

MC33816 DevTool IDE

Reference Manual

by

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ASH WARE, Inc.

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ASH WARE Inc.

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1

Overview

This introductory section provides a high level overview of some of the key aspects of the MC33816 Development Tool. More detail is provided in the remainder of this manual.

Source Code Files

[Source code files](#) are built using an assembler and the resulting executable image is loaded into the target/core code space. When executing code, it is actually the executable image that gets executed. Source level debugging information cross references the source code files' line numbers and variables with the underlying executable image thereby supporting key debugging capabilities such as breakpoints, single stepping, viewing/modifying variables in watch windows, etc. Source code files can be edited directly within the IDE. Once edited, the source code is considered 'dirty' and will be rebuilt prior to resuming execution. The process of rebuilding and loading of the executable image is done automatically and largely transparently to the user.

Script Commands Files

[Script commands files](#) have several purposes. The primary script file used to automate things like loading code, initialization, and functional verification. Startup script commands files (available to the MC33816 and CPU) are executed following a reset or when the MC33816 Development Tool is initially launched. The purposes of the startup script

commands file is initialization and getting the target/core into the correct state for loading code when MC33816 Development Tool is launched.

Test Vector Files

[Test vector files](#) provide the user with one means of exercising input and I/O pins with complex test patterns. While a script commands file functionally represents the CPU or Host-MCU interface, a test vector file represents the external interface. And whereas a script commands file provides a broad range of functions, the test vector file provides the narrow but powerful capability of driving nodes to "high" or "low" states.

Concurrently Developing Code for Multiple Targets/Cores

Code for multiple targets/cores can be developed, and debugged, concurrently. Interactions between and among multiple targets/cores are modeled precisely and accurately. All the normal debugging techniques such as single stepping, setting breakpoints, stepping into functions, etc., are available for each target/core. The IDE supports instantaneous target/core switching such that it is possible in the system simulator, for example, to run to a CPU breakpoint, and then switch to a eTPU or MC33816 core and single step it. All the while, all targets/cores are kept fully synchronized.

Miscellaneous Capabilities

The MC33816 Development Tool has a number of additional features not yet mentioned. These include [project sessions](#), [source code files](#), [functional verification](#), [external logic simulation](#), [multiple workshops](#), a rich set of [dialog boxes](#), a [menu system](#), and an IDE with hot keys, a toolbar, and target status indicators.

1.1 On-Line Help Contents

The following help topics are available.

[Overview](#)

[Software Deployment, Upgrades, and Technical Support](#)

[Supported Targets and Available Products](#)

[Project Sessions](#)

[Source Code Files](#)

[Script Commands Files](#)
[Script Commands Groups](#)
[Test Vector Files](#)
[Functional Verification](#)
[External Logic Simulation](#)
[Workshops](#)
[Operational Status Windows](#)
[Dialog Boxes](#)
[Menus](#)

2

Demo Descriptions

Note that YouTube videos covering several of these demos as well as feature tutorial demos are available on our website at www.ashware.com/product_videos.htm.

The following GTM demos install by default with MC33816 Development Tool.

Direct Injection Demo

- A simple 'starting point' injector demo.
- Implemented as a graphical state machine.

DC DC Converter Demo

- Use of the NXP DC/DC Converter function.
- A simple implementation of the DC to DC Converter function
- Script command variables used programmatically to inject Battery droop and overload conditions while verifying VBoost voltage

H-Bridge Demo

2. Demo Descriptions

- A simple 'starting point' H-Bridge demo.
- Advanced scripting including use of a two-dimensional array to hold test cases and expected behavior as well as looping and inner-scope variable declarations.

Direct Injection 'Diagnostics Faults' Demo

- Use of the diagnostics to detect and isolate various injector faults.
- Use of script commands to inject fault test cases.

Direct Injection 'Moving to Hardware' Demo

- A demo is available at the following link. www.ashware.com/product_videos.htm
- GTM is controlled by 'C' code compiled for, and running in, a simulated CPU
- Implements the required steps to interface to the GTM from a Host CPU Across a SPI Bus
- Data RAM initialization by using the initialization macros auto-generated by the assembler to perform a block write across the SPI bus
- Code RAM initialization by doing a block write across the SPI Bus of the ciphered code image
- Registers initialization by compiling the startup script and performing SPI block writes using the resulting initialized array data
- Run time control of the GTM by controlling the start pins to fire the injector and updating of data RAM variables to affect operational parameters.

3

Software Upgrades

World Wide Web Software Deployment

All ASH WARE software is now deployed directly from the World Wide Web. This is done using the following procedure.

- Download and install a demo version of the desired software product. All software products are available at a demonstration level.
- Purchase the software product(s) either from ASH WARE or one of our distributors.
- E-mail to ASH WARE the license file, named "AshWareComputerKey.ack", found in the installation directory.
- Wait until you receive an e-mail notification that the information from your license file has been added to the installation utility.
- Download and re-install again. The software product(s) you purchased are now fully functional. All other software products are still available at a demonstration level.

World Wide Web Software Upgrades

3. Software Upgrades

All versions since 2.1 can be upgraded directly through the World Wide Web. The following procedure is required when performing this upgrade. Note that versions prior to 2.1 cannot be upgraded via the World Wide Web.

- [Upon receiving notification from ASH WARE that a new version of the MC33816 Development Tool is available, download and re-install.](#)

After the initial software upgrade, ASH WARE no longer requires a new software key.

Network Floating Licenses

Version 4.30 and above support a floating license capability. A central License Server has a pool of one or more licenses. Client computers request floating licenses from the License Server. The License Server issues licenses until its pool of licenses has been depleted. When a client computer no longer needs a license it becomes available for the License Server to distribute to a different client.

When a client requests a license it normally exits if no license is available. However, it may choose instead to wait a certain user-defined amount of time for a license to become available. If a license does become available the software is able to operate. If, after the user-specified amount of time is exceeded, no license becomes available then the software exits. This is especially useful in automated testing where the test would otherwise fail if no floating license were available. The amount of time to wait for a floating license to become available is specified by the `-NetworkRetry` parameter passed on the command line. See the [Command Line Parameters](#) section for specifying this parameter.

Dongle Licensing

A dongle is a physical device that attaches to a USB port on your computer. With a dongle license you can run the software in a fully-functional mode as long as the dongle is connected to your computer. If you unplug the dongle, then the software will run only in a demo-limited mode.

A dongle effectively replaces the license file in that you can move the software and dongle to a different computer and it will run in fully-functional mode without any interaction with ASH WARE. This is particularly valuable in (say) aerospace in which the software must be functional for many decades. Since the software can be moved between computers with no interaction with ASH WARE, this constitutes a stable long-term development and maintenance scenario.

Hearing about Software Releases

In order to be notified about ASH WARE's software releases, be sure to provide your e-mail address to ASH WARE. This will ensure that you are automatically alerted to production and beta software releases. Otherwise you will have to periodically check the ASH WARE Web site to find out about new software releases. Note that your e-mail address and other contact information will never be released outside of ASH WARE. Further, ASH WARE will only add you to our e-mail list if you specifically request us to do so.

The MC33816 Development Tool automatically displays an informational message when your software subscription is close to expiration. Note that the software license has no expiration so it is legal to use the MC33816 Development Tool beyond the software subscription expiration date. The software subscription entitles you to free technical support and Web-based software upgrades.

Technical Support Contact Information

With the purchase of this product comes a one-year software subscription and free technical support. This technical support is available through Email, the World Wide Web, and telephone. Contact information is listed below.

- (503) 533-0271 (phone)
- www.ashware.com
- support@ashware.com

3.1 Handling Multiple Versions

Each software version is installed (by default) into a unique installation directory by concatenating the program name with the version, as follows:

```
C:\Program Files (x86)\ASH WARE\MC33816 DevTool IDE V1_01A
```

Note that the default installation directory can be overridden during the installation.

Although it is great to be able to have multiple software versions installed at once, this can lead to problems when trying to run regression tests and the version changes. How can the

3. Software Upgrades

regression test 'find' the latest version? To solve this problem, during installation an environment variable is updated to reflect the last-installed version, as follows.

```
DEV_TOOL_MC33816_BIN="C:\Program Files (x86)\ASH WARE\MC33816 DevTool IDE V1_01D\"
```

Automated regression tests can find the software version using the following Console .BAT command sequence. Note that this is from the 'Direct Injection' demo.

```
set DEVTOOL=%DEV_TOOL_MC33816_BIN%\Mc33816DevTool.exe

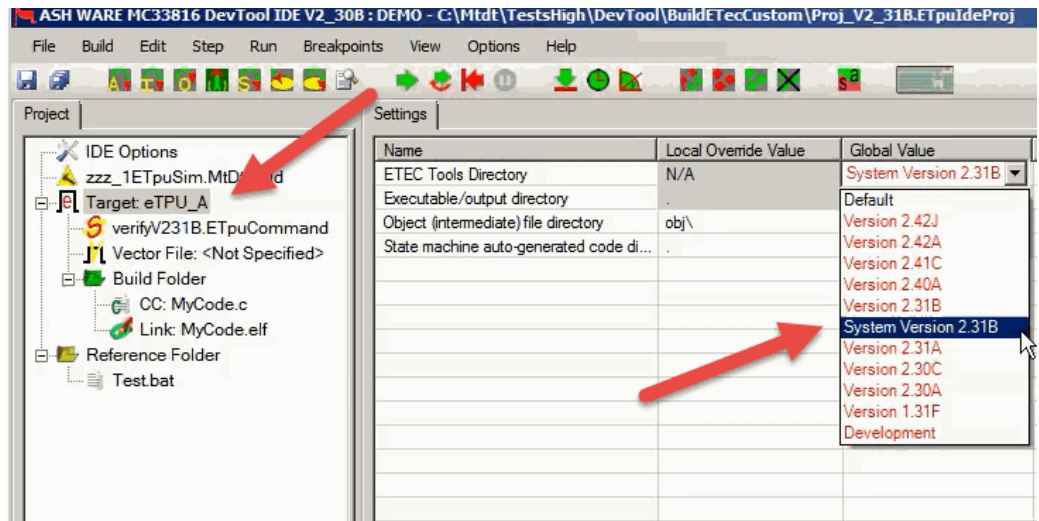
%DEVTOOL% -p=DirectInjectionDemo.Spd816IdeProj -AutoBuild -AutoRun -
lf5=Sim.Log -q
if %ERRORLEVEL% NEQ 0 ( goto errors )

goto end
:errors
echo *****
echo          YIKES, WE GOT ERRORS!!
echo *****
exit /b 1
:end
```

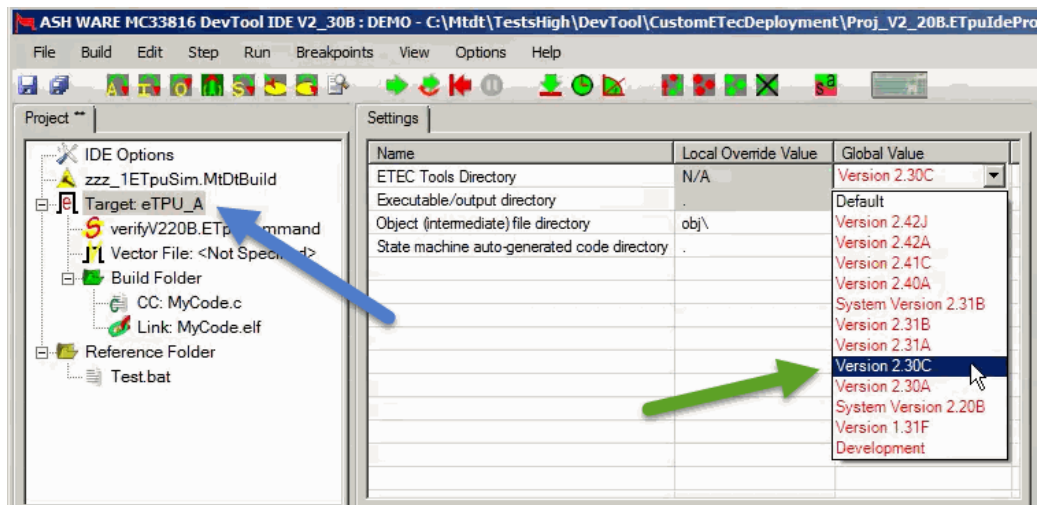
3.2 Using Non-Installed ETEC Versions

Certain customers may desire to deploy the ETEC Compiler Toolset on multiple users computers (often in conjunction with the network license capability) and in this type of situation it can be onerous to install ETEC on every computer. The following describes the process for accessing ETEC from the MC33816 Development Tool when ETEC has not actually been installed.

1. Copy the ETEC directory on to the users machine at the same location on every machine. For example, to c:\Tools\eTPU Compiler V2_31B\.
2. Set the System Environment Variable as shown below. The Variable Name's format must follow this pattern:
COMPILER_ASH_<VersionHigh><VersionLow><BuildLetter>.



- That's it except you might need to reboot the computer before the environment variable takes effect. Open the settings window and then click on a target as shown below. In the options for the ETEC compilers you will now see the ETEC version as an option but with the word 'System' prepended as shown below.



4

IDE and Editors

This section covers some of the basic features of the MC33816 Development Tool and editor windows.

4.1 IDE Options

The IDE Options are accessed through the Project window - right-click on the "IDE Options" tree node to open the settings. Settings allow control over how the editor handles tabs and spaces, the font type and size, and several global simulation options.

4.2 Panel Layout Options

The MC33816 Development Tool window framework is highly configurable. By default there are 5 panels - three side-by-side above a horizontal divider, and two side-by-side below. All dividers can be adjusted as needed. Right-clicking in the tab area of these panels gives users the options of dividing the panel vertically or horizontally into sub-panels - this can be done to any depth desired. Right-clicking in the tab area of a child panel provides the option of closing the panel. The default 5 panels cannot be closed.

In addition to the panel layout controls, individual windows (non-editor windows only) can be "floated". This is accomplished by right-clicking on the desired window and selecting "Float This Tab". Doing so moves the tab into its own modeless dialog, which can be

minimized or moved wherever desired. This is a particularly powerful feature for users with multiple displays. Tabs that have been floated can be re-docked with right-clicking on the window and selecting "Dock This Tab".

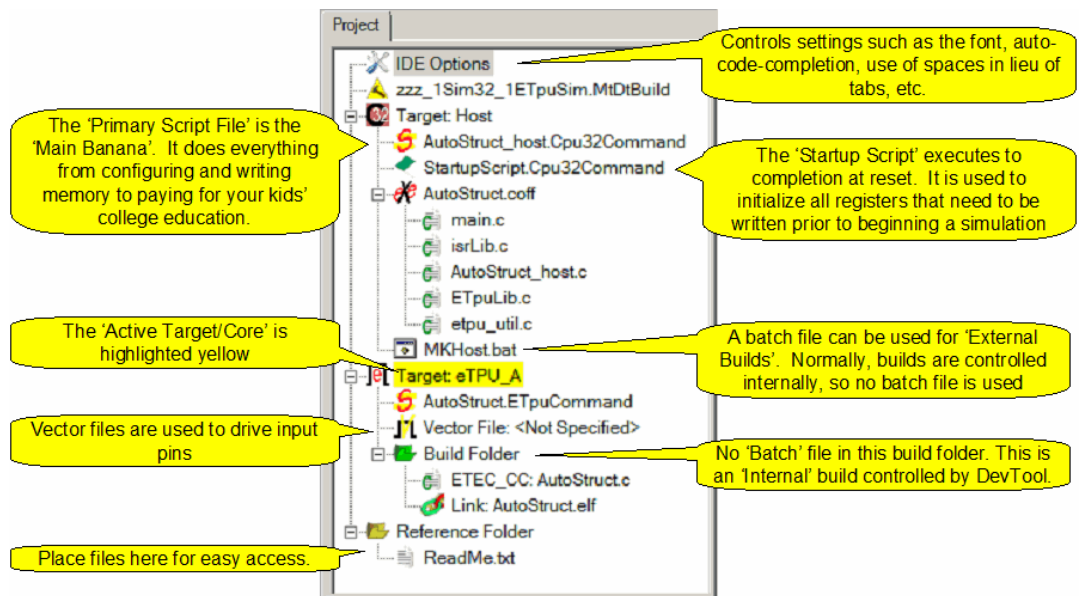
4.3 Code Auto-Completion

When writing script files or MC33816 assembly code, the editor provides code auto-completion tips. When a new instruction is started with any letter keystroke, a listbox appears with all instruction possibilities, with the closest alphabetically selected. The user can select the desired instruction (mouse, up/down, page up/down) and then hit the enter, space or tab key to have the instruction automatically placed into the code. Each parameter with its options follows in the listbox. For MC33816 assembly, when the last parameter is entered a semi-colon is automatically added to end the instruction. Hitting the 'escape' key or clicking outside the auto-complete box exits auto-complete mode. Double-clicking on a list item auto-completes the word similar to space/tab/enter.

5

The Project

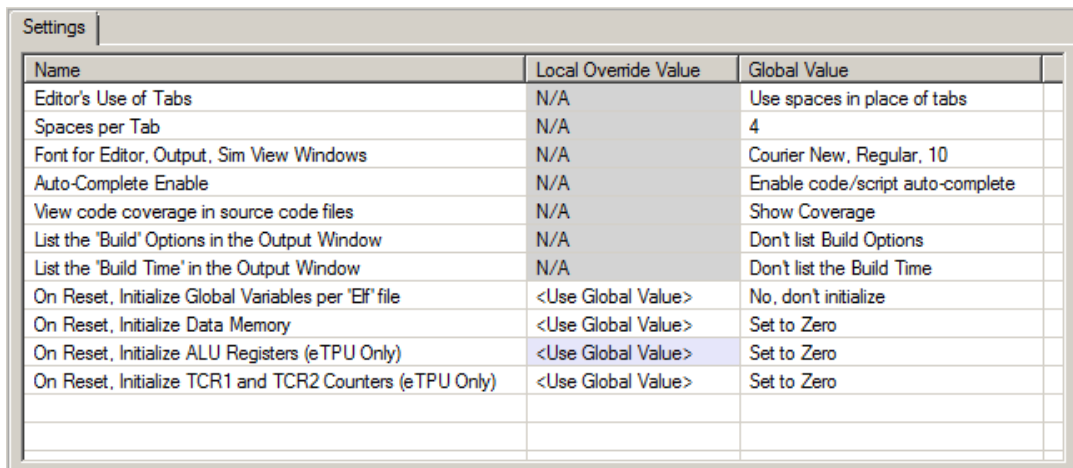
The project is the glue that holds the MC33816 Development Tool together.



5. The Project

5.1 Ide Settings

To modify the IDE settings, right-click on the 'IDE Options' project node and select 'Settings'. The following will appear. From this settings window an number of settings can be modified such as the user of tabs (or spaces) the font, enabling of auto-completions, and various other options.



Settings		
Name	Local Override Value	Global Value
Editor's Use of Tabs	N/A	Use spaces in place of tabs
Spaces per Tab	N/A	4
Font for Editor, Output, Sim View Windows	N/A	Courier New, Regular, 10
Auto-Complete Enable	N/A	Enable code/script auto-complete
View code coverage in source code files	N/A	Show Coverage
List the 'Build' Options in the Output Window	N/A	Don't list Build Options
List the 'Build Time' in the Output Window	N/A	Don't list the Build Time
On Reset, Initialize Global Variables per 'Elf' file	<Use Global Value>	No, don't initialize
On Reset, Initialize Data Memory	<Use Global Value>	Set to Zero
On Reset, Initialize ALU Registers (eTPU Only)	<Use Global Value>	Set to Zero
On Reset, Initialize TCR1 and TCR2 Counters (eTPU Only)	<Use Global Value>	Set to Zero

5.2 The Project Files

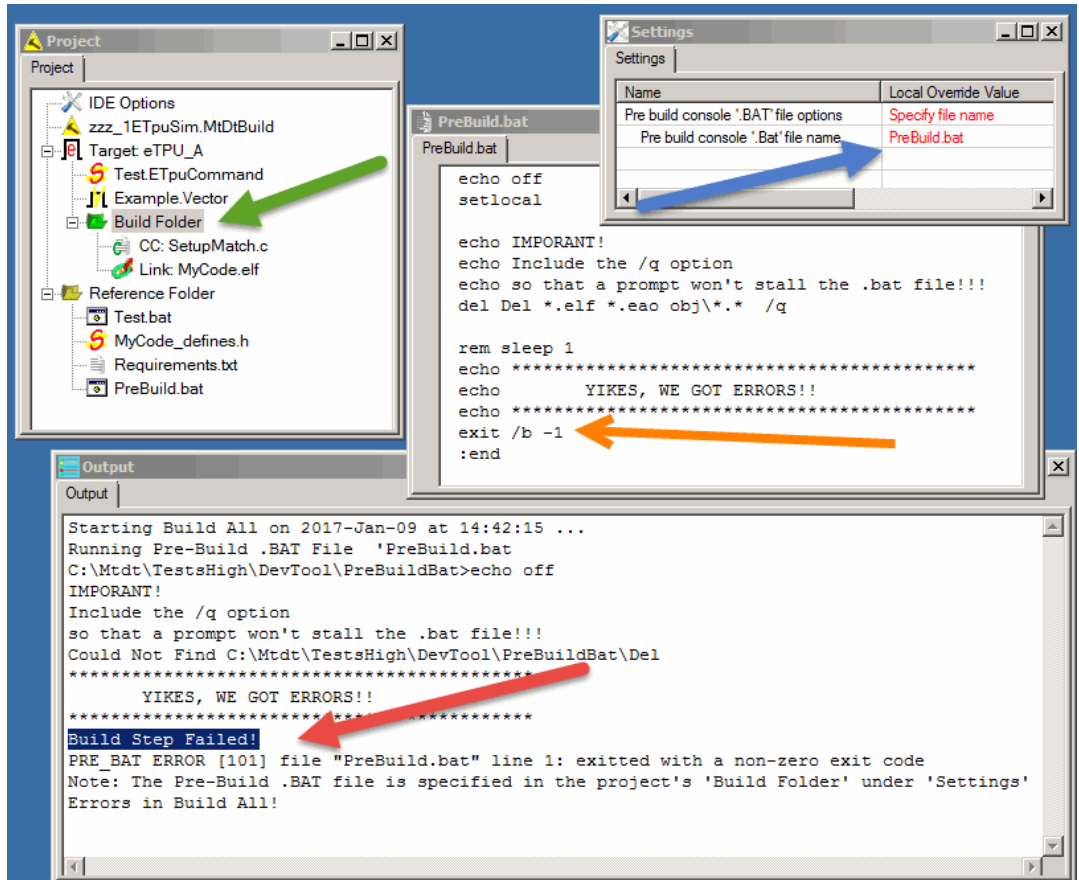
The project settings are saved in two files; the 'Project File' and the 'Environment File'.

The 'Project File' contains the key settings that are generally put under a versioning system such as CVS. It contains key filenames such as the primary script filename, source code filenames (if the build is controlled by the MC33816 Development Tool) build options such as the memory model, etc.

The 'Environment file' contains settings that are generally specific to the user such as window sizes and positions, the font, etc. Most users will NOT keep this file in a versioning systems such as CVS. The environment file has the same name as the project file except that the user-name is appended to the base file name and has a different file suffix.

5.3 The Pre-Build Windows' Console '.BAT' File

A pre-build Windows' console '.BAT' file can be specified from within the project window by right-clicking on the Build Folder (pointed to in the picture seen below by the green arrow) and selecting 'Settings'. The Settings windows then becomes visible and the '.BAT' file can be entered as seen by the blue arrow. Text which is echoed from the '.Bat' file is displayed in DevTool's Output Window as shown by the lower red arrow. Note that the '.BAT' file can return a pass by exiting with a '0' exit code thereby allowing the build to proceed. However in the example shown below, the '.BAT' file's exit code is '-1' thereby preventing the build or make from proceeding.



6

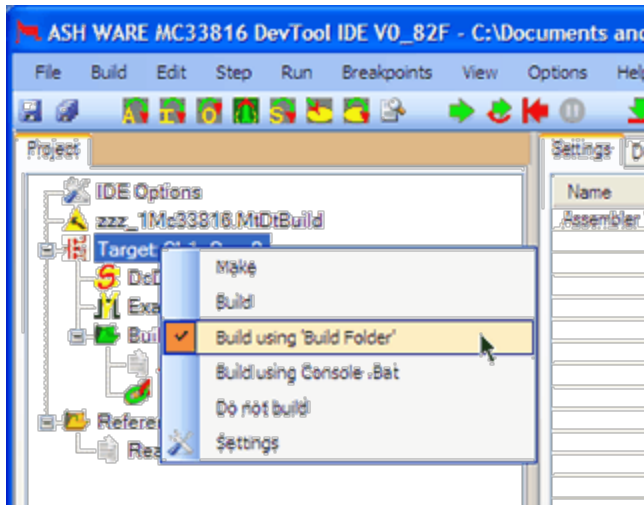
Integrated Build

The Development Tool supports an internal and an external integrated build.

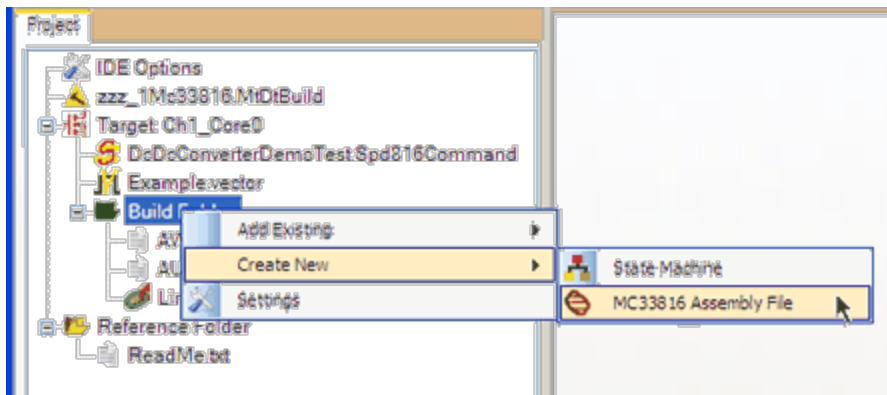
6.1 Internal Build

An 'Internal Build' is controlled by the MC33816 Development Tool. A target is set to perform an 'Internal Build' within the Project by right-clicking the target's on the target node.

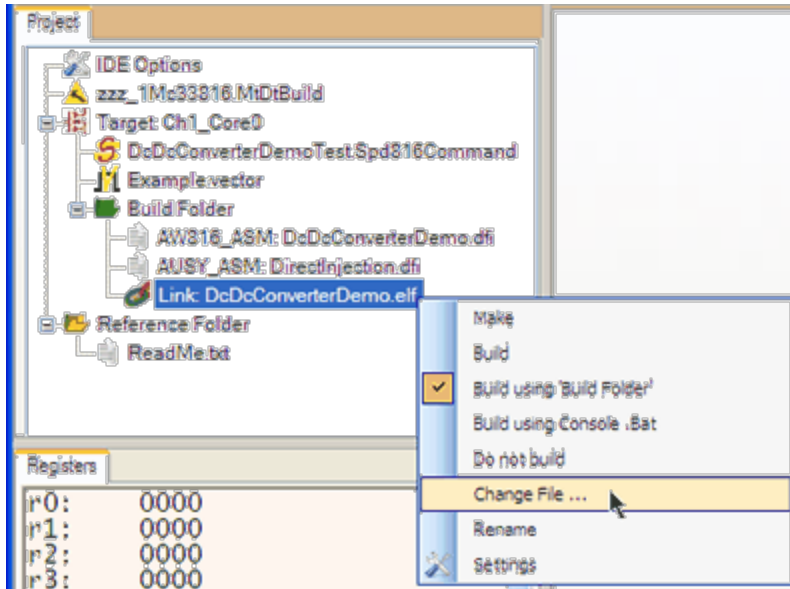
6. Integrated Build



The source code files to be compiled or assembled are added to the target's 'Build Folder' as shown below.



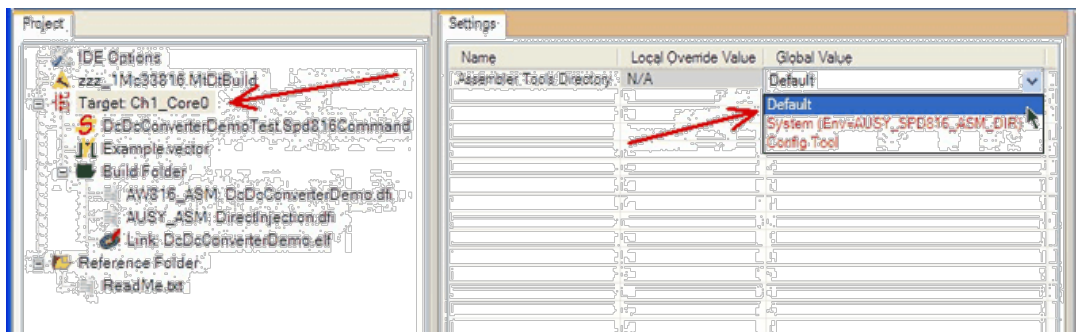
The executable image filename is set in the target's 'Link' node, as shown below.



6.1.1 Building MC33816 Assembly

The ASH WARE Assembler

The ASH WARE MC33816 Assembler is the default. The ASH WARE MC33816 Assembler is used when 'Default' is chosen in the 'Settings' window (when the project's Target is active) as shown below.



The '816 Development Studio' Assembler

6. Integrated Build

The NXP MC33816 Assembler gets installed as part of NXP's '816 Development Studio'. This assembler installation will show up as the following option in the Assembler Tools Directory setting.

The Default NXP Assembler

The NXP assembler does not provide a location mechanism for other programs such as the MC33816 Development Tool to find the installation location. So an the environment variable approach explained in this section has been employed to provide the MC33816 Development Tool with a trace to the installed program. Once the Environment variable has been setup, and the computer has been restarted, the following Assembler Tools Directory setting will appear.

```
System (Env=AUSY_SPD816_ASM_DIR)
```

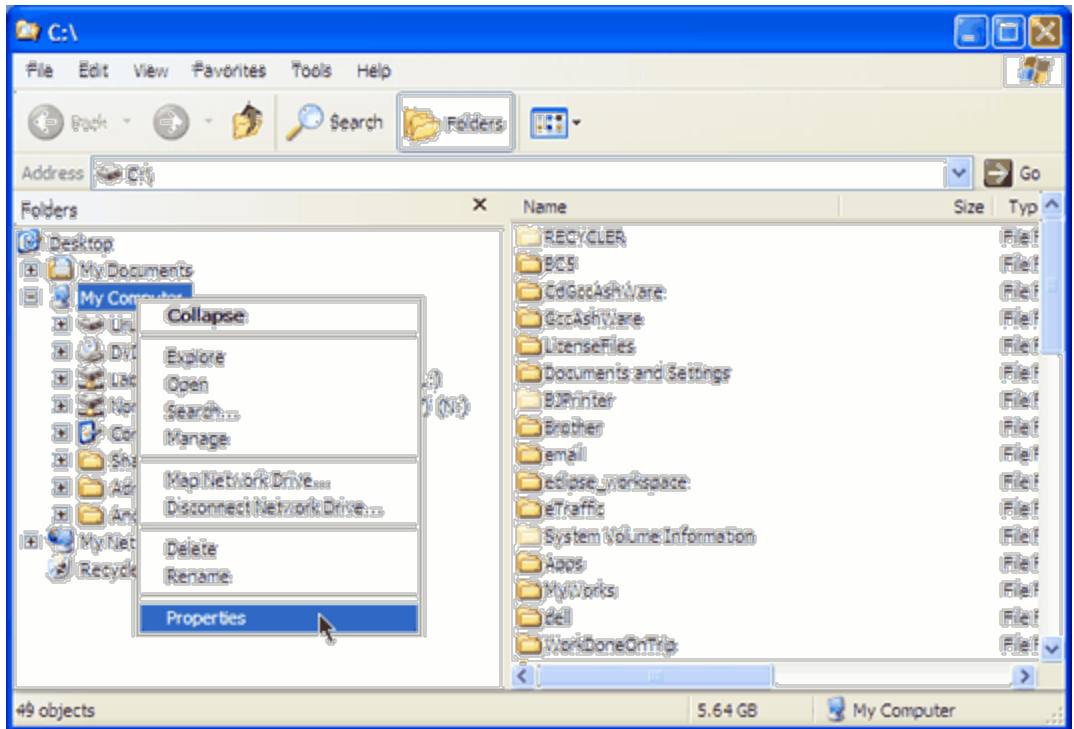
The NXP assembler installation location within the computers directory system is defined by the `AUSY_SPD816_ASM_DIR` environment variable. For instance, if the this variable is set as show below to look in the 'c:\Tools\Mc33816\ directory for the NXP assembler.

```
AUSY_SPD816_ASM_DIR=c:\tools\Mc33816Assembler
```

From the command line, set this variable using the following command

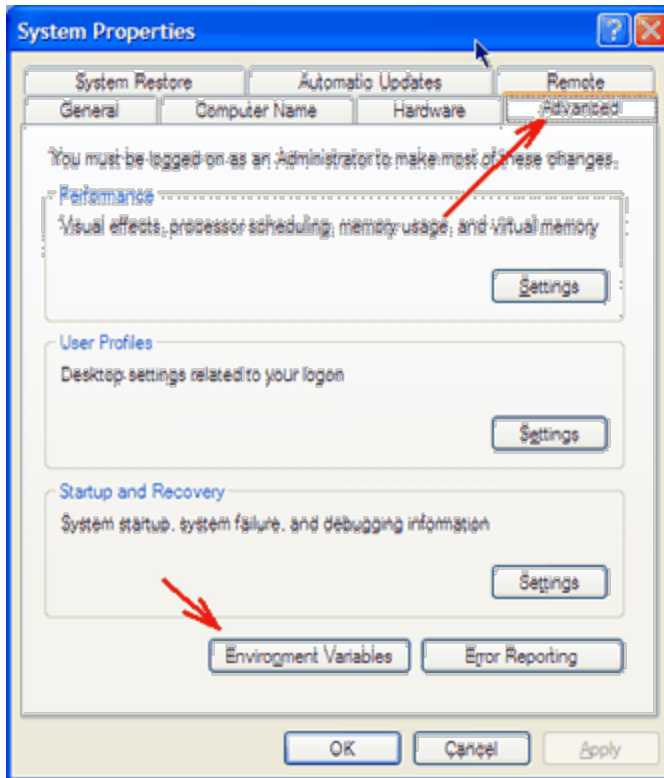
```
set AUSY_SPD816_ASM_DIR=c:\tools\Mc33816Assembler
```

Note that the command listed above is active only for the console window in which it is entered. To permanently add or change this option, from 'Files Explorer' right-click to get the popup menu shown below and select 'Properties.'

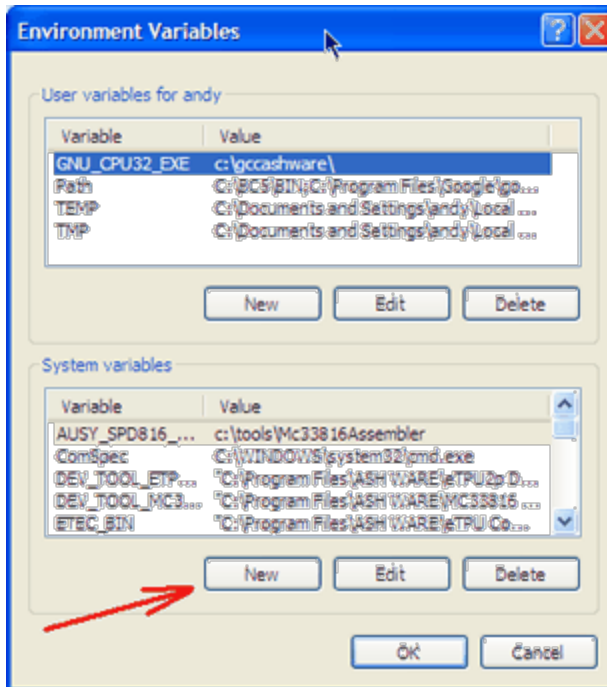


From the 'System Options' dialog select the 'Advanced' tab and click on the 'Environment Variables' button as shown below.

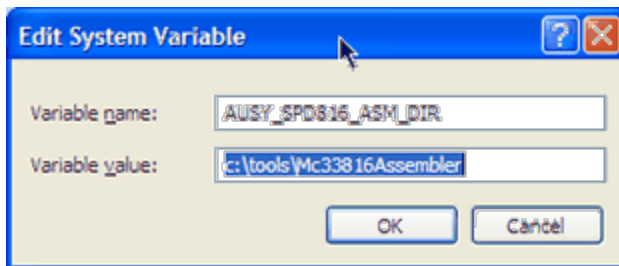
6. Integrated Build



Then click on the LOWER 'new' button as shown below. Note that the environment variable can also be changed using the top 'New' button, however then if the computer is used under a different login name, the assembler will not be available.



The enter the variable name and value as show below.



Note that computer must be restarted for the newly-added or changed environment variable to take affect.

6. Integrated Build

6.1.2 Host Target Build

The "generic" host target available in System DevTool now supports internal builds of C code. Startup code and a few basic libraries are automatically linked. The user code must contain an entry point function called "user_main" that has a return type of "int" and takes no parameters.

Users can enable interrupt handling from other targets (e.g. eTPU) during system simulation by taking the following steps:

- run "isrLibInit()" at the start of the entry function, and call "isrEnableAllInterrupts()" to enable interrupt handling. Then use "isrConnect" to set up handlers for the expected (eTPU) interrupts of the application. See isrLib.h in the "Include" directory under the DevTool installation directory.
- from the script environment of the host target, run the "enable_target_interrupts()" script command for each target from which to enable interrupts.

The host target code can also access the scripting environment through a provided API. See "scriptLib.h" in the "Include" directory for more details on what is available. The "at_time", "wait_time" and "read_time" calls can be particularly useful for synchronizing with .

6.2 External Build

Normally, a software build is done using an 'Internal Build.' However, there are occasions when it is preferable to call an external batch file (.BAT) to perform the build process.

To specify an external build, right-click on the project's Target node and select 'Build using Console Bat.'

One significant issue is retrieving the exit code from the batch file. The batch file must be terminated using the following console batch command

```
exit <ID>
```

The 'ID' indicates to the MC33816 Development Tool if there was an error or not. **If the build was successful then the ID should be zero, otherwise the ID should be non-zero.**

One common mistake is to terminate just the batch command using the /b option.

```
exit /b <ID> DO NOT DO THIS!!!
```

So this can be a problem because if the batch file is also used as a part of a regression test suite then the /b might be needed to prevent the console window from closing. To address this conundrum, the MC33816 Development Tool passes the console batch file the following parameter.

`EXIT_CMD_PROCESSOR`

This can be used to differentiate between a MC33816 Development Tool external build and a regression test suite, as follows.

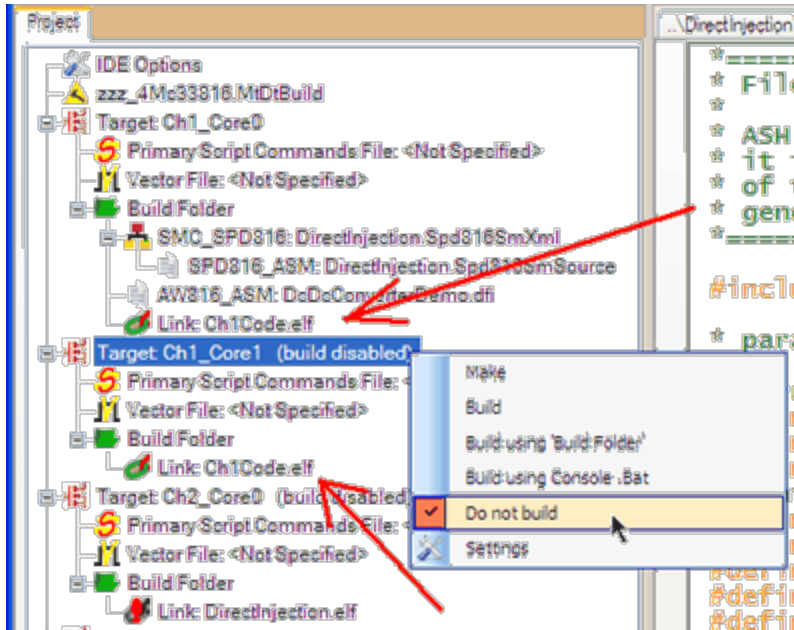
```
set EXIT_CMD=%1
if not defined EXIT_CMD goto do_exit_batch
if %EXIT_CMD% EQU EXIT_CMD_PROCESSOR exit -1

:do_exit_batch
exit /b -1
:end
```

6.3 Disabled Build

It is often desirable to disable a build such that the MC33816 Development Tool does not rebuild the executable image file. This is particularly helpful when two cores share a code memory such that a single executable code image file is used by both cores.

6. Integrated Build



7

Source Code Files

Source code files is built using code build tools. For the MC33816 code is built using the ASH WARE MC33816 assembler.

These executable files are loaded into the target/core's memory space. The MC33816 Development Tool also loads the associated source code files and displays them in source code windows, highlighting the line associated with the instruction being executed. Several hot keys allow the user to set breakpoints, execute to a specific line of code, or execute until a point in time.

Source code files can be edited directly within the IDE. Once edited, the source code is considered 'dirty' and will be rebuilt prior to resuming execution. The process of rebuilding and loading of the executable image is done automatically and largely transparently to the user.

Editing of source code files outside the IDE is also supported. When file is saved by the external editor, MC33816 Development Tool automatically recognizes that the file is 'dirty' and will both reload the file and rebuild the code prior to resuming execution.

7.1 Source Code Search Rules

Source code files may be contained in multiple directories. In order to provide source-level debugging, the MC33816 Development Tool must be able to locate these files. Source code search rules provide the mechanism for these files to be located.

7. Source Code Files

The search rules are as shown below. These rules are performed in the order listed. If multiple files with the same name are located in different directories the first encountered instance of that file, per the search rules, will be used.

- Search relative to the directory where the main build file, such as A.OUT is located.
- Search relative to the directories established for the specific target associated with the source code.
- Search relative to the global directories established for all targets.

In the search rules listed above the phrase "search relative to the directory . . ." is used. What does this mean? It means that if the file is specified as "..\Dir1\Dir2\FileName.xyz", start at the base directory and go up one, then look down in directory "Dir2" and search in this directory for the file, "FileName.xyz".

Note that the search rules apply only to source code files in which an exact path is not available. If an exact path is available, the source code file will be searched only at that exact path. If an exact path is provided and the file is not located at that exact path, the search will fail.

