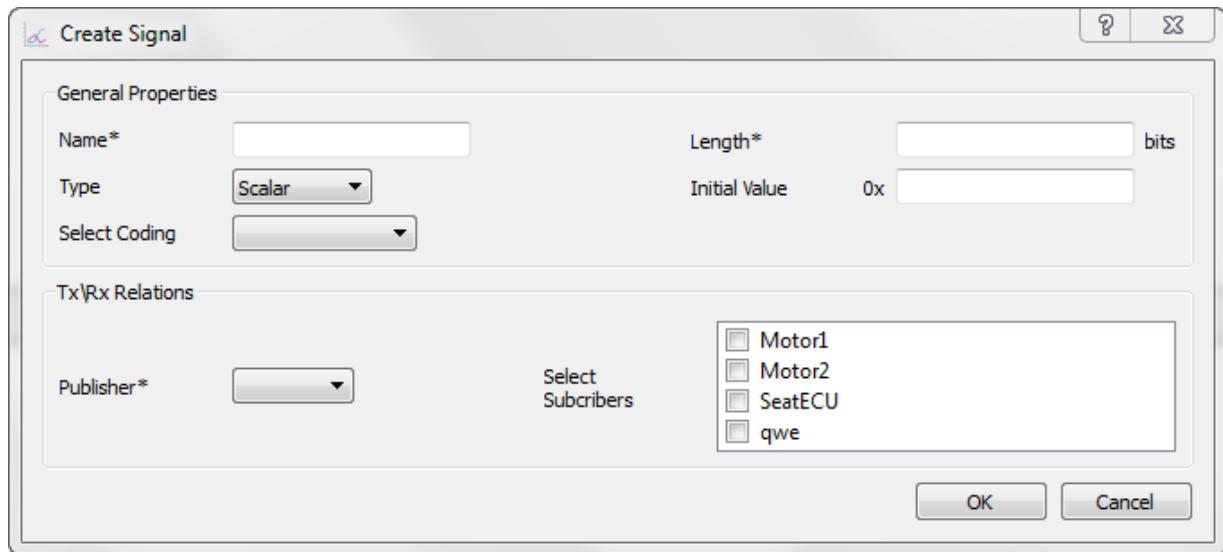
Removing Diagnostic Support:

To remove diagnostic support right click on 'Diagnostic Frames' in the Element view and click on 'Remove Diagnostic Support' which removes diagnostic frames and diagnostic signals.

Signals

Creating Signals:

To create Signals right click on the **Signals** element in the element view and click on pop up menu 'New'.A dialog Box as Shown in below image will be displayed.



1. General Properties:

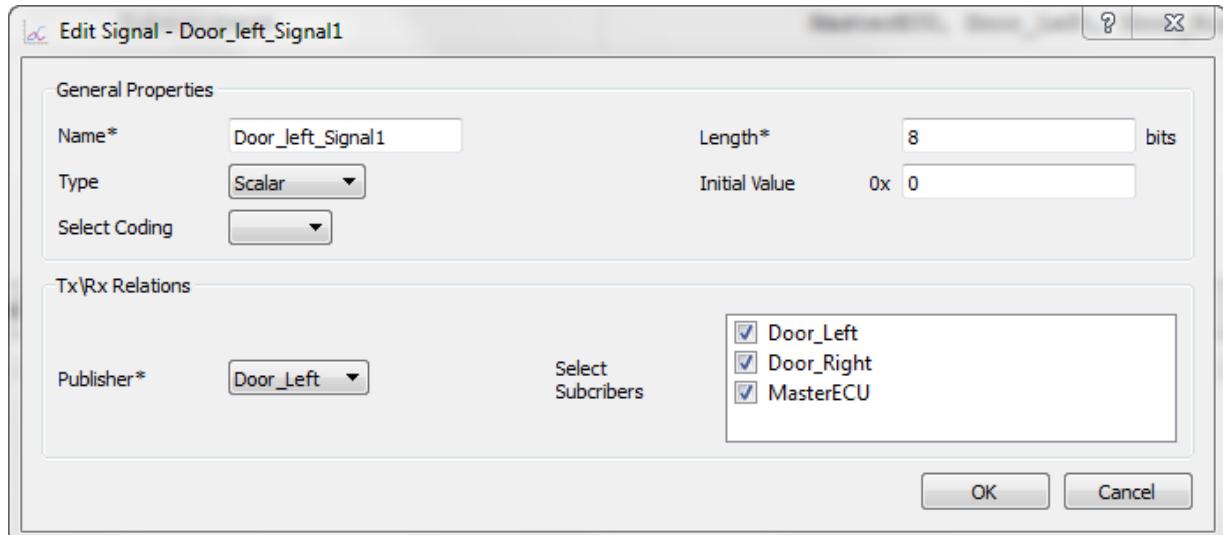
- Name:** Name of the Signal should follow C identifier rules and should be unique in signal list.
- Length:** Length of the Signals in bits. The value always will be displayed as Decimal mode
- Type:** Signal type can be either scalar or Byte array.
- Initial Value:** This will be the initial value of the signal.
- Coding:** Coding for the signal can be selected from the drop down **Select Coding**, which lists all the defined Codings. To define new coding refer the section Codings.

2. Publisher and Subscribers:

- Signal publisher can be selected from the **Publisher** drop down which lists Master and all the Slave nodes
- Subscribers of the signals can be selected from the **Select Subscribers** list.

Editing Signals:

To edit existing Signal right click on the required signal item in the Element view and click on 'Edit'. **Edit Signal - <Signal Name>** dialog is displayed as shown below.



If the publisher is changed, the signal will be unmapped from the frames which are published by the old ECU.

To save the changes click on 'OK' button. Errors are displayed if validation fails.

The following validations are performed:

- Signal name will be checked for its uniqueness
- Initial value should be in range of 0 (to $2^{\text{signal_length}} - 1$)

- A Publisher should be selected.

To discard the changes click on 'Cancel' button.

Deleting Signal:

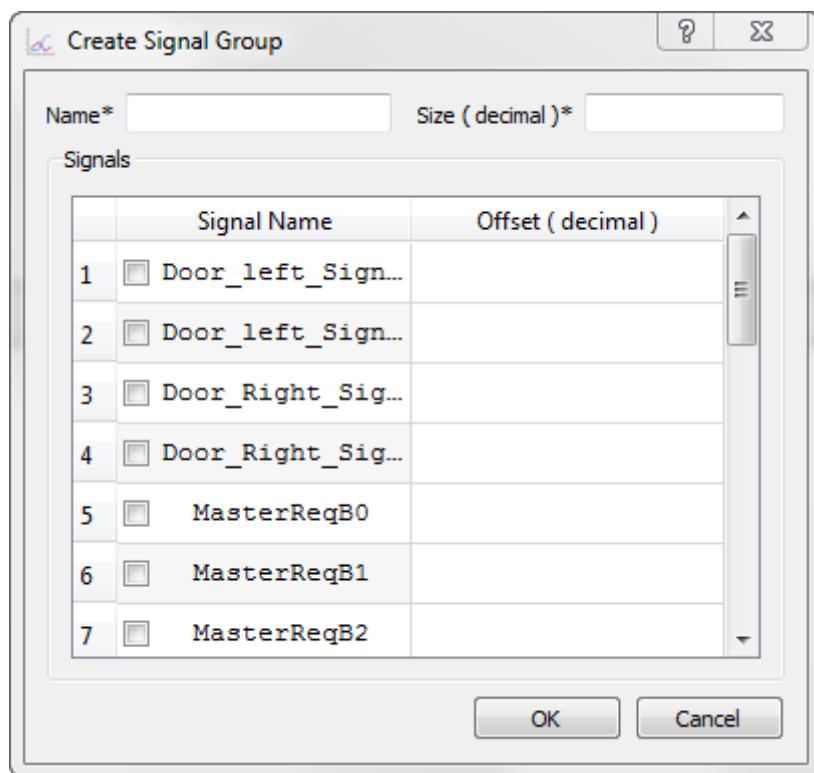
To delete any signal, right click on the Signal item in the Element view and click on the pop up menu **Delete**. A confirmation message will be displayed before deleting the signal.