The [Source Code Search Options dialog box](#) allows the user to specify the global directories search list as well as the search lists associated with each individual target.

Absolute and Relative Paths

The MC33816 Development Tool accepts both absolute and relative paths.

An absolute path is one in which the file can be precisely located based solely that path. The following is an absolute path.

`C:\Compiler\Library\`

A relative path is one in which the resolution of the full path requires a starting point. The following is an example of a relative path.

`..\ControlLaws\`

Relative paths are internally converted to absolute paths using the main build file as the starting point. As an example, suppose the main build file named A.OUT is located at the following location.

`C:\MainBuild\TopLevel\A.out`

Now assume that in the search rules the following relative path has been established.

`..\ControlLaws\`

Now assume that file Spark.C is referenced from the build file A.OUT. Where would the MC33816 Development Tool search for this file? The following location would be searched first because this is where the main build file, A.OUT, is located.

`C:\MainBuild\TopLevel\`

If file Spark.C were not located at the above location, then the following location would be searched. This location is established by using the location of the main build file as the starting location for the `..\ControlLaws\` relative path.

`C:\MainBuild\ControlLaws\`

8

Script Commands Files

Overview

Script commands files provide a number of important capabilities. Script commands files provide a mechanism whereby actions available within the GUI can be automated. In the MC33816 simulator, script commands can take the place of the HOST MCU.

Each script commands file is arranged as a sequential array of commands, i.e., the MC33816 Development Tool executes the script commands in sequential order. This allows the MC33816 Development Tool to know when to execute the commands. Timing commands cause the MC33816 Development Tool to cease executing commands until a particular point in time. At that point in time, the MC33816 Development Tool begins executing subsequent script commands until it reaches the next timing script command. Timing commands are not allowed in startup script files.

The following script help topics are found later in this section.

- [Script Commands File Format](#)
- [Script Command Groups](#)
- [Multiple Target Scripts](#)
- [Automatic and Predefined #define Directives](#)
- [Predefined Enumerated Data Types](#)

8. Script Commands Files

- [Enhanced Scripting capabilities](#) (variables, loops, etc)

Types of Script Commands Files

The different types of script commands files are as follows.

- [The Primary Script Commands Files](#)
- [The Startup Script Commands File](#)

It is best to just have a single primary script command associated with just one target/core. Alternatively, in a multi-target/core simulation, each target/core can have it's own primary script commands file. The MC33816 Development Tool can have only a single active MtDt build batch file.

Similarities to the C Programming Language

The script commands files are intended to be a subset of the "C" programming language. In fact, with very little modification these files will compile under C.

8.1 The Primary Script Command Files

The MC33816 Development Tool automatically executes a primary script commands file if one is open. A new or alternate script commands file must be opened before it is available to the MC33816 Development Tool for execution. The script command file can be changed within the project window. Right click on the script commands file node and select 'Change Script Commands File. The MC33816 Development Tool displays the open or active script commands file in the target's configuration window. Only one primary script commands file may be active at one time. Help is available for this window when it is active and can be accessed by depressing the <F1> function key.

8.2 The Startup Script Commands File

Startup scripts provide the capability to get the target into a known state following the MC33816 Development Tool controlled reset. It is particularly useful for the case in which the MC33816 Development Tool is configured to load an executable image when launched. In the 683xx Hardware Debugger, for instance, startup scripts can be used to configure the SIM registers so that the executable image can be immediately loaded when it is launched.

Each target can have an associated startup script. Make sure the desired target is active. From the [Files menu](#) select the Scripts, Startup submenu.

A report file is generated each time the startup script is executed. This file has the same name as the startup script; its extension is "report."

There are some restrictions to startup scripts. These are listed below.

- [No windows are supported.](#)
- [Flow control, such as breakpoints and single step, is not supported.](#)
- [Certain script commands are not supported. Restricted commands are noted as such in the reference section.](#)

8.3 The "ETEC_cpp.exe" Preprocessor

The ETEC C Pre-Processor (ETEC_cpp.exe) provides enhanced preprocessing capabilities that significantly increase the power of the scripting language. In most cases this capability is transparent to the user, though one side affect is that the preprocessing stage is case sensitive.

8.4 Enhanced Scripting Capabilities

The ASH WARE scripting syntax has always been based upon the C language, and enhanced scripting continues that tradition. In some cases it may be possible to share the same code between the scripting environment and host code. Enhanced scripting support includes

- ability to declare enumerated types and use enumeration literals in place of constants in expressions
- variables (called "script variables") can be declared, assigned to, used in expressions and used as inputs to script commands in places wherein previously a numeric constant was required.
- most C statements are supported: if-else, switch, for loops, while and do-while loops, and goto/labels.

8. Script Commands Files

More information on each of the above is found in the ensuing sections. A script file is treated like the contents of a C function from a scoping perspective, with the exception that variables defined in the outermost scope are treated as "global" and can thus be seen from ISR scripts. Inner scopes can be created with pairs of '{' and '}' tokens.

8.4.1 Enumeration Declarations

C Enumeration declarations are supported in the scripting language. The enumeration literals may be used in place of constants in expressions or as numerical arguments to script commands. Enumeration literals are treated as S32 type - signed 32-bit integers. Below is an example of supported syntax.

```
enum I2C_SLAVE_MODE
{
    I2C_SLAVE_MODE_FIND_IDLE,
    I2C_SLAVE_MODE_IDLE,
    I2C_SLAVE_MODE_START_SDA_LOW,
    I2C_SLAVE_MODE_WRITE_HEADER,
    I2C_SLAVE_MODE_WRITE_BYTE,
    I2C_SLAVE_MODE_WRITE_BYTE_CHECK_STOP,
    I2C_SLAVE_MODE_READ_BYTE,
    I2C_SLAVE_MODE_READ_FIND_STOP,
    I2C_SLAVE_MODE_ACK_OUT,
    I2C_SLAVE_MODE_ACK_IN,
    I2C_SLAVE_MODE_ACK_COMPLETE = I2C_SLAVE_MODE_ACK_IN +
1,
    I2C_SLAVE_MODE_IGNORE = -1,
};
```

If the script file has been parsed, when hovering the mouse over an enumeration literal its value will be displayed in the tooltip. Currently declaration of script variables of enumerated type is not supported.

8.4.2 Script Variables

Use of script variables in the scripting environment allows for true closed-loop feedback control, allowing scripts to do essentially anything a host CPU or MCU would do. Script variables follow C scoping rules with a few small exceptions, (1) you cannot re-use the same name in an inner scope, hiding the outer scope variable, and (2) variables defined at the outermost scope of the first target's primary script file are treated as "global" and can

be referenced in ISR script files. Three basic variable types are supported - S32 (32-bit signed int), U32 (32-bit unsigned int), and F64 (64-bit floating point). Declaration lists and initializers are supported.

```
S32 a;
S32 b = -33, c, d = 0;
U32 e = 0xfebc, f = ENUM_LITERAL;
F64 g = 1.25e9, h = 0.0, i = 0x11;
```

Multi-dimensional arrays of the basic types are supported, including initializers.

```
S32 x[20];
U32 y[10][3] = { {1,2,3}, {4,5}, {6} };
F64 z[4][4][2] = { { {1.11, 2.22, } } };
```

Array element access is supported, but not incomplete de-referencing as pointers are not supported in the scripting environment.

```
x[5] = (S32)(y[c][d] * z[3][2][1]); // valid
y[3] = read_dim_length("z", 1); // error, y not fully de-
referenced
```

Script variables lifetime ends when their scope ends. Note that C99-style late declarations are allowed.

```
{
    // code...
    S32 myVar;
    myVar = read_chan_data_u24(5, 0x11);
    if (myVar == 0x34)
    {
        // do something...
    }
    // code...
}
myVar += 10; // ERROR!!
```

Script variable values can be viewed in the tooltip by hovering the mouse over the variable name, or all in-scope script variables can be viewed in the Script Variable window. Script variables can additionally be configured as discrete nodes to be viewed in the Waveform window.

8.4.3 Expression Statements

All C operators are supported except the following:

- array and pointer operators (unary *, unary &, [], ->, '.' struct member de-reference)
- expression comma operator

From an implicit type conversion precedence standpoint, type precedence is S32 -> U32 -> F64. Note that for historical reasons constant expressions are computed in U32.

```
while (1)
{
    F64 rpm;
    F64 tooth_period;
    U32 tooth_per_sync;
    tooth_period = read_chan_data_u24( CRANK_CHAN,
FS_ETPU_CRANK_OFFSET_LAST_TOOTH_PERIOD );
    tooth_per_sync = read_chan_data_u8 (CRANK_CHAN,
FS_ETPU_CRANK_OFFSET_TEETH_PER_SYNC );
    rpm = (1.0 / (tooth_period * tooth_per_sync /
TCR1_FREQ_HZ)) * 60;
    // done if RPM has gone above 2000
    if (rpm > 2000.0)
        break;
    wait_time(1);
}
```

Explicit typecasts are supported.

```
write_chan_data_u24( PWM_CHAN, PERIOD_OFFSET, (U24)(1333.33
* SOME_SCALAR));
write_chan_data_u24( CRANK_CHAN, WINDOW_RATIO_OFFSET,
(UFRACT24)0.45);
```

Along with the 3 basic script types, the S32 and U32 base types have several supported sub-types available just for cast:

S32 subtypes (result of all these casts are stored as an S32)

- S24
- S16
- S8
- SFRACT24
- SFRACT16
- SFRACT8

U32 subtypes (result of all these casts are stored as an U32)

- U24
- U16
- U8
- UFRACT24
- UFRACT16
- UFRACT8

8.4.4 Selection Statements

The C if-else syntax is fully supported by the MC33816 Development Tool script parser/interpreter.

```
if (<expression>
    c_statement
[else
    c_statement]
```

Where c_statement can be any single C statement or script command (but not declaration), or it can be a compound statement enclosed by scope '{ '}' tokens.

The C switch statement is also available in the script environment, along with the associated case and default statements. The syntax for these statements is:

```
switch (<expression>
    c_statement

case <constant expression>:

default:
```

The only difference with the C spec is that case constant expressions with floating point are allowed.

8.4.5 Loop and Jump Statements

All types of C looping are supported by the enhanced scripting environment. For loops:

```
for ([expression];[expression];[expression])
    c_statement
```

8. Script Commands Files

Where `c_statement` can be any single C statement or script command (but not declaration), or it can be a compound statement enclosed by scope '{ '}' tokens. Each of the [expression] terms in the for statement are optional. At the current time variable declarations are not allowed in the first term.

While and do-while loops:

```
while (<expression>
c_statement
```

and

```
do
c_statement
while (<expression>) ;
```

In all of these loop types the 'break' and 'continue' statements are fully supported.

C labels and the goto statement are supported by the scripting environment.

```
label:
// code...
goto label;
```

Since the script is like the contents of a C function, any label in the script is accessible to a goto statement.

8.5 File Format and Features

The script commands file must be ASCII text. It may be generated using any editor or word processor (such as WordPerfect or Microsoft Word) that supports an ASCII file storage and retrieval capability.

The following is a list of script command features.

- [Multiple-target scripts](#)
- [Directives](#)
- [Enumerated data types](#)
- [Integer data types](#)
- [Referenced memory](#)
- [Assignment operators](#)
- [Operators and expressions](#)

- [Comments](#)
- [Numeric Notation](#)
- [String notation](#)

Script Commands Format

The command is case sensitive (though this is currently not enforced) and, in general, has the following format:

```
command([data1],[data2],[data3]);
```

The contents within the parenthesis, data1, data2, and data3, are command parameters. The actual number of such data parameters varies with each particular command. Data parameters may be integers, floating point numbers, or strings. Integers are specified using either hexadecimal [or decimal](#) notation. Floating point parameters are specified using [floating point notation](#), and strings are specified using [string notation](#). Hexadecimal and decimal are fully interchangeable.

8.5.1 Multiple-Target Scripts

In a multiple target environment it is generally best to have just a single script file in the first target/core found in the project.

Script commands executed in this target/core affect specifically that core. For example, the following script command will affect just this first target/core.

```
Ch1_Core0.write_spi_data16( CkPerAddr, 1);
```

So how can scripts control other targets/cores besides the (default) one with which the script file is associated? For a script to operate on a specific target/core the target name is prepended to the script as follows.

```
<TargetName>.<ScriptCommand>
```

The specific target for which a script command will run is specified as shown above. The following example illustrates co-simulation of an eTPU and a MC33816

```
write_chan_hsrr (TEST_CHAN, 1);  
Ch1_Core0.write_spi_bit ( CH1_FlashEnableAddr, 3, 1 );
```

8.5.2 Script Directives, Define, Ifdef, Include

The #define directive

Script commands files may contain the C-style define directive. The define directive starts with the pound character "#" followed by the word "define" followed by an identifier and optional replacement text. When the identifier is encountered subsequently in the script file, the identifier text is replaced by the replacement text. The following example shows the define directive in use.

```
#define THIS_CHANNEL 8
#define THIS_FUNC 4
set_chan_func(THIS_CHANNEL, THIS_FUNC);
```

Since the define directive uses a straight text replacement, more complicated replacements are also possible as follows.

```
#define THIS_SETUP 8,4
set_chan_func(THIS_SETUP);
```

There are a number of [automatic and predefined define directive](#) as described in the like-named section.

The #include <FileName.h> directive

Allows inclusion of multiple files within a single script file. Note that included files do not support things like script breakpoints, script stepping, etc.

```
#include "AngleMode.h"
```

In this example, file AngleMode.h is included into the script commands file that included it.

The #ifdef, #ifndef, #else, #endif directives

These directives support conditional parsing of the text between the directives.

```
//===== That is all she wrote!!
#ifdef _ASH_WARE_AUTO_RUN_
exit();
# print else
("All tests are done!!");
#endif // _ASH_WARE_AUTO_RUN_
```

The above directive is commonly found at the very end of a script commands file that is part of an automated test suite. It allows behavior dependent on the test conditions. Note that _ASH_WARE_AUTO_RUN_ is automatically defined when the MC33816 Development Tool is launched in such a way that it runs without user input. In this case,

upon reaching the end of the script file the MC33816 Development Tool is closed when it is part of an automated test suite and otherwise a message is issued to the user.

8.5.3 Script Enumerated Data Types

Many defined functions have arguments that require specific enumerated data as arguments. Internally enumerated data types are defined for many script commands and the tighter checking and version independence provided by enumerated data types make them an important aspect of script files.

In general, the enumerated data types are defined for each specific target or script file application. The following is an example of an internally defined enumeration.

```
enum TARGET_TYPE    {  
    SIM33816,  
};
```

Note that in C++ it would be possible to pass an integer as the first argument and at worst a warning would be generated. In fact, in C++, even the warning could be avoided by casting the integer as the proper enumerated data type. This is not possible in a script file because of tighter checking and because casting is not supported.

8.5.4 Script Integer Data Types

In order to maximize load-time checking, script command files support a large number of integer data types. This allows "constant overflow" warnings to be identified at load-time rather than at run-time. In addition, since the scripting language supports a variety of CPUs with different fundamental data sizes, the script command data types are designed to be target independent. This allows use of the same script files on any target without the possibility of data type errors related to different data sizes.

The following is a list of the supported data types along with the minimum and maximum value.

- U1 valid range is 0 to 1
- U2 valid range is 0 to 3
- U3 valid range is 0 to 7
- U4 valid range is 0 to 15
- U5A valid range is 0 to 16

8. Script Commands Files

- **U5B** valid range is 0 to 31
- **U8** valid range is 0 to 0xFF
- **U16** valid range is 0 to 0xFFFF
- **U32** valid range is 0 to 0xFFFFFFFF
- **U64** valid range is 0 to 0xFFFFFFFFFFFFFFFF

8.5.5 Referencing Memory in Script Files

Memory can be directly accessed by referencing an address. Two parameters must be available for this construct: an address and a memory access size. In addition, there is an implied address space, which for most targets is supervisor data. For some targets the address space may be explicitly overridden.

- **(U8 *) ADDRESS** // References an 8-bit memory location
- **(U16 *) ADDRESS** // References a 16-bit memory location
- **(U32 *) ADDRESS** // References a 32-bit memory location
- **(U64 *) ADDRESS** // References a 64-bit memory location
- **(U128 *) ADDRESS** // References a 128-bit memory location

The following are examples of referenced memory constructs. Note that these examples do not form complete script commands and therefore in this form would cause load errors.

```
*((U8 *) 0x20    // Refers to an 8-bit byte at addr 0x20
*((U24 *) 0x17)  // Refers to a 24-bit word at addr 0x17
*((U32 *) 0x40   // Refers to a 32-bit word at addr 0x40
```

8.5.6 Assignments in Script Commands Files - DEPRECATED

Note: it is now possible to declare and manipulate variables in script commands. Therefore use of variables such as the following should now be used instead of those listed farther down in this section.

```
S32 val;
val = read_mem_u32(ETPU_DATA_SPACE,0x200);
val |= ((1<<12) | (1<<28));
write_global_data32(0x200, val);
```

DEPRECATED

Assignments can be used to modify the value of referenced memory, a practice commonly referred to as "bit wiggling." Using this it is possible to set, clear, and toggle specific groups of bits at referenced memory. The following is a list of supported assignment operators.

- =	Assignment
- +=, -=	Arithmetic addition and subtraction
- *=, /=, %=	Arithmetic multiply, divide, and remainder
- <<=, >>=	Bitwise shift right and shift left
- &=, =, ^=	Bitwise "and," "or," and "exclusive or"
- <<=, >>=	Bitwise "shift left" and "shift right"

The following examples perform assignments on memory.

```
// Writes a 44 decimal to the 8 bit byte at address 17
*((U8 *) 0x17) = 44;
// Writes a 0xAABBCC to the 24 bit word at address 0x31
*((U24 *) 0x31) = 0xAABBCC;
// Sets bits 31 and 15 of the 32-bit word at addr 0x200
*((U32 *) 0x200) |= 0x10001000;
// Increments by one the 16-bit word at address 0x3300
*((U16 *) 0x3300) += 1;
```

Using an optional memory space qualifier, memory from a specific address space can be modified. See the [Build Script ADDR_SPACE Enumerated Data Type](#) section for a listing of the various available address spaces.

```
// Sets the eTPU I/O pins for channel 15 and channel 3
*((ETPU_PINS_SPACE U32 *) 0x0) |= ((1<<15) + (1<<3));
// Injects a new opcode into the eTPU's code space
*((ETPU_CODE_SPACE U32 *) 0x20) = 0x12345678;
```

NOTE: Because the use of the ADDR_SPACE Enumerated Data Type as in the above expressions is not legal C syntax, the use of such in a script commands file disables the code reference capability. It is recommended that the `write_global_data[8/16/24/32]()` and `write_global_bits[8/16/24/32]()` script commands be used instead whenever possible.

8.5.7 Operators and expressions in Script Commands Files

Operators can be used to create simple expressions in script commands files. Note that these simple expressions must be fully resolved at load time. The precedence and ordering is the same as in the C language. The following is a list of the supported operators.

8. Script Commands Files

- +, - Arithmetic addition and subtraction
- *, /, % Arithmetic multiply, divide and remainder
- &, |, ^, ~ Bitwise AND, OR, and EXCLUSIVE OR
- <<, >> Bitwise shift left and shift right

The following example makes use of simple expressions to specify the channel base.

```
#define PARAMETER_RAM 0x100
#define BYTES_PER_CHAN 16
#define SPARK_CHAN_ADDR PARAMETER_RAM + BYTES_PER_CHAN * 5
// Write a 77 (hex) byte to address 150 (hex)
*((U8 *) SPARK_CHAN_ADDR) = 0x22+0x55;
```

The normal C precedence rules can be overridden using brackets as follows.

```
write_chan_func(1, 3+4*2); // Set chan 1 to function 11
write_chan_func(1, (3+4)*2); // Set chan 1 to function 14
```

8.5.8 String within a string supports formatted symbolic information

The "string within a string" formatted supports generation of formatted symbolic information by certain script commands. The format is a "C" string with a second embedded C string. The embedded sting must use the backslash escape character to begin and end the embedded string. Two example uses of this are shown below.

```
write_chan_hsrr ( TEST1_CHAN, 5);
wait_time(0.12);
// Send the results to the trace window
print_to_trace("\nTEST RESULTS (trace):\n"
               "    A=%d\n"
               "    B=%d\n"
               "    C=%d\n",A,B,C");
// Same as above ... but to the screen
print          ("\nTEST RESULTS (screen):\n"
               "    A=%d\n"
               "    B=%d\n"
               "    C=%d\n",A,B,C");
```


8.5.9 Comments in Script Commands Files

Legacy "C" and the new "C++" style comments are supported, as follows.

```
// This is a comment.  
set_tdl(3);  
  
/* This is a legacy C-style comment.  
This is also a comment.  
This is the end of the multiple-line comment. */  
set_tdl(/* more comment */ 3);
```

8.5.10 Decimal, Hexadecimal, and Floating Point Notation in Script Files

Decimal and Hexadecimal notation are interchangeable.

```
357          // Decimal Notation  
0x200        // Hexadecimal Notation
```

In certain cases floating point notation is also supported.

```
3.3e5        // Floating Point
```

8.5.11 String Notation

The following is the accepted string notation.

```
"STRING"
```

The characters between the first quote and the second quote are interpreted as a string.

```
"File.dat"
```

This denotes a string with eight characters and termination character as follows, 'F', 'i', 'l', 'e', '.', 'd', 'a', 't', '\0'.

Concatenation

It is often desirable to concatenate strings. The following example illustrates a case in which this is particularly useful.

```
#define TEST_DIR  "..\\TestDataFiles\\"  
read_behavior_file (TEST_DIR "Test.bv");  
vector(TEST_DIR "Example");
```

C-Style Escape Sequences

8. Script Commands Files

In the C language, special characters are specified within a string using the backslash character, '\'. For instance, a new-line character is specified with the backslash character followed by the letter "n", or '\n'. The character following the backslash character is treated as a special character. The following special characters are supported.

```
\\    References a backslash character
"..\\File.dat"
```

Planned Obsolescence of Single Backslash within Strings

In previous versions of this software a C-style escape sequence was not supported and a single backslash character was treated as a just that, a single backslash character. In anticipation of future software versions supporting enhanced C-style escape sequences, the single backslash character within a string now causes a warning. ASH WARE recommends using a double-backslash to ensure compatibility with future versions of this software.

```
//The following string causes a warning.
"..\\File.dat"
```

8.6 Script Commands

Listed below are the available script command functional groups. Clicking on the desired command functional group will access the command listing for that group.

All Target Types Script Commands

- [Clock control script commands](#)
- [Timing script commands](#)
- [Verify traversal time commands](#)
- [Modify memory script commands](#)
- [Verify memory script commands](#)
- [Register write script commands](#)
- [Register verification script commands](#)
- [Symbol value write script commands](#)
- [Symbol value verification script commands](#)
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MC33816 Script Commands

- [Hardware Configuration commands](#)

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Build Script Commands

[Build script commands](#)

8.6.1 Timing

Script commands in this group provide capabilities such as the ability to set the system frequency, control when (other) script commands execute, clear the worst case threads (used following the init threads,) and to find worst case information for a time region.

8.6.1.1 Timing Script Commands

```
wait_time(T);
```

No script commands are executed until the simulation's current time plus the T microseconds.

```
wait_time(33.5); // (assume current time=50 microseconds)
set_link(5);
wait_time(100.0);
set_link(2);
```

In this example at 83.5 microseconds (from the start of the simulation) channel 5's Link Service Latch (LSL) will be set. No script commands are executed for an additional 100 microseconds. At 183.5 microseconds (from the start of the simulation) channel 2's LSL will be set.

```
at_time(T);
```

When this command is reached, no subsequent commands are executed until T microseconds from the simulation's start time. At that time the script commands following the at_time statement are executed.

The MC33816 Development Tool's enhanced scripting provides a script command to read the current time in microseconds into a script variable.

```
F64 time_us;
time_us = read_time();
```

8. Script Commands Files

See the [Enhanced Scripting Capabilities](#) section for more information on the use of variables within the scripting environment.

```
at_code_tag_ex(TagString, Timeout, TimeoutAction);
```

These commands prevent subsequent commands from executing until the target hits the source code that contains the string, <TagString>. Note that all source code files are searched and that the string should be unique so that it is found at just one location (for otherwise the command will fail).

```
at_code_tag("$$MyTest1$$");  
verify_val("failFlag", "==", "0");
```

In the example above, the target executes until it gets to the point in the source code that contains the text, \$\$MyTest1\$\$ and then verifies that the variable named failFlag is equal to zero. It is important to note that the variable could be local to the function that contains the tag string such that it may be only briefly in scope. The only scoping requirement is that the variable is valid right when the target is paused to examine this variable.

The extended version of the command, at_code_tag_ex(), also supports a timeout (in microseconds) such that if the tagged source code is not traversed in the amount time specified by Timeout, then the action specified by TimeoutAction will occur. Supported actions are FAIL_ON_TIMEOUT, FAIL_ON_TAG, and ALWAYS_PASS.

FAIL_ON_TIMEOUT causes a verification failure (and subsequent test suite failure) if the tagged code is not traversed in the specified time. FAIL_ON_TAG is just the opposite and is used when the tagged code is NOT expected to be traversed. ALWAYS_PASS allows the script command execution to proceed on the first of either the tagged code being traversed or on the timeout, and no verification error is generated in either case.

```
at_code_tag_ex("$$MyTest2$$", 4.5, FAIL_ON_TIMEOUT);
```

In example above, the target executes until the point in the source code is traversed that contains the text, \$\$MyTest2\$\$\$. If in 4.5 microseconds the tagged code has NOT yet been traversed than a verification failure results. Script command execution continues on the first of the tagged text being traversed (the expected case) or the timeout (the failing case.)

In this example at 83.5 microseconds (from the start of the simulation) channel 5's Link Service Latch (LSL) will be set. No script commands are executed for an additional 100 microseconds. At 183.5 microseconds (from the start of the simulation) channel 2's LSL will be set.

```
delay_warnings(T);
```

No MC33816 startup warnings are generated until T microseconds from the simulation's start time. Note that this command is global so that it acts on all four cores and therefore does not need to be duplicated if multiple MC33816 cores are being simulated.

```
ch1_core0.delay_warnings( 2000.0 );
```

In this example certain messages that occur at startup (e.g., 'core not enabled' or 'invalid checksum') are delayed for 2 milliseconds. This is generally the amount of time a simulated CPU would take to initialize the the MC33816's registers, code memory, and data RAMS.

8.6.1.2 Verify Timing Script Commands

The verify timing script command verifies that timing requirements are met. The format is as follows.

```
verify_timer_clks("TimingTag", MinSysClks, MaxSysClks);
```

The "ActionTag" parameter is a string that must match a similarly-named timing time-window within your code. The MinSysClk and MaxSysClk parameters describe the allowable minimum and maximum number of system clocks (inclusive) that execution of the code is allowed to take in order for the verification test to pass. If the code takes less time than the minimum or more time than the maximum to execute then a verification error occurs.

If the code has been traversed multiple times than the verification command verifies the last full traversal.

The following is an example of a region of code marked for timing. See the [Timer Action Commands](#) section for more information on naming timing regions.

```
int MyFunc(int x)
{
    int y;           // @ASH@timer_start("Test A");
    y = x + 25;
    return y         // @ASH@timer_stop("Test A");
}
```

In the following example, the last full traversal of the above code is verified to have taken between 10 and 20 system clocks. A verification error occurs if the code has never been fully traversed, if the last traversal took 9 or fewer system clocks, or if the last traversal took 21 or more system clocks.

```
verify_timer_clks("Test A", 10, 20);
```

Related Information

8. Script Commands Files

[Naming timing regions](#) in source code

[Verifying traversal times](#) a script command file

[View named timing regions timing using the Watch Window](#)

8.6.1.3 Clock Control Script Commands

The script commands described in this section provide control over the clock and frequency settings.

The `set_cpu_frequency()` script command has been deprecated. Instead, use the `set_clk_period()` script command described in this section. A warning message is generated when this command is used. This message can be disabled from the [Message Options dialog box](#).

```
set_clk_period(femtoSecondPerClkTick);
```

The script command listed above sets the target's clock period in femto-seconds per clock tick. Note that one femto second is 1e-15 of a second or one billionth of a micro-second. A simple conversion is to invert the desired MHz and multiply by a billion.

```
// 1e9/16.778 = 59601860 femto-seconds  
set_clk_period(59601860);
```

In this example the CPU clock frequency is set to 59,601,860 femto-seconds, which is 16.778 MHz.

8.6.2 MCU Configuration

These include a host of MCU-specific configuration script commands such as setting the entry table base address (ETBA) in the eTPU or setting the DC load in the MC339816.

8.6.2.1 MC33816 Hardware Commands

Injector Circuit

See the section '[Built-in Injector](#)' or more information on the this built-in circuit.

```
place_injector( INJECTOR_SLOT, HIGH_SIDE_BOOST,  
HIGH_SIDE_BATTERY, LOW_SIDE, SENSE_RESISTOR, INDUCTANCE,  
RESISTANCE );
```

This command creates an instance of the built-in external injector circuit. The parameters are as follows.

- **INJECTOR_SLOT** must be one of the eight supported injector slots, 'INJECTOR1' through 'INJECTOR8' which indicates which of the slots this injector circuit gets placed. Multiple injectors can be created but each injector must be placed into its own slot.
- **HS_BOOST** is one of the high side driver pins, 'G_HS1' through 'G_HS5' that specifies to which of the MC33816's high side driver pins the BOOST transistor is connected.
- **HS_BATTERY** is one of the high side driver pins, 'G_HS1' through 'G_HS5' that specifies to which of the MC33816's high side driver pins the BATTERY transistor is connected.
- **LS** is one of the eight low side driver pins, 'G_LS1' through 'G_LS7' that specifies to which of the MC33816's high side driver pins the low side driver is connected.
- **SENSE_RESISTOR** specifies across which of the four current sense pin pairs 'VSENSE1' through 'VSENSE4' that the injector's current sense resistor is connected. Note that the simulation model allows multiple injectors to be connected to the same sense pins and that the voltage across the sense resistor is calculated based on the sum of all current sources. Note also that the sense resistance is specified with the `set_sense_resistance()` script command (see below).
- **INDUCTANCE** is the injector's inductance specified in micro-henries.
- **RESISTANCE** is the injector's resistance specified in ohms.

The following is an example of this script command.

```
place_injector( INJECTOR1, G_HS2, G_HS1, G_LS1, VSENSE1, 60.0, 2.0);
```

In the above example an external injector circuit model is created in slot 1. The Boost driver's gate is connected to the HS2 pin and the battery driver's gate is connected to the HS1 pin. The Low side driver is connected to the LS1 pin. The current sense point is connected to the Sense1 pin. The injector's inductance is 60 micro-henries and its resistance is 2 ohms.

DC To DC Converter Circuit

See the section '[Built-in DC to DC Boost Converter](#)' or more information on this built-in circuit.

```
place_dcdc_converter( INDUCTANCE, CAPACITANCE );
```

This command creates the built-in external DC to DC converter circuit. The circuit power driver gets connected to pin G_LS7 and the current sense gets connected to the SENSE4 pins and the VBOOST voltage output gets connected to the VBOOST pin, and none of these pins can be changed. The circuit's inductor's inductance is specified with the INDUCTANCE parameter and the units are micro-henries.

```
place_dcdc_converter( 50, 25 );
```

In the above example an external DC to DC converter is created, the inductance is set to 50 micro henries, and the capacitance is set to 25 micro farads.

```
set_dcdc_iloading( CURRENT );
```

The above script sets or changes the DC to DC Converters load current to the parameter CURRENT, in amperes.

```
set_dcdc_iloading( 0.13 );  
wait_time(500);  
set_dcdc_iloading( .4 );
```

In the above example the DC to DC Converter's load current is initially set to 0.13 amps and 500 micro-seconds later is changed to 0.4 amps.

H-Bridge Circuit

See the section '[Build-in H-Bridge](#)' for more information on the this built-in circuit.

```
place_h_bridge(WHICH_BRIDGE_SLOT, TOP_LEFT, BTM_RIGHT,  
TOP_RIGHT, BOTTOM_LEFT, SENSE_RESISTOR, INDUCTANCE,  
RESISTANCE);
```

This command creates the built-in H-bridge. The parameters are as follows.

- **BRIDGE_SLOT** must be one of the two H-Bridge slots, either 'HBRIDGE1' or 'HBRIDGE2'.
- **TOP_LEFT** This is the left top high-side driver that supplies the positive current to the h-bridge from the battery.
- **BOTTOM_RIGHT** This is the bottom right driver that drains positive current to ground via the current-sense

- `resistor`. Note that as of 2020, December it can now be either a high-side driver or a low-side driver.
- **TOP_RIGHT** This is the right top high-side driver that supplies the negative current to the h-bridge from the battery.
 - **BOTTOM_LEFT** This is the bottom left driver that drains positive current to ground via the current-sense resistor. Note that as of 2020, December it can now be either a high-side driver or a low-side driver.
 - **SENSE_RESISTOR** specifies across which of the four current sense pin pairs 'VSENSE1' through 'VSENSE4' that the h-bridge's current sense resistor is connected. Note that although other built-in circuits may share a sense resistor, the h-bridge must have its own dedicated sense resistor.
 - **INDUCTANCE** is the h-bridge's inductance specified in micro-henries.
 - **RESISTANCE** is the h-bridges's resistance specified in ohms.

This command creates the built-in H-bridge.

```
place_h_bridge(HBRIDGE1,G_HS1,G_LS6,G_HS5,G_LS2,VSENSE3,
55.0, 10.0);
```

In the above example an external h-bridge circuit model is created in slot 1. Current is driven in the positive direction by enabling HS1 and LS6. Current is driven in the negative direction by enabling HS5 and LS2. The current sense point is connected to the Sense3 pin. The h-bridge's inductance is 55 micro-henries and its resistance is 10 ohms.

Resistor/Inductor Load Circuit

See the section '[Built-in Load](#)' or more information on the this built-in circuit.

```
place_load_r(DRIVER, SUPPLY, LOAD_RESISTANCE);
place_load_rl(DRIVER, SUPPLY, LOAD_RESISTANCE,
LOAD_INDUCTANCE);
place_load_r_regulated(DRIVER, SUPPLY, LOAD_RESISTANCE,
SENSE_RESISTOR);
place_load_rl_regulated(DRIVER, SUPPLY, LOAD_RESISTANCE,
LOAD_INDUCTANCE, SENSE_RESISTOR);
```

8. Script Commands Files

The above commands create loads between the battery and ground. The loads can be controlled by either High-side drivers (HS1-HS5) or Low-side drivers (LS1-LS7.) The loads can also be regulated (a sense resistor (VS1-VS4) is used to sense current or the load can simply be unregulated which means that it is powered on/off without measuring the current using a sense resistor. The parameters are as follows.

- **DRIVER** must be HS1-HS5 or LS1-LS7.
- **SUPPLY** can be either BOOST or BATTERY.
- **LOAD_RESISTANCE** is the load's resistance specified in ohms. Note that although HS1, HS3, and HS5 can be connected to either BOOST or BATTERY, the VDS diagnostics comparator is hard-coded to BATTERY and cannot be changed. Therefore, if connected these to the BOOST supply, the VDS Diagnostics comparator cannot be used.
- **LOAD_INDUCTANCE** is the load's inductance specified in micro-henries (if used).
- **SENSE_RESISTOR** specifies across which of the four current sense pin pairs 'VSENSE1' through 'VSENSE4' that the injector's current sense resistor is connected (if used). Note that the simulation model allows multiple loads and/or injectors to be connected to the same sense pins and that the voltage across the sense resistor is calculated based on the sum of all current sources. Note also that the sense resistance is specified with the `set_sense_resistance();` script command (see below).

The following is an example of this script command.

```
place_load_rl_regulated(G_HS2, BOOST, 2, 60, VSENSE3);
```

In the above example an external R/L (Resistor and inductor) load model is created between High Side driver 2 and a sense resistor 3. The current sense point is connected to the Sense3 pin. The load's resistance is 2 ohms and the load's inductance is 60 micro-henries. The BOOST supply is selected.

```
place_load_r(G_LS4, BATTERY, 2);
```

In the above example an external R (Resistor-only) load model is created between the battery and Low Side driver 4. Load side driver 4 is connected to ground and there is no sense resistor that measures current making it an unregulated load. The load's resistance is 2 ohms.

Additional Circuit Configuration

```
set_rds_on_resistance(DRIVER, INDEX, RESISTANCE);
```

This command sets a driver's on-drain-to-source 'on' resistance.

The supported DRIVER are HIGH_SIDE_DRIVER and LOW_SIDE_DRIVER.

Then index must be valid for that driver type. The high side drivers, the range of valid indexes is 1 to 5 and for low-side driver the valid index is 1 to 7.

RESISTANCE is specified in ohms.

Then index must be valid for that element type. For instance, for the high side drivers, the range of valid indexes is 1 to 5. Also, for injectors and the DC to DC converter, the device must have been placed before a fault can be forced.

```
set_sense_resistance(RESISTANCE, SENSE_RESISTOR);
```

This command sets resistance of the current sense resistor. RESISTANCE is specified in ohms. The current sense resistor, 'SENSE_RESISTOR' must be across one of the four senses pin pairs, 'VSENSE1' through 'VSENSE4'.

```
set_sense_resistance(0.010, VSENSE4);
```

In the above example the 'SENSE4' sense resistor's resistance is set to 0.010 ohms.

```
set_shared_sense_resistor(RESISTANCE, SENSE_BLOCK1,  
SENSE_BLOCK2);
```

This command sets resistance of a current sense resistor, and attaches the resistor to two current sense blocks. The current blocks must be across two of the four sense pin pairs, 'VSENSE1' through 'VSENSE4'. Note that the second listed current sense block cannot be driven by any of the built-in models.

```
set_shared_sense_resistor(0.020, VSENSE3, VSENSE4);
```

In the above example 'SENSE3' and 'SENSE4' current sense blocks are both tied to a single (common) 0.020 ohms resistor. Note that because VSENSE4 is the second current sense block listed, it cannot be an injector's or the DC/DC converter's sense resistor.

```
set_voltage(VOLTAGE, VOLTAGE_SOURCE);
```

This command sets a voltage source's voltage. Voltage is specified in Volts. VOLTAGE_SOURCE must be either VBOOST or VBATT.

```
set_voltage(12.5, VBATT);  
wait_time(1000);  
set_voltage(14.7, VBATT);
```

The above series of script command sets the initial battery voltage to 12.5 volts and after 1 millisecond, changes the battery voltage to 14.7 volts.

```
write_binary_pin(LOGIC_LEVEL, INPUT_PIN);
```

8. Script Commands Files

This command writes the pin specified by the [Pin and Node enumerated](#) type to the logic level specified by LOGIC_LEVEL (either 0 or 1).

```
// Wait a bit for micro to initialize
// then set the driven pin
wait_time(2);
write_binary_pin(1, DRVEN);
```

The above series of script commands waits 2 microseconds for the cores to initialize, sets the DRVEN pin to a '1' logic level.

```
set_fault(ELEMENT, INDEX, FAULT_TYPE);
```

This command forces or removes a fault on a circuit element. INDEX specifies the elements index and FAULT_TYPE specifies the type of fault to force on to the element.

```
set_fault(HIGH_SIDE_DRIVER, 2, DEVICE_SHORT);
wait_time(20);
verify_current(SENSE1, 0.0, 0.01);
set_fault(HIGH_SIDE_DRIVER, 2, NO_FAULT);
```

In the above example High Side Driver #2 (HS2) is set to the 'DEVICE_SHORT' fault condition in which the driver's source pin is shorted to the drain pin. After 20 microseconds the current in the sense resistor is verified to be off. Lastly, the fault is removed.

The supported ELEMENT types are the following:

- INJECTOR
- DC_DC_CONVERTER
- LOAD_HIGH_SIDE
- LOAD_LOW_SIDE
- HBRIDGE
- HIGH_SIDE_DRIVER
- LOW_SIDE_DRIVER

Then index must be valid for that element type. For instance, for the high side drivers, the range of valid indexes is 1 to 5. Also, for injectors and the DC to DC converter, the device must have been placed before a fault can be forced.

Faults are removed using the fault type 'NO_FAULT'.

Note that not all types of faults are supported for all elements. The following table shows the supported faults for each element.

Element	Valid INDEX range	Supported FAULT types
Injector	1-8	NO_FAULT, DEVICE_SHORT, OPEN, GND_SHORT_HIGH_SIDE, BOOST_SHORT_HIGH_SIDE, BATTERY_SHORT_HIGH_SIDE, GND_SHORT_LOW_SIDE, BOOST_SHORT_LOW_SIDE, BATTERY_SHORT_LOW_SIDE
DC to DC Converter's Inductor	1	NO_FAULT
Load (R/L, R)	n/a	NO_FAULT, DEVICE_SHORT, OPEN
H-Bridge	1-2	NO_FAULT, DEVICE_SHORT, OPEN,
High Side Driver	1-5	NO_FAULT, DEVICE_SHORT, OPEN
Low Side Driver	1-7	NO_FAULT, DEVICE_SHORT, OPEN

THE FOLLOWING COMMANDS HAVE BEEN DEPRECATED!

```

force_short(CIRCUIT_TYPE, CIRCUIT_INDEX, NODE0, NODE1); //
NO LONGER SUPPORTED!
remove_short(CIRCUIT_TYPE, CIRCUIT_INDEX, NODE0, NODE1); //
NO LONGER SUPPORTED!

```

8. Script Commands Files

8.6.3 Variable, Memory, and Register Modification and Verification

These are the 'main banana' script commands as far as data flow goes. Values in variables, (more generic) memory, registers, etc., can be both modified and verified.

8.6.3.1 Memory Read Script Commands

Read memory script commands provide the mechanism for reading data from the target memory into the scripting environment (variables). The required syntax is to assign a script variable to the return value of the script command. The first argument of the script command is an [address space-enumerated type](#). The second argument is the address from which the value should be read.

```
x = read_mem_u8(enum ADDR_SPACE, U32 address);
x = read_mem_u16(enum ADDR_SPACE, U32 address);
x = read_mem_u32(enum ADDR_SPACE, U32 address);

U32 x;
x = read_mem_u8(MC33816_DATA_SPACE, 0x7);
```

In the above script command example, the byte found at address 0x7 is read into script variable 'x'.

Note: Under the hood the variable to which the read value is assigned is actually treated as the first argument. This means a statement like this:

```
x = read_mem_u16(MC33816_DATA_SPACE,
_AW816DA_IMM_MinCurrent_);
```

Could also be written like below.

```
read_mem_u16("x", MC33816_DATA_SPACE,
_AW816DA_IMM_MinCurrent_);
```

8.6.3.2 Memory Modify Script Commands

Modify memory script command provide a way to read-modify-write any data in any target memory. The first argument is an [address space-enumerated type](#). The second argument is the address at which the value should be written or read-modified-written. The third argument is an [assignment operation type](#). The fourth argument is the value to be used for the assignment operation.

```
modify_mem_u8(enum ADDR_SPACE, U32 address, enum ASSIGNMENT_TYPE op,
U8 val);
```

```
modify_mem_u16(enum ADDR_SPACE, U32 address, enum ASSIGNMENT_TYPE  
op, U16 val);  
modify_mem_u32(enum ADDR_SPACE, U32 address, enum ASSIGNMENT_TYPE  
op, U32 val);
```

Memory can also be modified within script commands using the assignment operator. See the [Assignments in Script Commands Files](#) section for a description. Note that since the assignment syntax is not actually C-compatible, it is recommended that memory modification script commands be used instead, as the non-C assignment syntax causes script file code references not to be available.

8.6.3.3 Memory Verify Script Commands

Verify memory script commands provide the mechanism for verifying the values of the target memory. The first argument is an [address space-enumerated type](#). The second argument is the address at which the value should be verified. The third argument is a mask that allows certain bits within the memory location to be ignored. The fourth argument is the value that the memory location must equal.

```
verify_mem_u8(enum ADDR_SPACE, U32 address, U8 mask, U8 val);  
verify_mem_u16(enum ADDR_SPACE, U32 address, U16 mask, U16 val);  
verify_mem_u32(enum ADDR_SPACE, U32 address, U32 mask, U32 val);
```

This command uses the following algorithm.

- Read the memory location in the specified address space and address.
- Perform a logical "and" of the mask with the value that was read from memory.
- Compare the result to the expected value.
- If the expected value is not equal to the masked value, generate a verification error.

The following example verifies the value of an 8-bit (byte) memory location.

```
verify_mem_u8(MC33816_DATA_SPACE, 0x7, 0xc0, 0x80);
```

The example above verifies that the two most significant bits found at address 0x7 are equal to 10b. The lower 6 bits are ignored. If the bits are not equal to 10b, a script failure message is generated and the target's script failure count is incremented.

```
verify_mem_u16(MC33816_DATA_SPACE, 0x10, 0xffff, 0x55aa);
```

In the example above, a 16-bit (two-byte) memory at address 10h is verified to equal 0x55aa. By using a mask of FFFFh, the entire word is verified.

```
verify_mem_u32(MC33816_DATA_SPACE, 0x20, 1<<27, 1<<27);
```

8. Script Commands Files

In the example above, bit 27 of a 32-bit (four-byte) memory location at address 20h is verified to be set. All other bits except bit 27 are ignored.

8.6.3.4 Register Write Script Commands

Write register script commands provide the mechanism for changing the values of the target registers. The first argument is the value to which the register will be set. The second argument is a [MC33816 register enumerated type](#) with a definition that depends on the specific target and register width on which the script command is acting.

```
write_reg8(U8, enum REGISTERS_U8);  
write_reg16(U16, enum REGISTERS_U16);  
write_reg32(U32, enum REGISTERS_U32);  
  
write_reg16(0x5557, REG_R0);
```

In the above script command example 5557 hexadecimal is written to register R0.

8.6.3.5 Register Verify Script Commands

Verify register script commands provide the mechanism for verifying the values of the target registers. The first argument is a [MC33816 register enumerated type](#) with a definition that depends on the specific target and register width on which the script command is acting. The second argument is the value against which the register will be verified.

```
verify_reg8(enum REGISTERS_U8, U8);  
verify_reg16(enum REGISTERS_U16, U16);  
verify_reg32(enum REGISTERS_U32, U32);  
  
verify_reg16(REG_R0, 0x5557);
```

In the script command example above, register R0 is verified to be 5557 hexadecimal. If not, a script failure message is generated and the script failure count is incremented.

8.6.3.6 Symbol Write Script Commands

Write symbol value script commands provide a mechanism for writing data to simulated/target memory using the symbolic names from the source code. The `write_val()` command is for writing data of a basic type to a symbolically referenced memory location.


```
write_val("symbolExprString", "exprString");
```

The expression string (exprString) can be a numerical constant or a simple symbolic expression. Constants can be supplied as decimal signed integers, unsigned hexadecimal numbers (prepended with '0x'), floating point numbers, or as a character (e.g. 'A'). A symbolic expression can be just a local/global symbol or a simple expression such as *V (de-reference), &V (address of V), V[constant], V.member or V->member, where V is a symbol of the appropriate type. "symbolExprString" must be a symbolic expression as described above, an "l-value" in compiler parlance. The type of the symbolic expression must be a basic type – char, int, float, etc. If the types of the two sides differ then C type conversion rules are followed before writing the data to memory.

Two other forms of the write symbol value script command are also supported that directly take the numerical value to write as an argument.

```
write_val_int("symbolExprString", U32 val);  
write_val_fp("symbolExprString", double val);
```

These forms allow the value to be input as a constant expression, perhaps using a series of macros, thereby providing more flexibility.

The write_str() command is provided as a shorthand way to write a string into the memory pointed to by a symbolic expression of pointer type..

```
write_str("pointerExprString", "stringExprString");
```

The pointer expression string (pointerExprString) is symbolic expression as described above, but of type pointer rather than a basic type. It can be a pointer to any type, and is implicitly type-cast to the char* type. "stringExprString" can either be a string constant, or it can be of type char array or char pointer. In either case, write_str() function like the C library function strcpy(). Use write_str with caution; no effort is made to check that the destination buffer has sufficient space available, and the resulting bug induced by such a buffer overflow can be extremely difficult to debug.

A key concept is that of symbol scope. A variable defined within a particular function goes out of scope if that function is not being executed. To get around this, a script command can be set to execute when the function becomes active using the at_code_tag(); script command. See the [Timing Script Commands](#) section for a description.

```
at_code_tag("&&Test1Here&&");  
write_val("FailFlag", "0");
```

In the above example the target is run until it gets to the address associated with the source code that contains the text &&Test1Here&&. Once this address is reached, symbol FailFlag is set equal to zero.

```
at_code_tag("&&Test23Here&&");
```

8. Script Commands Files

```
write_str("PlayerBuffer", "Michael Jordan");
```

In this case the string "Michael Jordan" is written to the buffer named "PlayerBuffer". If the buffer has insufficient space to hold this string, a bug that is difficult to identify would result.

8.6.3.7 Verify Symbol Value Script Commands

These verify symbol value commands have a similar syntax to those commands described in the [Write Symbol Value Script Command](#) section.

```
verify_val("exprString", "testOpString", "exprString");
```

The expression strings (exprString) can be a numerical constant or a simple symbolic expression. Constants can be supplied as decimal signed integers, unsigned hexadecimal numbers (prefixed with '0x'), floating point numbers, or as a character (e.g. 'A'). A symbolic expression can be just a local/global symbol or a simple expression such as *V (de-reference), &V (address of V), V[constant], V.member or V->member, where V is a symbol of the appropriate type. If the types of the two sides differ, C type conversion rules are followed before performing the test operation.

"testOpString" is a C test operator. Supported operators are ==, !=, >, >=, <, <=, &&, and ||.

If the result of the specified operation on the expressions is 0, or false, a verification error is generated.

```
at_code_tag("&&Test1Here&&");  
verify_val("FailFlag", "==", "0");
```

In the example above, the target is run until it gets to the address associated with the source code that contains the text &&Test1Here&&. Once this address is reached, the value of symbol FailFlag is read and a verification error is generated if it does not equal zero.

Two other forms of the verify symbol value script command are also supported that directly take the numerical value to compare against as an argument.

```
verify_val_int("exprString", "testOpString", U32 val);  
verify_val_fp("exprString", "testOpString", double val);
```

These forms allow the test value to be input as a constant expression, perhaps using a series of macros, thereby providing more flexibility.

Separate script commands are available to compare and verify string values.

```
verify_str("expr1", "testOp", "expr2");
```

```
verify_str_ex("expr1", "testOp", "expr2", len);
```

The "expr1" and "expr2" parameters can either be a string constant, or can be of type char array or char pointer. If strings are resolved from both parameters then they are compared using the comparator specified in "testOp". If the outcome of this is true (non-zero), the verification test passes; otherwise a failure is reported. Supported comparator operators are ==, !=, >, and <, >= and <=. Greater-than and less-than operations follow the same rules as the strcmp() standard library function.

The extended version of this command, verify_str_ex(); also support a length specifier, len. Think strncmp where the comparison acts only on the first "len" characters and the remainder are ignored.

```
at_code_tag("^^StringTest1^^");
verify_str("somePtr", "==", "Hello World");
```

In the example above, the target is run until it gets to the address associated with the source code that contains the text ^^StringTest1^. Once this address is reached, the ASCII values are read until the terminating character, a byte of value zero, is reached. The resulting string is compared, case-sensitively, with the string "Hello World". If the two strings are not equal, a verification error is generated.

```
at_code_tag("^^StringTest2^^");
verify_str_ex("somePtr", "<=", "Hello World", 5);
```

In the example above, the first five letters of two strings are compared and verification error results unless somePtr is less than or equal to "Hello".

8.6.3.8 MC33816 SPI Data Write/Verify Commands

```
write_spi_data16(Addr, Val);
verify_spi_data16(Addr, Val);
```

These commands write and verify spi data. The 'Addr' parameter is specified in bytes so the addresses given in the MC33816 manual must be right-shifted by one bit. The Val parameter is the value that gets written in the write command, or verified in the verify command.

```
#define CH1_UC0_OutputAccessAddr (0x184<<1)
write_spi_data16 ( CH1_UC0_OutputAccessAddr, 0x0eee );
verify_spi_data16( CH1_UC0_OutputAccessAddr, 0x0eee );
```

In this example the 'Output Access' register for Channel 1, Core 0 is set to 0x0EEE. It's value is then verified.

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Note the MC33816 assembler automatically generates all needed global variable address from the data ram data into the auto-defines file and that all global register addresses (in their word-to-byte shifted format) are available in file 'StdDefMc33816.h'.

Bitwise access is supported with the following functions:

```
write_spi_bit(Addr, BitPosition, Val);
verify_spi_bit(Addr, BitPosition, Val);
```

These script commands allow the writing and verification of bitfields. The 'BitPosition' parameter is from the LSB of the 16 bit register.

```
// Start the micro
// by setting 'flash_enable.pre_flash_enable' (bit 4)
#define CH1_FlashEnableAddr (0x100<<1)
write_spi_bit ( CH1_FlashEnableAddr, 4, 1 );
verify_spi_bit ( CH1_FlashEnableAddr, 4, 1 );
```

8.6.3.9 MC33816 Register Script Commands

```
set_reset_source(<reset_source>);
```

The above script command allows the user to set the reset source (which can then be read via the SPI reset source register, which is read-only and clears on read). E.g.

```
set_reset_source(SPI_RESET);
verify_mem_u16(MC33816_SPI_SPACE, ResetSourceAddr, 0xffff,
0x4);
verify_mem_u16(MC33816_SPI_SPACE, ResetSourceAddr, 0xffff,
0x0);
```

See the [reset source enumerated type](#) for all valid reset source parameters.

```
set_diagnostic_isr(<channel>, <uc0_isr_addr>, <uc1_isr
addr>);
```

This script command configures a diagnostic ISR register. If channel 1 is specified SPI address 0x10C is written, if channel 2 then SPI address 0x12C is written. The script command verifies that the ISR addresses are in the valid range.

```
set_driver_disabled_isr(<channel>, <uc0_isr_addr>, <uc1_isr
addr>);
```

This script command configures a driver disabled ISR register. If channel 1 is specified SPI address 0x10D is written, if channel 2 then SPI address 0x12D is written. The script command verifies that the ISR addresses are in the valid range.

```
set_software_isr(<channel>, <uc0_isr_addr>, <uc1_isr_addr>,  
<uc0_rising_start_isr_enable>, <uc0_falling_start_isr  
enable>, <uc1_rising_start_isr_enable>, <uc1_falling_start  
isr_enable>);
```

The `set_software_isr()` script command configures a software ISR register. If channel 1 is specified SPI address 0x10E is written, if channel 2 then SPI address 0x12E is written. The script command verifies that the ISR addresses are in the valid range. The command also configures the start signal software interrupt settings (0 = disable, 1 = enable).

8.6.4 Pin and Node Modification and Verification

This section includes script commands for controlling, modifying, and verifying pins and nodes. For all devices, input pins are controlled and their values are verified. Verification can be over a region of time (e.g., a 3 micro-second pulse should occur somewhere between 100 and 200 microseconds) or at a specific snapshot in time (e.g., the pin must be high at exactly the time when the script executes.) For analog devices such as the MC33816, the various voltages and currents can be both controlled and verified.

8.6.4.1 Pin Window Verification Commands

These command have the purpose of verifying the state of the pin (or node) within a time-window. Within this time-window an entire pulse can be verified, a single transition can be verified, or the absence of any transitions at all can be verified. The commands in this section differ from the commands like, 'verify_chan_output_pin();' (documented in section Pin Verification and Control Script Commands) which verify the pin state at a snapshot in time and is therefore subject to 'false pass' scenarios in which the pin pulses occur (and are not detected) between adjacent snapshots. These script commands described in this section are not subject to this limitation because the pin state is verified over an entire time-window.

Script `verify_pulse()`;

The `verify_pulse()` script command verifies that exactly one pulse (two transitions) occurs on a pin (or node) within a time-window.

Parameter 'Node' specifies the Node or Pin type. See the [Pin and Node Enumerated Type](#) section for a listing of the pin and node names. For the MC33816, only the VSENSE1 to VSENSE4 nodes are valid and these refer to the current comparator's output node.

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Parameter 'Index' is the index of the Node. For example, in the eTPU, this might signify the channel number.

Parameters 'StartTime' and 'EndTime' specify the beginning and end of the time-window in which the pulse must occur.

Parameter 'PulseType' can be either LO_HI_LO (a positive pulse) or HI_LO_HI (a negative pulse.)

Parameters 'FirstTransitionTime' and 'SecondTransitionTime' specify the times of the two transitions in micro-seconds.

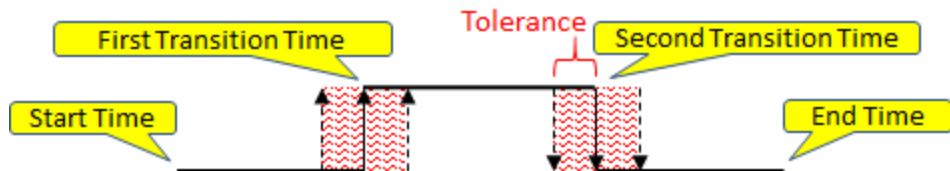
Parameter 'Index' is the index of the pin. For instance, in the eTPU there are 32-channels, so a Node of 'CHAN_OUTPUT' and an index of '4' refers the the eTPU's channel 4 output pin.

```
verify_pulse(Node, Index, StartTime, PulseType,  
FirstTransitionTime, SecondTransitionTime, EndTime);
```

The default 'tolerance' is one system clock minus one nanosecond. This can be overridden with the 'set_verify_region_tolerance(); [script command described below](#).

This script command verifies the following aspects of this waveform. Note that the script must execute after the pulse and as such verifies that the pin transitions that have already occurred.

- At the 'Start Time' the pin is at State1 (low in this diagram)
- The First Transition occurs within +/- the allowed tolerance
- The Second Transition occurs within +/- the allowed tolerance
- Exactly two transitions occur between the Start Time and the End Time



Script `verify_transition();`

The `verify_transition()`; script command verifies that exactly one transitions occurs on a pin (or node) within a time-window.

Parameter 'Node' specifies the Node or Pin type. See the [Pin and Node Enumerated Type](#) section for a listing of the pin and node names. For the MC33816, only the VSENSE1 to VSENSE4 nodes are valid and these refer to the current comparator's output node.

Parameter 'Index' is the index of the Node. For example, in the eTPU, this might signify the channel number.

Parameters 'StartTime' and 'EndTime' specify the beginning and end of the time-window in which the transition must occur.

Parameter 'TransitionType' can be either RISING (a low to high transition) or FALLING (a high to low transition.)

Parameters 'TransitionTime' specify the time of the transition in micro-seconds.

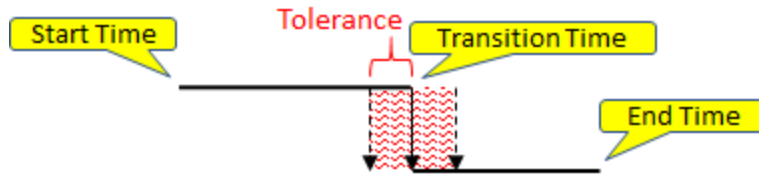
Parameter 'Index' is the index of the pin. For instance, in the eTPU there are 32-channels, so a Node of 'CHAN_OUTPUT' and an index of '4' refers the the eTPU's channel 4 output pin.

```
verify_transition(Node, Index, StartTime, PulseType,  
TransitionTime, EndTime);
```

The default 'tolerance' is one system clock minus one nanosecond. This can be overridden with the '`set_verify_region_tolerance()`'; [script command described below](#).

This script command verifies the following aspects of this waveform. Note that the script must execute after the transition and as such verifies that the pin transition have already occurred.

- At the 'Start Time' the pin is either low (if verifying a rising edge) or high (if specifying a falling edge.)
- The Transition occurs within +/- the allowed tolerance
- Exactly one transition occurs between the Start Time and the End Time



Script `verify_pin_region();`

The `verify_pin_region();` enhanced script command verifies the pin (or node) over a time-window. The intent of the command is to verify that pin (or node) stays at a particular state (high or low) over an entire time-window, and specifically that no pin transitions occur within the time-window. Note that there is no 'tolerance' band.

Parameter 'Node' specifies the Node or Pin type. See the [Pin and Node Enumerated Type](#) section for a listing of the pin and node names. For the MC33816, only the VSENSE1 to VSENSE4 nodes are valid and these refer to the current comparator's output node.

Parameter 'Index' is the index of the Node. For example, in the eTPU, this might signify the channel number.

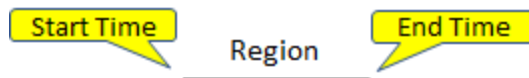
Parameters 'StartTime' and 'EndTime' specify the beginning and end of the time-window in which the pin must be at 'State' (HI or LO).

Parameter 'State', is the pin state in the time-window. Allowed values are HI and LO.

```
verify_pin_region(Node, Index, StartTime, State, EndTime);
```

Note that there is no implied tolerance. I suppose you could think of the tolerance as being zero in the same way as I think of myself as being a billionaire with zero billions of dollars.

- Between the Start Time and the Script Execution Time the pin is at State
- No transitions occur between the Start Time and the End Time



Script `set_verify_region_tolerance();`


```
set_verify_region_tolerance(MicroSecondsTolerance);
```

The `set_verify_region_tolerance()` script command sets the tolerance for the `verify_pulse()`; and `verify_transition()`; script commands to 'MicroSecondsTolerance'.

Note that only this tolerance only applies to the time of the transitions. It does not apply to either time-window boundaries (set by 'StartTime and EndTime'.) This does not apply to the 'verify_pin_region(); script command because it does not have a pin-transition to which this script command would apply.

Note that once set, this value applies for future script commands. However, if the simulator is reset, then the tolerance is restored to the default.

8.6.4.2 External Logic Commands

Boolean logic that is external to the MC33816 is instantiated through the use of **place_xyz()**; script commands. Several types of external logic are available. The script command used to instantiate each type of logic is listed below. See the [External Logic Simulation](#) chapter for a detailed description of the use of external Boolean logic gates.

- `place_buffer(InPin, OutPin);` Instantiates a buffer follower
- `place_inverter(InPin, OutPin);` Instantiates an inverter
- `place_and_gate(In1Pin, In2Pin, OutPin);` Instantiates an 'AND' gate
- `place_or_gate(In1Pin, In2Pin, OutPin);` Instantiates an 'OR' gate
- `place_xor_gate(In1Pin, In2Pin, OutPin);` Instantiates an 'XOR' gate
- `place_nand_gate(In1Pin, In2Pin, OutPin);` Instantiates a 'NAND' gate
- `place_nor_gate(In1Pin, In2Pin, OutPin);` Instantiates a 'NOR' gate
- `place_nxor_gate(In1Pin, In2Pin, OutPin);` Instantiates an 'INVERTING XOR' gate
- `remove_gate(Out);` Removes the gate that drives channel 'Out'

The MC33816 has the following pins that can be used. Indexes are defined as follows for the MC33816.

- 0 to 2 FLAG0 through FLAG2
- 3 to 8 START1 through START6
- 9 IRQB
- 10 to 11 OA_1 through OA_2

- ```
place or gate(0, 2, 4);
```

Each of the **place\_xyz()**; script command has an extended version that supports cross target/core gates, as shown below.

- Target, In1Target, In2Target and OutTarget are the names of the target and are used as strings such as "eTPU\_A" or "Ch1\_Core0".

In the above example an 'OR' gate is placed with its two inputs coming from the eTPU A's channel 16 output pin and the MC33816's OA\_1 pin. The output of the OR gate drives eTPU A's channel 11's input pin.

#### 8.6.4.3 MC33816 Verification Script Commands

```
verify_current(SENSE, MIN, MAX);
```

The above script command verifies that the current, in amperes, is between MIN and MAX. The currently-supported current sense points are the voltage flowing through the sense resistors (SENSE1 through SENSE4), through the high side drivers (HS1-HS5), through the low side drivers (LS1-LS7) and the injectors (INJECTOR1-INJECTOR8).

```
verify_current(SENSE1, 4.5, 6.0);
```

The above script command verifies that the current through the sense resistor 'SENSE1' is between 4.5 amps and 6.0 amps.

```
verify_voltage(NODE, MIN, MAX);
```

The above script command verifies that the voltage at the voltage source, VBOOST or VBATT.

```
verify_voltage(VBOOST, 69.0, 69.5);
```

The above script command verifies that the VBOOST voltage is between 69 and 69.5 volts.

```
verify_binary_pin(PIN_NAME, VAL);
```

The above script command verifies that a pin is at a logic level. See the [Pin and Node Enumerated Type](#) section for a listing of the pin and node names.

```
verify_binary_pin(START1, 0);
```

The above script command verifies that the pin named 'Start1' is at a 0 logic level.

#### 8.6.5 Code

Code coverage, which is a critical aspect of structured testing, is done with the script commands found in this section. It is also possible to arm the simulator to create a warning when a specific (and presumably unexpected) section of code executes.

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### 8.6.5.1 Code Coverage Script Commands

An important index of test suite completeness is the coverage percentage that a test suite achieves. The MC33816 Development Tool provides several script commands that aid in the determination of coverage percentages. In addition, script commands provide the capability to verify that minimum coverage percentages have been achieved. A discussion of this topic is found in the [Code Coverage Analysis](#) section. The following are the script commands that provide these capabilities.

```
write_coverage_file("Report.Coverage");
verify_file_coverage("MyFile.uc",instPct,braPct);
verify_all_coverage(instPct,braPct);
```

The `write_coverage_file(...)` command generates a report file that lists the coverage statistics. Statistics for individual files are listed as well as a cumulative file for the entire loaded code.

The `verify_file_coverage(...)`; and `verify_file_coverage_ex(...)`; commands are used as part of automation testing of a specific source file. The `instPct` and `braPct` parameters are the minimum required branch and coverage percentages in order for the test to pass. These parameters are both expressed in [floating point notation](#). The valid range of coverage percentage is zero to 100. Note that for each branch instruction there are two possible branch paths: the branch can either be taken or not taken. Therefore, in order to achieve full branch coverage, each branch instruction must be encountered at least twice and the branch must both be taken and not taken.

The `verify_all_coverage(...)`; and `verify_all_coverage_ex(...)`; are similar to the `verify_file_coverage` commands except these commands focus on the entire build rather than specific source code modules. As such, they are less useful as a successful testing strategy will focus on specific modules rather than on the entire build.

Note that this capability is also available directly from the [file menu](#).

```
wait_time(100);
verify_file_coverage("toggle.uc",92.5,66.5);
verify_all_coverage(33.3,47.5);
write_coverage_file("record.Coverage");
```

The code in this example waits 100 microseconds and then verifies that at least 92.5 percent of the instructions associated with file `toggle.uc` have been executed and 66.5 percent of the possible branch paths associated with file `toggle.uc` have been traversed. In addition, the example verifies that at least 33.3 percent of all instructions have been executed and that 47.5 percent of all branch paths have been traversed. A complete report of instruction and branch coverage is written to file `record`.

## Cumulative Coverage

To produce the highest quality software it is imperative that testing cover 100% of instructions and branches.. Additionally, for quality control purposes, this coverage should be proven using the `verify_coverage` scripts. But most test suites consist of multiple tests, such that the coverage is achieved only after all tests have run. The cumulative coverage scripts provide the ability to prove that the entire test suite cumulatively has achieved 100% coverage.

The typical testing procedure might work as follows. A series of tests is run, and at the end of each test the coverage data is stored. At the end of the very last test, the coverage data from all previous tests are loaded such that the resulting coverage is an accumulation of the coverage of all previous tests. Then the `verify_coverage` script command is run proving that all tests have passed. The following illustrates this process.

```
... Run Test A.
save_cumulative_file_coverage("MyFunc.c", "TestA.CoverageData");

... Run Test B.
save_cumulative_file_coverage("MyFunc.c", "TestB.CoverageData");

...

... Run Test M.
save_cumulative_file_coverage("MyFunc.c", "TestM.CoverageData");

... Run Test N.
load_cumulative_file_coverage("MyFunc.c", "TestA.CoverageData");
load_cumulative_file_coverage("MyFunc.c", "TestB.CoverageData");
...
load_cumulative_file_coverage("MyFunc.c", "TestM.CoverageData");
verify_file_coverage("MyFunc.c ",100,100,100);
```

## Code Coverage Annotated Listing Files

It can be useful to generate reports files that provide coverage information at the source and opcode level. The `write_coverage_listing_file()` has been provided to generate such reports.

```
write_coverage_listing_file("ModuleName.c",
 "ListingFileName", enum COVERAGE_LISTING_OPTIONS);
```

For a specified module (source file name), a code coverage annotated listing file with the name specified by the "ListingFileName" argument is created. Any previous file of the

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same name is overwritten. The output form is very much like a regular listing file as generated by the ETEC compiler, with the additions of

- source file line number prepended to each line
- opcode/disassembly lines include a coverage field that indicates to what level the opcode has been executed by tests (none, full execution, true branch, false branch, inferred coverage)

The COVERAGE\_LISTING\_OPTIONS argument supports two mode options

```
ALL_LINES : Output all lines of the specified module/source
file with listing information.
NON_COVERED_ONLY_LINES : Output only line associated with
opcodes not fully executed.
```

Independent flags that modify the modes listed above may be added to the COVERAGE\_LISTING\_OPTIONS argument.

### 8.6.5.2 Code Warning Script Commands

A warning can be generated when the first opcode following a code label is executed. Note that the warning is generated on execution of the code, not when the program counter gets to the code. This means that the warning is executed a bit later than might be expected.

```
set_code_label_warning("PWMF_Error");
```

In the above script command a warning is assigned to the code label 'PWMF\_Error'. If the code following this label is executed a warning is generated.

This can be used (say) when code that is not expected to execute actually executes. One example of this is in the eTPU

```
<...snip...>
/*-----+
-----+
| Catch all unspecified entry table conditions
|
+-----*/
else
{
 PWMF_Error:
 ClearAllLatches();
```

```
 }
}
```

Note that a similar result can also be achieved using a Print action tag described more fully in the ['Print Action Tag'](#) section. This capability is illustrated below.

```
<...snip...>
/*-----
-----+
| Catch all unspecified entry table conditions
|
+-----*/
else
{
 ClearAllLatches(); // @ASH@print("The 'dangling
else' thread is executing");
}
}
```

## 8.6.6 Files

These script commands control creation of files. For instance, trace data can be piped to an output file and 'data dump' files can be generated from regions of data or code memory.

### 8.6.6.1 Trace Buffer and Files

#### Overview

Trace files have two primary purposes; they are useful for generation of a file that appears identical to the trace window but can be loaded into a file viewer to access advanced search capabilities, and they are used to load into a post-processing facility for advanced trace analyses. The various capabilities and settings are focused on these two purposes.

#### Generating Viewable Files

Viewable trace files can be generated by selecting the Trace buffer, Save As ... submenu from the Files menu. Note that the trace buffer is about five times larger than what appears in the trace window. A viewable trace file can also be generated using script commands. See the [Trace Script Commands](#) section.

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Because viewable files are appropriate only for things like advanced search capabilities, no error or warning is generated if the underlying trace buffer has overflowed.

### Generating Parseable Files

Parseable files can be generated only by using the trace commands described in the [Trace Script Commands](#) section. To ensure generation of deterministic parseable trace files, these files can be generated only if the selected trace events are enabled within the MC33816 Development Tool and the trace buffer has not overflowed when generating a trace file from the buffer.

For large trace files it is best to use the streaming capability, thereby avoiding possible trace buffer overflow issues.

### Parsing the Trace File

All post processing on the trace files should be done on files generated using the "parseable" option.

Although the file format is intended to be self-explanatory, it is purposely left undocumented to retain flexibility for future enhancements. Instead, it is recommended that those wishing to post-process the trace files use the trace file parse source code available from ASH WARE. The public methods in the TraceParser class are documented and will remain stable for future releases.

#### 8.6.6.2 File Script Commands

These commands support loading and saving files via script commands.

```
dump_file(startAddress, stopAddress, enum ADDR_SPACE,
 "filename.dump", enum FILE_TYPE,
 enum DUMP_FILE_OPTIONS);
```

This command creates the file filename.dump of type [FILE\\_TYPE](#), using the options specified by [DUMP\\_FILE\\_OPTIONS](#). The file is created from the image located between startAddress and stopAddress, out of the address space [ADDR\\_SPACE](#).

```
dump_file(0, 0xffff, CPU32_SUPV_DATA_SPACE, "Dump.S19",
 SRECORD, DUMP_FILE_DEFAULT);
#define MY_OPTIONS NO_ADDR + NO_SYMBOLS
dump_file(0, 0xffff, CPU32_SUPV_CODE_SPACE, "Dump.dat",
 DIS_ASM, MY_OPTIONS);
```



The downside of the `dump_file` command is that it does a one-time dump of the entire file overwriting any previous file. An alternative to this is to continuously write the trace data to a file as it is generated. See the [Trace Script Commands](#) section.

This example creates a Motorola SRECORD file, `Dump.S19`, from the first 64K of the CPU32's supervisor data space. The default options are used for this dump. An assembly file, `Dump.dat`, is also created from the first 64K of supervisor code space and both address mode and symbolic information are excluded. Assuming the target processor is a CPU32, the generated assembly code is for the CPU32.

```
verify_files("fileName1.dat", "fileName2.dat",
 enum VERIFY_FILES_RESULT);
```

This script command verifies two file named `fileName1.dat` and `fileName2.dat`. In addition to checking for matching or mismatching, this script command also can verify non-existence of either file or both files. Expected results are specified with the `VERIFY_FILES_RESULT` enumeration.

```
verify_files("new.dat", "gold.dat", FILE1_MISSING);
dump_file(0, 0x28, MC33816_DATA_SPACE, "new.dat", IMAGE,
DATA8);
verify_files("new.dat", "gold.dat", FILESMATCH);
```

In the above example a new file named "new.dat" is generated, and is compared against file "gold.dat" to make sure that they match. By first verifying that file "new.dat" does not exist the fact that file "new.dat" is actually generated by the dump command is also verified.

```
dump_file(0, 0x28, MC33816_DATA_SPACE, "new.dat", IMAGE,
DATA8);
verify_files("new.dat", "gold.dat", FILES_MISMATCH);
wait_time(100);
dump_file(0, 0x28, MC33816_DATA_SPACE, "new.dat", IMAGE,
DATA8 | FILE_APPEND);
verify_files("new.dat", "gold.dat", FILES_MATCH);
```

The above example illustrates use of the `FILE_APPEND` options to store multiple data snapshots into a single file. By first verifying that the files mismatch, then that the files match, it proves that it is this verification process that actually generated the passing results.

### Related Topics:

[Trace Script Commands](#)

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### 8.6.6.3 MC33816 SPI and Configuration File Creation Script Commands

```
create_spi_commands_file();
```

The above script command exports the script commands file as a series of SPI bus commands in a format that can be used by the create\_spi\_commands\_file(); command line utility.

```
create_all_config_files(SUB_DIRECTORY);
```

The above script command creates the configuration files needed by the NXP SPI bus utility that initializes and runs the MC33816 across a SPI bus. The files are placed in the directory SUB\_DIRECTORY.

```
create_all_config_files("MyFilesDirectory");
```

In the above example the current state of the MC33816 is exported as a series of SPI-Gen compatible files and places the files in directory 'MyFilesDirectory'.

### 8.6.6.4 CSV Data Import/Export

```
read_csv_1d("<data_1d_array_var>", "<csv format file>",
SCRIPT_CSV_CONTROL);
read_csv_2d("<data_2d_array_var>", "<csv format file>",
SCRIPT_CSV_CONTROL);
```

The above script commands read a data file in CSV format into script array variables. The one-dimensional version will read the first column of a CSV file into the specified array, while the two-dimensional version will read the entire CSV file into the specified script array variable. Any necessary type conversions will be performed. IMPORTANT

NOTE: the script array variable dimensions will be enlarged IF NEEDED to hold the data.

```
S32 a[20];
F64 b[1][1];
S32 a_len;
S32 b_len[2];
read_csv_1d("a", "csv_data_file_10rows.csv",
CSV_READ_FIRST_LINE); // first line of file is data, not
header
a_len = read_dim_length("a", 0); // a_len gets value of 20
read_csv_2d("b", "csv_data_file_15rows_3cols.csv",
CSV_IGNORE_FIRST_LINE); // first line in file is header;
ignore
b_len[0] = read_dim_length("b", 0); // returns 15
b_len[1] = read_dim_length("b", 1); // returns 3
```

Since the read of a CSV file may change the dimensions of an array, there is a script command to retrieve the length of a script array variable dimension.

```
read_dim_length("<array_var>", <dimension index>);
```

Array data can also be exported to a CSV-format file.

```
write_csv("<source array var>", "<output file>", "<header text>");
```

The source array variable can be one or two dimensional. It's entire contents are written to the specified file in CSV format. If the header text parameter is an empty string, no header line is written to the file and data starts on the first line, otherwise the header text is written out as the first line.

```
write_csv("capture", "pin_data.csv", "TIME, PIN STATE");
```

For enhanced flexibility, data can be appended to existing files. The file must exist before executing the command, whose format is as follows:

```
append_csv("<source var>", "<output file>");
```

The source variable may be non-array or one dimensional (appends one line), or two dimensional, in which case the number lines appended is equal to the number of rows in the array variable.

### 8.6.7 System Script Commands

```
system(commandString);
verify_system(commandString, returnVal);
```

These commands invoke the operating system command processor to execute an operating system command, batch file, or other program named by the string, <commandString>. The first command, system, ignores the return value, while the second command, verify\_system, verifies that the value returned is equal to the expected value, returnVal. If the returned value is not equal to the expected value than a script verification error is generated.

```
system("copy c:\\temp\\report.txt check.txt");
verify_system("fc check.txt expected.txt", 0);
```

In this example the operating system is invoked to generate a file named check.txt from a file named report.txt. The file check.txt is then compared to file expected.txt using the fc utility. A script verification error is generated if the files do not match.

```
exit();
```

## 8. Script Commands Files

---

This shuts down the MC33816 Development Tool and sets the error level to non-zero if any verification tests failed. If all tests pass, the error level is set to zero. The error level can be examined by a batch file that launched the MC33816 Development Tool, thereby supported automated testing. See the Regression Testing [section](#) for a detailed explanation of and examples showing how this command can be used as part of an automated test suite.

```
print(messageString);
print_pass(messageString);
// NOTE: does not affect exit code in auto-run mode
```

These commands are geared toward promoting camaraderie between coworkers. These commands cause a dialog box to open that contains the string, <messageString>. The truly devious practical joker will find a way to combine this script command with sound effects.

```
print("Hit any key to fuse all P-wells "
 "with all N-substrates in your target silicon");
```

In the example above, your coworker at the adjacent lab bench pauses for a certain amount of healthy introspection. A well-placed and timed bzilch-chord can significantly enhance its effect.

```
print("\n\"TEST RESULTS:\n"
 " A=%d\n"
 " B=%d\n"
 " C=%d\",A,B,C");
```

The print\_pass() print command is identical to the print() script command except print\_pass() leaves the error level of the simulation unaffected. The print() script command always sets the simulation error level to 1.

The print command supports using \_\_FILE\_\_ as an argument that gets replaced by the name (and absolute path) of the file in which it is found.

```
print("\n%s : TEST COMPLETE\", __FILE__); // outputs
"<filename> : TEST COMPLETE"
```

In the case of print\_sfn(), the error level of the simulation run is unaffected. These script commands are available to be used via action tags as well.

Formatted symbolic information can be generated using as described in the ["String within a String"](#) section. See the example shown above.

```
verify_version_ex(Tool, verHi, verLo, verBuildChar,
messageString);
```

This command generates a warning message if the Tool version is earlier than that specified by <verHi>, <verLo> and <verBuildChar>. Tool can be either

TOOL\_DEV\_TOOL or TOOL\_ETEC. If an earlier than required version of the MC33816 Development Tool is actually running then a dialog appears that contains the text specified by <messageString>.

```
verify_version_ex(TOOL_DEV_TOOL, 0,82,'A',
 "This demo application that illustrates GLOBAL INITIALIZATION\n"
 "will not work in this early version of the MC33816 Development
 Tool.");
```

In the example above the message, "this demo ..." appears if run on a MC33816 Development Tool version earlier than version 3.50, build B. We recommend this script command be placed first in the script file so that it gets processed before any parse errors or unsupported command errors can occur.

Note that the following script command is deprecated in the MC33816 Development Tool! However, if it is run in the MC33816 Development Tool it checks the equivalent Mtdt Version. This prevents false-passes because the MC33816 Development Tool version are restarted at version 1.00.

```
verify_version(verHi, verLo, verBuildChar, messageString);
```

This command generates a warning message if the MC33816 Development Tool version is earlier than that specified by <verHi>, <verLo> and <verBuildChar>. If an earlier than required version of the MC33816 Development Tool is actually running then a dialog appears that contains the text specified by <messageString>.

```
verify_version(3,50,'B',
 "This demo application that illustrates GLOBAL INITIALIZATION\n"
 "will not work in this early version of the MC33816 Development
 Tool.");
```

In the example above the message, "this demo ..." appears if run on a MC33816 Development Tool version earlier than version 3.50, build B. We recommend this script command be placed first in the script file so that it gets processed before any parse errors or unsupported command errors can occur.

### 8.6.8 Trace Script Commands

```
print_to_trace(Message)
```

This command prints the string 'Message' to the Trace Window assuming that the last executed channel at the time the script was executed is enabled in the [Trace Options ... dialog box](#) (or to a current trace stream if so configured).

```
start_trace_stream_ex("FileName.Trace", enum TRACE_EVENT_OPTIONS,
 enum TRACE_FILE_OPTIONS, enum BASE_TIME,
```

## 8. Script Commands Files

---

```
U32 numTrailingDigits, int isZeroTraceTime);

start_trace_stream_ex("FileName.Trace", enum TRACE_EVENT_OPTIONS,
enum TRACE_FILE_OPTIONS, enum BASE_TIME,
U32 numTrailingDigits, int isZeroTraceTime);
```

These commands saves the target's trace buffer to file FileName.trace with the options set by [TRACE\\_EVENT\\_OPTIONS](#)., [TRACE\\_FILE\\_OPTION](#), [BASE\\_TIME\\_OPTIONS](#), and numTrailingDigits.

The numTrailingDigits field defines the number of digits to display after the decimal point. For example, if you specify numTrailingDigits to be 2 and the time options to use micro-seconds then the representation of 1.333 microseconds is '1.33'.

The 'isZeroTraceTime' parameter specifies if the time reference used by the tracing capability gets referenced to the time when the 'start\_trace\_stream' script command is executed. For instance, if the start\_trace\_stream were to be issued at time 100 microseconds and 22 microseconds an 'Pin Transition' occurred, then the time of the 'Pin Transition' event time would be listed at 122 microseconds if 'isZeroTraceTime' is a '0.' Conversely, if 'isZeroTraceTime' is a '1' the time would be listed as 22 microseconds.

Note that the start\_trace\_stream\_ex() and the start\_trace\_stream() script commands take identical parameters. The difference between the two command is that start\_trace\_stream\_ex() allows OPCODE\_FETCH to be disabled while MEM\_READ is enabled. In the legacy start\_trace\_stream() if MEM\_READ is enabled then the OPCODE\_FETCH is also enabled.

Note that this command has been improved starting with Version 4.8. The enabled events specified by the script command all get logged to the trace file, even if not enabled in the GUI. Any and all events specified in the script command get sent to the trace log file. Previously, when saving in 'VIEWABLE' mode, any and all events in displayed in the trace window were sent to the log file, and the parameters passed in the script file were ignored. This VIEWABLE mode behavior of previous versions was, well, goofy. And the limitation of not being able to continuously log events to the trace file if those events were not enabled in the GUI was beyond goofy ... it was flat out weak.

```
end_trace_stream();
```

This command stops tracing to a stream and closes the file so that it can be opened by a text viewer that requires write permission on the file.

```
at_time(400);
start_trace_stream("Stream.Trace", ALL-DIVIDER - MEM_READ,
PARSEABLE, US, 3, 1);
```

```

print_to_trace("*****\n"
 "***** START OF TEST \n"
 "*****\n");
wait_time(1500);
end_trace_stream();

```

The above example begins streaming all trace data except dividers and memory reads to a trace file named "Stream.Trace". Time is recorded in micro-seconds with three trailing digits following the period such that the least significant digit represents nano-seconds. The isResetTime field is set to "true" so that script execution time of 400 micro-seconds is subtracted from the time and the clocks field.

Formatted symbolic information can be generated using as described in the ["String within a String"](#) section. The following is an example of this format.

```

print_to_trace("\nTEST RESULTS:\n"
 " A=%d\n"
 " B=%d\n"
 " C=%d\n", A, B, C);

```

In the above example, variables A, B, and C must be in scope at the time the script command is executed.

However, it is possible to print eTPU Channel Variables using the '@<ChanNum>' syntax as shown below.