On deletion, deleted signal will be unmapped from all associated frames, Publisher and the Subscribers.

Signal Group

Creating Signal Groups:

To create Signal group right click on the **Signal Group** element in the element view and click on pop up menu '**New**'. A dialog Box as Shown in below image will be displayed.



1. General Properties:

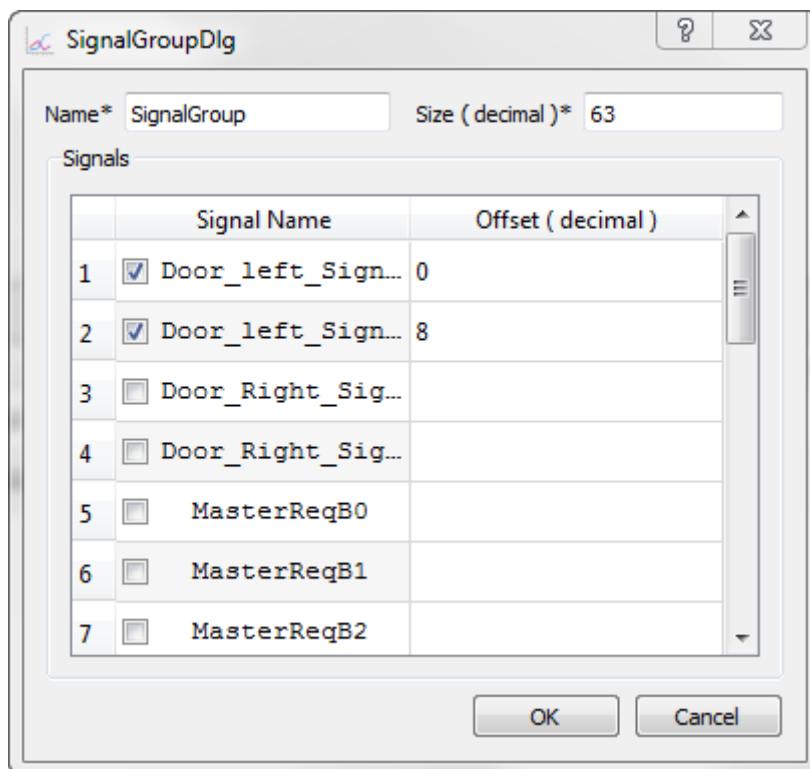
- **Name:** Name of the Signal Group should follow C identifier rules and should be unique in Signal and Signal Group List.
- **Size:** The size of the signal group can be defined here.

2. Signals:

- This list the all the signal defined in the LIN Cluster. Signals can be added\deleted from the group by checking\ unchecking.

Editing Signal Group:

To edit existing Signal group right click on the required Signal group item in the Element view and click on 'Edit'. **Edit Signal - <Signal Group Name>** dialog will be displayed as shown below.



Signals can be added\deleted from the group by checking\ unchecking corresponding check box.The signal offset can be changed in the Offset filled.

To save the changes click on 'OK' button. Errors are displayed if validation fails.

The following validations are performed:

- Signal group name will be checked for its uniqueness.
- The offset of each signal should be less than the Signal Group size.

To discard the changes click on 'Cancel' button.

Deleting Signal Group:

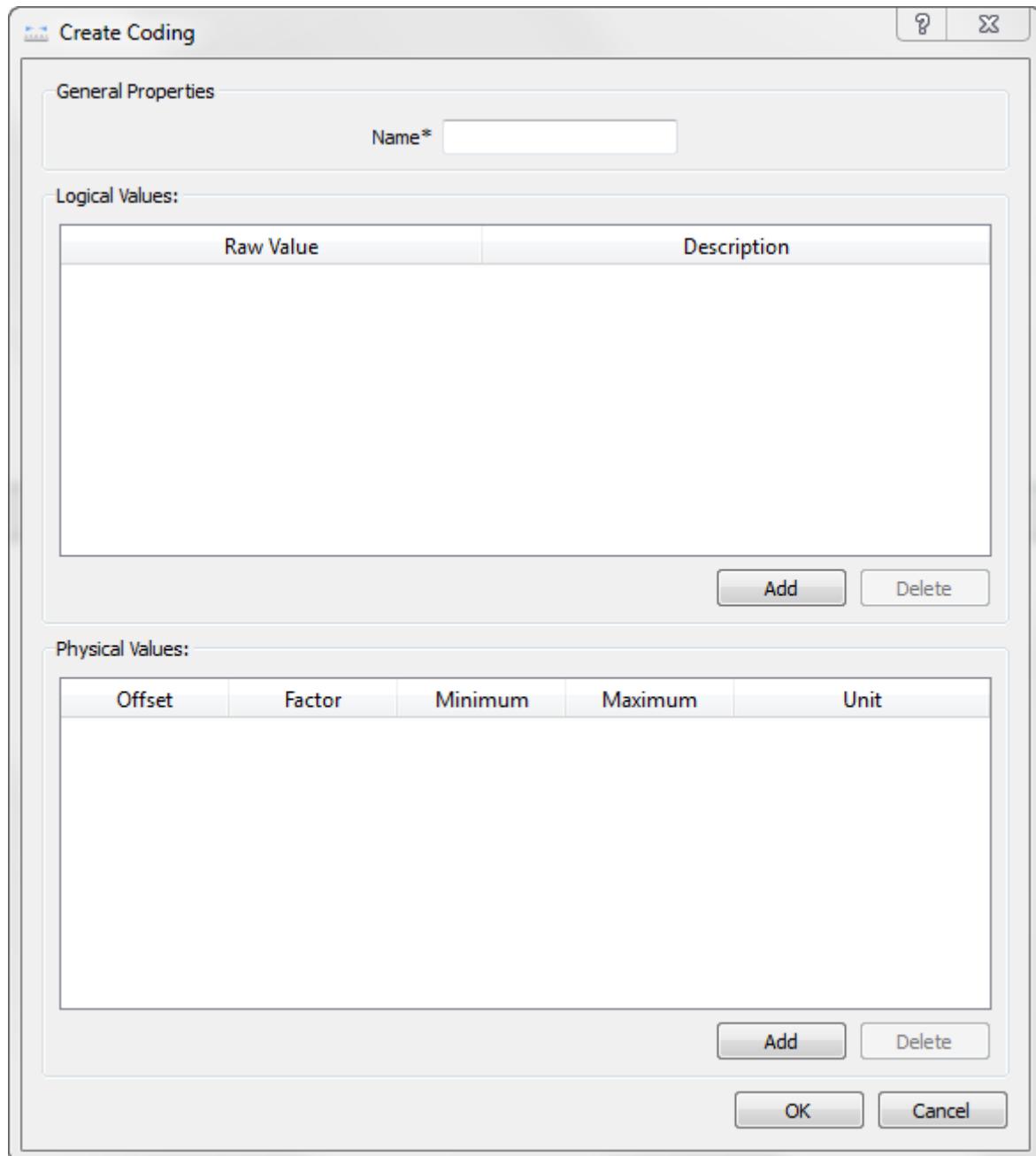
To delete any signal group, right click on the signal group item in the Element view and click on the pop up menu **Delete**. A confirmation message will be displayed before deleting the coding.

Note: Signal groups are depreciated from LDF2.x version.

Codings

Creating Codings:

To create Codings right click on the Codings element in the element view and click on pop up menu '*New*'.A dialog Box as Shown in below image will be displayed.

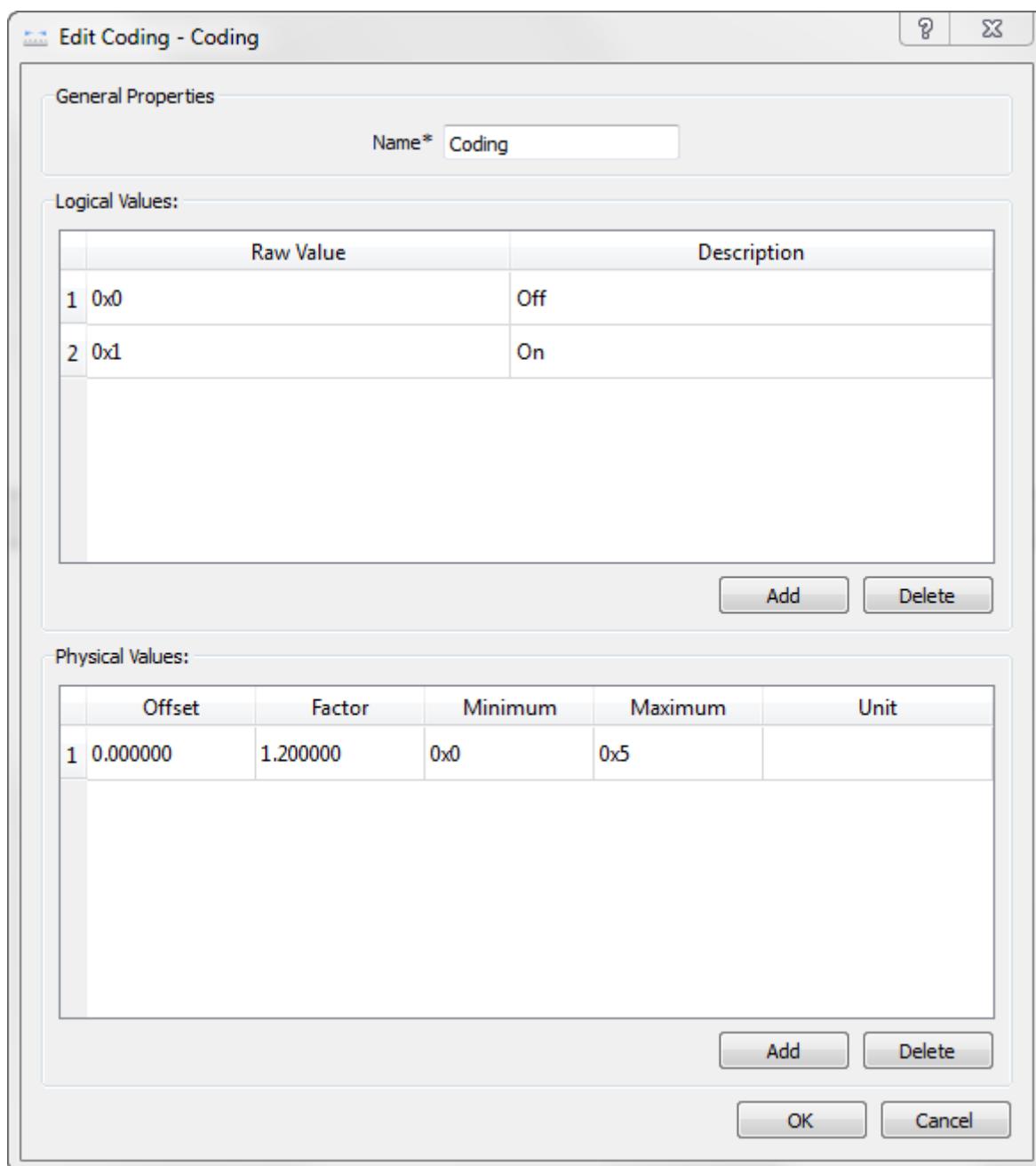


1. General Properties:

- **Name:** Name of the Coding should follow C identifier rules and should be unique in coding list.
- 2.** Logical values and physical values can be created using Add Buttons provided in the corresponding sections.

Editing Codings:

To edit existing Coding right click on the required coding item in the Element view and click on 'Edit'. **Edit Coding - <Coding Name>** dialog will be displayed as shown below. All The values are editable



To delete a logical element select the logical row and click on the Delete button provided in the same section. Similarly Physical values also can be deleted using the delete button provided in the same section.

To save the changes click on 'OK' button. Errors are displayed if validation fails.

The following validations are performed:

- Coding name will be checked for its uniqueness

To discard the changes click on 'Cancel' button.

Deleting Coding:

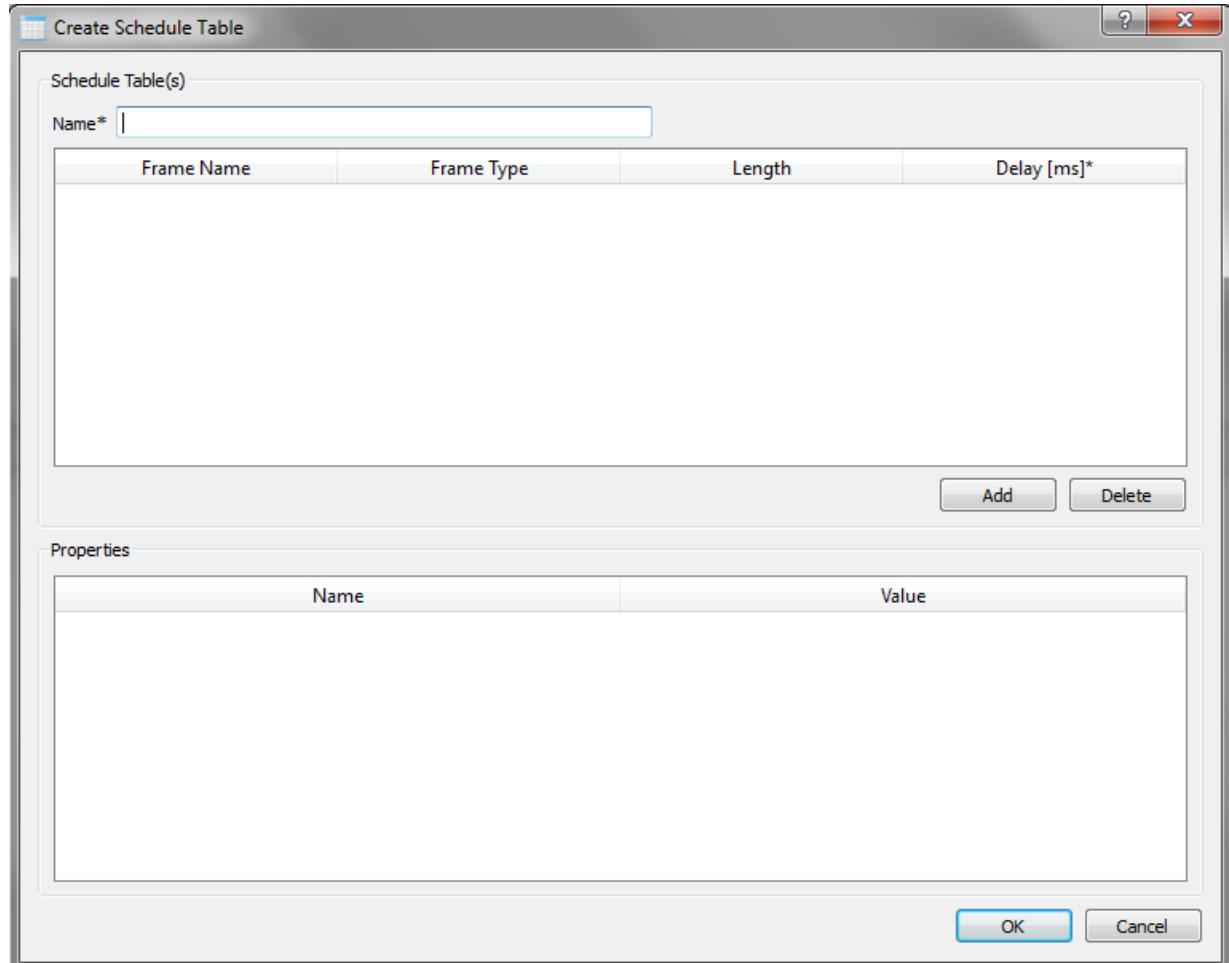
To delete any coding, right click on the coding item in the Element view and click on the pop up menu **Delete**. A confirmation message will be displayed before deleting the coding.