The print\_to\_trace command supports using \_\_FILE\_\_ and/or \_\_LINE\_\_ as arguments that get replaced by the name (and absolute path) of the file in which it is found, or the file line number of the text.

```

print_to_trace("\n%s(%d) : TEST COMPLETE\n", __FILE__,
 __LINE__); // outputs "<filename>(<linenum>) : TEST
COMPLETE"

```

### Save Trace Buffer Script Command (DEPRECATED!)

```

save_trace_buffer("FileName.trace", enum TRACE_EVENT_OPTIONS,
 enum TRACE_FILE_OPTION, enum BASE_TIME,
 U32 numTrailingDigits);

```

WARNING: this save\_trace\_buffer() script command is deprecated.

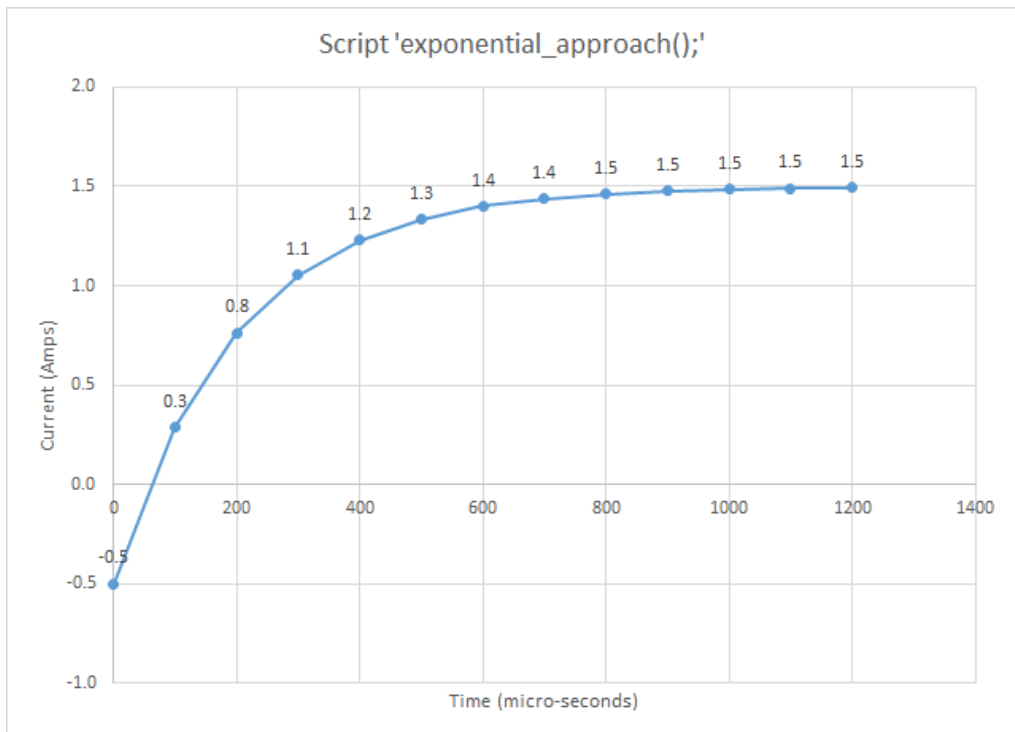
WARNING: This command won't work if the '-NoEnvFile' is used as part of a command line because the default behavior is for traces to NOT be saved to a trace buffer.

### 8.6.9 Math Script Commands

#### Exponential Approach

Say an R/L circuit starts at -0.5 amps and exponentially approaches 1.5 amps. How long does it take to cross 1.4 amps? This script command calculates the amount of time for this threshold to be reached.

```
#define INDUCTOR_MICRO_HENRIES 2000.0
#define LOAD_OHMS 10.0
F64 time_constant_us = INDUCTOR_MICRO_HENRIES / LOAD_OHMS;
F64 start_amps = -0.500;
F64 threshold_amps = 1.3;
F64 terminal_amps = 1.5;
F64 crossover_time_us;
// The crossover time gets set to 460 micro-seconds.
crossover_time_us = exponential_approach(start_amps,
threshold_amps, terminal_amps, time_constant_us);
```





## Natural Log

```
F64 result;
result = natural_log(val);
```

This command returns the natural log of number 'Val'.

```
// Calculate the (negative) number of time constants
// for a 90% decay. Note: returns -2.3.
F64 neg_time_constants;
neg_time_constants = natural_log(0.1);
```

### 8.6.10 Simulation Configuration

```
enable_target_interrupts(InterruptSourceTarget)
```

This command enables cross-target interrupts in a multi-target environment that support such behavior. By default such interrupts are disabled from invoking interrupt handlers in the destination target, but do signal via interrupt registers. In a System DevTool simulation, this is intended to allow eTPU interrupts (channel and global exception) to activate interrupt handlers in the simulated Host target.

```
enable_target_interrupts("eTPU_A"); // enable ISRs from
eTPU_A (run in Host script environment)
```

For eTPU targets, by default interrupts are mapped to the Host vector table as follows:

eTPU-A : channel interrupts 0-31, global exception 32

eTPU-B : channel interrupts 64-95, global exception 96

eTPU-C : channel interrupts 128-159, global exception 160

Note: this script command is currently only available on the Host target.

### 8.7 Automatic and Pre-Defined Define Directives

#### ASH WARE Specific Script

It is often desirable to conditionally parse (or not parse) portions of a script command file depending on whether or not it is in the ASH WARE development environment. The following #define is automatically prepended when parsing any script file, and therefore can be used to control the aforementioned conditional parsing.

```
#define _ASH_WARE_SCRIPT_ 1
```

This #define is prepended prior to parsing every script file.

```
#ifndef _ASH_WARE_SCRIPT_
void RunEngineDemo()
{
#endif
```

The code above causes the function declaration to be ignored by the ASH WARE parser.

#### Tool-Specific Scripts

With the introduction of the new Development Tool in some cases it may be helpful to have tool-specific behavior. This is achieved using the 'Development Tool' define as follows.

```
#define _ASH_WARE_DEV_TOOL_ 1
```

This #define is prepended prior to parsing every script file in the 'Development Tool' but NOT in the legacy 'Mtdt' tool.

When running as a hardware debugger (rather than a simulator) the following define allows differentiation between the simulator and debugger.

```
#define _ASH_WARE_DEV_TOOL_ 1
```

The following is an example usage of simulator/debugger specific scripting.

```
#ifdef _ASH_WARE_HARDWARE_DEBUGGER_
// These scripts will execute if it is a debugger
verify_spi_data16(_AW816DA_IMM_StartPins_, 0x08);
verify_spi_data16(_AW816DA_IMM_StartPins45_, 0x00);
#else
// These scripts will execute if it is a simulator
verify_spi_data16(_AW816DA_IMM_StartPins_, 0x00);
verify_spi_data16(_AW816DA_IMM_StartPins45_, 0x01);
#endif
```

#### Target-Specific Scripts

It is often desirable to have a single script commands file run on multiple targets. In this case target-dependent behavior is accomplished using the target define. The target define is generated using the target name as follows.

```
#define _ASH_WARE_<TargetName>_ 1
```

TargetName is defined in the build batch file and is found in a pull-down menu in the upper right hand side of the MC33816 Development Tool.

```
#ifdef _ASH_WARE_DBG32_
set_crystal_frequency(32768);
#endif // _ASH_WARE_DBG32_
```

Note the the target name as embedded in the macro name always has all letters capitalized. In this example the set\_crystal\_frequency(); script command executes only if the script command is running under a target named DBG32.

The build define is also injected as a macro into the script environment.

```
#define <BuildDefine> 1
```

A script file shared among projects testing on different targets can then have target-specific sections:

```
#ifdef SIM_CHANNEL_1_CORE_1
// do Channel 1, Core 1 stuff
#elif defined(SIM_CHANNEL_2_CORE_0)
// do Channel 2, Core 0 stuff
#endif
```

## Determining the Auto-Run Mode

The MC33816 Development Tool is often launched as part of an [automated test suite](#). Under these conditions the test starts running and executes to completion (assuming no failures) with no user intervention. The following is automatically defined when the MC33816 Development Tool is launched in auto-run mode.

```
_ASH_WARE_AUTO_RUN_
```

The following is typically found at the end of a script file used as part of an automated test suite.

```
#ifdef _ASH_WARE_AUTO_RUN_
exit();
#else
print("All tests are done!!");
#endif // _ASH_WARE_AUTO_RUN_
```

## Passing Defines from the Command Line

## 8. Script Commands Files

---

When launching the MC33816 Development Tool it is often useful to pass #define directives to the primary script commands file from the command line. This is explained in detail in the [Regression Testing](#) section.

The following command line is found in the batch files used as part of the automated testing of the MC33816 simulator. It is a 'negative' test in that the expected test result is a failure.

```
echo Running Injector 'Force a Failure' Test
set DEVTOOL="c:\Program Files (x86)\ASH WARE\MC33816 DevTool IDE V1_01A\Mc33816DevTool.exe"
%DEVTOOL% -p=InjectorTest.Spd816IdeProj -dFORCE_FAIL
if %ERRORLEVEL% EQU 0 (goto errors)
```

### 8.8 Listing of Script Enumerated Data Types

This section describes the pre-defined enumerated types used by various script commands.

#### 8.8.1 Script FILE\_TYPE Enumerated Data Type

The following enumerated data type is used to specify the file type used in various script commands. This specifies a dis-assembly, S Record, Intel Hexadecimal, or C data structure file type.

```
enum FILE_TYPE {DIS_ASM, SRECORD, IHEX, IMAGE, C_STRUCT, }
```

#### 8.8.2 Script VERIFY\_FILES Enumerated Data Type

The following enumerated data type is used to specify the expected results of a file comparison.

```
enum VERIFY_FILES_RESULT {
 FILES_MATCH, FILES_MISMATCH,
 FILE1_MISSING, FILE2_MISSING, BOTH_FILES_MISSING
}
```

#### 8.8.3 Script FILE\_OPTIONS Enumerated Data Type

The following enumerated data type is used to specify the options when dumping data to a file. The available options depend on the type of file being dumped.

```
enum DUMP_FILE_OPTIONS {
```

```
// Disables listing of address information in dis-assembly
// and "C" data structure files:
NO_ADDR,

// Disables listing of hexadecimal dump, addressing mode,
// and symbol data
// in dis-assembly files:
NO_HEX, NO_ADDR_MODE, NO_SYMBOLS,

// Adds a #pragma format "val" to each dis-assembly line
// This is helpful for non-deterministic assembly languages
// to cause the assembler to generate a deterministic opcode
YES_PRAGMA,

// Adds a blank line between assembly lines
// Handy for finding opcode boundaries in parallel instr sets
// such as eTPU where a single opcode's dis-assembly
// can span multiple lines.
YES_BLANK_LINES,

// Selects the endian ordering for image
// and "C" data structure files:
ENDIAN_MSB_LSB, ENDIAN_LSB_MSB,

// Selects data size in image and "C" data structure files:
DATA8, DATA16, DATA32,

// Selects decimal data instead of hexadecimal
// for "C" data structure files:
OUT_DEC,

// Append to file if it already exists
// (default is to overwrite any existing file)
// Available only for CStruct and Image files
FILE_APPEND,

// Specifies default options:
DUMP_FILE_DEFAULT,
};
```

### 8.8.4 Trace Options Enumerated Data Types

The following enumerated data type is used to specify the event options when saving a trace buffer to a file.

```
enum TRACE_EVENT_OPTIONS {
 // All targets
 STEP, EXCEPTION, OPCODE_FETCH, MEM_READ, MEM_WRITE,
 DIVIDER, PRINT, ERROR,

 // MC33816 Only
 MC33816_TERMINAL_COUNTER, MC33816_WAIT,
 MC33816_PINS, MC33816_LS_HS_GATE_DRIVE,
 MC33816_CURRENT_FEEDBACK, MC33816_FLAGS,

 // All options
 ALL,
}
```

Note the 'OPCODE\_FETCH' option has been added to the MC33816 Development Tool in version 2.3 and can be used with the `start_trace_stream_ex()` script command. It was added because it is generally desired to see memory reads, while opcode fetches are generally not desired and are so numerous as to get in the way. Note that when using the `start_trace_stream()` script command, the OPCODE\_FETCH is also enabled by MEM\_READ.

The following enumerated data type is used to specify the file format options when saving a trace buffer to a file.

```
enum TRACE_FILE_OPTIONS {
 VIEWABLE, // This format is optimized for viewing
 PARSEABLE, // This format is optimized for parsing
}
```

### 8.8.5 Code Coverage Listing Options Enumerated Data Type

The following enumerated data type is used to specify the listing file options when writing a code coverage annotated listing file (`write_coverage_listing_file()` script command).

```
enum COVERAGE_LISTING_OPTIONS {
 // listing file modes
 ALL_LINES, // output all source module lines and
 disassembly
}
```

```
NON_COVERED_ONLY_LINES, // output only non-fully-covered
source module lines
// flag items below can be added to alter main modes above
};
```

### 8.8.6 Base Time Options Enumerated Data Type

The following enumerated data type is used to specify the base time for various script commands.

```
enum BASE_TIME { US, NS, PS, }
```

### 8.8.7 Build Script TARGET\_TYPE Enumerated Data Type

The following enumerated data type is used to specify the target type. No mathematical manipulation of this data type is valid.

```
enum TARGET_TYPE {
SIM33816,
};
```

### 8.8.8 Build Script TARGET\_SUB\_TYPE Enumerated Data Type

The following enumerated data type is used to specify the target's sub type. No mathematical manipulation of this data type is valid.

```
enum TARGET_SUB_TYPE {

// MC33816 Simulator
CHAN_1_CORE_0,
CHAN_1_CORE_1,
CHAN_2_CORE_0,
CHAN_2_CORE_1,
};
```

### 8.8.9 Build Script ADDR\_SPACE Enumerated Data Type

This enumerated data type is used when specifying the applicable address spaces for various build script commands. It is also used in the generic modify\_mem\_uXX() and verify\_mem\_uXX() script commands.

```
enum ADDR_SPACE {
```

## 8. Script Commands Files

---

```
// MC33816
MC33816_CODE_SPACE, MC33816_DATA_SPACE, MC33816_PINS_SPACE,
// Covers the entire space, registers, both rams, etc.
MC33816_SPI_SPACE,
MC33816_UNUSED_SPACE,

//
ALL_SPACES,
};
```

In the following very specific cases, mathematical manipulation of this enumerated data type is allowed.

- Single instances of values referencing the same target may be added to each other.
- Single instances of values referencing the same target may be subtracted from ALL\_SPACES.

The following are some valid mathematical manipulations of this data type.

```
// The following references
// a CPU32's USER and SUPERVISOR code spaces
CPU32_USER_CODE_SPACE + CPU32_SUPV_CODE_SPACE
// The following references
// all used CPU32 address spaces
ALL_SPACES - CPU32_UNUSED_SPACE
```

The following are some invalid valid mathematical manipulations of this data type.

```
// !!INVALID!! Target types (GTM and MC33816) cannot be
intermixed
GTM_RAM_SPACE + MC33816_DATA_SPACE
// !!INVALID!!
// The same value cannot be added or subtracted to itself
ETPU_DATA_SPACE + ETPU_DATA_SPACE
```

### 8.8.10 Build Script READ\_WRITE Enumerated Data Type

This enumerated data type is used when specifying the applicable read and/or write cycles for various build script commands.

```
enum READ_WRITE {
RW_READ8, RW_READ16, RW_READ24,
RW_READ32, RW_READ64, RW_READ128
RW_WRITE8, RW_WRITE16, RW_WRITE24,
```



```
RW_WRITE32, RW_WRITE64, RW_WRITE128,
RW_ALL,
};
```

Some mathematical manipulations are allowed. Single instances of all but the RW\_ALL values can be added together and single instances of each value may be subtracted from RW\_ALL.

```
#define SOME_READS RW_READ8 + RW_READ16 + RW_READ32
#define NON_ACCESS32S RW_ALL - RW_WRITE32 - RW_READ32
```

In this example, ALL\_READS is defined as any read access, be it an 8-, 16-, or a 32-bit read cycle. NON\_ACCESS32S is defined as all 8-, 16-, 24-, 64-, and 128-bit read and write cycles.

### 8.8.11 Assignment Operation Enumerated Data Type

This enumerated data type is used in the modify\_mem\_uXX() script commands.

```
enum ASSIGNMENT_TYPE {
 ASSIGN_EQUAL, // =
 AND_EQUAL, // &=
 OR_EQUAL, // |=
 XOR_EQUAL, // ^=
 BSL_EQUAL, // <<=
 BSR_EQUAL, // >>=
 PLUS_EQUAL, // +=
 MINUS_EQUAL, // -=
 TIMES_EQUAL, // *=
 DIVIDE_EQUAL, // /=
 REMAINDER_EQUAL, // %=
};
```

### 8.8.12 Pin and Node Enumerated Type

This enumerated type is used to specify external pins and various simulation nodes.

```
enum PIN_AND_NODE {

 // MC33816 'Flag' input pins
 FLAG0, FLAG1, FLAG2,

 // MC33816 'Start' input pins
```

## 8. Script Commands Files

---

```
START1, START2, START3, START4, START5, START6,

// MC33816 MCU Interrupt pin
// NOTE: the MC33816 interrupts the host CPU using this pin
IRQB,

// MC33816 The 'Output Analog' pins
OA_1, OA_2,

// MC33816 The 'DBG' pin
DBG,

// MC33816 Driver Enable input pin
DRVEN,

// MC33816 The 'RESETB' pin
RESETB,

// MC33816 Low Side Driver Gate Sense Pins
G_LS1, G_LS2, G_LS3, G_LS4, G_LS5, G_LS6, G_LS7,

// MC33816 High Side Driver Gate Pins
G_HS1, G_HS2, G_HS3, G_HS4, G_HS5,

// MC33816 Current Sense Pins
// NOTE: The current sense pins are assumed to be
// connected in pairs. For example, VSENSEp1 and VSENSEN1
// are specified with VSENSEN1
VSENSE1, VSENSE2, VSENSE3, VSENSE4,

// MC33816 Voltage source nodes for the Battery
// and the Vboost voltage.
VBATT, VBOOST,

};
```

### 8.8.13 MC33816 Reset Source Enumerated Type

This enumerated type is used to specify (set) an MC33816 reset source.

```
enum RESET_SOURCE
{
 SPI_RESET,
```

```
 POWER_ON_RESET,
 PIN_RESET,
 };
```

### 8.8.14 MC33816 Register Enumerated Data Types

The MC33816 register enumerated data types provide the mechanism for referencing the MC33816 registers. These enumerated data types are used in commands that reference the MC33816 registers such as the register write commands that are defined in the [Write Register Script Commands](#) section.

The following enumeration provides the mechanism for referencing the MC33816's registers.

```
enum REGISTERS_U16 {
 REG_PC, REG_IR, REG_MH, REG_ML,
 REG_RO, REG_R1, REG_R2, REG_R3, REG_R4,
};
```

The following are examples of how the enumerated register types are used.

```
write_reg16(0x1234, REG_IR);
verify_reg16(REG_IR, 0x1234);
```

### 8.8.15 Script CSV\_CONTROL Enumeated Data Type

This is used in the CSV import script commands to control how the file is read and processed.

```
enum SCRIPT_CSV_CONTROL { CSV_IGNORE_FIRST_LINE,
 CSV_READ_FIRST_LINE, }
```



# 9

## Test Vector Files

### Overview

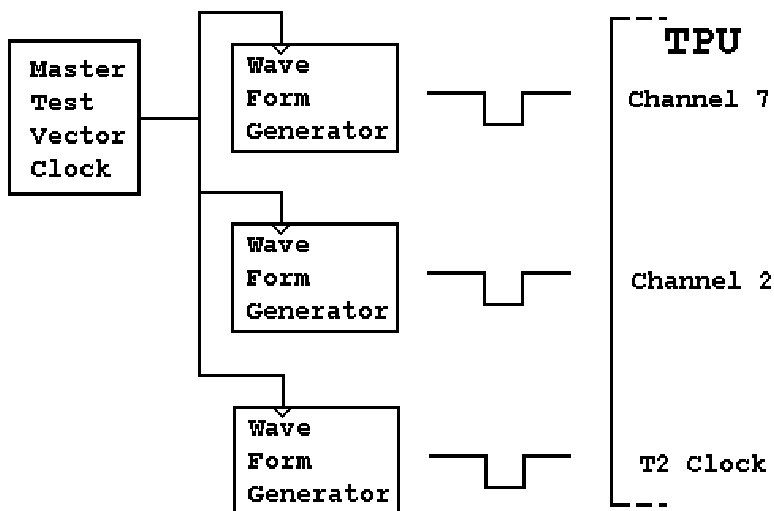
Test vector provides a complex test vector generation capability. Simulated signals similar to those found in a typical environment can be generated. Test vector files are used for forcing of "high" or "low" states at the device's input or I/O pins.

It is helpful to compare test vector files to script commands files. Roughly, test vector files represent the external interface to the device, while script commands files represent the CPU (or host MCU) interface. Test vector files are treated quite differently from script commands files. While script commands file lines are executed sequentially and at specific simulated times, test vector files are loaded all at once. Test vector files are used solely to generate complex test vectors on particular MC33816 Development Tool nodes. As the MC33816 Development Tool executes, these test vectors are driven unto the specified nodes.

### Loading and Editing the Test Vector File

Test vector files are opened (and created ... if appropriate) by double clicking on the 'Vector' node in the project window. Once created, the test vector file will always be reloaded prior to beginning or restarting execution.

### Test Vector Generation Functional Model



The test vector generation model consists of a single master test vector clock and a number of wave form generators. The same master test vector clock clocks all wave form generators. The wave form generators cannot produce waveforms whose frequencies exceed that of the master test vector clock.

A wave form might consist of a loop in which a node is driven high for 10 master test vector clock periods then low for 15. The loop could be set up to run forever.

Test vector files provide the following functionality.

- The master test vector clock frequency is specified.
- The wave form generators are created and defined.
- Wave form outputs drive device input pins (nodes).
- Multiple nodes are grouped (i.e., group COMM consists of UART\_RCV1 and UART\_RCV2).
- Complex Boolean states are defined.

Before being parsed, test vector files are run through a C Preprocessor. Thus the files can use the #include mechanism as well as macros and other preprocessor directives and capabilities.

# Command Reference

The following test vector commands are available.

- [Node](#)
- [Group](#)
- [State](#)
- [Frequency](#)
- [Wave](#)

In addition there is an [eMC33816 example of the waveforms generated for an Direct Injection system](#).

## Comments

Test vector files may contain the object-oriented, C++ style double slash comments. A comment field is started with two sequential slash characters, //. All text starting from the slashes and continuing to the end of the line is interpreted as comment. The following is an example of a comment.

```
// This is a comment.
```

## 9.1 Node Command

```
node <Name> <Node>
```

The node commands assign the user defined name, "Name" to a node, "Node". Note that depending on the microcontroller, the input and output from each channel may (or may not) be brought to external pins. Please refer to the NXP literature for the specific microcontroller being used.

### Standard MC33816 Nodes

- |   |        |                  |
|---|--------|------------------|
| - | START1 | The 'START1' pin |
| - | START2 | The 'START2' pin |
| - | START3 | The 'START3' pin |
| - | START4 | The 'START4' pin |
| - | START5 | The 'START5' pin |
| - | START6 | The 'START6' pin |
| - | FLAG0  | The 'FLAG0' pin  |
| - | FLAG1  | The 'FLAG1' pin  |
| - | FLAG2  | The 'FLAG2' pin  |

## 9. Test Vector Files

---

In the example shown below the name 'Injector3Start' is assigned to the MC33816's 'START3' pin.

```
define START3 Injector3Start
```

### 9.2 Group Command

```
group <GROUP_NAME> <NODE 1> [NODE 2] ... [NODE N]
```

The group command assigns multiple nodes, "NODE N" to a group name GROUP\_NAME. These nodes can be referred to later by this group name. The group name may contain any ASCII printable text. These group names are case sensitive (though this is currently not enforced.) Up to 30 nodes may be grouped.

```
// Create a multiple-node groups
group DrivePinGroup start1 start2 start3 start4
```

In this example a group with the name DrivePinGroup is associated with MC33816 pins channel pins start1 start2 start3, and start4.

### 9.3 State Command

```
state <STATE_NAME> <BIT_VALUE>
```

The state command assigns a bit value BIT\_VALUE to a user-defined state name STATE\_NAME. State names may contain any ASCII printable text. These state names are case sensitive (though this is currently not enforced.) Bit values must consist of a sequence zeros and ones. The total number of zeros and ones must be between one and 30.

```
state NULL 0110
```

In this example a user-defined state NULL is associated with the bit pattern 0110.

### 9.4 Frequency Command

```
frequency <FREQUENCY>
```

The frequency command sets the master test vector clock to FREQUENCY which is a floating point number whose terms are million cycles per second (MHz). All test vectors are set by this frequency. Since the entire test vector file is loaded at once, if a test vector





### 9.6 Direct Injection Example, MC33816

```
//
// File Example.vector, copyright ASH WARE, Inc. 2013-2017
//

// These nodes will be driven by a WAVE command
node start1 START1
node start2 START2
node start3 START3
node start4 START4

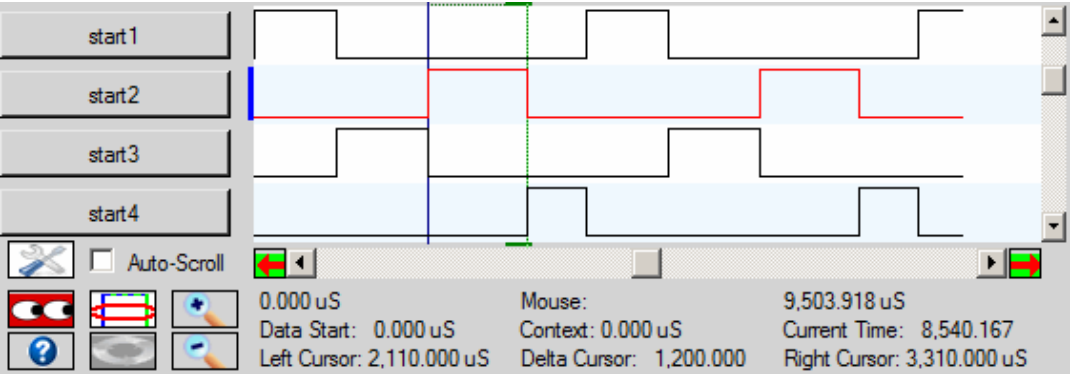
// Create a multiple-node groups
group DrivePinGroup start1 start2 start3 start4

// Create some states
state all_off 0000
state one_on 1000
state three_on 0010
state two_on 0100
state four_on 0001

// Set the test vector step to 1 GHz
// (This is a 1 uS time-step)
frequency 1

// Drive a complex input waveform on to these input pins.
// embedded loops (loops within loops)
// and multiple 'wave' commands are possible
wave DrivePinGroup all_off 10
(
 one_on 1000
 // Just make the last three short,
 // Not actually using them yet, ...
 three_on 1100
 two_on 1200
 four_on 700
) *
end
```

The above example produces the waveform shown below.





# 10

## Functional Verification

Functional verification supports an automated method for verifying that behavioral requirements are met by the code. These capabilities can be grouped as [data flow verification](#) and [code coverage verification](#).

Data flows between the MC33816 and the Host-MCU via interface registers. Data flow verification provides the capability of verifying this data flow.

Pin transitions are generated by the MC33816 or by external hardware. Pin transition verification capabilities allow the user to verify this pin transition behavior.

Code coverage provides the capability to determine the thoroughness of a test suite. Code coverage verification allows the user to verify that a test suite thoroughly exercises the code.

### A Full Life-Cycle Verification Perspective

The following describes a typical software life-cycle. Initially, a set of requirements is established. Then the code is designed to meet these requirements. Following design, the code is written and debugged. A set of formal tests is then developed to verify that the software meets the requirements. The software is then released.

## 10. Functional Verification

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Now the software enters a maintenance stage. In the maintenance stage, changes must be made to support new features and perhaps to fix bugs. Along with this, the formal tests must be modified and rerun. Then the software must be re-released.

This life-cycle can be described as having three stages: development, verification, and maintenance. All of these three stages are supported. The IDE and GUI are primarily of interest in the initial development phase. Verification involves developing a set of repeatable and automated tests that show that the requirements are being met. In the maintenance stage these previously-developed automated tests are rerun to prove that requirements are still being met when bug fixes and enhancements cause the code base to change.

There is a significant emphasis on automation such that a complete test suite can be run, sometimes spanning hours, and a series of tests results in a single 'pass' or 'fail' result.

### 10.1 Data Flow Verification

Data flow verification is one of the verification capabilities for which an overview is given in the [Functional Verification](#) chapter.

Data flows between the MC33816 and the Host-MCU primarily across the SPI bus to/from either the global registers or the data RAM

In the following example data flow across the SPI bus to the data RAM is verified. A RAM location corresponding to a variable named 'Signature' is initialized to the value '0xBAD'. The simulation runs for 5 micro-seconds. The data RAM location of variable 'Signature' is then verified to contain the value 0xA538.

```
write_spi_data16(_AW816DA_signature_, 0xBAD);
at_time(5);
verify_spi_data16(_AW816DBA_bank_csignature_, 0xA538);
```

### 10.2 Pin Transition Verification Example

The following is an example eTPU Commands Script that both generates, and verifies pin transition data. The #define '\_CREATE\_EBV\_FILE\_' determines if the .EBV file will be generated (create the gold file) or tested (test the current run against a previously-generated gold file).

```
// Linker-generated header file
#include "MyCode_defines.h"
```

```

#define TEST_CHAN 4

// Set the clock to 100 MHz (10 ns/clock -->1e7
FemtoSeconds/clock)
set_clk_period(10000000);
write_entry_table_base_addr(_ENTRY_TABLE_BASE_ADDR_);
write_tcr1_control(2); // System clock/2, NOT gated
by TCRCLK
write_tcr1_prescaler(1);
write_global_time_base_enable(1);

// Channel Configuration Registers Functions (CxCR, CxSCR,
CxHSRR)
write_chan_base_addr(TEST_CHAN, 0x300);
write_chan_func(TEST_CHAN, _FUNCTION_NUM_Pwm_);
write_chan_entry_condition(TEST_CHAN,
_ENTRY_TABLE_TYPE_Pwm_);

//

write_chan_cpr (TEST_CHAN, 3);
write_chan_hsrr (TEST_CHAN, 7);
write_chan_data24 (TEST_CHAN, _CPBA24_Pwm_Period_,
0x000400);
write_chan_data24 (TEST_CHAN, _CPBA24_Pwm_HighTime_,
0x000050);

//#define _CREATE_EBV_FILE_

#ifdef _CREATE_EBV_FILE_
create_ebehavior_file("MyGoldSim.ebv");
add_ebehavior_pin("PWM");
#else
run_ebehavior_file("MyGoldSim.ebv");
#endif // _CREATE_EBV_FILE_

//

// Run the simulator for awhile

```

```
// Compare recorded pin-transitions with known-good gold
file
wait_time(1000);

#ifdef _CREATE_EBV_FILE_
close_ebehavior_file();
#else
stop_ebehavior_file();
#endif // #ifdef _CREATE_EBV_FILE_

#ifdef _ASH_WARE_AUTO_RUN_
exit();
#else
print("All tests are done!!");
#endif // _ASH_WARE_AUTO_RUN_
```





### 10.3 Code Coverage Analysis

Code coverage analysis is one of the verification capabilities for which an overview is given in the [Functional Verification](#) chapter.



There are two aspects to code coverage. The first aspect is the code coverage visual interface while the second aspect is the coverage verification commands.

#### Code Coverage Visual Interface

The visual interface is enabled and disabled using the project's IDE Options settings. When this is enabled, black boxes appear as the first character of each source code line that is associated with a microinstruction. As the code executes, and the instruction coverage changes, these black boxes change to reflect the change in the coverage. This is summarized below.

-  A black box indicates a 'C' source line or assembly instruction that has not been executed.
-  An orange box indicates 'C' source line that has been partially executed.
-  A blue box indicates an assembly branch instruction in which neither branch path has been traversed.
-  A green box indicates an assembly branch instruction where the branch path has been traversed.



-  A red box indicates an assembly branch instruction where the non-branch path has been traversed.
-  A white box indicates a 'C' source line or assembly instruction that has been executed.

## Code Coverage Verification Commands

The code coverage verification commands, described in the [Code Coverage Script Commands](#) section provide the capability to verify both instruction and branch coverage percentages on both an individual file basis and a complete microcode build.

## Code Coverage Report Files

Code coverage report files can be generated using the `write_coverage_file("filename.Coverage")` script command described in the [Code Coverage Script Commands](#) section. Code coverage report files can also be generated directly from the File menu by selecting the Coverage submenu. This is described in the [Files Menu](#) section.

The top of the code coverage report file contains a title line, a copyright declaration line, and a time stamp line.

Following this generic information is a series of sections. The first section provides coverage data on the entire microcode build. Succeeding sections provide coverage information on each file used to create the microcode build.

Each section contains a number of lines that provide the following information. The instruction line lists the total number of instructions. Both regular and branch instructions are counted, but entry table information is not. The instruction hits line lists the number of instructions that have been fully covered. The instruction coverage percent line lists the percent of instructions that have been covered. The branches line lists the total number of branch paths. This is always an even number because for each branch instruction there are two possible paths (branch taken and branch not taken.) If the branch path has been traversed then this counts as a single branch hit. Conversely if the non-branch path has been traversed then this also counts as a single branch hit. The branch instruction is considered fully covered when both the branch-path and the non-branch-path have been traversed. The branch coverage percent line contains the percentage of branch paths that have been traversed.

Flushed instructions for which a NOP has been executed are not counted as having been covered.

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An example of such a file (eTPU target) follows.

```
// Code coverage analysis file.
// Copyright 1996 ASH WARE, Inc.
// Wed Feb 6 09:08:29 2019

Total
 Instructions: 43
 Instruction Hits: 14
 Instruction Coverage Percent: 32.56
 Branches: 18
 Branch Hits: 4
 Branch Coverage Percent: 22.22
 Entries: 32
 Entry Hits: 5
 Entry Coverage Percent: 15.63
C:\Mtdt\TestsHigh\ETpu\Coverage\Pwm.c
 Instructions: 14
 Instruction Hits: 14
 Instruction Coverage Percent: 100.00
 Branches: 4
 Branch Hits: 4
 Branch Coverage Percent: 100.00
 Entries: 32
 Entry Hits: 5
 Entry Coverage Percent: 15.63
C:\Mtdt\Gui\testfiles\Lib_global_error_handler.sta
 Instructions: 29
 Instruction Hits: 0
 Instruction Coverage Percent: 0.00
 Branches: 14
 Branch Hits: 0
 Branch Coverage Percent: 0.00
 Entries: 0
 Entry Hits: 0
 Entry Coverage Percent: 0.00
```

### Code Coverage Annotated Listing Files

Listing files (source file lines with the associated disassembled opcodes shown below each line that generates code) annotated with code coverage information can be generated with

the `write_coverage_listing_file()` script command described in the [Code Coverage Script Commands](#) section. An option parameter allows users to select between outputting a complete annotated listing file for a specified module, or output just the source lines and object code not executed (covered). In both cases every line is prepended with the original source line number. When the non-covered listing option is specified, a line gap is placed between annotated source/assembly wherever source code lines have been filtered. A small annotated sample is shown below.

```
[536]: else if (IsMatchAEvent() && (flag1==1) &&
(flag0==1))
[536]: [X]: 0016: 0x4250 Alt Entry 11, Addr 0x940, EnableMatches,
p_31_0=*((channel U32 *) 0x0), diob=*((channel U24 *) 0x5) [0]
[536]: : : HSR==0b000 Link==X matchA/TranB==1
matchB/TranA==0 InputPin==0 ChanFlag1==1 ChanFlag0==1 [2]
[536]: []: 001E: 0x4250 Alt Entry 15, Addr 0x940, EnableMatches,
p_31_0=*((channel U32 *) 0x0), diob=*((channel U24 *) 0x5) [0]
[536]: : : HSR==0b000 Link==X matchA/TranB==1
matchB/TranA==0 InputPin==1 ChanFlag1==1 ChanFlag0==1 [2]
[537]: {
[538]: // All 32 bits were received & half a gap has
been detected
[539]: // filtering (if any) is done now, while parity
check is done
[540]: // when the full gap is validated
[541]: AW_A429R_ValidHalfGapFilter:
[542]:
[543]: ClrFlag0();
[543]: [X]: 0940: 0xDFE87A8C ram p_23_0 = *((channel int24 *) 0x31);
FormatD6 [0]
[543]: : : 0xDFE87A8C chan clear ChannelFlag0, clear
MatchRecognitionLatchA;; FormatD6 [4]
[544]: ClearMatchAEvent();
[545]:
[546]: if (RxFilter.Label)
[546]: [X]: 0944: 0x0008F019 alu nil = p+0x0, SampleFlags;; FormatA2
[4]
[546]: [T]: 0948: 0xF0D84BC7 seq if z==true then goto addr_0x978,
flush;; FormatE1 [4]
[547]: {
[548]: unsigned int24 bitIndex;
[549]: unsigned int24 filterWord;
[550]: #ifdef __ETEC__
[551]: bitIndex = __bit_n_update(0,
Data.B.Bits23_0 & 15, 1, 0);
[551]: []: 094C: 0xBFEEFFB80 ram p_23_0 = *((channel int24 *) 0x1);;
FormatB2 [4]
[551]: []: 0950: 0x0C380BFA alu a = p & 0xF;; FormatA3 [4]
```

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```
[551]: []: 0954: 0x3F3F1FFD alu sr = ((u24) 0) | (1<<a);; FormatB6
[4]
```

After the prepended source code line number, each opcode line has coverage status shown inside brackets [], followed by code address, opcode (or entry point), and disassembly. The coverage status can be one of the following:

```
[] - not executed at all
[X] - fully executed (both paths taken if branch)
[T] - only branch true path executed
[F] - only branch false path executed
[I] - inferred entry point coverage
```

Note, if the non-covered listing option is specified, and the module has been fully executed, the result is an empty output file.

For eTPU targets, an additional flag option can be applied that causes entry table items to be ignored (no disassembly for "all" mode, all entry source and disassembly filtered for non-covered mode).

### 10.4 Regression Testing (Automation)

Regression Testing supports the ability to launch the MC33816 Development Tool from a DOS command line shell. Command line parameters allow specific tests to be run. From the command line the project file that is run and the primary script file(s) that are loaded into each target are specified. Command line parameters also are used to specify that the target system automatically start running with no user intervention, and to accept the license agreement thereby bypassing the dialog box that would otherwise open up and require user intervention. A script command is used to terminate the MC33816 Development Tool once all the tests have been run.

Upon termination, the MC33816 Development Tool sets the error level to zero if no verification tests failed, and otherwise error level is set to be non zero. This error level is the MC33816 Development Tool's termination code and can be queried within a batch file running under the operating system's DOS shell. By launching the MC33816 Development Tool multiple times, each time with a different set of tests specified, and by checking the error level each time the MC33816 Development Tool terminates, multiple tests can be run automatically and a single pass (meaning all tests passed) or fail (meaning one or more tests failed) result can be determined.

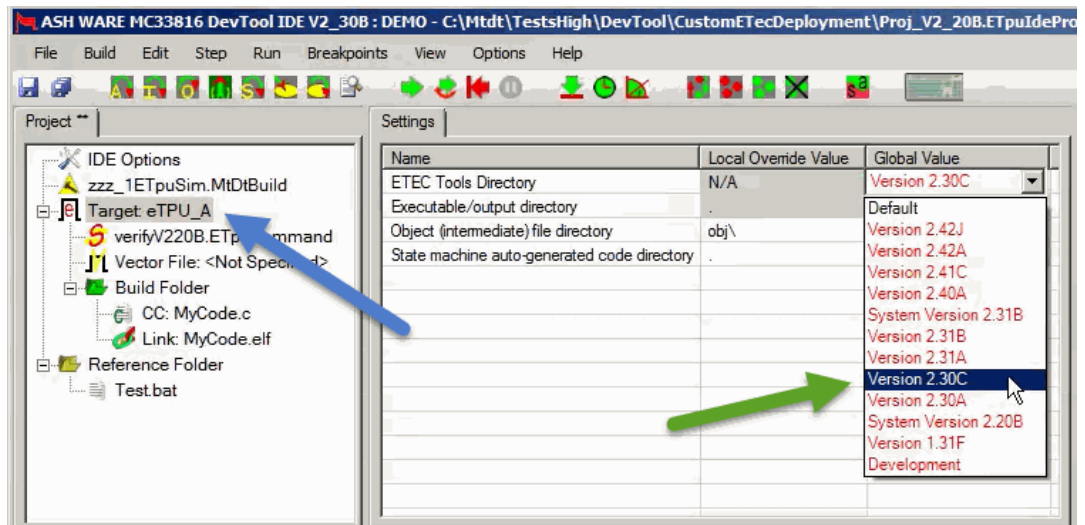
Note that this only works in operating systems that support access to exit codes from a batch file. **Windows 98 does not support this.** True operating systems such as Windows 7,

Windows XP Professional, Windows 2000 Professional, and Windows NT 4.0. do support automation.

## 10.5 Testing with a Specific Compiler Version

A production software release will generally be tied to a specific ETEC Compiler version. However as ASH WARE continues to release new software versions, the once-default (latest installed) software version will at some point longer be the default. It is therefore important to be able to tie regression tests to a specific ETEC compiler version. This is done by selecting the build target as show by the blue arrow, below. Right-click to bring up the popup menu and select 'settings' to bring up the settings window shown below. Within the settings window, select the version of the compiler you wish to tie the tests to. The green arrow shows the tests being tied to ETEC compiler version 230C. Note that if the tests were to be run on a compiler that does not have version 2.30C installed, then the tests would fail. This setting is stored in the project file and not the environment file!

Also, see related section '[Using Non-Installed ETEC Versions](#)'.



## 10.6 Command Line Options

When launching the MC33816 Development Tool the last-loaded project file is automatically loaded and the project file contains most of the settings such as the name of the script file to load, which messages to suppress, etc. However, it can be useful to specify the project file to load or even to override settings contained in the project file. This is by specifying settings at the command line when launching the MC33816 Development Tool. This is especially useful when building regression tests.

| Setting                                                                                                                                                                                                                                                                                                                                                              | Option               | Example                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------------------------------------------------------------|
| Display Help<br>Prints a list of all the Command Line Parameters                                                                                                                                                                                                                                                                                                     | -h                   | -h                                                               |
| Project File<br>Loads the specified project file. Note that if a relative path is used to specify the project file, it is relative to the current working directory at app launch. Also note that all other relative paths is command line options are relative to the project file directory, NOT the current working directory (although they are often the same). | -p=<ProjectFileName> | -p=Test.Spd816IdeProj<br>Loads project file "Test.Spd816IdeProj" |
| Executable Image File<br>Loads the specified executable image file (e.g., MyCode.elf)                                                                                                                                                                                                                                                                                | -exe=<ExeImageFile>  | -exe=<MyCode.elf><br>Loads "MyCode.elf"                          |
| Script File                                                                                                                                                                                                                                                                                                                                                          | -s=<ScriptFileName>  | -s=RarChunkTest.Cmd                                              |

| Setting                                                                                                                                                          | Option                             | Example                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Loads the specified script file (single target). Path relative to project file directory.                                                                        |                                    | Loads script file "RarChunkTest.Cmd"                                                                                              |
| Script File<br>Loads the specified script file into the specified target (multiple targets). Path relative to project file directory.                            | -s=<ScriptFileName>@<TargetName>   | -s=MyScript.Cmd@ @Cpu32<br>Loads script "MyScript.Cmd" into the CPU32 simulation model named "Cpu32"                              |
| Vector File<br>Loads the specified vector file (single target) path relative to project file directory.                                                          | -v=<VectorFileName>                | -v=MyVector.vector                                                                                                                |
| Vector File<br>Loads the specified vector file into the specified target (multiple targets). Path relative to project file directory.                            | -v=<VectorFileName>@ @<TargetName> | -v=MyVector.vector@ @Ch1_Core0                                                                                                    |
| Vector Define<br>In vector file, define the DefinedText as Val. Note that the '=<Val>' portion can be omitted and 'VAL' will be assigned a default value of '1'. | -vd=<DefinedText>=<Val>            | -vd=CONTROL_CASE<br>Passes the #define CONTROL_CASE 1 to the vector file<br><br>-vd=CMD_LINE_DEFINE_A=01 -vd=CMD_LINE_DEFINE_B=10 |

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| Setting                                                                                                                                                                            | Option              | Example                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|-------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                    |                     | Passes two defines with values '01' and '10' on the command line.                                           |
| Define as true<br>In script commands file,<br>#define DefinedText 1                                                                                                                | -d=<DefinedText>    | -d=CODE_BASELINE<br>Passes the #define CODE_BASELINE 1 to the script file                                   |
| Define as value<br>In script commands file,<br>#define DefTxt Val                                                                                                                  | -d=<DefTxt>=<Val>   | -d=MY_VAR=55<br>Passes the #define MY_VAR 55 to the script file                                             |
| Build Define<br>In MtDt build script, define the DefinedText as true                                                                                                               | -bd=<DefinedText>   | -bd=MPC5674_2<br>Defines MPC5674 as 'true' in the build define such that the MPC5674 rev 2 model is loaded. |
| Log File<br>Logs messages to end of file, "FileName.log". Path relative to project file directory.                                                                                 | -lf5=<FileName.log> | -lf5=Error.log<br>Logs messages to file "Error.log"                                                         |
| Log File Test Suite Mode<br>Outputs formatted messages and extra verification information into the log file, when specified. Useful when using the tool for verification purposes. | -lfmTestSuite       | -lfmTestSuite<br>Sets logging to test suite mode (only applies if logging enabled via -lf5).                |



| Setting                                                                                                                                                                                                                                          | Option               | Example                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------------------------------------------------------------------------------------------------|
| <b>Test Name</b><br>Used in conjunction with the log file to append a test result to the end of the log file.                                                                                                                                    | -tn=<TestName>       | "-tn=Pulse Width Test"<br>Appends 'Pulse Width Test Passes' (or 'fails') to the end of the log file. |
| <b>Suppress Warning #1</b><br>Suppress the "Source Code Missing" warning                                                                                                                                                                         | -ws=1                | -ws=1                                                                                                |
| <b>No Popup Dialogs</b><br>Disables display of dialog boxes                                                                                                                                                                                      | -q                   | -q                                                                                                   |
| <b>Build Log File</b><br>Logs Auto Build output to the file, "FileName.log". Path relative to project file directory. Can only be used in conjunction with the -AutoBuild option.                                                                | -blf5=<FileName.log> | -blf5=Build.log<br>Logs build output to file "Build.log"                                             |
| <b>Suppress Environment File Load</b><br>Normally an environment file is loaded that specified window positions, file scroll locations, etc. This suppresses loading of the environment file and can improve the repeatability of certain tests. | -NoEnvFile           | -NoEnvFile                                                                                           |
| <b>Run Minimized</b>                                                                                                                                                                                                                             | -Minimize            | -Minimize                                                                                            |

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| Setting                                                                                                                                                                                                                                                                                   | Option                    | Example                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|-------------------------|
| Runs the MC33816 Development Tool 'Minimized' such that it is possible to continue on ones computer while running regression tests.                                                                                                                                                       |                           |                         |
| Automatically Build<br><br>Forces the target system to rebuild the code, even when not out of date, when the MC33816 Development Tool is launched. Note that if a target's build is disabled, this will NOT cause the code to build. Instead, use the '-EnableCodeBuild=<Target>' option. | -AutoBuild                | -AutoBuild              |
| Override a Disabled Build<br><br>For a target with it's build disabled in the project file, this overrides the 'Disable' such that the code will be built.                                                                                                                                | -EnableCodeBuild=<Target> | -EnableCodeBuild=eTPU_A |
| Prevent Build<br><br>Prevents code rebuild even if the code is out of date.                                                                                                                                                                                                               | -NoBuild                  | -NoBuild                |
| Automatically Run<br><br>Sets the target system to running when the MC33816                                                                                                                                                                                                               | -AutoRun                  | -AutoRun                |

| Setting                                                                                                                                       | Option                        | Example                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------------------------|
| Development Tool is launched                                                                                                                  |                               |                                                                                                   |
| Network Retry Time<br>Time to wait (in seconds) for a network license if none is available                                                    | -NetworkRetry=<Sec>           | -NetworkRetry=30<br><br>Retries for 30 seconds if unable to make a network connection             |
| Network License Checkout<br>Perform a network license checkout, providing success/fail status, and then exiting.                              | - NetworkCheckout=<y:m:d:h:m> | - networkcheckout=2035:5:6:16:00<br><br>Attempts to check out a license until 4pm of May 6, 2035. |
| Network License Checkin<br>Check back in a checked-out license, which frees the license for other users (after the linger time has completed) | -NetworkCheckin               | -NetworkCheckin                                                                                   |

### 10.6.1 Using the -d (define) Option and Escape Characters

There are issues with passing a quote character into MC33816 Development Tool in Windows because Windows uses the quote character to bunch multiple pieces of text into a single command line parameter. Consider the case where a filename is to be passed into the MC33816 Development Tool. A good way of doing this is to define a string, then use the `dump_file()`; script command as follows.

```
#define FILE_TO_DUMP "n:\\MyDataFile.dat"
dump_file(0, 0x28, MC33816_DATA_SPACE, FILE_TO_DUMP, IMAGE, DATA8);
```

It is possible to pass the `FILE_TO_DUMP` #define into the MC33816 Development Tool from the command line (instead of having it in the script commands file) using the following command line parameter.

## 10. Functional Verification

---

```
"-dFILE_TO_DUMP=\"MyDataFile.dat\""
```

There are four quote characters in the command line parameter shown above. The first and last quote characters are used by Windows to bunch everything between them together into a single command line parameter which would (for example) allow spaces to appear within the single parameter.

But the filename, MyDataFile.dat, is a string, and strings must be surrounded by quote characters in the script commands file. This is accomplished by preceding the quote character with the backslash character. Windows interprets this backslash-quote combination literally and the quote character is thereby passed along with the filename into MC33816 Development Tool.

### 10.6.2 Warning Suppression Command Line Options

Warning suppression command line options are used to suppress warnings from being generated.

This is useful for regression testing in which a warning can cause a regression test to fail.

Although warning can also be suppressed in the 'Messages Options' dialog box, doing so does not work well in conjunction with regression tests, and here is why. Messages disabled in the 'Messages Options' dialog are stored in the environment file. Each user has their own environment file. So a regression test that might pass when one user runs it might fail when the other user runs it because one user has a message enabled that the other user has disabled. So by disabling options on the command line, all users running the same regression test will get the same behavior.

Note that this is significantly different in DevTool relative to MtDt because MtDt did not have environment files and therefore MtDt stored these Messages Options in the (generally common) project file.

### 10.6.3 Preventing Multiple Rebuilds by Forcing 'No Build'

The '-NoBuild' Development Tool command line option prevents code from being rebuilt, even when if the code image is out of date such that the MC33816 Development Tool's internal 'Make' capability would normally force a code rebuild. This allows (say) a series of tests to be run on a set of source code without an executable code image getting re-built over and over again, thereby saving time. Note that this option adds a tad bit of risk that your code could potentially be out of date and would no longer work correctly if it were to be rebuilt.

Question: Why not just disable the code rebuild by not passing '-AutoBuild' on the the command line? Answer - when '-AutoBuild' is not specified on the command line a 'Make' occurs in which a build may (or may not) occur depending on the many files' time stamps. However the make timestamps (currently) go into the environment file (yuck - this should be changed) which generally don't get saved as part of a regression test suite. So generally, even if '-AutoBuild' is NOT specified on the command line, your code is likely going to get rebuilt on every test run. The '-NoBuild' option overcomes this by forcing your code to not be rebuilt.

## 10.7 File Location Considerations

Although this discussion is equally applicable to MC33816 Development Tool as a whole it is important to point out how files are located within the context of Regression Testing.

A "project file relative" approach is used for searching and finding almost all files. This means that the user should generally locate the project files near the source code and script files within the directory structure. Consider the following directory structure.

```
C:\BaseDir\SubDirA\Test.Sim32Project
C:\BaseDir\SubDirB\Test.Cpu32Command
```

To load the script command file, Test.Cpu32Command, the following option could be used

```
-s=..\SubDirB\Test.Cpu32Command
```

By employing this "project file relative" approach the testing environment can be moved around without having to modify the tests and therefore the files names can be smaller and easier to use.

### Log File

The log file is written to the directory where the project file is located. However, the -lf5=<LogFileName> does accept relative (or absolute) directory information. For instance, if the following command line option is specified,

```
-lf5=..\MySubDir\MyLogFile.log
```

then the log file will be generated up one directory and then down into directory 'MySubDir' relative to the project file. So take the following example.

Starting directory where the MC33816 Development Tool is called:

```
c:\WorkingCode\
DevTool.exe -p=MySubDir1\MySubDir2\Proj.ETpuIdeProj -lf5=..
\MySubDir3\MyLogFile.log
```

## 10. Functional Verification

---

Then the log file will be generated in the following directory.

`c:\WorkingCode\MySubDir1\MySubDir3\MyLogFile.log`

Note that the MC33816 Development Tool will continue to use that log file in that directory until it is closed even if the user manually changes to a different project file in a different directory.

Note that this is different from the way Mtdt worked in that Mtdt always used the 'Current Working Directory' as the starting point for where the log file is generated.

### 10.8 Test Termination

Termination of MC33816 Development Tool and the passing of the test results to the command line batch file is a key element of Regression Testing. At the conclusion of a script file, MC33816 Development Tool can be shut down using the exit script command, as described in the [System Commands section](#). This command causes the MC33816 Development Tool's termination error level to be set to be non-zero if any verification tests failed, or zero if all the tests passed.

The overall strategy in ensuring that a zero error level truly represents that all tests have run error free and to completion is to treat any unusual situation as a failure. Specifically, a failing non-zero termination code will result unless the following set of conditions has been met.

- No verification tests are allowed to fail in any target.
- All targets must have executed all their script commands.
- MC33816 Development Tool must terminate through the exit(); script command. Abnormal termination such as detection of a fatal internal diagnostic error results in a non-zero error level.

### 10.9 Cumulative Logged Regression Testing

Cumulative logged regression testing supports the ability to run an entire test suite without user intervention, even if one or more of the tests fail. This capability overcomes the problem in which a failure halts the entire test suite until acknowledged by the user. Using this capability, the alert is logged to a file rather than being displayed in a dialog box.

Test completion occurs when the exit() script command is encountered. At this time, a PASS or FAIL indicator is appended to the end of the log file. Because it is appended to

the end of the log file, the normal usage would be to delete the log file prior to beginning the test suite. Then, upon completion of a test run, the log file grows. At the end of the test suite, the log file can be perused, and any failing tests are quickly identified.

Note that only certain types of failures bypass the normal message dialog box. For instance, if the failure log file itself cannot be written, then this generates a failure message in a dialog box which must be manually acknowledged.

This capability is invoked using a combination of two Command Line Parameters, shown below.

**-LF5=MyLogFile.log -Quiet**

The first command, **-LF5=MyLogFile.log** specifies that message are appended to the end of a log file named, "MyLogFile.log."

The second command, **-Quiet**, specifies that the dialog boxes that normally carry test errors or warnings are not displayed. Note that this command only works in conjunction with **-AutoRun**, **-IAcceptLicense**, and **-LF5<LogFileName.log>**. If any of these options is not selected, then this **-Quiet** command is ignored. Note also that if the user halts the simulation, then this option is disabled such that messages shown in dialog boxes will require manual acknowledgement.

It is convenient to name each test run. That is, when MC33816 Development Tool is launched, the command line parameter shown below applies a name the test run. This name shows up in the log file. This allows the particular test run that is causing any failures to be easily identified when perusing the log file.

**-tn=<TestName>**

Note that command line parameters do not handle spaces will. To include spaces in the name, enclose the parameter in quotes, as shown below. In the following example, the name, "Angle Mode" is specified.

**"-tn=Angle Mode"**

## 10.10 Regression Test Example

The keys to successful Regression Testing is the ability to launch MC33816 Development Tool multiple times within a batch file that runs in a DOS command line shell and to verify within this batch file that the tests that were automatically run had no errors. These multiple launches of MC33816 Development Tool, and the tests contained therein, form a test suite.

## 10. Functional Verification

---

The following is a batch file used to launch the MC33816 Development Tool multiple times.

Note that there is only a single target such that no target must be specified on the command line. Had this been a test running in a multiple-target environment, the target name would have to be specified along with each script file.

Note that DEV\_TOOL\_MC33816\_BIN is a system variable set by the installer that allows regression tests to 'find' the installation directory.

```
echo off

set EXE=%DEV_TOOL_MC33816_BIN%\Mc33816DevTool.exe

%EXE% -p=MyProj.Spd816IdeProj -AutoBuild -AutoRun -lf5=Sim.Log -q -s=Test1.Spd816Command
if %ERRORLEVEL% NEQ 0 (goto errors)

%EXE% -p=MyProj.Spd816IdeProj -AutoBuild -AutoRun -lf5=Sim.Log -q -s=Test2.Spd816Command
if %ERRORLEVEL% NEQ 0 (goto errors)

echo *****
echo SUCCESS, ALL TESTS PASS
echo *****
goto end

:errors
echo *****
echo YIKES, WE GOT ERRORS!!
echo *****
:end
```

If the above test were named TestAll.bat then the test would be run by opening a DOS shell and typing the following command

```
C:\TestDir\TestAll
```



# 11

## Action Tags

An action tag is an identifier embedded in the source code as a comment that alerts MC33816 Development Tool to perform a specified action when code execution has reached that point in the source code. The action tag is "@ASH@". When target code is loaded, the MC33816 Development Tool scans the source code for action tags – thus if the source code can not be located, the associated action tags will not get activated.

The full form of an action tag includes the action – "@ASH@<action>". Code execution momentarily pauses when the associated source code is reached, and the requested action is performed. Simulation then re-starts as if nothing happened.

A few of the supported action tag commands are: print action, timer action and write value actions.

Action tags that are embedded in source code are associated with the underlying executable code as follows. The search for executable code begins at the line that contains the action tag and moves downwards in the source code file. If no executable code is found at or below the line where the action tag appears, then the search continues upwards. If there is no executable code associated with the source code file at all, then the action tag fails.

### 11.1 Print Action Tag

The Print action command is similar to the "C" languages `printf()` function, and has essentially the same syntax. There are two flavors available - the first being "print\_to\_trace". The resulting text appears as a line in the Trace window. When coupled with the [@ASH@ action tag](#) in the source code file looks similar to the following.

```
// @ASH@print_to_trace("action tag test 1");
/* @ASH@print_to_trace("action tag test 2"); */
// @ASH@print_to_trace("variable A = %d\n", A);
```

As with the "C" `printf`, the first argument is the format string. The ASH WARE Print command uses the same syntax for the format string, which can then be followed by a varying number of arguments. The Print command checks that the number of conversion characters in the format string matches the number of parameters that follow the format string and issues an error if there is a mismatch. The parameters can be constants or simple expressions (variables). With code compiled using tools that support more advanced debugging information, simple expressions such as `struct.member`, `structPtr->member`, `array[2]`, and `*pointer` are supported.

The output of the Print command always goes to the Trace window, and using the [start\\_trace\\_stream\(\)](#) script command it can also be directed to a file. Directing it to a file can be extremely useful for verification and automated testing.

**IMPORTANT NOTE:** although the print action command works via the `print_to_trace()` script command, it has a slightly different syntax. The `print_to_trace()` script command must have its input encapsulated in a single string, while the print action version has its format string and any additional arguments NOT encapsulated in an enclosing string.

The format specifier, `%`, is used to denote that a parameter value is to be inserted in the resulting text. The `%` character must always be followed by a valid conversion character such as `%d`. If the `%` character is not followed by a conversion character then a warning message is generated and any automated tests will fail. The `%` character is generated by two consecutive `%` characters.

The other flavor of the Print action commands have the same capabilities, but sends their output to either a message dialog (thereby pausing simulation), or to a log file if autorun logging is enabled. See the `print()` and `print_pass()` script command documentation for more details.

```
// @ASH@print("action tag print to dialog or log file");
// @ASH@print_pass("output a message without affecting the
simulator exit code");
```

## 11.2 Timer Action Commands

The timer action commands provide a method for instrumenting source code to verify that time critical paths are being met.

```
// @ASH@timer_start("Test 1");
// @ASH@timer_stop("Test 1");
```

The passed parameter is the test name and can contain any text with the restriction that each test must have both a timer\_start and a timer\_stop action command. In other words, timer action commands must come in pairs such that each named test has both a start and a stop. Additionally, only one start and one stop is permitted for each test.

In order for a timing measurement to be considered valid, the following must occur. The code containing the start tag must be first and the code containing the stop\_tag must be traversed next. In other words, the traversal must occur in pairs of start/stop, start/stop, etc. If this order is broken (a stop before a start, two starts in a row, or two stops in a row) then the action timer is invalidated and any verification scripts that thereafter test the timers will result in verification failures.

The test tag is case sensitive such that the following tag,

```
// @ASH@timer_start("TestTag");
```

is a different test from the following tag

```
// @ASH@timer_start("TESTTAG");
```

On both target-reset and on code-reload, all timing measurements are reset.

### Related Information

[Naming timing regions](#) in source code

[Verifying traversal times](#) a script command file

[View named timing regions timing using the Watch Window](#)

## 11.3 Write Value Action Tag

When the source code containing a write value action tag is traversed, the specified symbolic write value script command (write\_val, write\_val\_int or write\_val\_fp) is exercised.

```
// @ASH@write_val("s24", "0x123456");
/* @ASH@write_val_int("varui32", 0x10101010); */
// @ASH@write_val_fp("ratio", 0.232323);
```

## 11. Action Tags

---

See the [Print Action Tag](#) section for more information on referencing channel frame variables.

# 12

## External Circuitry

This section covers external circuitry.

### 12.1 Logic Simulation

External logic is used to drive one I/O or input pin with other I/O or output pin(s). External logic can include buffers, inverters, 'and' gates, 'or' gates, 'xor' gates, etc. These external logic gates are placed using [external logic commands](#) within [script commands files](#).

These external logic gates are evaluated on a 'one pass per per instruction cycle' basis and there is no attempt to elegantly handle a-stable situations. For instance, an inverter that has both it's input and output connected to the same pin would simply toggle once every instruction cycle.

There are a number of limitations to the Boolean logic.

- [There are only two logic states, one and zero.](#)
- [The logic is simulated with a single pass per instruction cycle.](#)
- [All output states are calculated before they are written, and therefore all calculations are based on the pre-calculated states. Thus it takes multiple passes for state changes to ripple through sequentially connected logic.](#)
- [All Boolean logic inputs and outputs must be input, output or I/O pins.](#)

## 12. External Circuitry

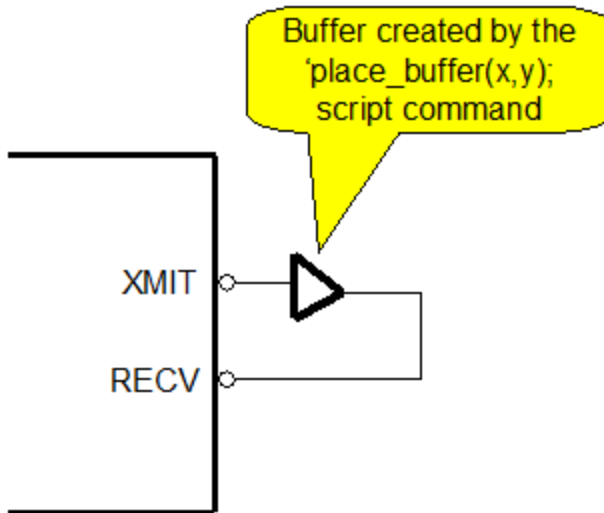
---

- Behavior of pins connected to Boolean logic outputs and also driven by test vectors is undefined.

### Example 1: Driving a Pin with another Pin

In the following script command the output pin which drives the buffers input is the MC33816's 'FLAG1' pin which is at index 1. The pin driven by the buffer's output is the 'START6' pin which is at index 8.

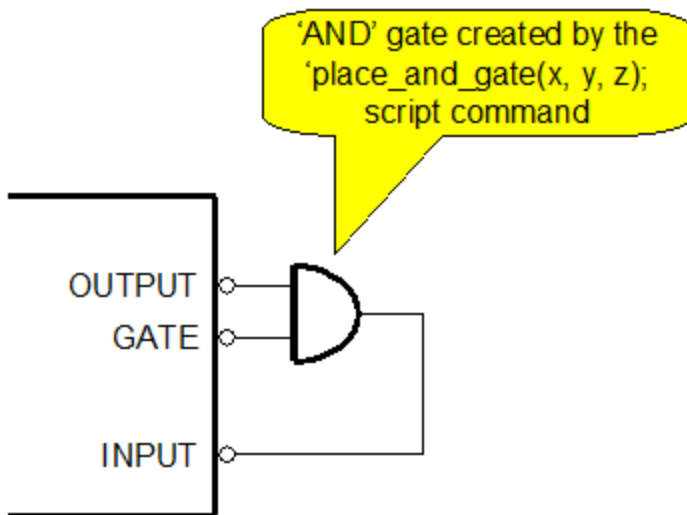
```
place_buffer(1, 8); // MC33816
```



### Example 2: Driving a Pin with the Logical Combination of Two Pins

In the following multi-drop communications example FLAG0 is a communications channel output. The FLAG2 pin is used as a gate to enable and disable the output. The START6 pin is the communications input. An idle line is low. An AND gate is instantiated using the `place_and_gate(X,Y,Z)` script command. The gate pin causes an idle (LOW) state on the input by going low. By going high the gate pin causes the state on the output channel to be driven unto the input pin.