On deletion, coding will be unmapped from all associated signals.

Schedule Table

Creating Schedule Table:

To create Schedule Table right click on the Schedule Table element in the Element view and click on popup menu 'New'. Create Schedule Table dialog is as shown below.



1. General Properties:

- **Name:** Name of the Schedule Table should follow C identifier rules and should be unique.

2. Adding Schedule Table Item:

- To Add Schedule Table Item, click on 'Add' button which adds a new row in Frame list.
- Frame Name drop down will be populated with the list of Unconditional frames, Event Triggered frames, Sporadic frame and Diagnostic Frames.
- Select the Frame name from the Frame Name drop down.
- Specify the delay in delay field.

3. Deleting Schedule Table Item:

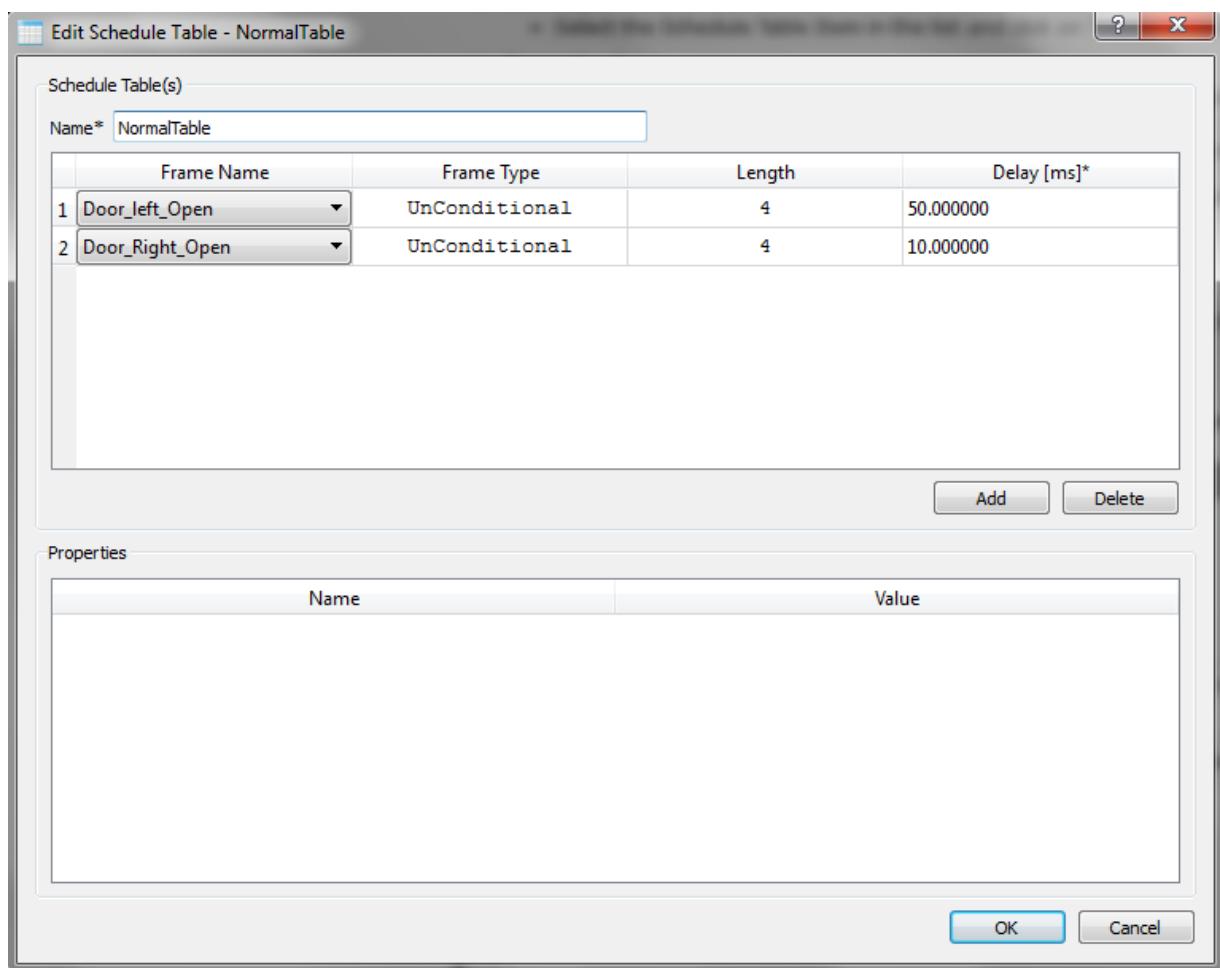
- Select the Schedule Table Item in the list and click on 'Delete' button

4. Property view:

- On selecting Schedule Table Item in the list, properties will be displayed in the property view based on the type of the frame selected
- User defined parameters will be editable in the Property view for user input

Editing Schedule Table:

To edit existing Schedule Table right click on the Schedule Table in the Element view and click on 'Edit'. 'Edit Schedule Table' dialog is displayed as shown below.



Deleting Schedule Table:

To delete Schedule Table, right click on the Schedule Table in the Element view and click on the popup menu 'Delete'. A confirmation message will be displayed before deleting the frame.

To save the changes click on 'OK' button. Errors are displayed if validation fails.

The following validations are performed:

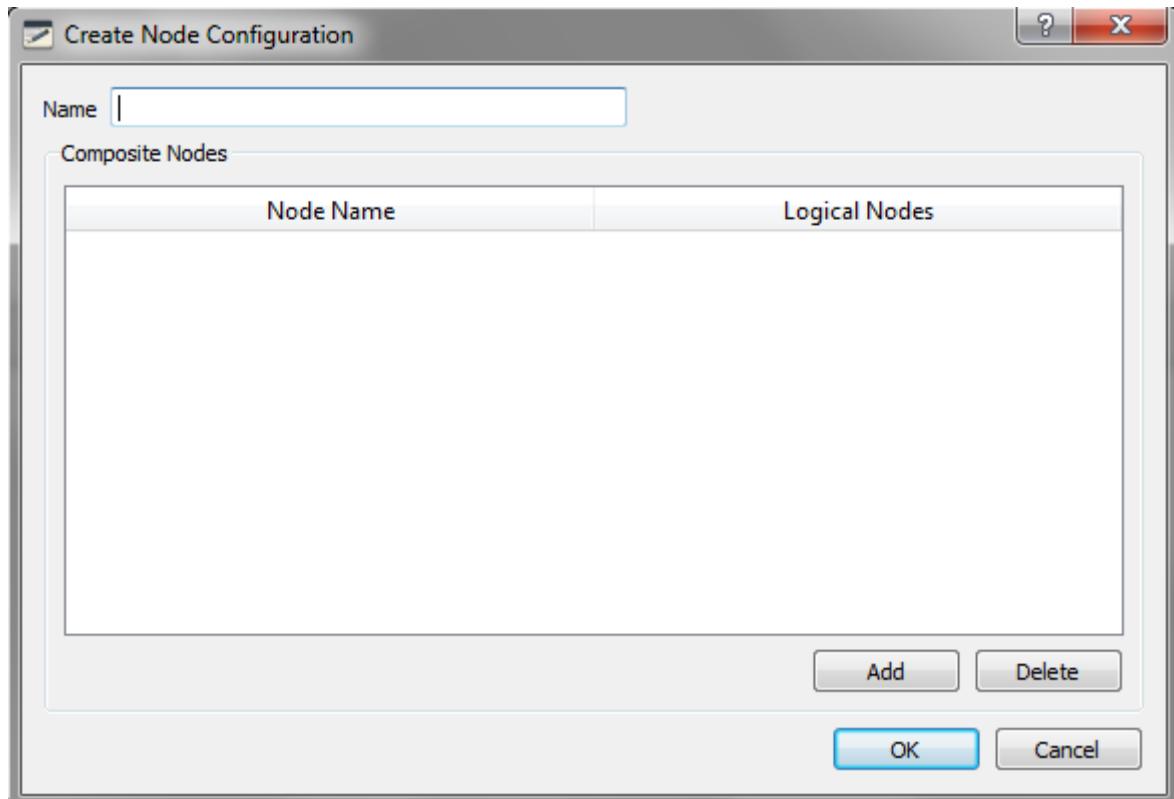
- Schedule Table name will be checked for its uniqueness

To discard the changes click on 'Cancel' button.

Node Composition

Creating Node Compositions:

To create Node Configuration right click on the Node Composition element in the element view and click on popup menu 'New'. Create Node Configuration dialog is as shown below.



1. General Properties:

- **Name:** Name of the Node Configuration should follow C identifier rules and should be unique.

2. Adding Node Composition:

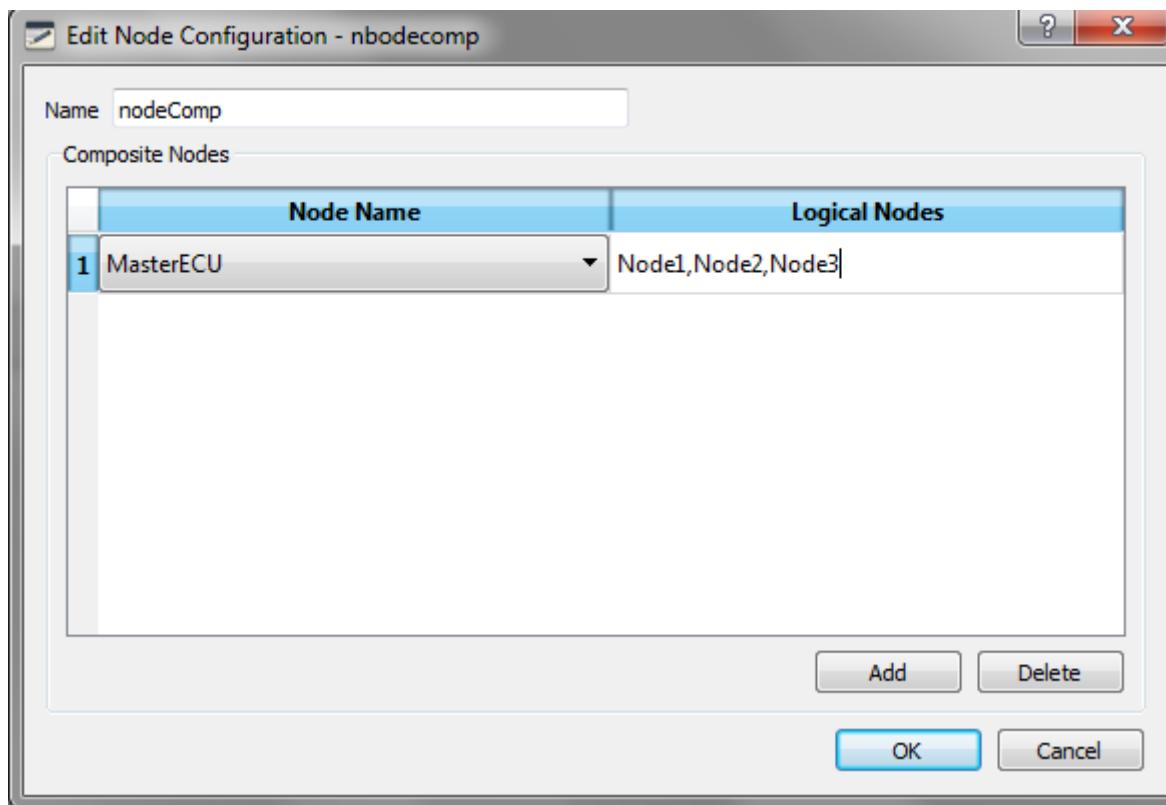
- To Add Node Composition, click on 'Add' button which adds a new row in Node list.
- Node Name drop down will be populated with the list of Nodes available.
- Select the Node from the Node Name drop down.
- Specify the logical nodes in the Logical Nodes field. Multiple Logical Nodes can be specified separating with comma.

3. Deleting Node Composition Item:

- Select the Node Composition Item in the list and click on 'Delete' button

Editing Node Compositions:

To edit existing Node Configuration right click on the Node Composition in the Element view and click on 'Edit'. 'Edit Node Configuration' dialog is displayed as shown below.

**Deleting Node Composition:**

To delete Node Configuration, right click on the Node Configuration in the Element view and click on the popup menu 'Delete'. A confirmation message will be displayed before deleting the Node Configuration.

To save the changes click on 'OK' button. Errors are displayed if validation fails.

The following validations are performed:

- Node Configuration name will be checked for its uniqueness
- Logical Nodes will be checked for its uniqueness

To discard the changes click on 'Cancel' button.

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*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.

gvcvt, gcvtf : format double or float as string

Synopsis

```
#include <stdlib.h>
char *gvcvt(double val, int precision, char *buf);
char *gcvtf(float val, int precision, char *buf);
```

Description

gcvt writes a fully formatted number as a null-terminated string in the buffer *buf. gdvtf produces corresponding character representations of float numbers.

gcvt 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 ferror 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 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.

fprintf : format output to file (integer only)

Synopsis

```
#include <stdio.h>
int fprintf(FILE *fd, const char *format, ...);
```

Description

fprintf 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

fprintf returns the number of bytes in the output string, save that the concluding NULL is not counted. fprintf returns when the end of the format string is encountered. If an error occurs, fprintf 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:

r	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.
w	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.
a	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 disasterous. 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-convertable 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).

siprintf : write formatted output (integer only)**Synopsis**

```
#include <stdio.h>
int siprintf(char *str, const char *format [, arg, ...]);
```

Description

siprintf is a restricted version of sprintf: 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

siprintf returns the number of bytes in the output string, save that the concluding NULL is not counted. siprintf 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, tempnam : name for a temporary file**Synopsis**

```
#include <stdio.h>
char *tmpnam(char *s);
char *tempnam(char *dir, char *pfx);
char *_tmpnam_r(void *reent, char *s);
char *_tempnam_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.

tempnam 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

strcmp : character string compare**Synopsis**

```
#include <string.h>
int strcmp(const char *a, const char * b, size_t length);
```

Description

strcmp compares up to length characters from 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 are equivalent, strcmp returns zero. If *a sorts lexicographically before *b, strcmp 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 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 $y'' + xy' + ny = 0$. 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.

`cbrt, cbrtf : cube root`**Synopsis**