```
place_and_gate(0,2,8); // MC33816
```



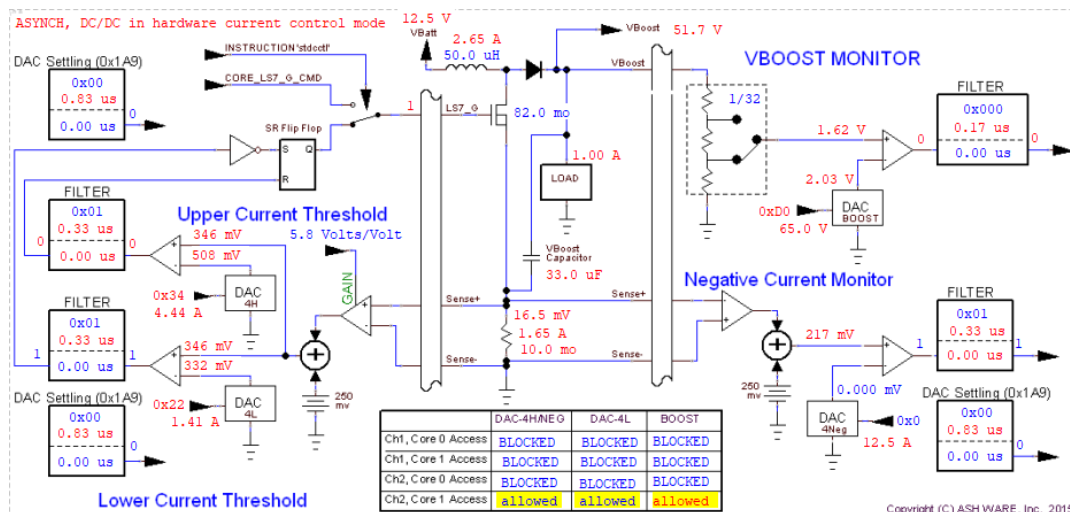
## 12.2 Built-in Injector

One or more built-in injectors are created with the `place_injector();` script command specified in the [MC33816 Hardware Commands](#) section.

Note if the VBOOST voltage source's voltage is not being generated by the DC to DC converter circuit then it's voltage should be specified with the `set_voltage` script command as described in the [MC33816 Hardware Commands](#) section.







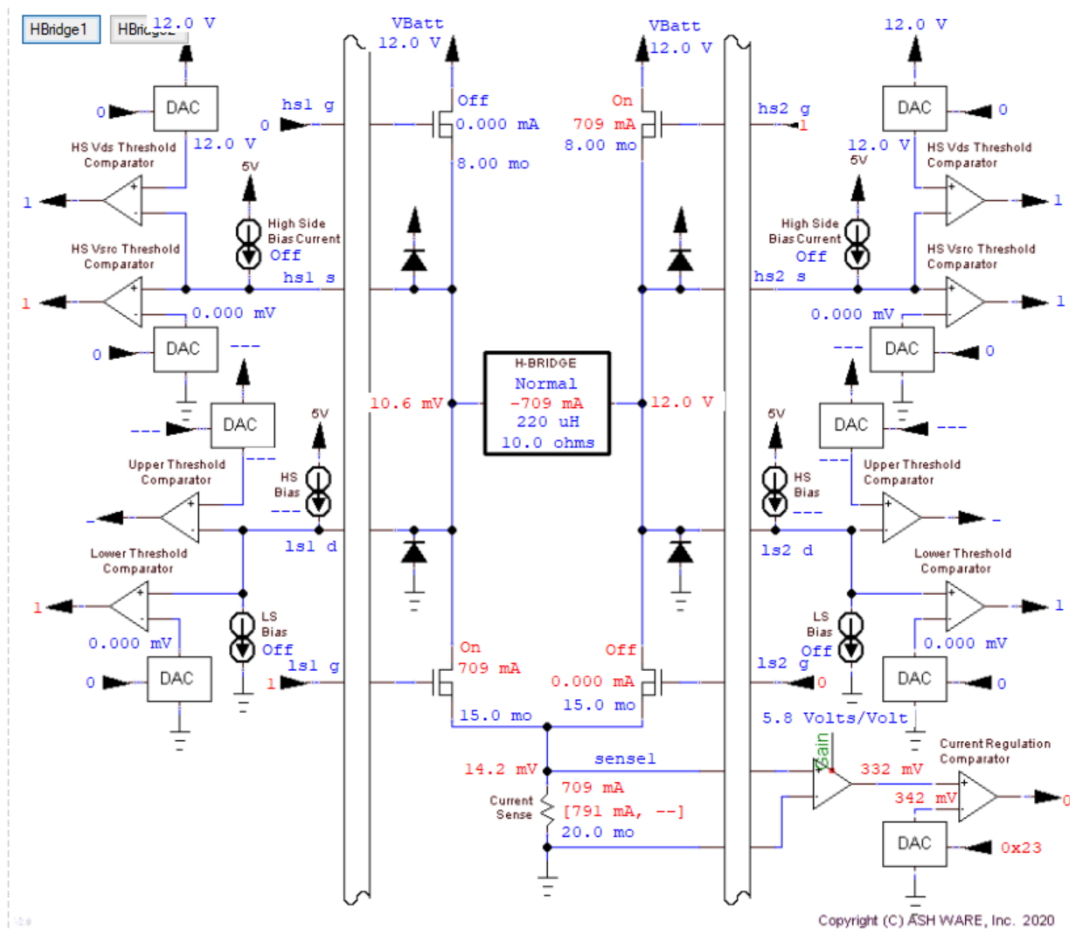
## 12.4 Built-in HBridge

The H-Bridge build-in external circuit shown below is instantiated using a script command defined in the the [MC33816 Hardware Commands](#) section. Note that this is only available in the MC33816 simulator.

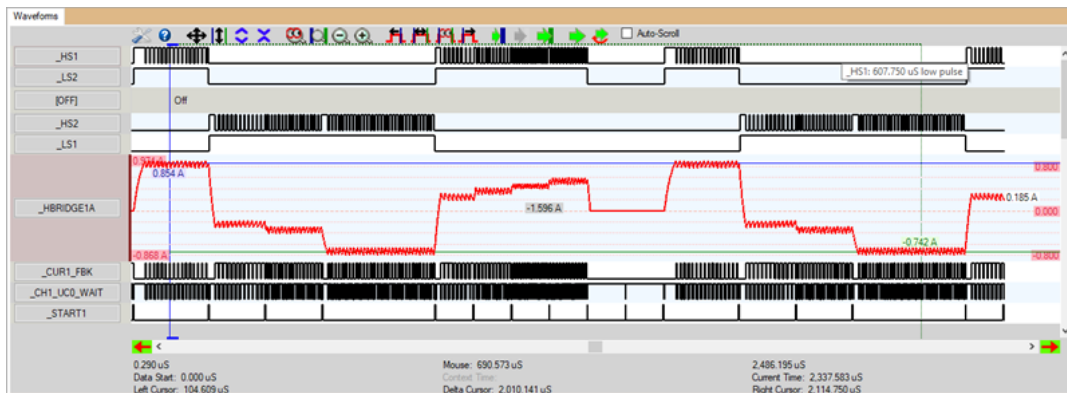
The h-bridge model supply must be the battery. In order for the VDS comparators to work on HS2 and HS4, they must be configured to monitor the Battery supply which can be done using the 'slfbk' instruction.

*NOTE: The HBridge now supports either HS or LS drivers on the ground side of the HBridge. This is why the GND-Side diagnostics have both Vds and Vsrc comparators.*

12. External Circuitry



This is the waveform produced by the h-bridge external circuit.



## 12.5 Built-in Load

The resistive load shown below is instantiated using a script command defined in the the [MC33816 Hardware Commands](#) section. Note that this is only available in the MC33816 simulator.

There are four flavors of the built-in load window, as follows.

- High Side
- High Side, Regulated
- Low Side
- Low Side regulated

The high-side circuit drives the load with one of high-side drivers, HS1-HS5.

The low-side circuit drives the load with one of low-side drivers, LS1-LS5.

The 'Regulated' measures the current using one of the four sense resistors, VSENSE1-VSENSE4.

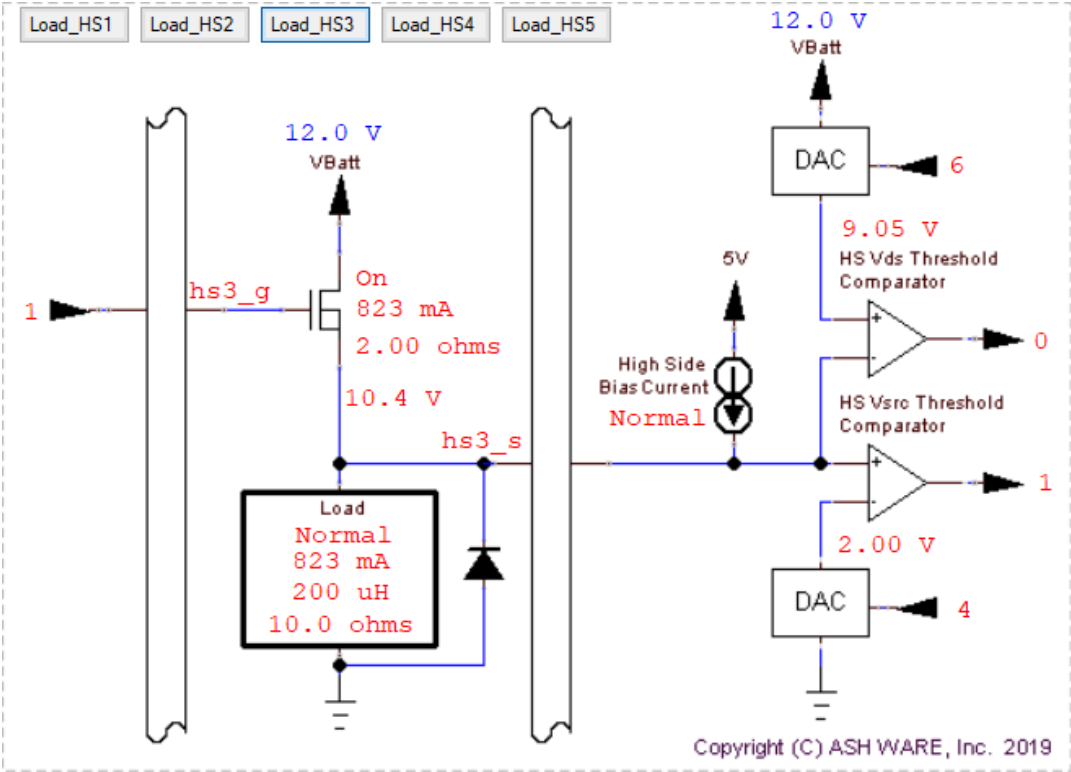
Additionally there are two load options.

- Resistor and inductor
- Resistive (only)

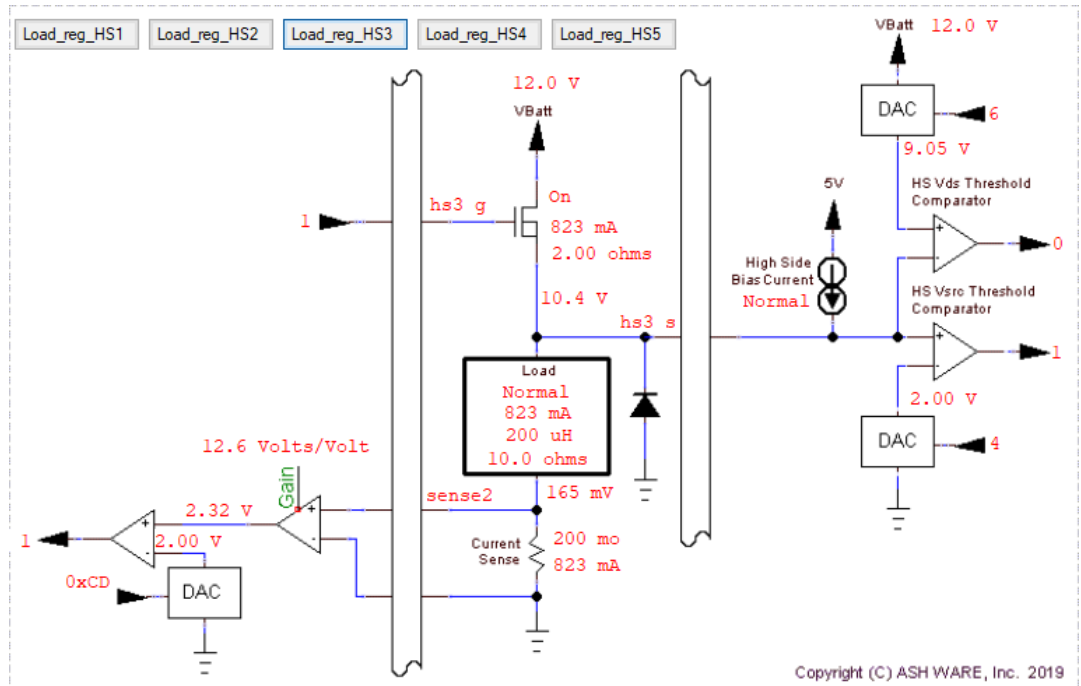
Additionally there are two load options.

### Load, High-Side (unregulated)

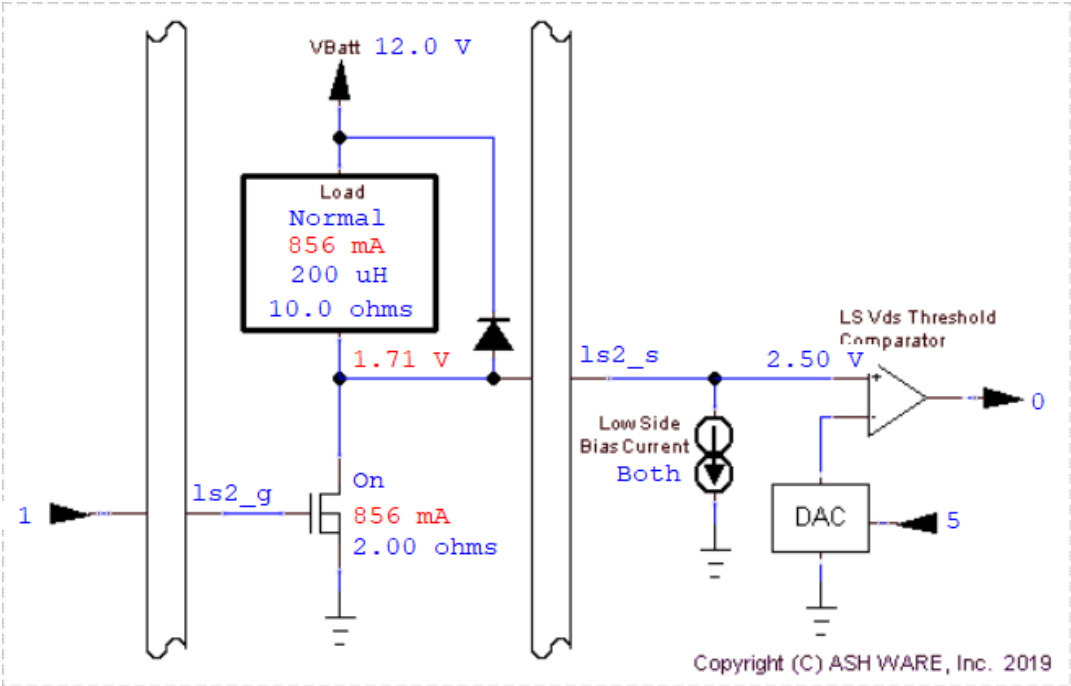
12. External Circuitry



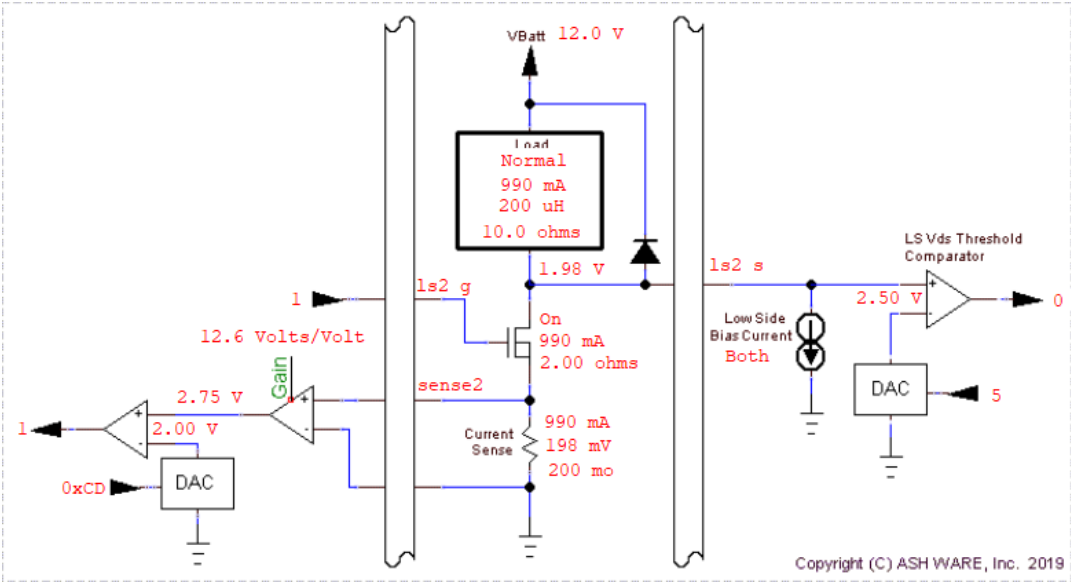
Load, Regulated High-Side



12. External Circuitry



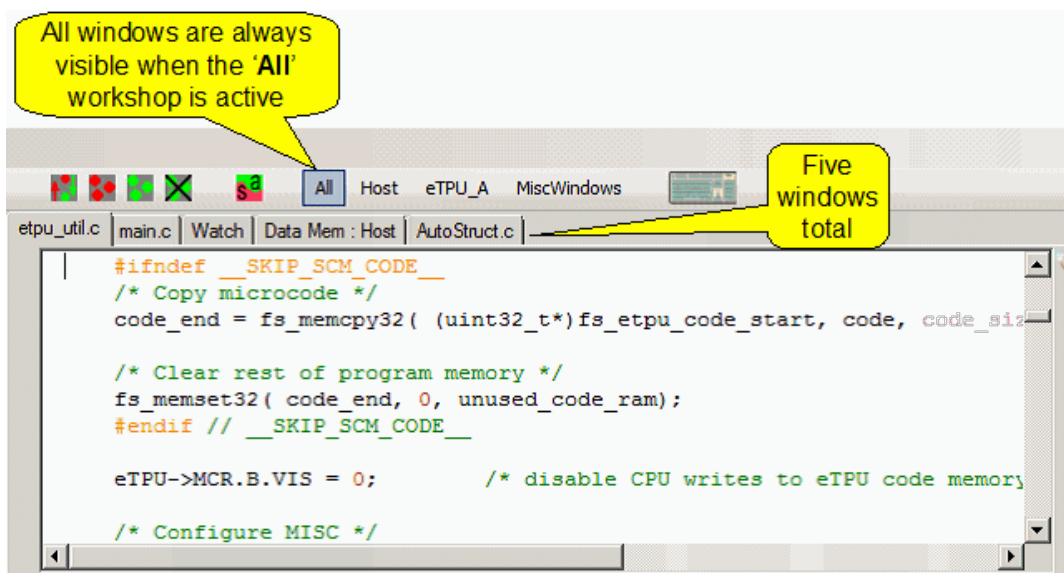
Load, Regulated Low-Side



# 13

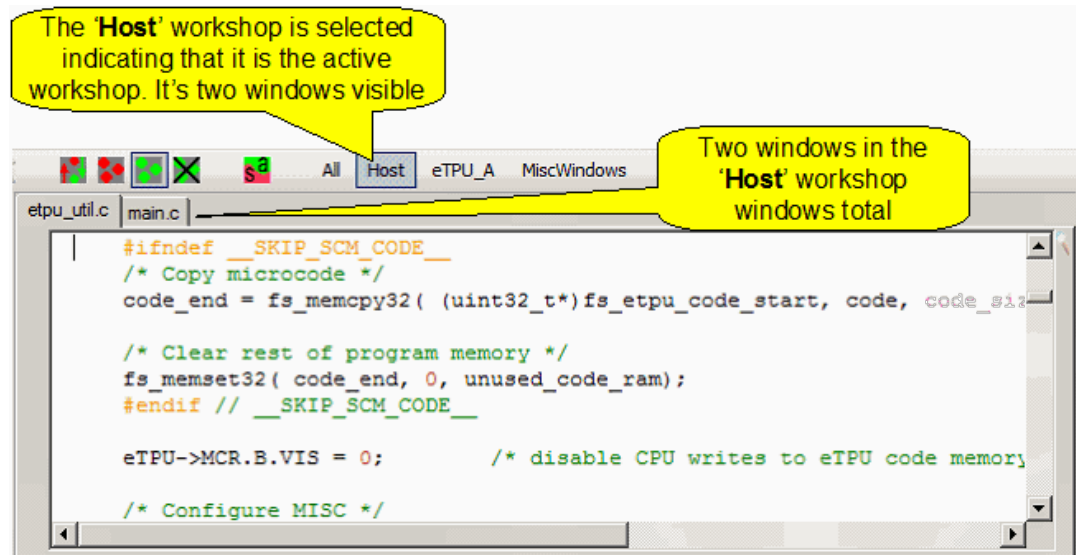
## Workshops

When debugging multiple targets/cores each will have it's own set of windows. That can be a lot of windows to keep sorted out! Workshops provide a mechanism to group windows into workshops ... thereby making it easy to show/hide whole groups of windows all at once. Consider the situation with five windows. These windows have been assigned to four workshops, 'All', 'Host', 'eTPU\_A', and 'MiscWindows' as shown below.



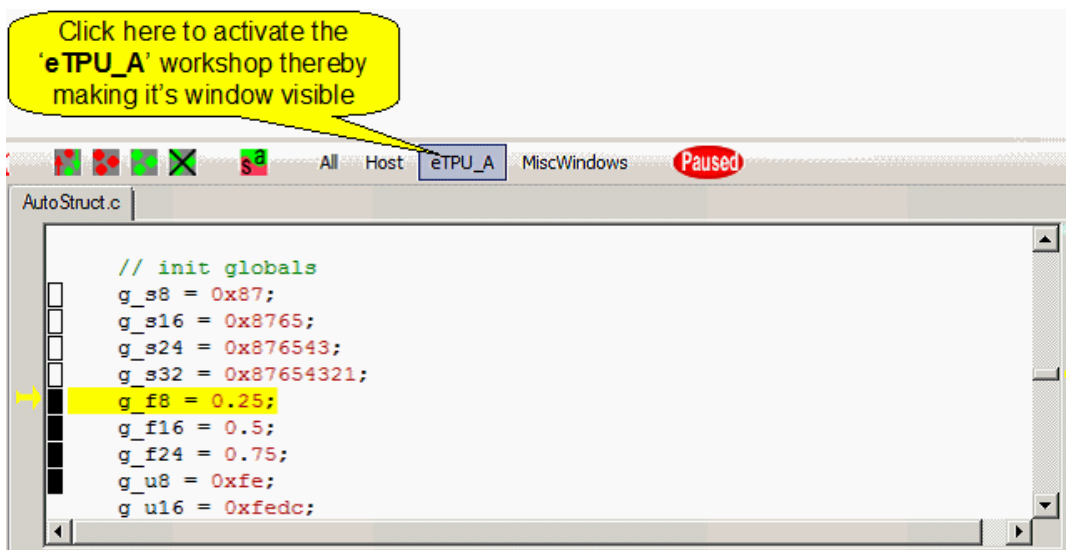
## 13. Workshops

Say the Host CPU hits a breakpoint. It's workshop is the 'Host' workshop which becomes active due to it hitting the breakpoint. Also, all 'Host' workshop window become visible and windows not in the 'Host' workshop become hidden.

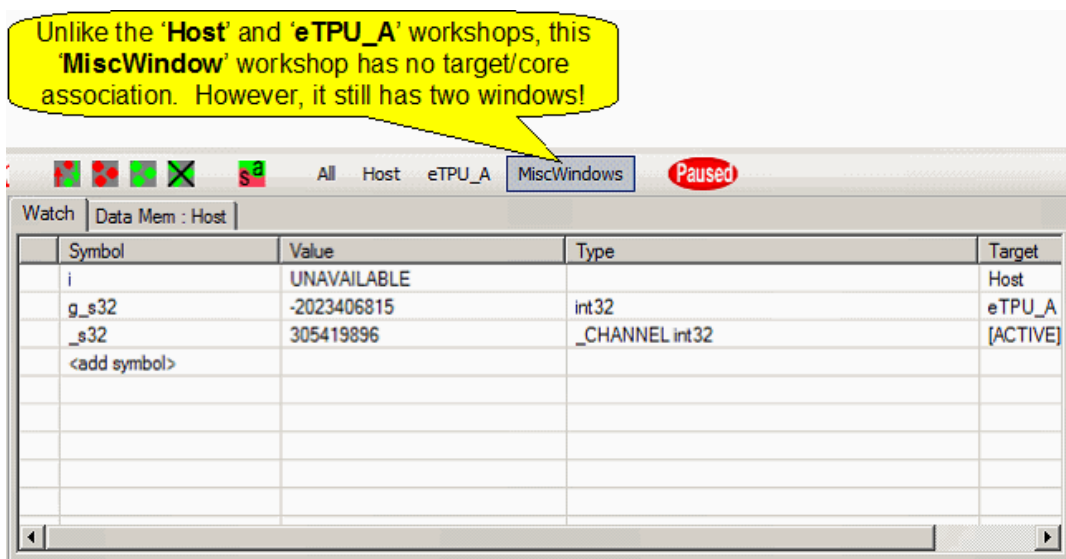




It is also possible to activate a window simply by clicking on it's workshop button.



'Target-less' workshops are also possible as shown below. The '**MiscWindows**' workshop has two associated windows.



## 13. Workshops

---

Closely coupled with workshops is the concept of the active target/core. It is generally best to associate targets/cores with workshops. Thusly, when the workshop is switched, the active target/core is also automatically switched to the one associated with the newly activated workshop. The active target/core is important in that MC33816 Development Tool acts on the active target/core in a variety of situations. For instance, when a single step command is issued, the active target/core is the one that gets single stepped and all other targets/cores are treated as slave devices and are stepped however much is required in order to cause the active target/core's simulation to progress by one step. MC33816 Development Tool makes use of the active target/core when a new executable code image is loaded. Clearly the user needs to have the ability to select a new executable image into a single specific target. But which target should this be? The MC33816 Development Tool automatically selects the active target/core as the one into which the executable code image is to be loaded.

To associate workshops with targets, see the [Workshops Options Dialog Box](#) section. In that section there are descriptions of putting workshop buttons on the toolbar, renaming workshops or automatically giving a workshop the same name of its associated target, and associating workshops with targets.

When a target is assigned to a workshop, the windows associated with that target are automatically made visible within the assigned workshop. It is often desirable to override this, either to make individual windows visible in multiple workshops or to remove window from specific targets. See the [Occupy Workshop Dialog Box](#) section for a detailed description of how this is done.

# 14

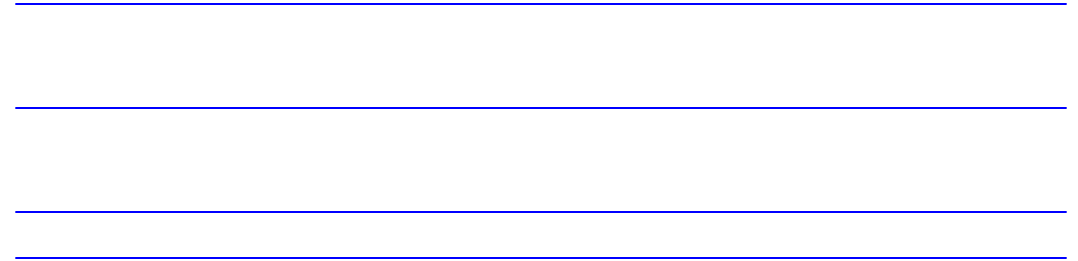
## The Waveform Window

The Waveform Window displays signals in a graphical format similar to that of a classical oscilloscope combined with a logic analyzer. [Variables](#), (including color-coded enumerations,) [analog signals](#), and [digital signals](#) can all be displayed displayed.

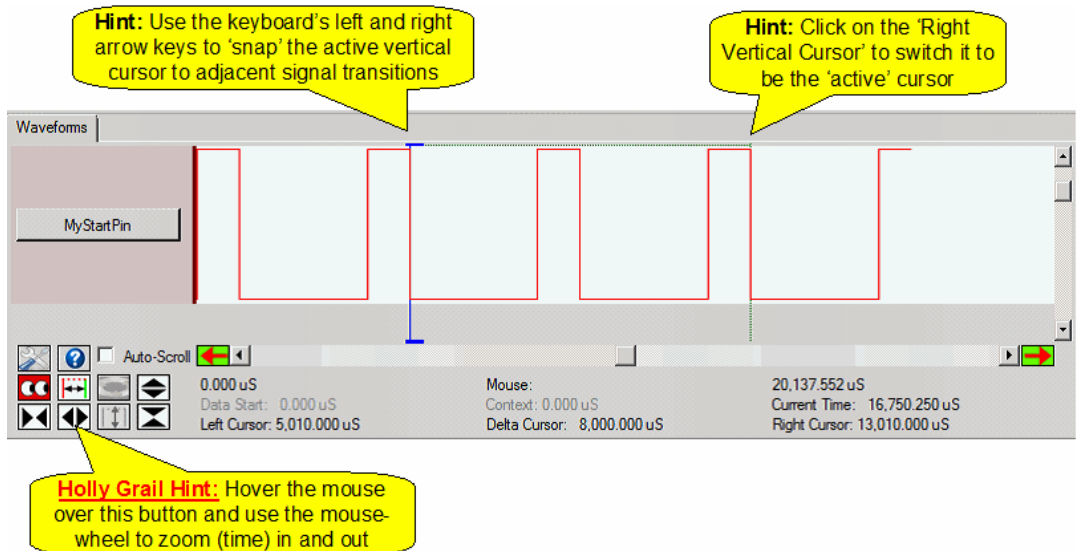
The following Waveform Window help topics are available:

- [Running the simulation](#) from the waveform window
- [Choosing signals](#) to display
- [Viewing a variable](#) as a waveform
- [Resizing the waveforms'](#) height and width individually, and all together
- [Resizing a waveform's amplitude](#) manually
- [Resizing the waveform's amplitude automatically](#), **very cool!**
- [Controlling the view of time](#) manually
- [Controlling the view of time automatically](#), **very cool!**
- [Enabling/disabling automatic scrolling](#), **avoid annoyance!**
- [Snapping to a transition](#)
- [Executing to a precise time](#) in the waveform, **the 'Holy Grail'!**

---



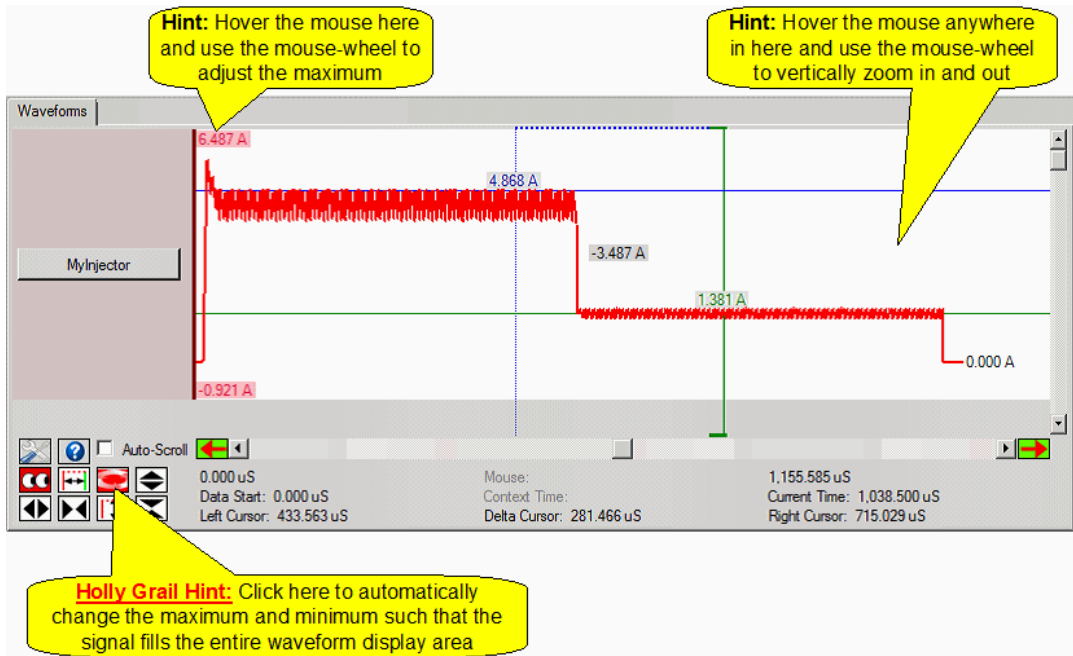
An example of this most basic waveform type is shown below.



### Analog Signal Waveform

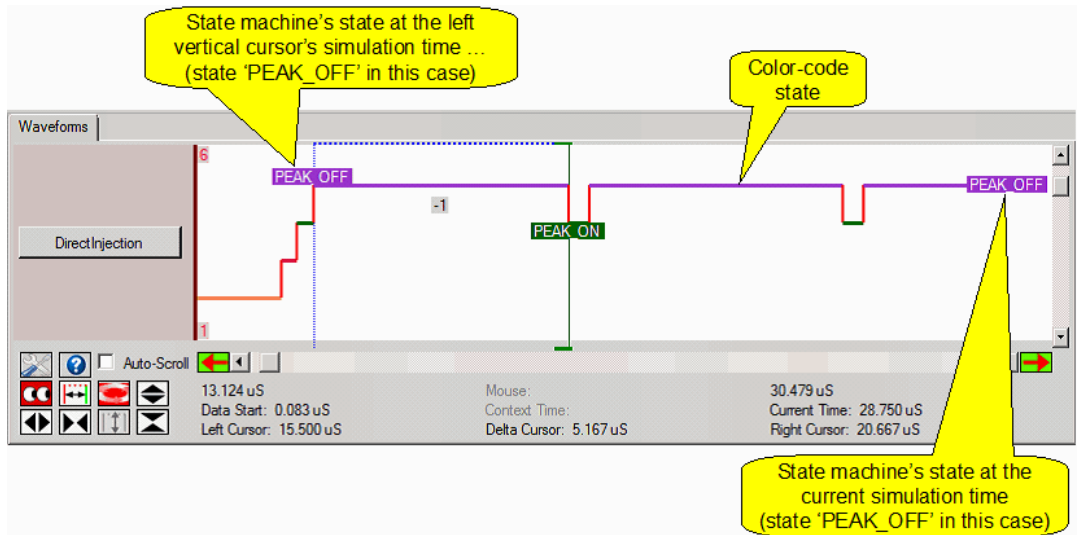
An example analog signal waveform is shown below.

## 14. The Waveform Window

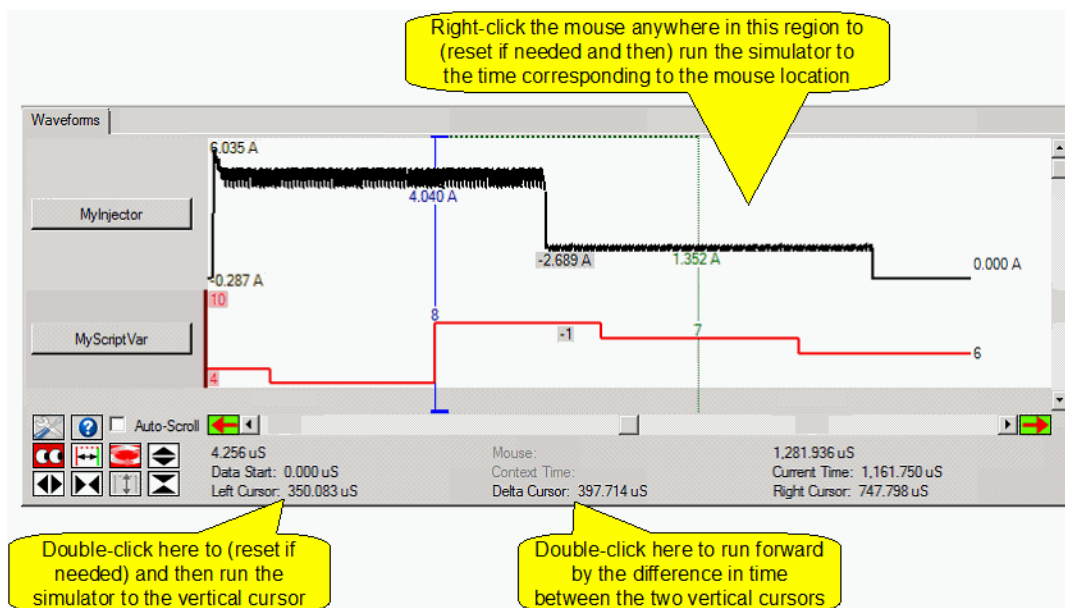


### State Machine State Waveform

The state machine's state is automatically available for viewing. Therefore, unlike variables, there is no need for it to be enabled before it can be viewed.

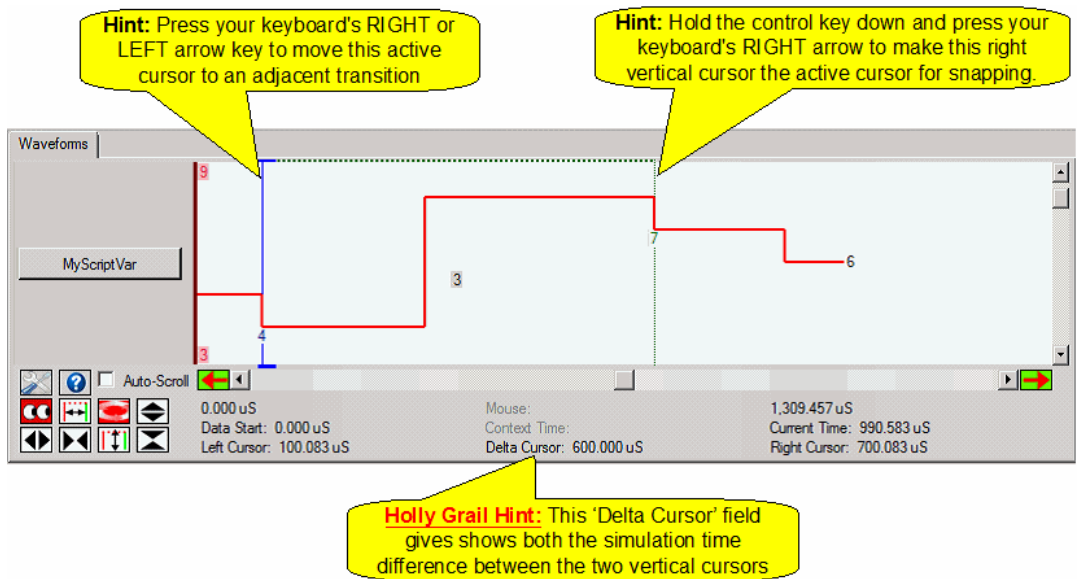


### 14.1 Running the Simulation

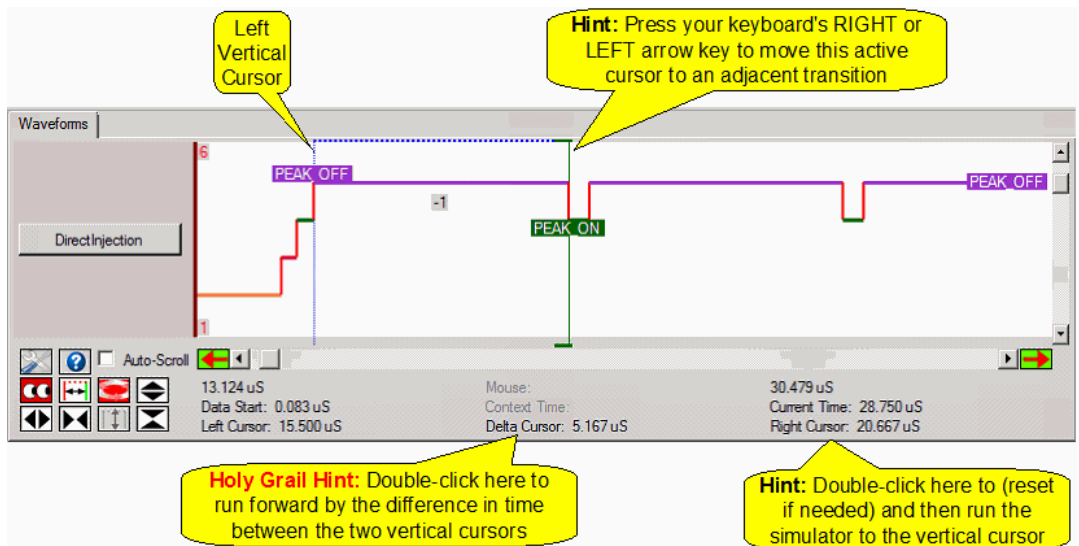




## 14.2 The Vertical Cursors and Snapping

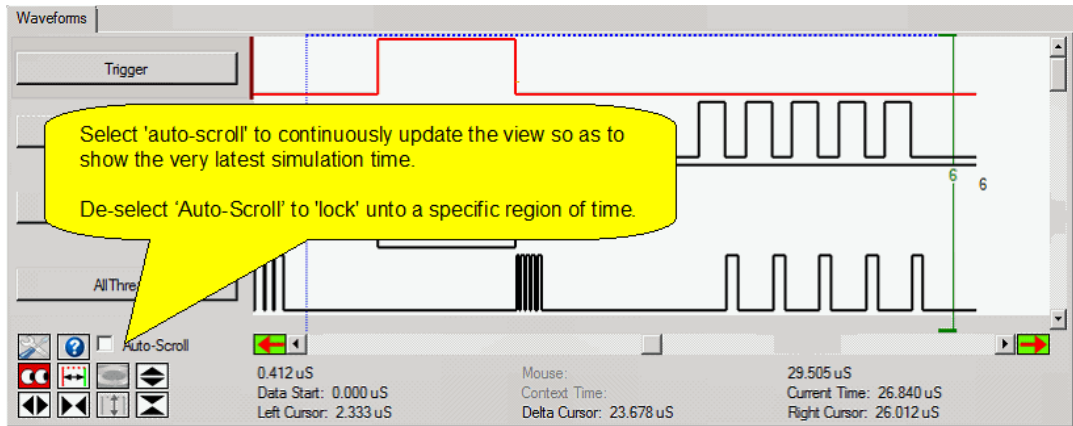


## 14.3 Executing to a Precise Time



### 14.4 Enabling/Disabling Automatic Scrolling ... CRITICAL!

**This is one of the most inconspicuous, BUT CRITICAL, aspects of the simulator!!!** The author notes, *'when I have auto-scrolled disabled, I really, really need it disabled. And conversely, when I have it enabled, I really, really, need it enabled.'* We are not quite talking defending the free world from the horde at the gate. But still, to use the simulator effectively, you really do need to understand how to use this key feature!



Should 'Auto-Scroll' be enabled?

The answer very 'situational'.

If you want the waveform window to continuously track and display the very most recent information, then enable 'Auto-Scroll'.

If you want to focus on something that is happening at a specific region of time and want execute over and over again within that time region, you definitely want to disable 'Auto-Scroll'.

### 14.5 Choosing Signals to Display

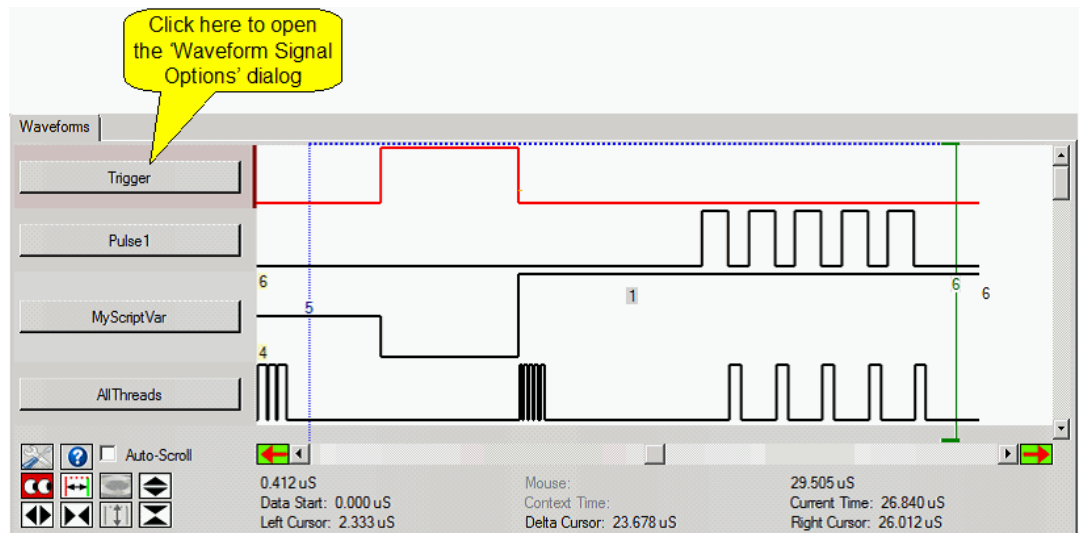
Click the mouse on any button on the left hand side of the waveform window. The [Waveform Signal Options dialog](#) will open from which any of the available signals can be viewed.

*On of the most powerful features of this tool  
is the ability to display variables  
(and color coded state machine states)  
(and color-coded enumerations)  
as waveforms alongside the other signals in your simulation!*

However, in order for a variable to be viewed, it first must first be enabled which is done by right-clicking the variable, and select it for viewing as a waveform, in one of the variable-viewing windows. The variable-viewing windows are the the 'Watch' window, the 'Local Variable' window, the 'Channel Frame' window and the 'Script Variable' window.

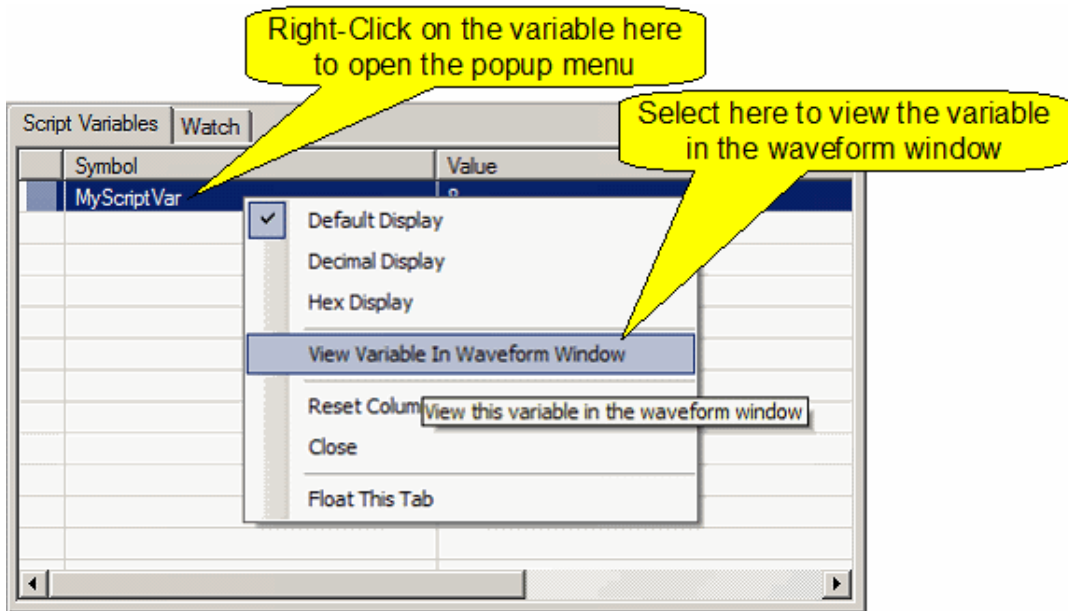
Note: The state machine state is automatically stored so, unlike normal variables, it does not need to be first enabled for viewing.

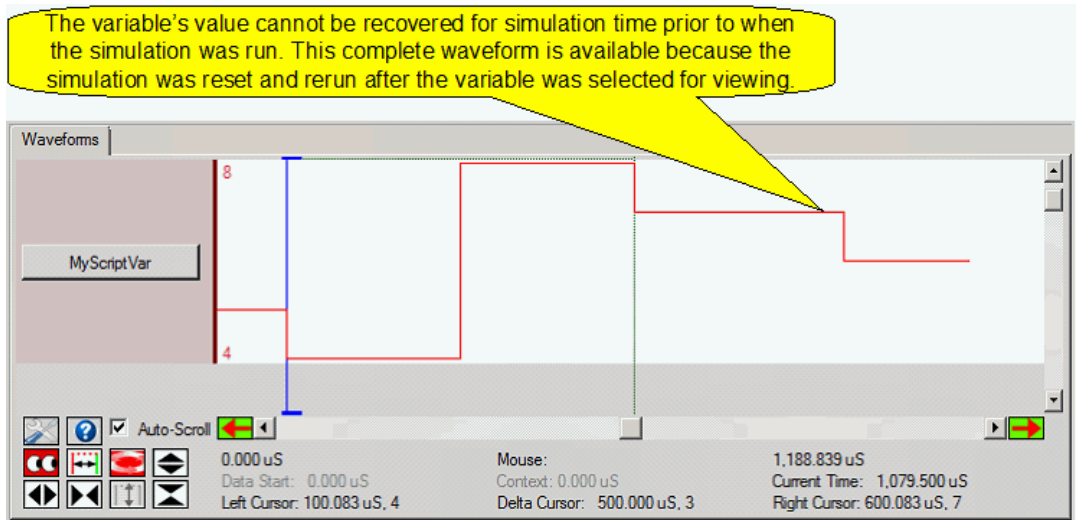
Important: storing variables for viewing can slow the simulation considerably. It is therefore recommended that this number be limited to under a half dozen. However, if you do need to view more variables, a great book is 'Boys in the Boat'.



### 14.6 Viewing a Variable as a Waveform

Variables are NOT stored to the waveform data buffer by default. Therefore, in order to be viewed, **THE VARIABLE MUST FIRST BE ENABLED FOR VIEWING!** This is done from the 'Watch Window', the 'Local Variable Window', the 'Channel Frame Window', or the 'Script Variable' window. Right click on the variable and select the variable for viewing in the popup menu as shown below.



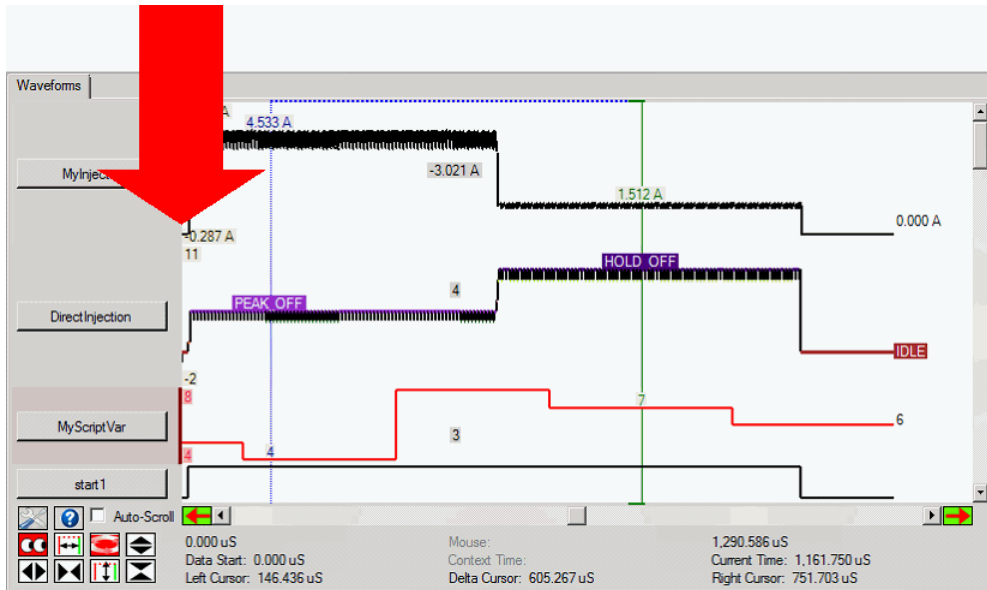


## 14.7 Resizing Waveforms Height and Width

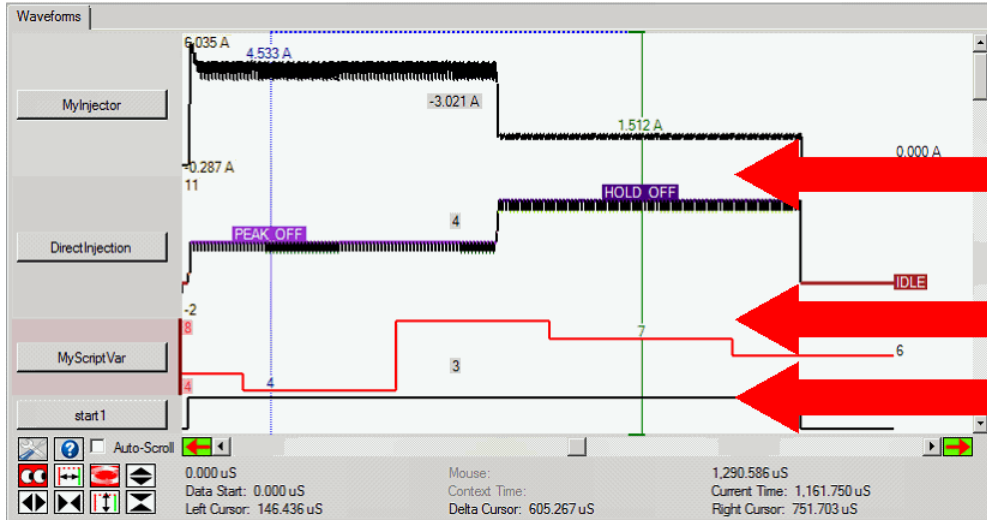
Waveforms can be resized individually and all together as a group.

On the left edge of the waveform display area (see below) is a region that allows the waveforms' width to be resized. When the cursor changes shape as shown below press and hold down the left mouse button to resize.

## 14. The Waveform Window

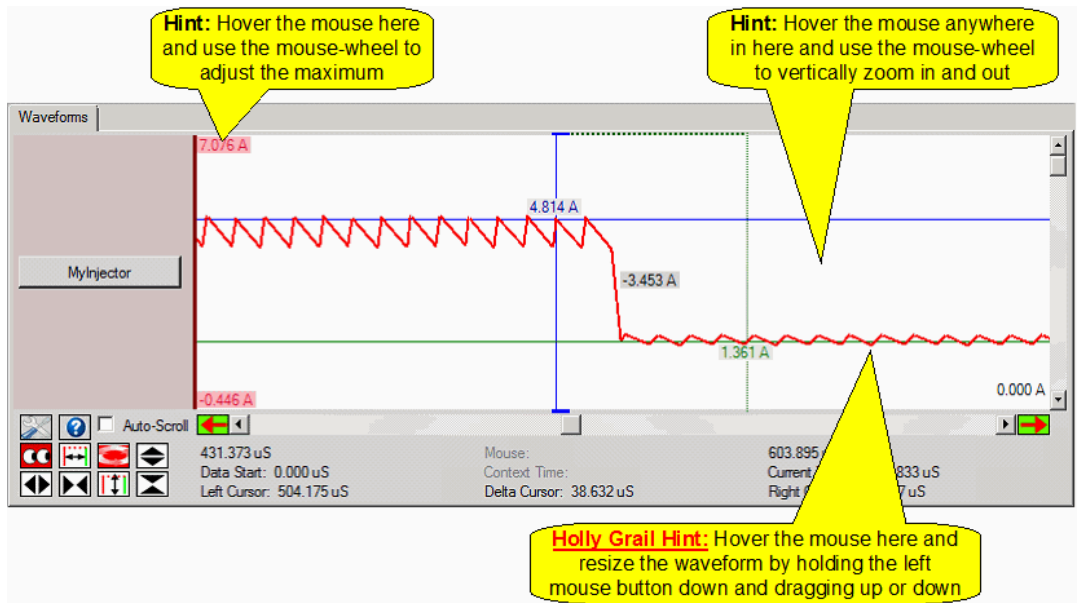


At the bottom edge each waveform there is a region that allows the waveform height to be resized.

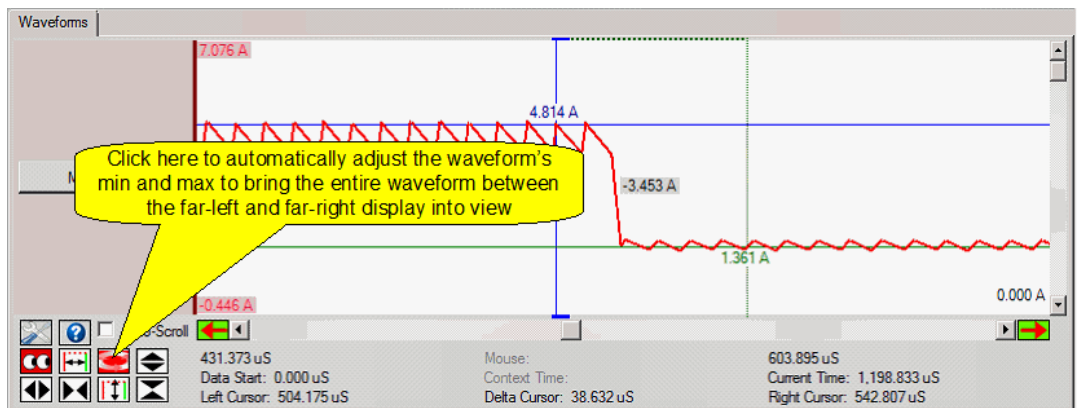


Note that it is possible to resize the height of all of the waveforms together. This is done (first) by resizing one waveform, then using the 'Equalize Waveforms Height' selection from the popup menu. Enter topic text here.

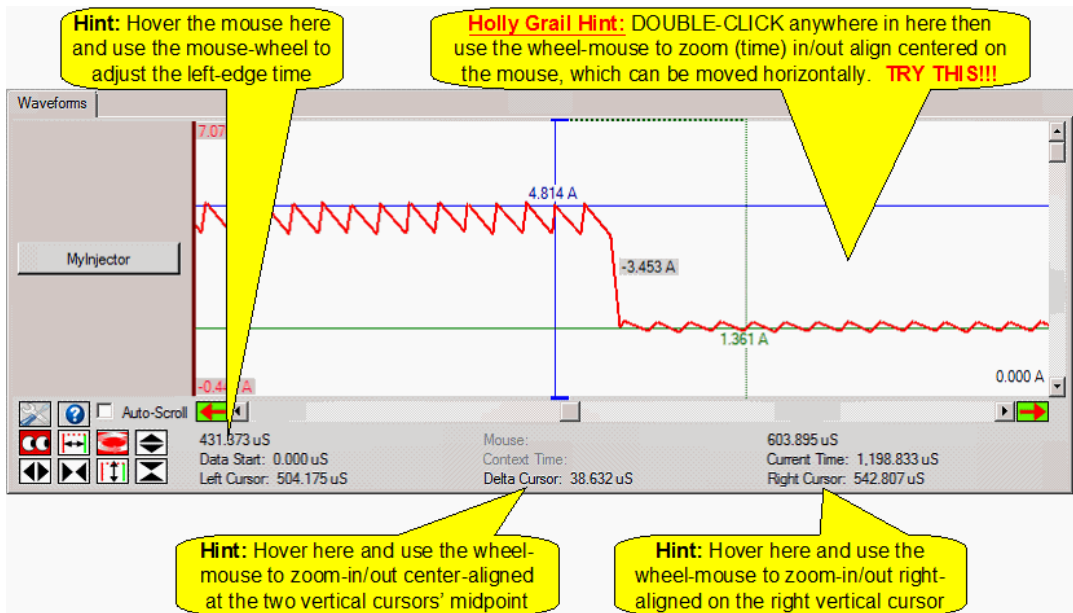
## 14.8 Resizing a Waveform's Amplitude Manually



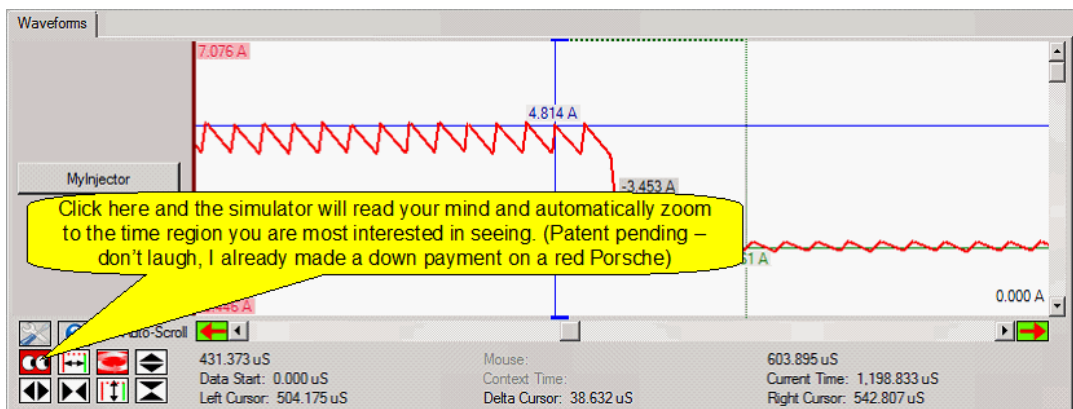
## 14.9 Resizing a Waveform's Amplitude Automatically



## 14.10 Controlling the View of Time ... Manually



## 14.11 Controlling the View of Time ... Automatically





# 15

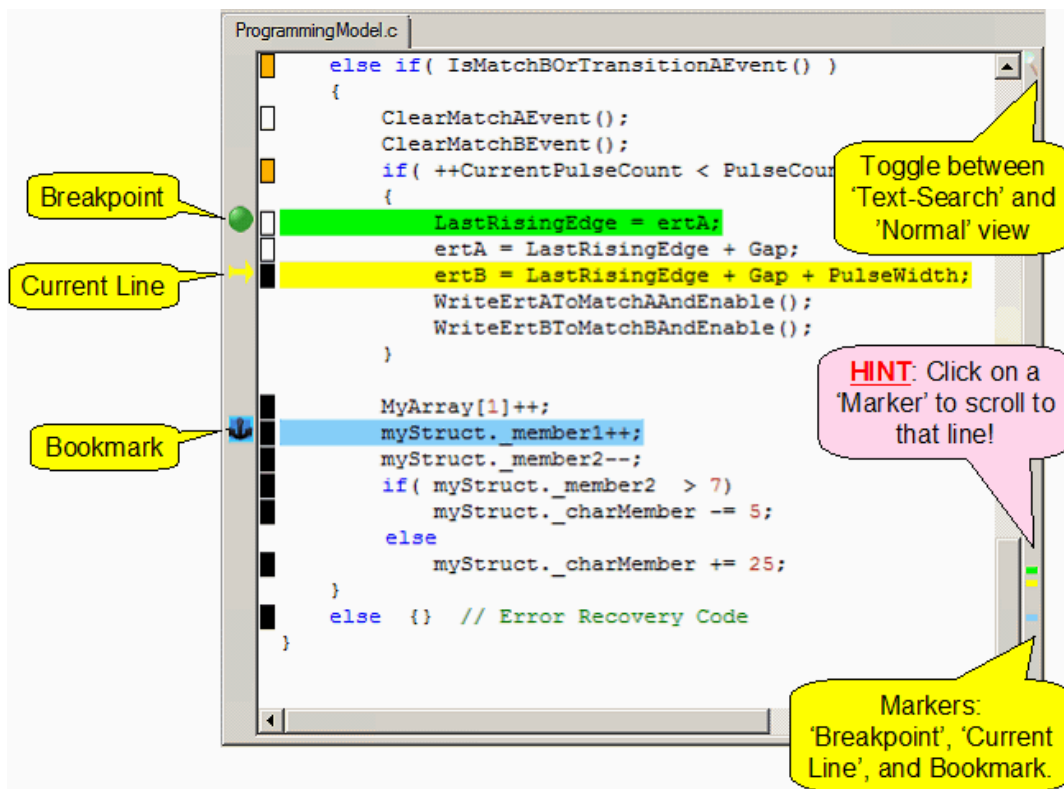
## Operational Status Windows

The target state is displayed in various operational status windows. These windows correspond to the various functional blocks associated with the specific target. Each of these windows can be floated, docked, scrolled. Depending on the window type, multiple instances of each window may be opened.

### 15.1 Source Code Windows

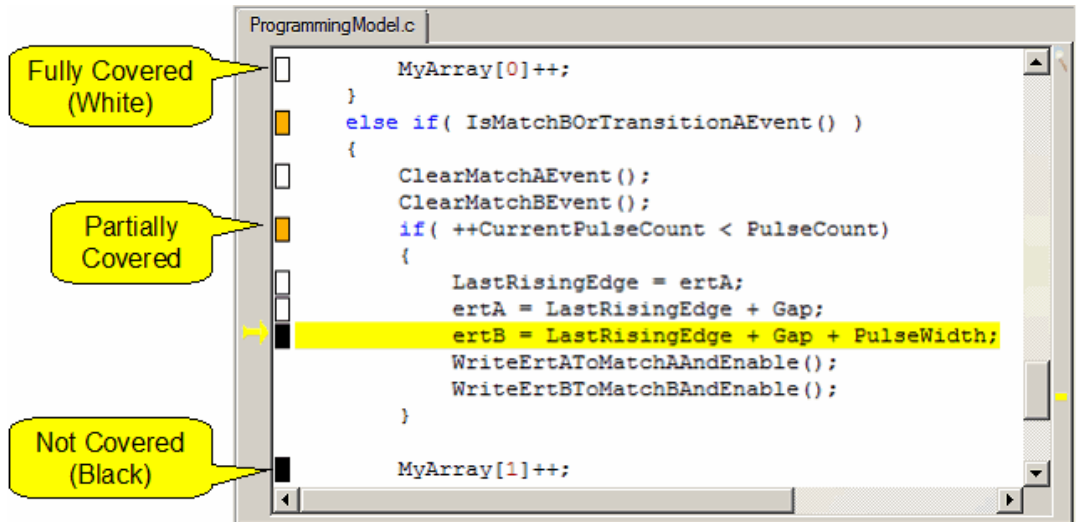
The source code windows are the focal point of the MC33816 Development Tool. Capabilities such as single stepping, breakpoints, setting and going to bookmarks, dragging variables into the watch window, and many more are all accessed from source code windows. Some of the major source code window features are shown below.

## 15. Operational Status Windows



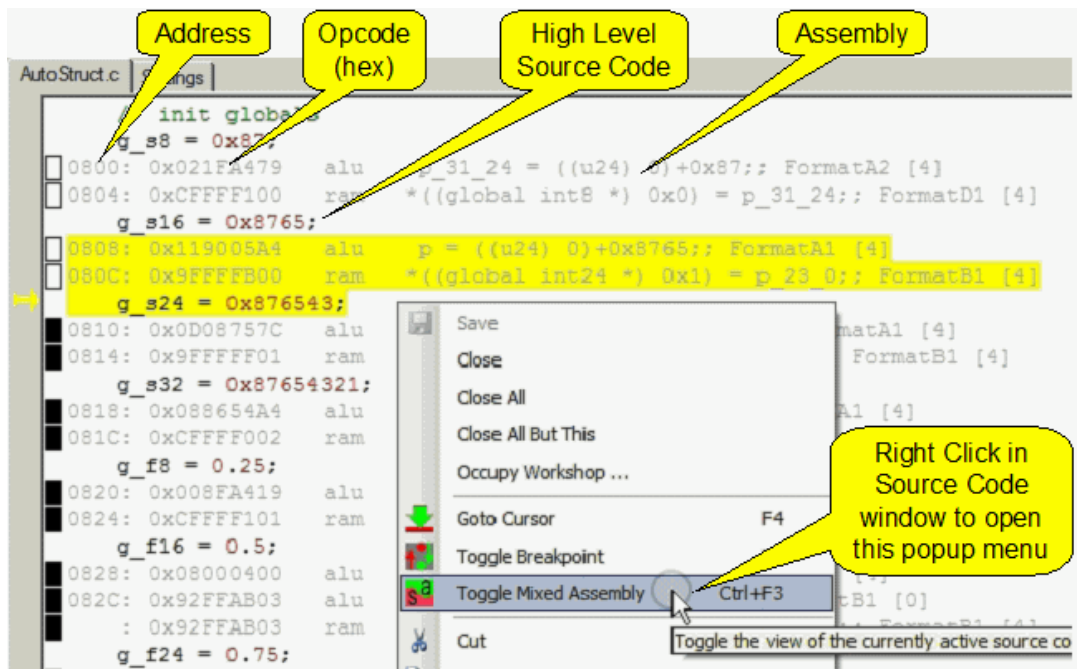
### Code Coverage Indicators

Verifying test suite code coverage is a critical aspect of testing your code and is described in the [Functional Verification](#) section. Code coverage indicators provides a quick visualization of code coverage as shown below. A code coverage indicator box changes color from white (not executed) to black (fully executed) as shown below. See the [Code Coverage Visual Interface](#) section for more details.



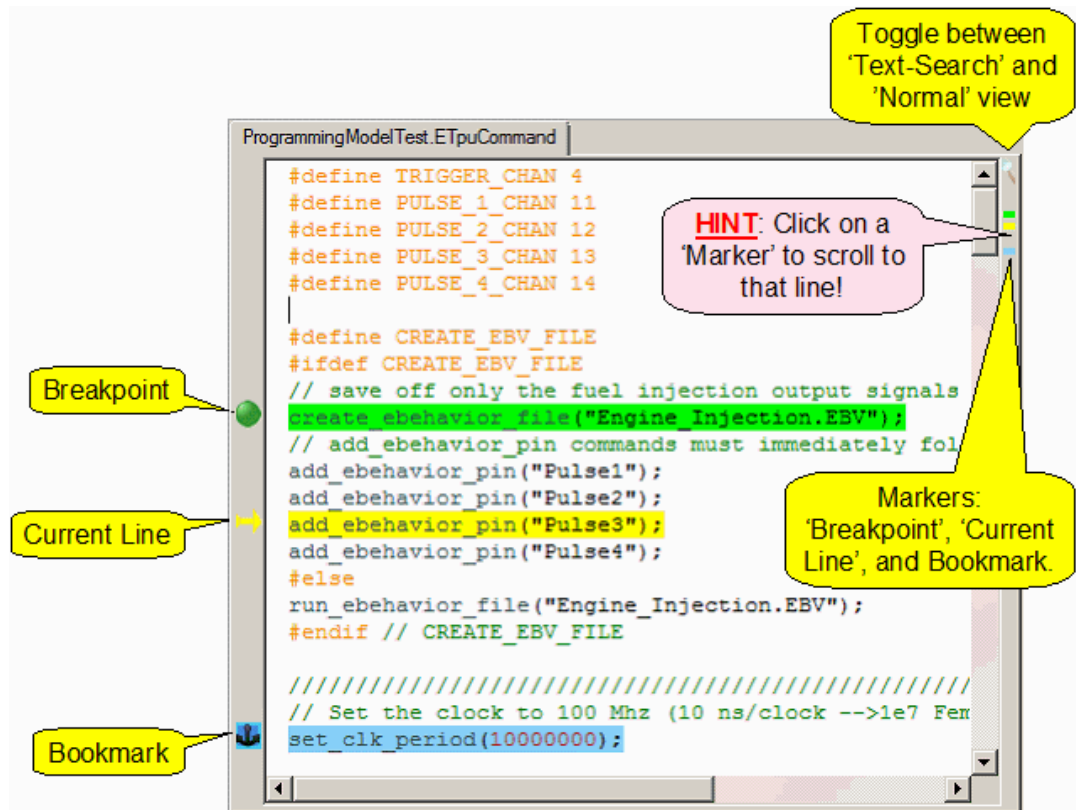
### Mixed Assembly View

Right-click in any source code window and select the 'Toggle Mixed Assembly' option to view the source code in mixed source assembly view as shown below.



## 15.2 Script Commands Window

Script commands file perform many of executive tasks required in a simulation such as initialization, verifying and modifying memory, verifying and modifying registers, etc. A list of the available script commands functional groups is given in the [Script Commands Groupings](#) section.



### Primary Script Commands Files

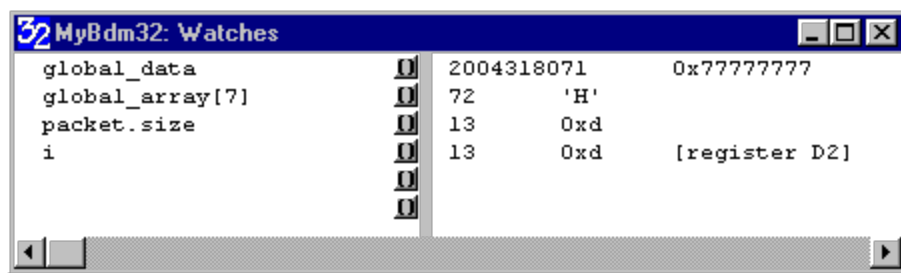
The primary script commands file is the 'main banana'. It is used to perform most of the administrative tasks during a simulation such as initialization, specifying behavior verification files, verifying that operational parameters are met during a simulation, etc. Most of the debugging capabilities available to source code files such as single stepping,

'goto cursor', etc., are available. See the [Script Commands File](#) section for more information.

### Startup Script Commands Files

Startup script commands run from start to end when the MC33816 Development Tool is reset. The purpose of the startup script commands file is to perform any required initialization prior to starting the simulation. Startup script commands do not support single stepping, 'goto cursor', or any other of the other debugging capabilities. Most of the normal script commands are available to startup scripts, however `at_time()` and `wait_time()` are not supported. Startup script commands are only available to the MC33816 simulator and the CPU32 simulator

## 15.3 Watch Windows



The Watches window displays symbolic data specified by the user. Both local and global variables can be displayed within this window. See the Local Variable window to automatically display local variables.

The Watches window has a user-specified symbol on the far left. This is the symbol whose resolved value will be displayed. To the right of the user-defined symbol is an options button. This button accesses the Watch Options dialog box. In future versions of this software, this dialog box will allow individual settings for the watch to be specified.

To the right of the options button is a vertical separator bar. You can drag the vertical separator bar left or right using the cursor. To the right of the vertical separator bar is the symbol resolution field. If a value from the user-specified symbol can be resolved, then this field is automatically displayed. Otherwise, a message is displayed indicating that the specified symbol could not be resolved.

The user can edit the user-resolution field. In future versions of this software, this will cause the actual variable values within the targets to be modified.

### Symbolic Data Options

The Watches window supports both global and local variables. Variables are resolved by looking at the innermost local scope first, followed by any outer scopes, in order, then followed by any static variables, and finally the global scope.

Currently, a subset of C syntax is supported for the left-hand side symbol input:

- Pointers can be dereferenced with the '\*' operator.
- The address of variables can be found with the '&' address operator.
- Array elements can be accessed with the '[]' operator, where the subscript is an integer.
- Structure members can be accessed via the '.' or '->' operators.

In the current release, only a single operator per watch is supported. Future versions will support a more full-feature C syntax. Note that code must be compiled with symbolic debug information for this functionality to be available.

### Viewing Named Timer Region Information

Code can be instrumented with [named timing regions](#). Traversal time information across these regions can be viewed in the watch window using the following format.

**@AshTimer.TimingRegionName**

The traversal time and the number of system clocks in the last traversal are listed. Also the number of times traversed and the cumulative amount of time spend in the regions is also listed. Depending on the target the number of instruction cycles spend in the traversal region may also be listed.

### Viewing Print Action Command Output

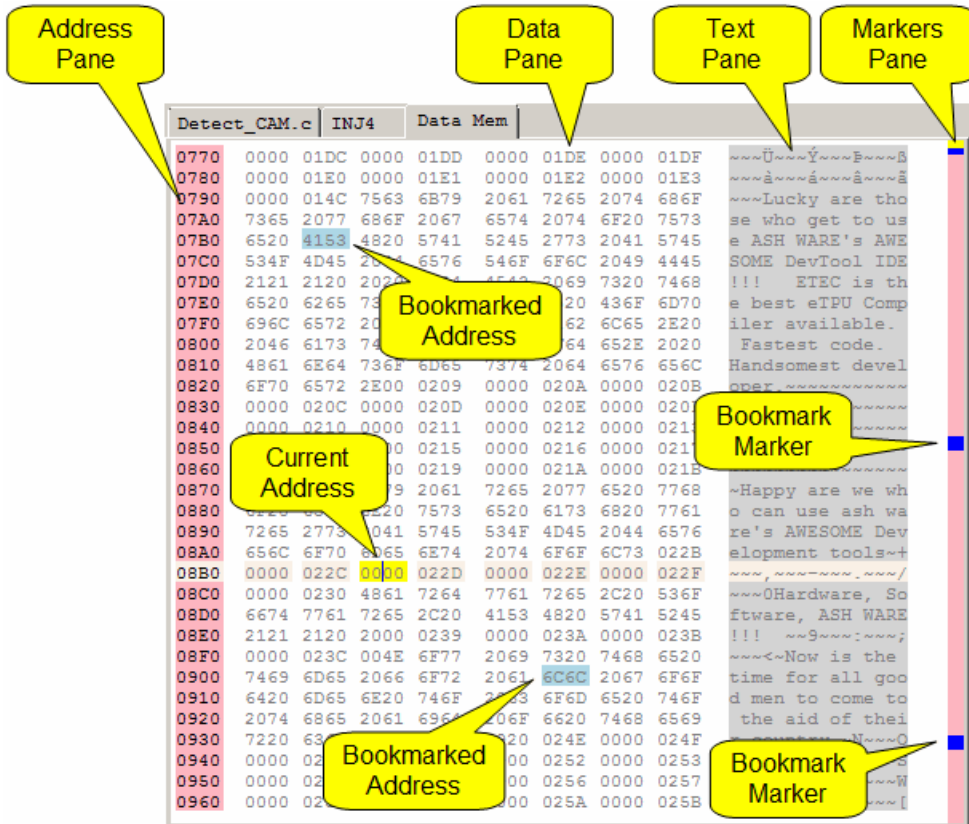
Print action commands support instrumentation of code to output code execution information. Think printf. This information is normally output to the trace buffer, and from the trace buffer can be piped to trace files for post processing. But it is also possible to view this information in the watch window using the following command.

**@AshTimer.FormatString**

Where the format string matches exactly a Print Action Command's format string from within the source code.

See the [Print Action Command section](#) for more information on how to instrument your code.

## 15.4 Memory Dump Window



### Miscellaneous capabilities

**To access the 'Goto Address' dialog,** double click an address box.

**General navigation** - use the keyboard's up/down, page-up/page-down, Home, End keys. Also, use the mouse's scroll bar or click anywhere in the markers pane, also, click on a marker to view it.

**To go to the first data in the row** - hit the 'Home' key twice.

**To go to address zero** - hit the 'Home' key three times.

**To go to the last address in the row** - hit the 'End' key twice.

**To go to the last address in memory** - hit the 'End' key three times.

**Editing** - Edit any data box to change it's value (only alphanumeric values are accepted). Edit in the text pane (most keystrokes are supported).

### Bookmarks

Bookmarks are used to quickly restore different views into the data memory. Stored view information includes selected address, the first row in the window, and active row within the window. The intent is to restore all aspects of the window layout. Bookmarks appear as little blue boxes in the 'Markers' box.

**To toggle a bookmark** - double click on any 'Data Box'

**To goto a bookmark** - click on the marker in the markers window.

**Additional bookmark navigation and hot-keys.** Right click to bring up the popup menu the various capabilities and associated hot keys are listed.

### Copy/Paste

**Multi-Select** - Hold the left mouse key down and select desired test. Note that the address and text fields can also be selected.

**Multi-Paste** - Multiple data's can be pasted from the window's clipboard. Data must be white-space or comma separated. Numbers are interpreted as decimal unless either a leading '0x' is detected or the number contains [a-zA-Z] characters. Out of range numbers are masked. The paste start is the cursor's address or the first address of the multi-select (if any).

**Example clipboard:**   0x1234, 0x4567 abcd





## 15.5 Local Variable Windows

| Local Variables |                      |        |                          |
|-----------------|----------------------|--------|--------------------------|
|                 | Symbol               | Value  | Type                     |
|                 | Delay                | 336    | _CHANNEL int24           |
|                 | PulseWidth           | 48     | _CHANNEL int24           |
|                 | Gap                  | 85     | _CHANNEL int24           |
|                 | PulseCount           | 5      | _CHANNEL int24           |
|                 | LastRisingEdge       | 836    | int24 [register sr]      |
| [-]             | MyArray              | 0x411  | _CHANNEL int24[]         |
|                 | MyArray[0]           | 257    | _CHANNEL int24           |
|                 | MyArray[1]           | 274    | _CHANNEL int24           |
|                 | MyArray[2]           | 546    | _CHANNEL int24           |
| [-]             | myStruct             | 0x41c  | _CHANNEL struct MyStruct |
|                 | myStruct._member1    | 6      | _CHANNEL int24           |
|                 | myStruct._member2    | 19     | _CHANNEL int24           |
|                 | myStruct._charMember | 45 ' ' | _CHANNEL unsigned char   |
|                 | CurrentPulseCount    | 1      | _CHANNEL int24           |
|                 |                      |        |                          |
|                 |                      |        |                          |

The Local Variables window automatically displays all local variables in the current context, along with their current values. Variable names are listed in a column on the left-hand side of the window. Values are displayed in a matching column on the right-hand side. The displayed format is relevant to the variable type. Additionally, if the variable is assigned a register, the register is output.

Based upon type, variables are automatically expanded. For example, if a variable is of type `int*`, the dereferenced pointer is displayed on the next line as an integer. Default expansion is up to three levels deep, with pointers, arrays, and structures/unions/bitfields supported. An alternative expansion level can be specified.

Future enhancements will give the user control over expansion and collapse of variables. Note that in order for this feature to be available, code must be compiled with symbolic debug information.

In order for this window to correctly identify and display local variables, the proper options for each compiler must be chosen. For instance, debugging information needs to be included and certain stack frame requirements must be met. In certain cases, highly optimized code may cause erratic behavior in this window. See the ASH WARE Web

page for a detailed explanation of the correct compiler settings for each target, and limitations when using certain specific compiler settings.

Note that as the target executes, the contents of the Local Variables window will usually change quite a bit. This is because each function generally has a unique set of local variables that are displayed. As the target moves from function to function, only the local variables of the currently executed function are displayed.

Global variables are not displayed within this window. See the description of the [Watches window](#) for information on how to display global variables.

## 15.6 Breakpoint Window

| File Name                        | Line | Hit Cnt | Hit Trg | Hit Lmt | Condition                           | Action                                    |
|----------------------------------|------|---------|---------|---------|-------------------------------------|-------------------------------------------|
| ● MeasurePulse.c (C:\GIT\ASH...  | 66   | 0       | %==0    | 10      |                                     |                                           |
| ● GatedPwm.c (C:\GIT\ASHWARE...  | 82   | 0       | always  | 1       | errorState == INPUT_PULSE_TOO_SHORT | print_to_trace("edge time = 0x%x", errA); |
| ✗ GatedPwmTest.EtpuCommand (...) | 34   | 0       | always  | 1       |                                     |                                           |
|                                  |      |         |         |         |                                     |                                           |
|                                  |      |         |         |         |                                     |                                           |

The Breakpoint Window displays all the source and script file breakpoints, and provides access to enhanced breakpoint capabilities. Breakpoints must initially be toggled on (created) from within a code/script editor window, by clicking on the left margin at the desired line. Once created, a breakpoint can be toggled off by left-clicking on the breakpoint icon. All other breakpoint attributes and capabilities are available within the Breakpoint Window, once a breakpoint is created.

All breakpoints from all targets and files are listed in the Breakpoint Window. It contains 8 columns. The first column indicates the breakpoint active status - clicking on this item toggles a breakpoint between enabled and disabled. Disabled breakpoints are ignored when simulation is running. Note that breakpoints can be completely deleted from within the window by selecting a breakpoint line (or multiple lines) and hitting the Delete key.

The second and third columns provide the file and line of the breakpoint. Left-clicking on either of these fields will cause the file to open/pop to the front of a tab, and scroll to the breakpoint.

The seventh column allows for a conditional expression to be entered for the breakpoint (source code breakpoints only). When execution reaches the breakpoint, the expression is evaluated. If it evaluates to a non-zero value, then the breakpoint is considered a "hit", whereas a zero result means execution continues and the breakpoint is ignored.

## 15. Operational Status Windows

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The fourth to sixth columns provide a hit count capability for breakpoints. This capability comes into play after a conditional expression is evaluated, if any. The fourth column displays the number of times the breakpoint has been encountered since simulation reset. The user can manually edit this field. The sixth column contains the hit limit value for the breakpoint (default of 1). This value can be used in conjunction with the hit count and the hit trigger type to determine whether the breakpoint should activate or be skipped. The hit trigger type is configured in the fifth column. The default is "always", which means the breakpoint should always activate, regardless of hit count or limit. The other trigger types are ">=", "=", "<", and "%=0" (modulo). For example, for the first, if hit count >= hit limit, then activate the breakpoint. The modulo trigger type activates when (hit count % hit limit) == 0.

The last column allows for the entry of a breakpoint action. This is essentially the same as the [action tag](#) capability, but linked to a breakpoint rather than an @ASH@ tag in the source code text. If a breakpoint passes its other tests and is set to activate, the logic checks to see if there is an action to process. If no action, the breakpoint halts execution as per normal. If there is, the action is processed (see the action tag section for the available commands), and if it succeeds, the breakpoint does not actually activate and execution proceeds.

# 16

## Dialog Boxes

This section covers the various dialog boxes used throughout the MC33816 Development Tool.

### 16.1 Goto Time Dialog Box

The Goto Time Dialog Box is opened via the Run menu by selecting the Goto Time submenu. It provides the capability to execute the MC33816 Development Tool until a user-specified time.

There are two types of Goto time options, one of which must be selected.

#### **Goto Until Time**

This sets the MC33816 Development Tool to execute until an absolute (simulation) time is reached. The simulation time is initially set to zero. The simulation time is reset to zero via the Run menu by selecting the Reset submenu.

#### **Goto Current Time, Plus**

This sets the MC33816 Development Tool to go to the current (simulation) time plus some user-specified additional time.

## 16. Dialog Boxes

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User-specified time is entered as thousands of seconds (ksec), seconds (secs), milliseconds (ms), microseconds (us), and nanoseconds (ns). Note that the MC33816 Development Tool resolution is one instruction cycle.

### Help

This accesses this help window.

### Goto

This closes the Goto Time dialog box and runs the MC33816 Development Tool until the specified time.

### OK, Save

This closes the Goto Time dialog box and saves any changes. The MC33816 Development Tool remains idle.

### Cancel

This closes the Goto Time dialog box without saving any changes.

## 16.2 Workshop Options Dialog Box

Each window is assigned to one or more Workshops.

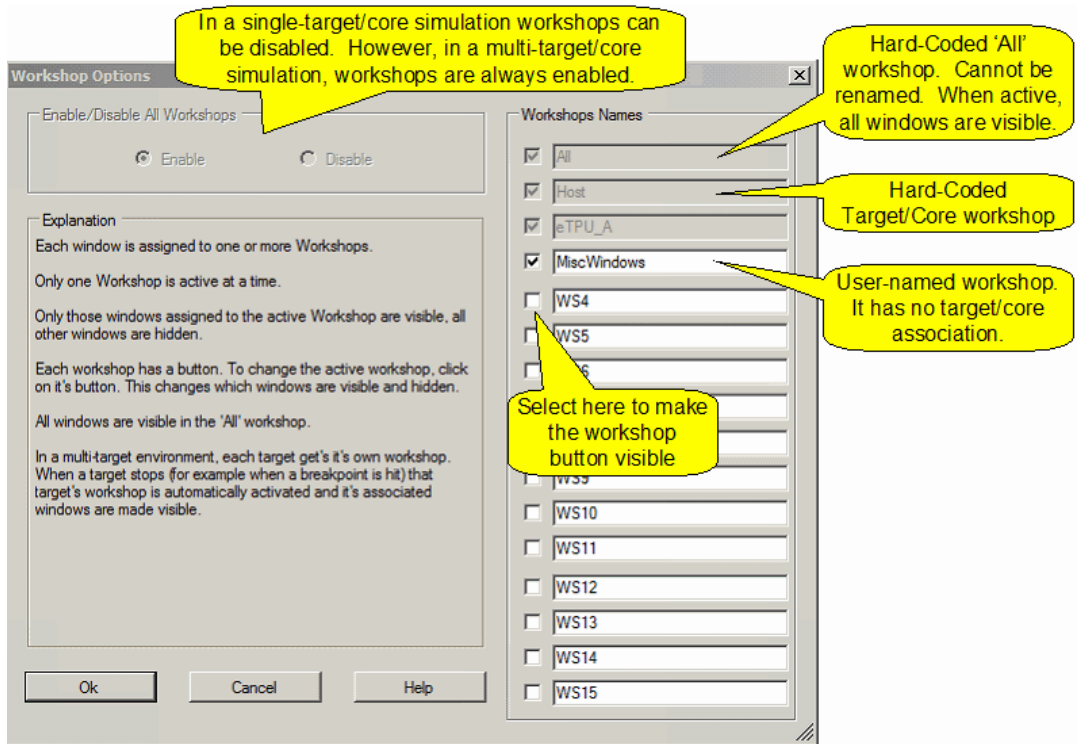
Only one Workshop is active at a time.

Only those windows assigned to the active Workshop are visible, all other windows are hidden.

Each workshop has a button. To change the active workshop, click on it's button. This changes which windows are visible and hidden.

All windows are visible in the 'All' workshop.

In a multi-target environment, each target get's it's own workshop. When a target stops (for example when a breakpoint is hit) that target's workshop is automatically activated and it's associated windows are made visible.



### Related Information

The ['Workshops'](#) section

The ['Workshops Occupy'](#) section on how to assign windows to workshops

## 16.3 Occupy Workshop Dialog Box

The Occupy Workshop dialog box provides the capability of specifying for individual windows which workshop(s) the window will be visible.

### OK

This closes the dialog box and saves any changes.

### Cancel

This closes the dialog box and discards all changes.

### Help

## 16. Dialog Boxes

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This accesses this help window.

### Occupy All

This causes the window to be visible in all workshops.

### Leave All

This causes the window to not be visible in any workshop. This should be treated as a shortcut for clearing all selections. Note that this is not the same as closing the window as the window will still exist within the MC33816 Development Tool .

### Revert

This causes any settings made since the dialog box was opened to be discarded.

### Options

This opens the [Workshop Options dialog box](#).

## 16.4 Message Options Dialog Box

The Message Options dialog box provides the capability to disable the display of various messages. These messages warn the users in a variety of situations such as a failed script verification command failure or when suspicious code is encountered.

## 16.5 Source Code Search Dialog Box

The Source Code Search Options dialog box is opened from the [Options menu](#) by selecting the Source Search submenu.

When the executable image is loaded, there are normally a number of source code files associated with the executable image that get loaded. The MC33816 Development Tool needs to be able to find these files. This dialog box allows specification of source code directories to be searched when searching for these source code files.

The search locations can be specified for each individual target, and for all targets globally. Specifying global search options is useful in situations in which multiple targets are using the same directories for their library files.

When searching for a source code file, the following algorithm.



- If the path to the file is fully-specified (e.g. c:\SomeDir\SomeFile.c) use that if the file exists there.
- If the path is partially specified (e.g. ..\OneUpDir\SomeFile.c) resolve the path relative to the code image file. For instance, if the code image file is at c:\SomeDir\SubDir\CodeImage.Elf, then check for this file c:\SomeDir\OneUpDir\SomeFile.c
- If the source file is still not found, use the raw file name (strip any prepended directory information) and search in the directory where the executable image file is located.
- If the source file is still not found, use the raw file name (strip any prepended directory information) and search for the file in the directory(s) listed in the 'Selected Targets' directory search list, starting from the top-listed directory.
- If file is still not found, use the raw file name (strip any prepended directory information) and search for the file in the directory(s) listed in the 'All Targets' directory search list, starting from the top-listed directory.

### **Add**

This button inserts a new directory into the search list.

### **Modify**

This button modifies a previously entered search location.

### **Delete**

This button removes a location from the search list.

### **Cut**

This button removes the currently selected search location from the search list, and places it into the paste buffer.

### **Copy**

This button adds the currently selected search location to the paste buffer without removing it from the search list.

### **Copy**

This button creates a new search location using the paste buffer.

### **Move Up**

This button moves the currently selected search location higher in the search list such that this location is searched earlier.

### **Move Down**

This button moves the currently selected search location lower in the search list such that this location is searched later.

## **16.6 Waveform Window Options Dialog Box**

The Waveform Window Options Dialog box defines the settings associated with the [Waveform](#) Window.

### **Clocks or Time**

Determines if the the Waveform Window should reference target clocks or time.

### **Display of Time**

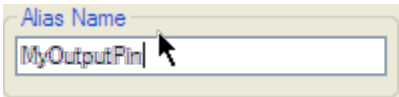
Determines the timebase and leading/trailing digits for the waveform window's display of time.

## **16.7 Waveform Signal Options Dialog Box**

The waveform dialog box allows a selection of a variety of signals for display in the waveform window. It also provides a options for viewing.

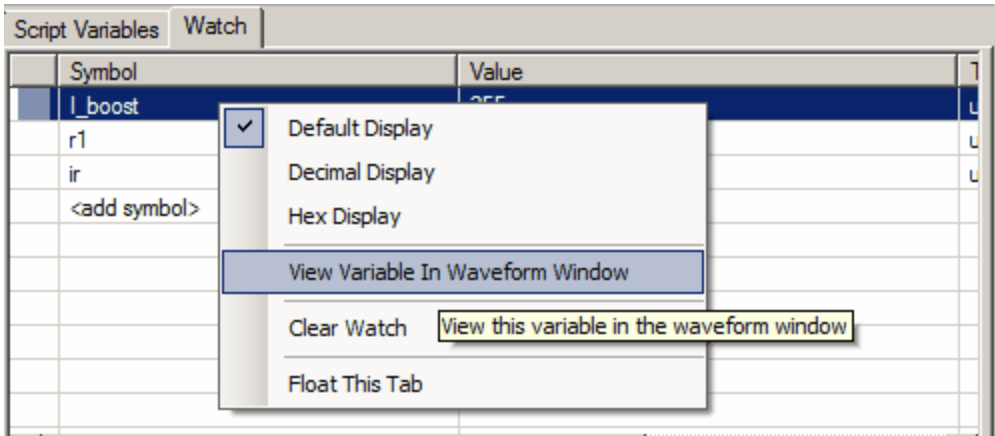
### **Alias Name**

The alias name allows the symbol name to be given a more intuitive and application-relevant name. For example, the underlying '\_ch10.out' signal could be renamed to be 'Spark 3'.



Code Variables

In order to display code variables as discrete nodes they first must be configured to be stored in the waveform data buffer. This is done from the watch window by right clicking on a symbol and selecting 'Make Waveform a Discrete Node' as shown below.



State Machine State

The state machine's state is automatically added to the waveform data buffer and is therefore available in the 'variables section'. Note that the State Name will appear if the mouse is hovered over the waveform as shown below in which the green portion of the waveform indicates that the 'HOLD\_ON' state was active over that period.



Analog and Discrete Signals

Analog and discrete signals can modify their vertical range.

The 'Auto Range View' button configures the waveform display visible portion of the waveform is fully visible in the display.

The 'Auto Range Buffer' button is exactly the same as the 'Auto Range View' button except that the entire waveform (including that in the buffer which may not be visible) will fit, vertically, into the display.

### Digital Signals

A variety of digital signals can be selected for viewing from the 'Node Selection' tree.

### Vector Files

A list of all nodes defined in the vector file is available along with the aliases for those named nodes. This allows waveforms to be quickly associated with aliases matching those in the vector file.

Note that unlike previous products, the waveform alias is not tied to the vector file. When the vector file reloads and the MC33816 Development Tool detects that the pin/signal of a waveform alias matching a vector file alias mismatch, the user will be asked if they want their waveform alias to update to the new pin/signal. This situation can happen if a user changes pin assignment in the vector file - the MC33816 Development Tool allows the user to easily update their Waveform configuration to match.

## 16.8 Trace Options Dialog Box

The Trace Options Dialog Box specifies which types of trace data are stored in the buffer and which are displayed in the trace window. Once a simulation is run, only data stored in the trace buffer can be displayed. However, trace data that is configured for storage in the buffer but not display can later be displayed without re-running the simulation. Data not configured for storage in the trace buffer cannot be viewed without re-running the simulation.

A computer's memory is finite and trace data can therefore sometimes overflow the trace buffer. In this case the oldest trace data is discarded to make room for the most recent trace data. One way to increase the effective buffer size is to disable certain types of data, or data from specific targets, from being stored in the trace buffer.

Note that in a multi-target environment 'Target Display' check boxes appear at the top of the trace window. These check boxes allow the enabling and disabling of all trace data for the entire target all at once. However, in order to be displayed, a trace type must be enabled in both the dialog box and in the checkbox at the top of the trace window.

Note that unlike previous simulation, all trace data from all targets is stored in a single trace buffer. So disabling storage of trace data from one target will increase the effective storage size of other targets.

### **Instruction Execution**

Selecting this option causes each instruction execution to be logged to the trace buffer.

### **Instruction Boundary**

Selecting this option causes each instruction boundary to be logged in the trace buffer. While an instruction boundary contains no useful information, the resulting dividing line makes the trace window easier to read.

### **Memory Read**

Selecting this option causes each memory read to be logged to the trace buffer.

### **Memory Write**

Selecting this option causes each memory write to be logged to the trace buffer.

### **Exception**

Selecting this option causes each exception to be logged to the trace buffer. This is only meaningful in the context of CPU targets.

### **Time Slot Transition**

Selecting this option causes each time slot transition to be logged to the trace buffer. This is only meaningful in the context of eTPU targets.

### **State End**

Selecting this option causes state end to be logged to the trace buffer. This is only meaningful in the context of TPU targets.

### **Pin Transition**

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Selecting this option causes each pin transition to be logged to the trace buffer. This is only meaningful in the context of TPU targets.

### SGL Negation NOP

Selecting this option causes SGL negation NOP to be logged to the trace buffer.

## 16.9 License Options Dialog Box

This dialog box allows you to enter additional information prior to sending a license file to ASH WARE Inc. A license file is generated whenever you install an ASH WARE product. Unfortunately, the license file generated at install time contains very little information other than a computer identifier. This dialog box allows you to add additional information such as your name, purchase order number, etc.

The license file has been a problem for ASH WARE in that users have sent in license files for purchased products but we were unable match the license files with the purchase. This dialog box is intended to reduce this confusion, thereby allowing us to serve you better.

All information is optional. Generally, it is best to include at least your company's purchase order number or the ASH WARE invoice number, if available.

## 16.10 Memory Tool Dialog Box

This tool supports specialized memory functions listed below. The dump file functions are also accessible from the `dump_file` script command listed in the [File Script Commands](#) section.

- [Fill memory with data or text](#)
- [Search for data or text](#)
- [Dump to disassembly file](#)
- [Dump to Motorola SRecord \(SREC\) file](#)
- [Dump to Intel Hexadecimal \(IHEX\) file](#)
- [Dump to image file](#)
- [Dump to "C" structure file](#)

For each function the address space and memory range can be specified. Earlier address ranges are stored in a buffer and can be retrieved using the recall button. For the file-dump options, selecting the change button can specify the file name.

In disassembly dump files inclusion of address, raw values, addressing mode information, and symbolic information can be selected.

When creating an image file or a "C" data structure file, or when using the fill function, the data word size can be 8, 16, or 32-bits. For the fill function, verification after the fill can be selected.

The find capability allows a specific byte pattern to be located in memory. Options include the ability to search for between one and eight sequential bytes, as well as the ability to search for both a case sensitive or case-insensitive string.

"C" data files can be written with the address included within a comment. Output format can be either hexadecimal, which is the default, or decimal.

Selection of endian ordering is available for where the data size exceeds one byte. This option is available when dumping to an image or a "C" structure file or when using the find function. In cases where the selected endian ordering does not match the natural endian ordering of the target a warning is displayed.

## 16.11 The 'About' Dialog Box

The MC33816 Development Tool (C) 2012-2024 ASH WARE, Inc.. All rights are reserved. Various national and international laws and treaties protect these rights. Any misuse or other violation of the copyright will be prosecuted to the full extent of the law.

The MC33816 Development Tool media may not be copied or transmitted except for the purpose of creating a backup copy for archival purposes.





# 17

## Menus

This section covers the various application menus in the MC33816 Development Tool.

### 17.1 Files Menu

#### **The Recent, ... submenu's**

The Recent Project, Source, Script, Vector, and Other submenu's allow recently-opened files to be readily re-opened.

#### **Open Existing, ... submenu's**

Opens a dialog for selection of existing files.

#### **Create New**

Creates a brand new file. A dialog opens that allows selection of the new file's filename. When creating a new Source code files, State Machine, or Primary Script file the new file can either be blank or created from a template.

#### **Save File**

Saves the currently-active file.

#### **Save All Files**

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Saves all open files that have been modified (dirty).

### **Close**

Closes the currently-active file.

### **Project, Save**

Saves the current settings to the project file and the environment file. The project file contains all the key settings and is typically placed in version control. The environment file contains all the user settings such as window positions, open files, etc., and is typically specific to each user and not placed in version control.

### **Write**

A number of files can be generated

The Code Coverage Statics file lists which code has been executed.

The Code Load report gives statics on the currently-loaded code.

The Trace Buffer file shows detailed trace information from the last simulation run.

The Symbol Table file gives detailed symbolic (variable) information on the loaded code.

The Window Snapshot takes a snapshot of the currently active window and saves it to a file. This is great for documentation.

## 17.2 Build Menu

### **Build All**

Force a re-build of all code, regardless of whether the source files have been modified or not

### **Make**

Conditionally re-build code, based on whether or not the source code files and project settings have changed since the last build.

### **Compile**

Compile (or assemble) the active source code file

### Re-Parse Script

Re parse just the script file. *Note that the hot-key for this action when editing is 'Ctrl+R' which is the same as 'Reset' when simulating.*

### Re-Parse Vector

Re parse just the vector file. *Note that the hot-key for this action when editing is 'Ctrl+R' which is the same as 'Reset' when simulating.*

### Help

This accesses this help screen.

## 17.3 Edit Menu

### Goto Error

In the Output Window, errors and warnings from the last build, script parse, and vector parse are listed. These menu items activates the referenced file and scrolls to the referenced file line.

### Goto Line ...

Opens a dialog to move the cursor to a specific line in a source code file.

### Find

Finds text in files. Options are as follows.

- Just a single file or multiple files can be searched
- Included files (using #include) can be searched
- The last search option can be repeated.
- All files in a specific directory can be searched
- Files in sub-directories can be included in the search

### Bookmarks

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Bookmarks can be dropped on to lines of code. These lines of code can be quickly brought back into view using 'Goto Next Bookmark'

### Select All

Selects all text in an editable file.

### Cut, Copy, Paste

Uses the standard windows clipboard to perform 'Cut, Copy and Paste' functions.

### Undo, Redo

Undo edits. Redo the undo edits.

### Block Indent, Block Un-Indent

Adds or removed indentation from multiple text lines.

### Help

This accesses this help screen.

## 17.4 Step Menu

### Into

This runs the active target until one line of source code is executed. If a function is called, MC33816 Development Tool halts on the first instruction within that function. If no instructions associated with source code lines occur, MC33816 Development Tool continues to run until stopped by selecting the Stop submenu in the Run menu.

### Over

This single steps the target by one line of source code, stepping over any function call. This is the same as the above "Into" function except the "Into" function will halt on a line of source code within the function that is called. If no instructions associated with source code lines occur, MC33816 Development Tool continues to run until stopped by selecting the Stop submenu in the Run menu.

### Out

This runs the active target until the current function returns. Execution is halted on the next line of source to be executed in the calling function. If no instructions associated with source code lines associated with a calling function occur, MC33816 Development Tool continues to run until stopped by selecting the Stop submenu in the Run menu.

### **Anything**

This causes one action to be performed. This action may be execution of a single instruction, execution of a script command, or simply a tick of the CPU clock. This is helpful for advancing execution by as small an amount of possible, allowing you to really zoom in on a problem.

### **Script**

This runs MC33816 Development Tool until one script command from the active target is executed. If no new script commands become available MC33816 Development Tool continues to run until stopped by selecting the Stop submenu in the Run menu.

### **Thread Start**

Runs until the beginning of the core's next thread (a wait-table's event becomes true.) Execution stops just prior to execution of the first opcode in the thread. If no thread occurs, execution continues to run until stopped by selecting the Stop submenu in the Run menu.

### **Thread End**

This command is excellent for running from thread-to-thread.

- If in a thread, run, then stop at the end of the thread.
- If at the end of a thread, run until the beginning of a thread

### **Assembly**

This runs the active target until a single assembly instruction occurs. If instructions occur, DevTool continues to run until stopped by selecting the Stop submenu in the Run menu.

### **Assembly, N**

This runs the active target until a user-specified number of assembly instructions occur. A dialog box opens allowing specification of the desired number of assembly instructions. If no assembly instructions occur, MC33816 Development Tool continues to run until stopped by selecting the Stop submenu in the Run menu.

### Help

This accesses this help screen.

## 17.5 Run Menu

### Goto Cursor

This runs MC33816 Development Tool until an instruction associated with the current cursor location is about to be executed or a breakpoint is encountered. A source code window must be active for this command to work.

### Goto Time

This opens the [Goto Time dialog box](#). Runs MC33816 Development Tool until the specified time or until a breakpoint is encountered.

### Goto Time, Fast

This behaves exactly like the Goto Time submenu, except the goto time dialog box is not opened. Instead, the previously specified Goto Time options are used.

### Go

This causes MC33816 Development Tool to execute indefinitely. MC33816 Development Tool executes until a breakpoint is encountered or until the user terminates execution by selecting the Stop submenu in the Run menu.

### Stop

This causes MC33816 Development Tool to stop executing. This is normally used to stop MC33816 Development Tool when the expected event (such as step, breakpoint, time slot transition, etc.) failed to occur.

### Reset and Go

This causes MC33816 Development Tool to reset and immediately begin execution. The reset actions are specified in the Reset Options submenu. MC33816 Development Tool will execute until a breakpoint is encountered or until interrupted by the user selecting the Stop submenu from the Run menu.

### Reset

This causes MC33816 Development Tool to reset. The reset actions are specified in the [Options](#) submenu in the Reset menu.

### **Help**

This accesses this help screen.

## **17.6 Breakpoints Menu**

The breakpoints menu controls the various functions associated with the breakpoint capabilities of the MC33816 Development Tool. These capabilities are accessed via the following submenu's.

### **Set (Toggle)**

This toggles a breakpoint at the source code window's cursor. If the instruction already has a breakpoint, then the breakpoint is deleted. A source code window must be active for this to work. If the source code is in mixed assembly view mode, and the cursor is at a dis-assembly line, then the breakpoint will be generated for only that address.

### **Delete All**

This deletes all active and all disabled breakpoints.

### **At Address ...**

This opens a dialog box which allows placing a breakpoint any user-specified address. This is useful when debugging code for which there is no line number information, such as GNU assembly code.

### **Delete All Script**

This deletes all breakpoints that are in the script commands file.

### **Help**

This accesses this help screen.

### 17.7 View Menu

This menu opens the various Simulator windows for viewing. The MC33816 Development Tool allows multiple instances of each window to be open simultaneously. When there are multiple targets a submenu for each target appears. Otherwise, all available windows are available directly within the view menu.

See the [Operational Status Windows](#) chapter for a listing of the available windows for each target.

#### Help

This accesses this help screen.

### 17.8 Options Menu

The Options menu provides the user with the capability of setting various Simulator options. These are listed below.

#### Workshop

This opens the [Workshops Options dialog box](#).

#### Messages

This opens the [Message Options dialog box](#).

#### Waveform, ...

This opens the [Waveform Window Options dialog box](#)

#### Waveform

This accesses a number of sub-menus used for setting the currently-active waveform in the waveform window.

#### Help

This accesses this help screen.



## 17.9 Help Menu

The Help menu provides the following options.

### **Contents**

Accesses the contents screen of MC33816 Development Tool's on-line help program.

### **Technical Support**

This accesses information on obtaining technical support for this product.

### **About**

This gives general information about MC33816 Development Tool.



# 18

## Supported Targets and Available Products

Due to its layered design, MC33816 Development Tool supports a variety of both simulated and hardware targets. Customer requirements dictate that these capabilities to be offered as specific individual products.

### 18.1 MC33816/CPU System Simulator

Our MC33816/CPU System Simulator supports instantiation and simulation of an arbitrary number and combination of MC33816s and CPUs. A dedicated external system modeling CPU could be used, for instance, to model the behavior of an automobile engine. Executable code can be individually loaded into each of these targets. Synchronization between targets is fully retained as the full system simulation progresses.

All CPU engine targets can be used with this system simulation include the CPU32 and soon-to-be-released, PPC simulation engines.

### 18.2 MC33816 Simulation Engine Target

The MC33816 is an twelve channel gate driver IC for automotive engine control, motor control, and other applications that can take advantage of the integration of the four microsequencers in the same device as the power drivers. The IC consists of five external MOSFET high side pre-drivers and six external MOSFET low side pre-drivers. The

## 18. Supported Targets and Available Products

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MC33816 provides a flexible solution for MOSFET's gate drive with a versatile control and optimized latency time. Gate drive, diagnosis, and protection are managed through four independent microcores, and two Code RAM and two Data RAM banks.

The MC33816 simulation engine can be used both as a stand-alone device and in conjunction with other targets including multiple CPUs. When used in stand-alone mode, of primary importance are [script commands files](#) and [test vector files](#).

# 19

## Building the Target Environment

The simulated or hardware development environment is specified in special MtDt build script files. ASH WARE provides standard build scripts for all its products. In the vast majority of cases these build scripts are sufficient and therefore effectively transparent to the user. But occasionally a user may desire to modify the simulation environment to unlock advanced capabilities. This chapter describes how to do so.

A complete system may consist of multiple CPUs, eTPUs, peripherals, and non-electrical devices such as automobile engines. The MC33816 Development Tool supports simulation of such advanced systems using MtDt build script files. MtDt build script files are used to create the targets and specify how they interact.

### Theory of Operation

MC33816 Development Tool is capable of instantiating and simulating multiple targets, allowing them to interact via shared memory while maintaining the correct synchronization and relative timing. In addition, a rich set of debugging capabilities normally associated with single target systems has been extended to this multiple target environment.

Each target loads and runs its own executable code image.

Each target can have primary and startup script commands files. TPU targets can also have ISR files that are associated with and activated by specific interrupts, and test vector file that can be used to wiggle the TPU's I/O pins.

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The relative timing of targets is maintained with one femto-second precision. Each target has its own atomic execution step size that must be a multiple of the femto-second precision. Negative numbers and zero are valid steps sizes. Since the currently-supported targets are all execution cycle simulators, the step size is equal to the amount of simulated time it takes to execute a single opcode.

As each target executes it is advanced by the amount of time the last opcode took to execute. It is then scheduled to execute again when the simulation time is equal to the target's next scheduled time. The current simulation time is defined as the time that the next scheduled target will execute.

Although all the currently-supported targets are execution-cycle simulation engines, this is not a fundamental restriction of MtDt. In fact, MtDt can support targets that have much finer execution granularities. This would allow, for instance, a VHDL target that properly models inter-target interaction down to the transistor level.

### Debugging Capabilities

All standard single-target debugging capabilities such as single stepping, breakpoints, goto cursor, etc., are available in the multiple target debugging environments. For instance, if breakpoints are injected and activated within multiple targets, the simulation halts on whichever breakpoint is encountered first.

A concept of an "active target" is employed to support specifically single-target capabilities such as single stepping. When the active target is single-stepped, the entire system simulation proceeds until the active target completes the commanded single step.

With an essentially limitless number of targets, and with the large number of possible windows per target, the vast number of windows can become unwieldy, to say the least. Actually, without some mechanism to bring order to the chaos of having way too many windows, MtDt becomes unusable. Workshops bring order to this chaos and are therefore a key enabling feature that makes MtDt usable. Each target can be associated with a specific workshop. Those target's windows are displayed only when the workshop associated with that target is activated. Individual windows can be overridden to appear in more than one target.

A target other than the active target can halt a simulation. In this situation the workshop is changed to one associated with the halting target. This can be caused, for instance, if a breakpoint is encountered in a non-active target. In this case, the simulation is halted, the halting target becomes the active target, and the workshop is switched to the one associated with the newly-active target.

## Building the MtDt Environment

With MtDt an entire hardware or simulation environment can be built. This is done using a dedicated build script file that gets loaded when the project file is loaded. A detailed description of each command that can be used within MtDt build script files is found in the [MtDt Build Script Commands File](#) section. That section explains how a complete system is defined using these build script commands.

## MtDt Simulated Memory

Simulated targets require memory for executing code, for holding data, and for providing capabilities supported in a simulated environment. The following is a list of simulated memory characteristics supported by MtDt memory.

- [Multiple address spaces](#)
- [Memory sizing](#)
- [Read only or read/write accesses](#)
- [Shared memory](#)
- [Byte, word, and long-word access widths](#)
- [Access speed based on even or odd access addresses](#)
- [Privilege violations](#)
- [Bus faults](#)
- [Address faults](#)
- [Banking](#)
- [Mirroring](#)

The ASH WARE MtDt simulated memory model supports all of these characteristics though at the cost of increased complexity. The good news is that for many applications the standard memory models work just fine so a detailed understanding of memory modeling is not required. In the vast majority of other cases only a small percentage of these capabilities are required.

## Memory Block

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Whereas a simulated memory map can support a large variety of characteristics that might change from one memory range and address space to the next, a memory block is a range of memory that has a single uniform set of characteristics.

A target's address space comprises a finite number of memory blocks. For instance, a 3 wait state RAM could reside at address 0 to FFFF hexadecimal. A 0 wait state ROM could reside at address 1000 to 1FFFF. The rest of memory, from 1000 to FFFFFFFF hexadecimal, could be empty.

There are a number of rules associated with memory blocks. A build of MtDt simulated memory will succeed only if both of the following rules are met:

- Memory blocks must cover all memory.

- Memory blocks may not occupy both the same address and address space.

A report file for each build attempt provides a detailed listing of the memory map, including the information required to fix any problems.

The following is an example script commands sequence.

```
#define MEM_DEVICE_STOP 0xffff
#define BLANK_START MEM_DEVICE_STOP + 1
#define MEM_END 0xffffffff
instantiate_target(SIM32, "MySim32");
add_mem_block("MySim32", 0, MEM_DEVICE_STOP,
 "RAM", ALL_SPACES);
add_non_mem_block("MySim32", BLANK_START, MEM_END, "OFF",
 ALL_SPACES);
```

In this example a single CPU32 CPU is instantiated. A 64K simulated memory device is added between addresses 0 and FFFF hexadecimal and is assigned the name "RAM." The device resides in all address spaces. A second memory block, also residing in all address spaces, fills the rest of memory between 1000 hexadecimal and FFFFFFFF hexadecimal and is assigned the name "OFF." This block is blank and as such takes up no physical memory on your computer.

### Address Spaces

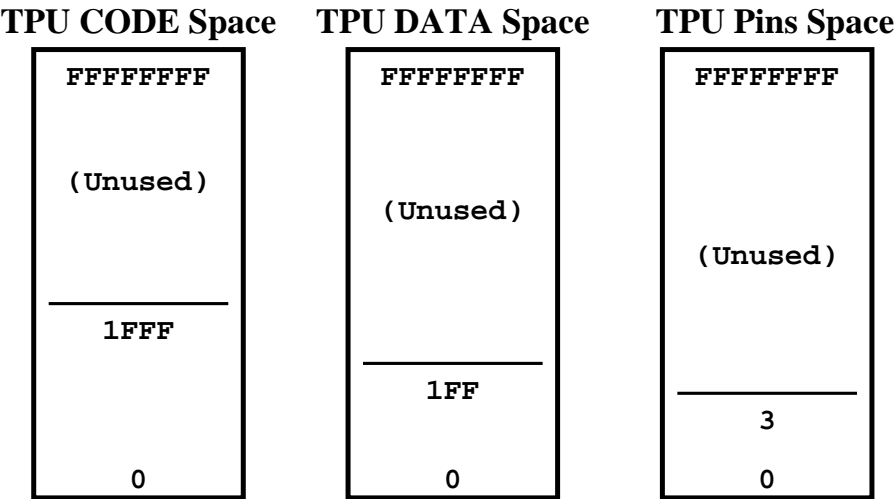
All MC33816 Development Tool simulated memory supports eight address spaces. The function of each address space depends entirely on the particular target and how it is specified in the build script file. For instance, a simulated TPU target makes use of three address spaces: Code, Data, and Pins. By treating its I/O pins as shared memory the simulated TPU exposes its pins to other targets. This allows, for instance, a simulated engine model to read and modify the TPU's pins.



With the nearly universal acceptance of the superiority of a single, unified, large address space why does MtDt still support non-unified memory space architecture? The answer is twofold. First, the MtDt supports older but still popular architectures such as CPU32 in which a split code/data and space might actually be employed. Second, the multiple address space model provides the required mechanism for support of advanced simulation features. These mechanisms do not necessarily exist in the actual hardware. For example, an engine modeling CPU might be set up to query and modify TPU channel I/O pins. To support this, the TPU pins have been exposed in a purely theoretical "PINS" address space. The MC33816 Development Tool can be configured so that a read or write in the engine modeling CPU's DATA\_SPACE occurs in the eTPU's PINS space, thus allowing the engine modeling CPU to react to and drive the TPU's pins. This mechanism does not have a hardware corollary, but it provides the powerful capability of simulating the full system.

In many cases a uniform address model is desirable. This is achieved by mapping all address spaces to the same physical memory.

The following diagram depicts the address spaces accessed by the TPU simulation engine.



The TPU simulation model fetches code between 0 and 1FFF hexadecimal from its CODE space. It accesses its parameter RAM and host interface registers between 0 and 1FF hexadecimal of its DATA space. And it accesses its channel pins in the first four bytes of a simulated PINS space. Note that its code banks are "unrolled" and placed linearly in memory.

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In order for accesses to these spaces to behave properly, simulated memory devices must be placed into these address spaces. The following build script commands create the required memory for a stand-alone TPU Simulation engine.