```
#include <math.h>
double cbrt(double x);
float cbrtf(float x);
```

Description

`cbrt` 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 `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

`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). `erfc` calculates the complementary probability; that is, $\text{erfc}(x)$ is $1 - \text{erf}(x)$. `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. `erff` and `erfcf` differ from `erf` and `erfc` only in the argument and result types.

Returns

For positive arguments, `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

`exp` and `expf` calculate the exponential of x , that is, is the base of the natural system of logarithms, approximately 2.71828). You can use the (non-ANSI) function `matherr` to specify error handling for these functions.

Returns

On success, `exp` and `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

`expm1` and `expm1f` calculate the exponential of x and subtract 1, that is, is the base of the natural system of logarithms, approximately 2.71828). The result is accurate even for small values of x , where using $\exp(x)-1$ 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 *signgamp);
float gammaf_r(float x, int *signgamp);
double lgamma_r(double x, int *signgamp);
float lgammaf_r(float x, int *signgamp);
```

Description

gamma calculates the natural logarithm of the gamma function of x. The gamma function ($\exp(\gamma(x))$) 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,finitef : 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 finitef(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 finitef 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 exp1.0nt 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, sinhf : hyperbolic sine

Synopsis

```
#include <math.h>
double sinh(double x);
float sinhf(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

This chapter describes miscellaneous routines not covered elsewhere.

unctrl : translate characters to upper case

Synopsis

```
#include <unctrl.h>
char *unctrl(int c);
int unctrllen(int c);
```

Description

unctrl is a macro which returns the printable representation of c as a string. unctrllen is a macro which returns the length of the printable representation of c.

Returns

unctrl returns a string of the printable representation of c. unctrllen 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_list.

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

C Library functions help is taken from GCC help content and it is from

The Cygnus C Support Library

Copyright (c) 1991 by AT&T.

Permission to use, copy, modify, and distribute this software for any purpose without fee is hereby granted, provided that this entire notice is included in all copies of any software which is or includes a copy or modification of this software and in all copies of the supporting documentation for such software.

THIS SOFTWARE IS BEING PROVIDED "AS IS", WITHOUT ANY EXPRESS OR IMPLIED WARRANTY. IN PARTICULAR, NEITHER THE AUTHOR NOR AT&T MAKES ANY REPRESENTATION OR WARRANTY OF ANY KIND CONCERNING THE MERCHANTABILITY OF THIS SOFTWARE OR ITS FITNESS FOR ANY PARTICULAR PURPOSE.

Hot Keys

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

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 an 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 reply. 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.

Question:Which version of MinGW Compiler is supported in BUSMASTER?

Answer:

MinGW gcc version 4.8.1 (tdm-1). It is available at <http://sourceforge.net/projects/tdm-gcc/files/TDM-GCC%20Installer/Previous/1.1309.0/tdm-gcc-4.8.1.exe/download>

Question: On compiling file in Node Simulation, the output window shows "No such file or directory" even though the file exists?

Answer:

Possible reasons could be:

1. MinGW doesn't support certain file path format such as having space in the file path.

Question: Even if the .cpp file is built and .dll is generated still on connecting, the output window display "Input File open error: [Filepath].def Unable to initialise handler functions for execution. The DLL [Filepath].dll is unloaded" and Node Simulation fails?

Answer:

This because the .def file of the .cpp might have got deleted. To create the .def file double click on the particular node and this opens function editor. When the function editor is opened automatically the .def file is created, and the .dll will be loaded on connection.

Unused chapters

Message Logging

User can configure the name of the log file to which the messages will be logged by following the steps given below

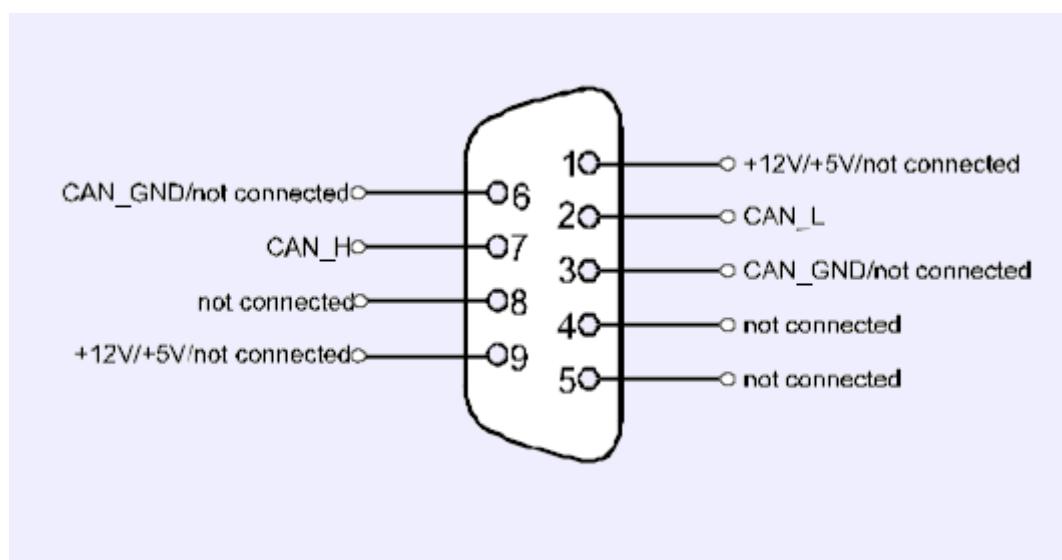
- Select **Configure > Log**
- Select log file name. You can also navigate to any folder to select the log file. If an existing file is selected it will be overwritten if Over Write Mode. Otherwise it will append the same log file for each new logging session. If a new file name is entered, you will 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

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.



Additional Installation

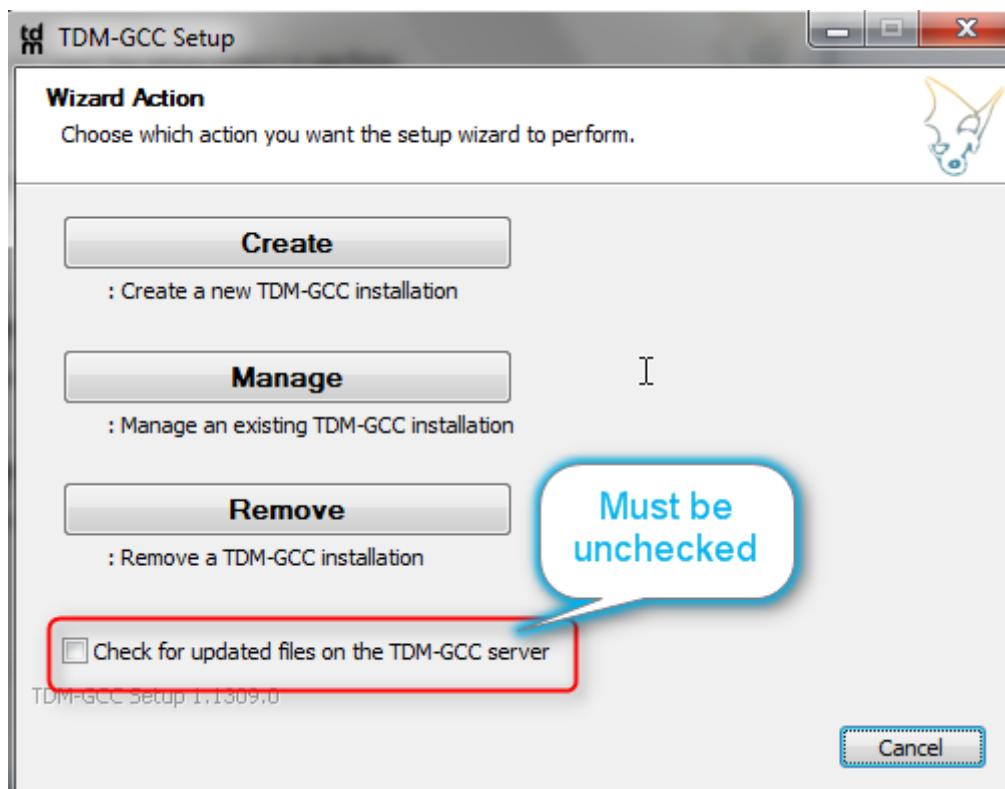
BUSMASTER Uses MinGw g++ compiler to build Node Simulation files. Follow the below link to install MinGw compiler.

MinGW Installation using TDM-GCC Installer

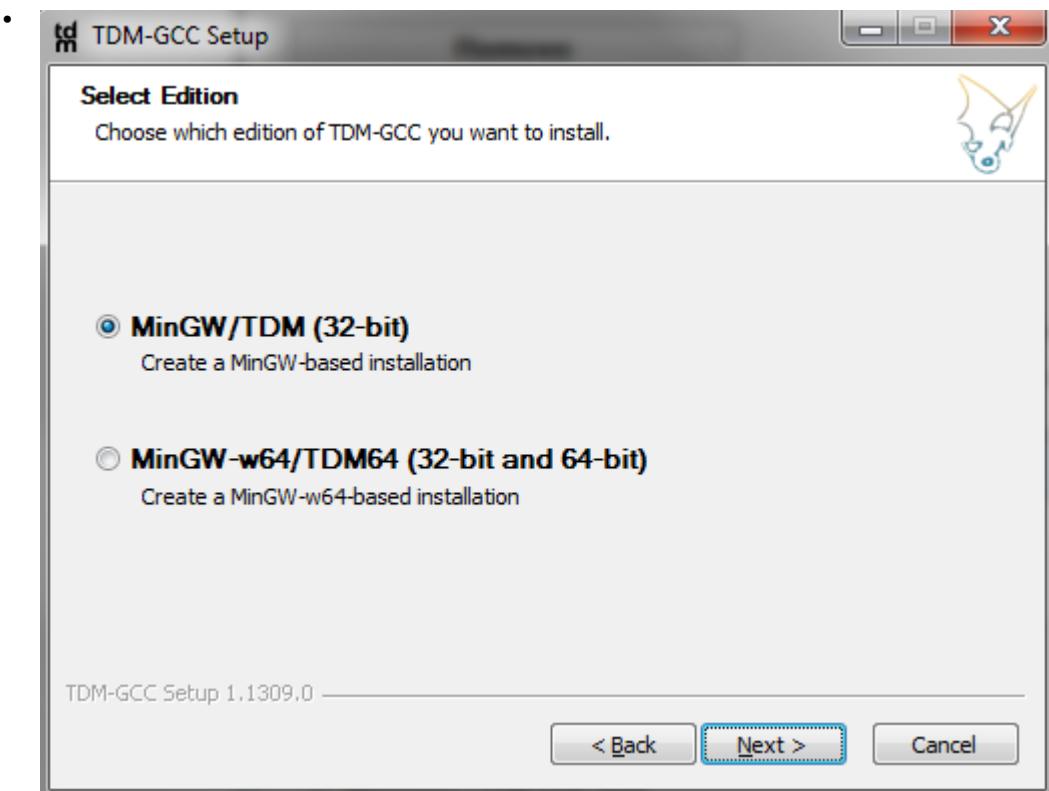
MinGW Installation

The following steps should be followed to Download and install MinGW using TDM-GCC Installer.

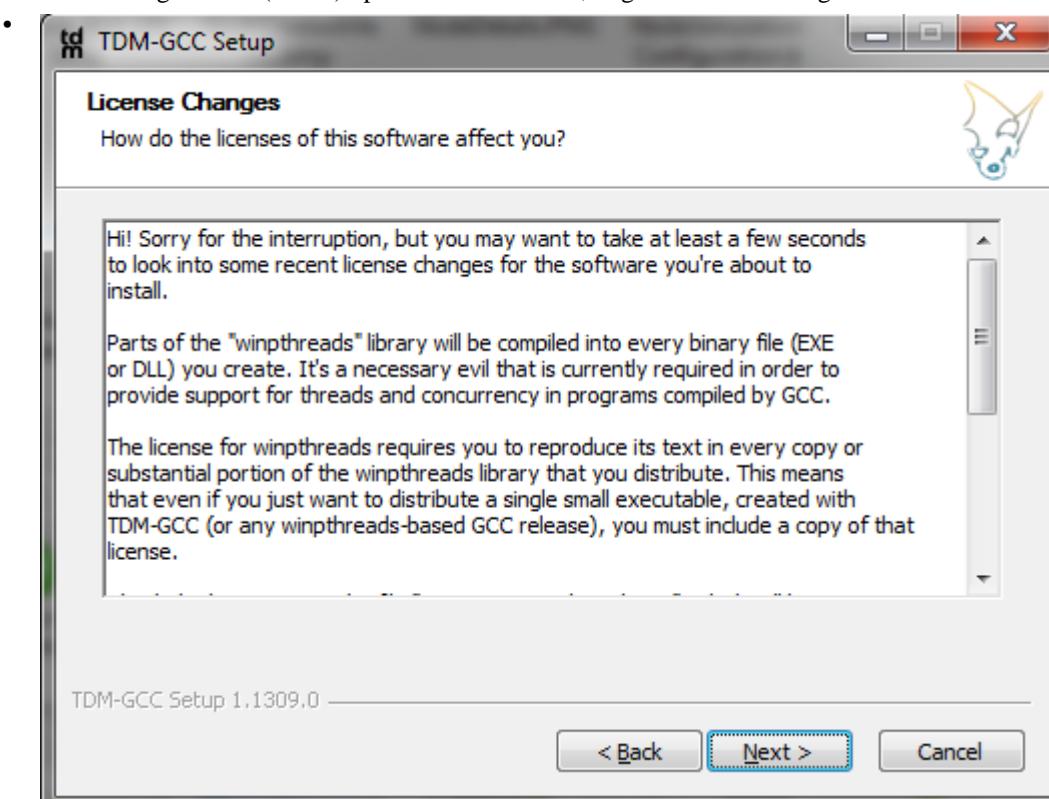
- Download the TDM-GCC from the following link <http://sourceforge.net/projects/tdm-gcc/files/TDM-GCC%20Installer/Previous/1.1309.0/tdm-gcc-4.8.1.exe/download>
- Run the installer. Following image will show the first screen of the installer.



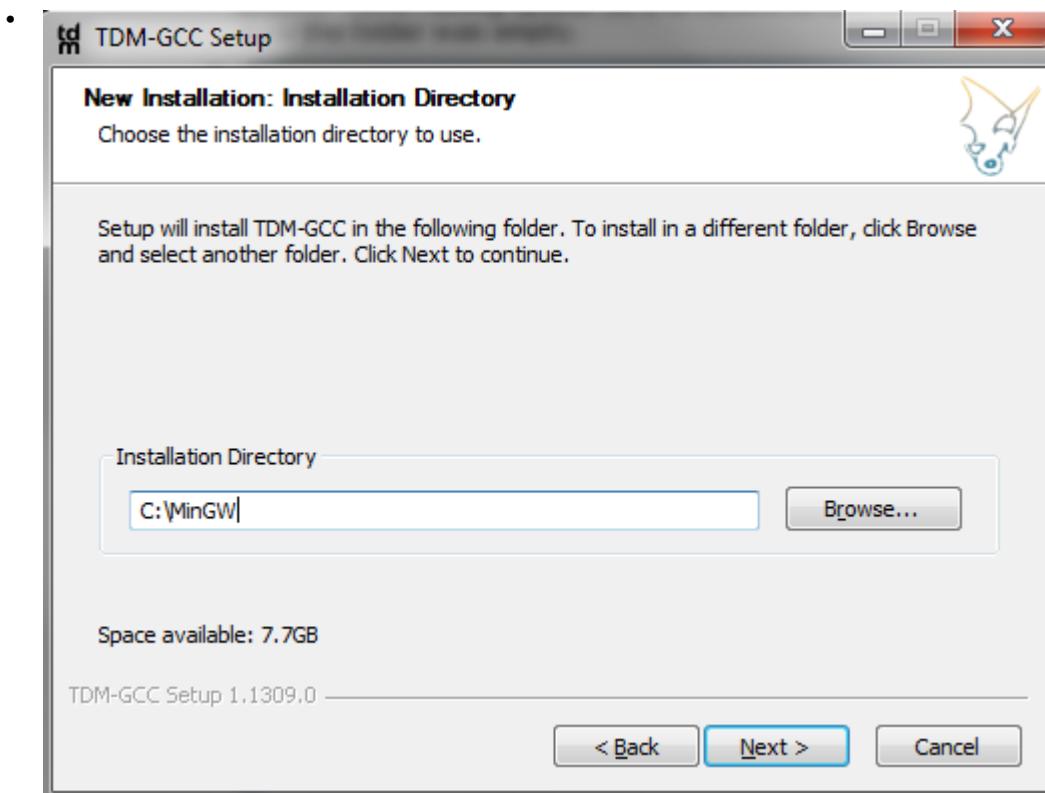
- Click on the create button, if you are installing the first time this will go to the following screen.



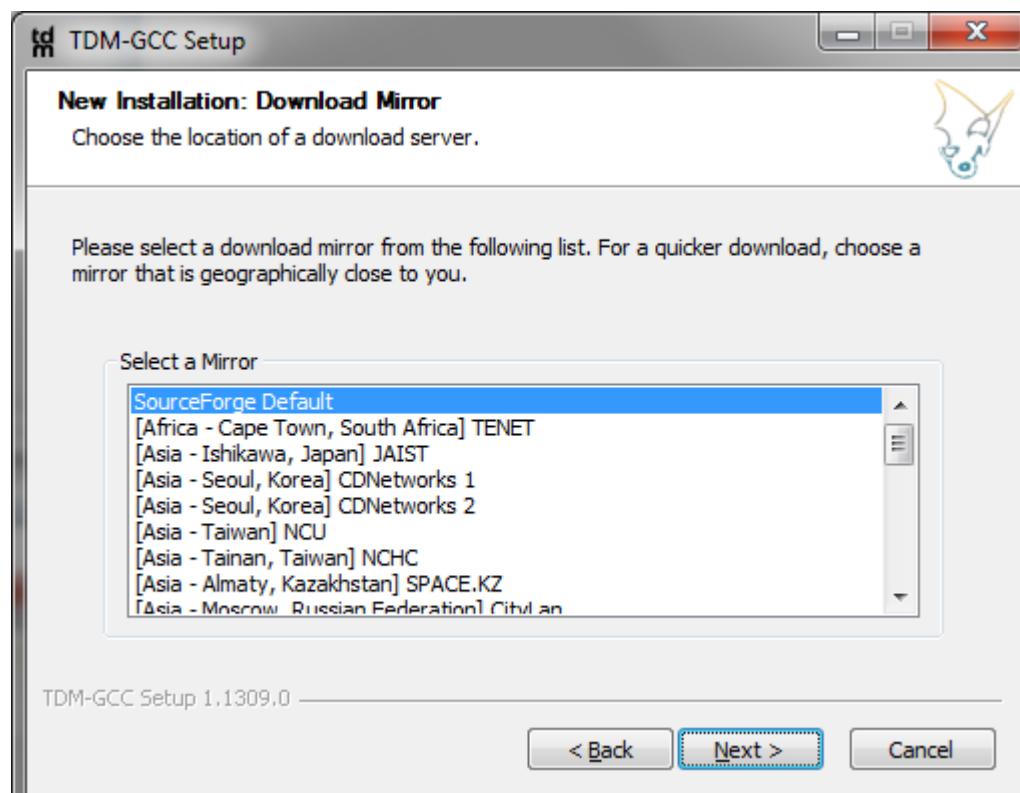
- Select MingW/TDM(32-bit) option and click Next, to get to the following screen.



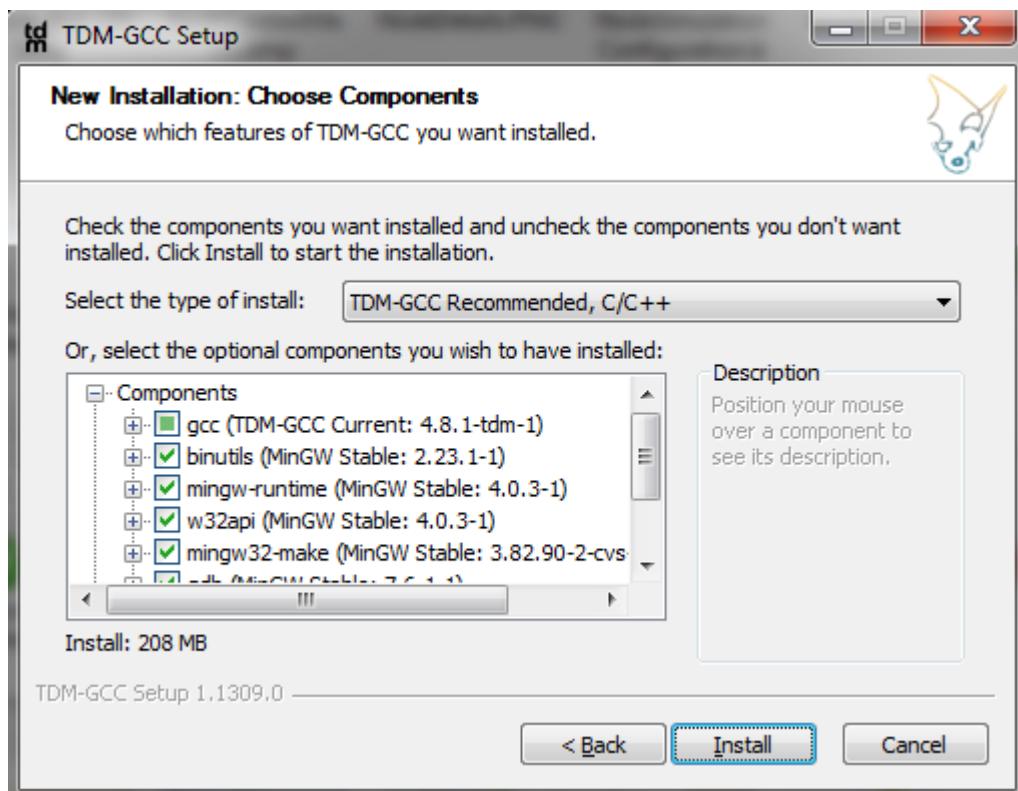
- Click Next and provide path to install the GCC . GCC has some problems if it is installed in a folder name having space. So it is recommended to install in path like C:\MinGw. Make sure the folder was empty.



- Click Next



- Click Next and select MingW Stable, C/C++ option as shown in the below image.



- Make sure 'Add to path' option is selected. Click to install.