```
// Create a target TPU
instantiate_target(TPU_SIM, "TpuSim");
// Create a simulated memory block
// for the TPU's code (microcode)
add_mem_block("TpuSim", 0, 0x1fff, "Code",
 TPU_CODE_SPACE);
add_non_mem_block("TpuSim", 0x2000, 0xFFFFFFFF,
 "UnusedCode", TPU_CODE_SPACE);

// Create a simulated memory block
// for the TPU's data (host interface)
add_mem_block("TpuSim", 0, 0x1fff, "Data",
 TPU_DATA_SPACE);
add_non_mem_block("TpuSim", 0x200, 0xFFFFFFFF,
 "UnusedData", TPU_DATA_SPACE);

// Create a simulated memory block for the TPU's pins
// (channel pins and TCR2 counter pin)
add_mem_block("TpuSim", 0x0, 0x3, "Pins",
 TPU_PINS_SPACE);
add_non_mem_block("TpuSim", 0x4, 0xFFFFFFFF,
 "UnusedPins", TPU_PINS_SPACE);

// Be sure to provide a non_mem block
// for the unused address spaces
add_non_mem_block("TpuSim", 0x0, 0xffffffff, "B4",
 TPU_UNUSED_SPACE);
```

In this example the TPU's code, data, and pins address spaces are filled with the memory devices required for proper operation. Unused space above and below the simulated devices is filled in with blank blocks. This is required, as all space must be filled in; even unused space must be provided with memory block(s).

### Memory Block Size

Each memory block has a specific size. The size is equal to the stop address minus the start address plus one. A common error is to overlap by one byte the end of one device with the start of the next device. MtDt cannot support multiple devices occupying the same address in the same address space so this causes an error. One method for avoiding

this error is to cascade ‘#define’ directives and thereby ensure that contiguous devices form the proper zero-byte seam.

```
#define FLASH_SIZE 0x10000 /* 64K FLASH device */
#define RAM_SIZE 0x8000 /* 32K RAM device */
#define FLASH_START 0
#define FLASH_END FLASH_START + FLASH_SIZE - 1
#define RAM_START FLASH_END + 1
#define RAM_END RAM_START + RAM_SIZE - 1
#define BLANK_START RAM_END + 1
#define BLANK_END FFFFFFFF
instantiate_target(SIM32, "MyCpu");
add_mem_block("MyCpu", FLASH_START, FLASH_END,
 "Flash", ALL_SPACES);
add_mem_block("MyCpu", RAM_START, RAM_END, "RAM",
 ALL_SPACES);
add_non_mem_block("MyCpu", BLANK_START, BLANK_END,
 "Empty", ALL_SPACES);
```

In this example, two devices are created in such a way that a zero-byte seams between them is guaranteed. All memory for every address spaces is covered. Notice that the FLASH and RAM sizes can be changed at a single location and that the devices will remain contiguous in memory.

## Memory Block Access Control

The purpose of the memory block access control is to make a simulated model match the behavior of real hardware. For instance you might want to make a ROM read-only, such that reads are simply ignored or perhaps cause a bus fault. An odd access may cause an address fault or an additional wait state. Memory block access control allows the required level of control to achieve this. This section serves as a high-level guide rather than a detailed description.

Each memory block supports the following access types.

```
8-bit read
8-bit write
16-bit read
16-bit write
24-bit read
24-bit write
32-bit read
32-bit write
64-bit read
```

```
64-bit write
128-bit read
128-bit write
```

For each access type, the user can specify a number of parameters. The following parameters are available.

```
Clocks per even access
Clocks per odd access
Odd access causes bus fault yes/no?
Bus fault yes/no?
Blank access yes/no?
Dock offset (applicable docked accesses only!)
Dock function code (applicable to docked accesses only)
```

In addition, there is a block-wide default, "blank access value." This is the value that is returned on a read access to a memory block that has been marked as blank.

### Read/Write Control

It is possible to disable specific types of memory accesses.

In this example a memory device is configured as read only. A write to this memory device will not cause the values in memory to change. This read only behavior could be used to model a ROM device.

```
#define ROM_STOP 0xffff
#define BLANK_START ROM_STOP + 1
#define MEM_END 0xffffffff
instantiate_target(SIM32, "MyCpu");
add_mem_block("MyCpu", 0, ROM_STOP, "Rom", ALL_SPACES);
add_non_mem_block("MyCpu", BLANK_START, MEM_END, "Empty",
 ALL_SPACES);

// Turn off READ access for the ROM device
#define WRITE_ALL RW_WRITE8 + RW_WRITE16 + RW_WRITE32
set_block_to_off("MyCpu", "Rom", ALL_SPACES, WRITE_ALL);
```

The command specifies that for all address spaces, all write accesses will be "empty." Despite this being an "empty" access, other parameters such as clocks per even cycle remain valid. The last two arguments specify the address spaces and access types affected by this script command. It is possible to indicate specific address spaces and a specific type of access. For instance, using this script command, one could specify 32-bit writes to user data space.

### Clocks per Access Control

For each memory block and type of access, the clocks per even access and the clocks per odd access can be specified. This capability effectively provides the capability of setting the number of wait states.

```
set_block_timing("MyCpu", "Rom", ALL_SPACES, RW_ALL, 2, 3);
```

In this example even accesses are set to two clocks per access and odd accesses are set to three clocks per access. In this example these settings apply to all address spaces and for all read and write accesses, though it is possible to indicate the specific set of address spaces and access types for which this applies.

## Address Fault Control

For each address space and access type an address fault can be set to occur on odd accesses. Note that this is generally not applicable to 8-bit accesses, though it is still available.

```
#define CODE_SPACE CPU32_SUPV_CODE_SPACE \
 + CPU32_USER_CODE_SPACE
set_block_to_addr_fault("MyCpu", "Rom", CODE_SPACE,
 READ_ALL);
```

In this example, odd read accesses to the memory block's code space are configured to cause an address fault.

## Bus Fault Control

For each address space and access type a bus fault can be set to occur.

```
set_block_to_bus_fault("MyCpu", "Rom",
 CPU32_USER_CODE_SPACE, RW_ALL);
```

In this example, any access while at the user privilege level result in a bus fault. This might be useful in a protected system in which a user process is prevented from accessing hardware.

## Sharing Memory

A fundamental aspect of multiple target simulation is the ability to share memory. MtDt employs "docking" to implement shared memory. If two targets are to share memory, one target must dock memory blocks to another target.

There is a fundamental and important lack of symmetry in that one target must provide the "dock-from" block and the other target must be the "dock-to." The "dock-to" target is

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relatively unaffected by being the recipient of a dock, other than that its physical memory might be modified on occasion.

On the other hand, there are numerous effects to the "dock-from" target. First and foremost, it must be able to support extrinsic, or externally mapped, memory. In other words, it must be able to project its memory access outside of itself and to a different target.

Note that this command must match exactly the memory bounds of an existing memory block for the docking device, but not for the "dock-to" target. In fact, the "dock-to" target could be any target such as a MC68332 across a BDM port. In fact, the "dock-to" target could be itself, and this is the recommended way of modeling multiple image memory. Although memory accesses are fully re-entrant, legal, and often necessary, it is possible to create an infinitely cyclic access that would, without guards, cause a stack overflow on your computer. To guard against this, MtDt has limited memory accesses re-entrance to a depth of 100.

The following build script command is presented in a later example.

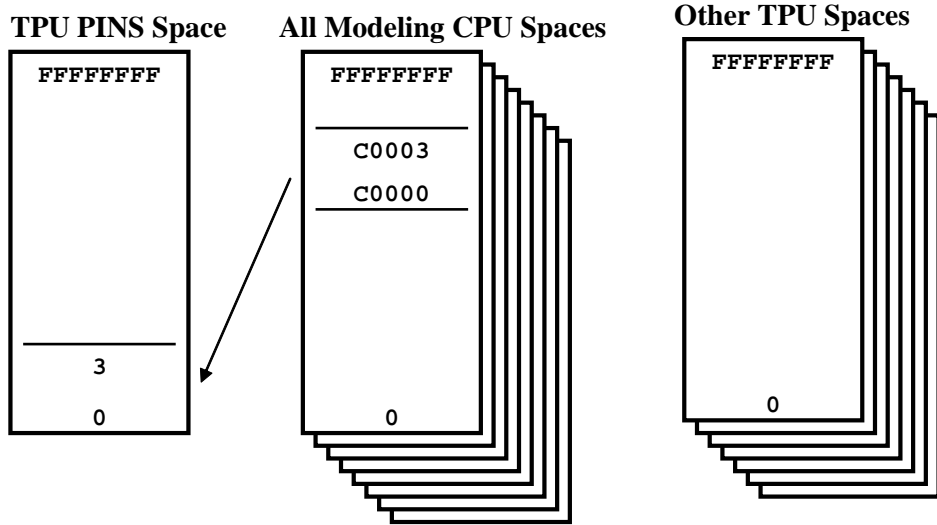
```
// ...
set_block_to_dock("HostCpu", "TpuDataDock", ALL_SPACES,
 "Tpu", 0-0x80000);
// ...
```

In the above command a previously-added blank block is docked to memory contained in a target named "TPU." The last argument, ALL\_SPACES, is potentially problematic, as will be discussed later.

### Shared Memory Address Space Transformation

No assumptions should be made about address spaces between or among dissimilar targets. In other words, the code space of a CPU32 may not map to the code space of memory shared with a TPU. For memory docks between dissimilar target types it is critical to fully specify all address spaces from the docking memory block. Due to the lack of symmetry, this is not true for the dockee. The following script command should be used to fully define all docked address spaces between dissimilar targets.

When docking a CPU to a TPU the following address space transformation such as that shown in the following figure is often required.



The following build script commands generate the address space transformations shown in the above figure. If the modeling CPU does a read from its address `C0000` hexadecimal, the read will actually access the shared memory with the TPU in its PINS space.

```
set_block_dock_space("ModelingCpu", "TpuPinsDock",
 ALL_SPACES, RW_ALL, TPU_PINS_SPACE);
```

In this example all address spaces from a docked block of a modeling CPU are set to the TPU's PINS address space. This is an eight-to-one transformation in that an access in any of the CPU's address spaces becomes an access to the TPU's PINS space. For example if the CPU performs a data read within this block, the value of the TPU's channel pins will be what actually gets read.

## Shared Memory Address Offset

Shared memory need not appear in the same address from the perspective of each target. Indeed, shared memory usually appears at different addresses for each target that is sharing that memory. The following illustrates this.

```
set_block_to_dock("HostCpu", "TpuDataDock", ALL_SPACES,
 "Tpu", TPU_DOCK_OFFSETT);
```

In this example an offset of `TPU_DOCK_OFFSETT` is applied to any `HostCpu` access within the docking block. For example if the docking block is at address `FFE00`

hexadecimal and an offset of -FFE00 hexadecimal is applied by defining TPU\_DOCK\_OFFSETT to this value, a CPU access at address FFE20 occurs at address 20 within the TPU.

### Shared Memory Timing

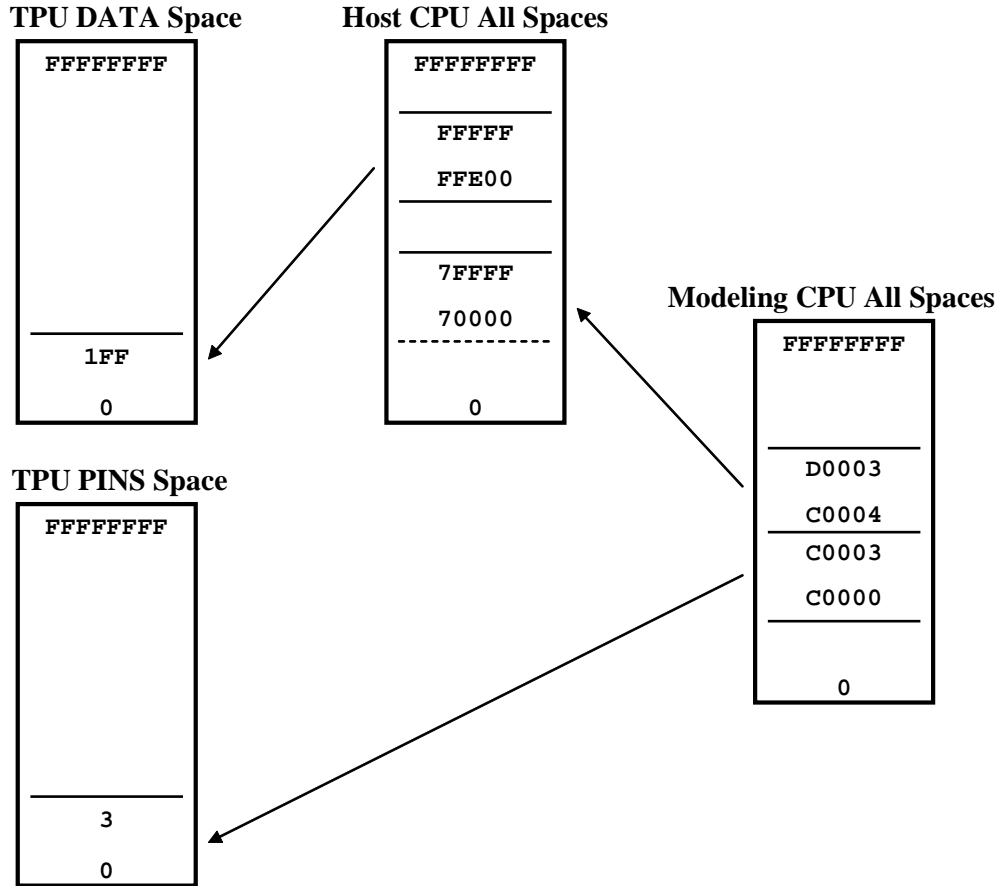
Timing transformations allow the clock per access to be specified for the docking block. For instance a shared memory block between a TPU and a CPU might take the CPU two clocks to access, but might take the TPU only a single clock.

There is no special method for doing this. The timing parameters specified by each of the targets own dock block apply to the docking target.

### A Complete Shared Memory Example

The example in this section creates a TPU simulation engine, a host CPU simulation engine, and a modeling CPU simulation engine. The shared memory architecture from the following figure is generated.





The following build script commands instantiate the shared memory architecture found in the above figure.

```
#define MEM_END 0xffffffff

// Create a target TPU
instantiate_target(TPU_SIM, "Tpu");

// Create a simulated memory block
// for the TPU's code (microcode)
add_mem_block("Tpu", 0, 0x1fff, "Code", TPU_CODE_SPACE);
add_non_mem_block("Tpu", 0x2000, MEM_END, "B1",
```

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```
 TPU_CODE_SPACE));

// Create a simulated memory block
// for the TPU's data (host interface)
add_mem_block("Tpu", 0, 0x1fff, "Data", TPU_DATA_SPACE);
add_non_mem_block("Tpu", 0x200, MEM_END, "B2",
 TPU_DATA_SPACE);
// Create a simulated memory block for the TPU's pins
// (channel pins and TCR2 counter pin)
add_mem_block("Tpu", 0x0, 0x3, "Pins", TPU_PINS_SPACE);
add_non_mem_block("Tpu", 0x4, MEM_END, "B3",
 TPU_PINS_SPACE);
// Be sure to provide a non_mem block
// for the unused address spaces
add_non_mem_block("Tpu", 0x0, MEM_END, "B4",
 TPU_UNUSED_SPACE);

//***** END OF TPU *****

// Create a target host CPU
instantiate_target(SIM32, "HostCpu");

// Add a half-meg RAM
add_mem_block("HostCpu", 0, 0x7FFFF, "RAM", ALL_SPACES);

// Add three empty spaces
add_non_mem_block("HostCpu", 0x80000, 0xFFDFF, "B1",
 ALL_SPACES);
add_non_mem_block("HostCpu", 0xFFE00, 0xFFFFF,
 "TpuDataDock", ALL_SPACES);
add_non_mem_block("HostCpu", 0x100000, MEM_END, "B2",
 ALL_SPACES);

// Set the middle empty block to dock with the TPU target
set_block_to_dock("HostCpu", "TpuDataDock", ALL_SPACES,
 "Tpu", 0-0x80000);
// Make sure that no matter which space
// the TPU accesses within this dock
// the TPU's data space is always accessed
set_block_dock_space("HostCpu", "TpuDataDock",
 ALL_SPACES, RW_ALL, TPU_DATA_SPACE);

//***** END OF HOST CPU *****
```

```
// Create a CPU for modeling the external system
instantiate_target(SIM32, "ModelCpu");

// Add a half-meg RAM
add_mem_block("ModelCpu", 0, 0xBFFFF, "RAM", ALL_SPACES);

// Add three empty spaces
add_non_mem_block("ModelCpu", 0xC0000, 0xC0003,
 "TpuPinsDock", ALL_SPACES);
add_non_mem_block("ModelCpu", 0xC0004, 0xD0003,
 "CpuCpuShare", ALL_SPACES);
add_non_mem_block("ModelCpu", 0xD0004, MEM_END, "B2",
 ALL_SPACES);

// Set the lowest empty block to dock with the TPU target
set_block_to_dock("ModelCpu", "TpuPinsDock", ALL_SPACES,
 "Tpu", 0-0xC0000);

// Make sure that no matter which space
// the TPU accesses within this dock
// the TPU's pins space is always accessed
set_block_dock_space("ModelCpu", "TpuPinsDock",
 ALL_SPACES, RW_ALL, TPU_PINS_SPACE);

// Set the middle empty block to dock with the HOST CPU
set_block_to_dock("ModelCpu", "CpuCpuShare", ALL_SPACES,
 "HostCpu", 0x70000-0xC0000);

//***** END OF MODELING CPU *****
```

In this example the shared memory architecture from the above figure is generated.

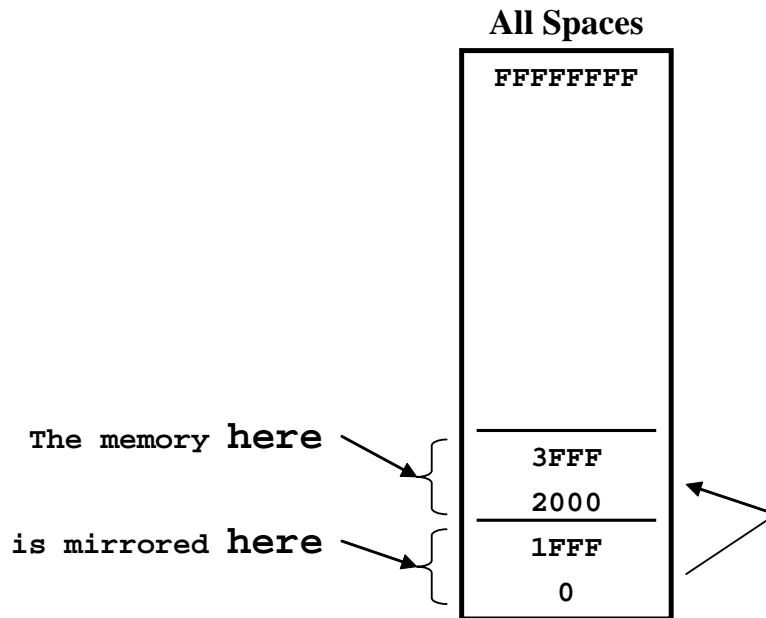
## Simulating Mirrored Memory

Mirrored memory is memory that is accessible at multiple address ranges within a memory map. This can occur, for instance, when not all address bits are decoded for a memory device. The following figure depicts an 8K memory device that resides in a 64K memory system. Assume it is an 8-bit wide device. Since the 8K device is on a byte wide bus, the device itself decodes the lower 13 address bits, A12 through A0. Assume that the memory controller decodes only the upper two address bits, A15 and A14, and enables the device

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when both are zero. This means that nothing decodes A13, and thus the memory device is activated when A15 and A14 are zero, regardless of the state of A13.



This mirrored memory architecture is created by implementing a dock from the address space to itself as follows.

```
instantiate_target(SIM32, "MyCpu");
add_non_mem_block("MyCpu", 0x0, 0x1FFF, "Mirror",
 ALL_SPACES);
add_mem_block("MyCpu", 0x2000, 0x3FFF, "RAM",
 ALL_SPACES);
add_non_mem_block("MyCpu", 0x4000, 0xFFFFFFFF, "B1",
 ALL_SPACES);

// Create a mirror at the lowest 8K of the next higher 8K
set_block_to_dock("MyCpu", "Mirror", ALL_SPACES, "MyCpu",
 0x2000);
```

In this example the previously-described memory architecture with mirrored memory is implemented.

## Computer Memory Considerations

MtDt uses your computer's memory to model the memory devices belonging to your target.

There is roughly a one-to-one correspondence between the total amount of memory occupied by the simulated devices and the amount of your computer's memory that is required. In the examples shown in the previous sections, simulated memory totals a few hundred kilobytes. This is a trivial amount of memory for a modern computer. When many megabytes are required, you are limited to the amount of virtual memory available for the MtDt application that your computer can provide. If you attempt to simulate a 100-gigabyte memory device, for example, but have only 50-gigabytes of available virtual memory on your computer, the build script file will fail to execute.

Note that since modern computer systems employ virtual memory, the amount of simulated memory can exceed the amount of RAM actually in your computer. Adjusting the available amount of virtual memory on your computer can increase the total amount of memory devices that you can simulate. A description of how to increase the swap file size of your computer is beyond the scope of this manual.

### 19.1 The Build Script File

MC33816 Development Tool supports both debugging and simulation of a variety of targets. Since MC33816 Development Tool can both simulate and debug a variety of simulation and hardware targets, how does MC33816 Development Tool know what to do?

Build batch files provide the instructions that MC33816 Development Tool requires to create and glue together the various copies of hardware and simulation targets. Although the user is encouraged to modify copies of these files when required, in many cases the standard build batch files loaded during MC33816 Development Tool installation will suffice.

Typical build script files might instantiate a CPU and a eTPU, then instantiate RAM and ROM for the CPU, and then cause the eTPU's memory to reside in the CPU's address space.

#### **MtDt Build Script Commands File Naming Conventions**

In order to prevent future installations of ASH WARE software from overwriting build script files that you have created or modified, ASH WARE recommends that you follow the following naming convention.

- Build script files from ASH WARE begin with "zzz."

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- Build script files not from ASH WARE don't begin with "zzz."

The string "zzz" was chosen so that these files would appear at the end of a directory listing sorted by file name. ASH WARE recommends that when you modify a build batch file you remove the letters "zzz" from the file name. When you create a new file, ASH WARE recommends that the file name not begin with the string "zzz." The following is a list of some of the build batch files loaded by the ASH WARE installation utility.

[zzz\\_1Gtm.MtDtBuild](#)  
[zzz\\_1ETpuSim.MtDtBuild](#)  
[zzz\\_1Mc33816.MtDtBuild](#)  
[zzz\\_1Sim32.MtDtBuild](#)  
[zzz\\_1Sim32\\_1ETpuSim.MtDtBuild](#)  
[zzz\\_1Sim32\\_1GTM.MtDtBuild](#)  
[zzz\\_1Sim32\\_1Mc33816.MtDtBuild](#)  
[zzz\\_1Sim32\\_3ETpuSim\\_MPC5676.MtDtBuild](#)  
[zzz\\_1Sim32\\_3ETpuSim\\_MPC5777.MtDtBuild](#)

How would you modify the [zzz\\_1Sim32.MtDtBuild](#) file to create a larger RAM? ASH WARE recommends the following procedure.

[Copy file zzz\\_1Sim32.MtDtBuild to file BigRamSim32.BuildScript](#)  
[Modify file BigRamSim32.BuildScript](#)

### 19.2 Custom Build Script File Pathing

When creating a Custom Build Script the question arises of, "where should the custom build script file be placed? There are three options discussed here.

**Option 1, Installation Location.** Place your Custom Build Script in the Build Scripts directory in the installation directory where the standard build scripts are located.

[C:\Program Files \(x86\)\ASH WARE\Full System DevTool IDE  
V2\\_20A\BuildScripts](#)

Advantage. Works seamlessly with the toolset.

Disadvantages. Every user needs to place the file into their installation directory and does not work well with CVS.

**Option 2, Project-File Relative.** If the custom build script is placed in the same directory tree as the project file in which it is referenced then only the 'relative path' to the project file is used.

```
Project File: c:\SomeDir\MyProjectDir\MyProject.GtmIdeProj
Custom Build Script File: c:
\SomeDir\MyCustomBuildScripts\MyCustomSimCfg.MtDtBuild
```

Then in the project file the following pathing will be used to find the build script.

```
..\MyCustomBuildScripts\MyCustomSimCfg.MtDtBuild
```

Advantage. Works well with CVS and projects are easily relocatable as long as the Build Script is retained and it relative pathing spot.

**Option 3, Independent Directory.** If the custom build script is placed in a separate directory tree as the project file in which it is referenced then only the complete fully-qualified path is stored in the project file.

```
Project File: c:\SomeDir\MyProjectDir\MyProject.GtmIdeProj
Custom Build Script File: c:\Tools\MyCustomSimCfg.MtDtBuild
```

Then in the project file the following pathing will be used to find the build script.

```
c:\Tools\MyCustomSimCfg.MtDtBuild
```

Advantage. Eliminates confusion on the location of the custom build script.

Disadvantages. Difficult to maintain.

### Pathing Search Rules

If the path is fully qualified, file must be at the fully-qualified location. Otherwise, first the 'BuildScripts' directory is used. If the file is not found, then the directory of the project file is searched.

When saving, if the file is in the BuildScripts directory then the path is fully removed. Otherwise, if the file is in the same directory tree as the BuildScripts directory then the file is saved relative to the BuildScripts directory. Otherwise, if the file is in the same directory tree as the Project file then the file is saved relative to the Project File. Otherwise, the file along with it's fully-qualified directory is saved.

### GTM Register Definitions File.

The GTM Register Definitions file allows each vendor's memory mapping to match that of the actual target hardware. Since each vendor can have a different memory mapping, the GTM Register Definition file allows the mapping of each vendor's device within the Host CPU's address space. The pathing rules described above also apply to this file.

## 19.3 Build Script Commands

```
instantiate_target_ex1(enum TARGET_TYPE,
 enum TARGET_SUB_TYPE,
 "TargetName");
```

This command instantiates a target [enum TARGET\\_TYPE](#) and assigns it the name TargetName. The [enum TARGET\\_SUB\\_TYPE](#) specifies target/core-specific settings. Subsequent references to this target use the target name specified in this command.

Of particular interest to the MC33816 is file "zzz\_mc33816Versions.Dat," which is found in the build directory. This file supports selection of the MC33816 core via a #define. The #define is specified in the project.

```
add_mem_block("TargetName", StartAddress, StopAddress,
 "BlockName", enum ADDR_SPACE);
```

This command adds a memory block to a range of simulated memory. The memory appears between stopAddress and startAddress in the memory space [ADDR\\_SPACE](#). The name BlockName is assigned to this block and is used by other script commands when referencing this block. The block name must be unique within its target, but other targets can have a block with this same block name. The size of the memory block is equal to one plus stopAddress minus startAddress. Only a single copy of this memory is created, regardless of how many address spaces the block occupies.

```
add_non_mem_block("TargetName", StartAddress, StopAddress,
 enum ADDR_SPACE);
```

This command adds a blank block of simulated memory to the target TargetName. It indicates that no physical memory exists in the specified memory range and specified address spaces, [ADDR\\_SPACE](#). The name BlockName is assigned to this block and is



used by other script commands when referencing this block. The block name must be unique within its target, but other targets can have a block with this same block name.

Since no memory is actually modeled by this command, it effectively uses almost none of your computer's virtual memory. This is important since the entire four GB address space must be represented by memory blocks, regardless of whether or not the simulation target actually supports this large of an address space.

This example specifies that no physical memory exists above the first 64K for both user and supervisor data spaces. Data space is defined by the define declaration as consisting of a combination of the supervisor data space and the user data space.

```
set_block_to_off("TargetName", "BlockName",
 enum ADDR_SPACE, enum READ_WRITE);
```

This command allows accesses of a simulated memory blocks can be turned off using this script command. Using this command a read-only memory device such as a ROM can be created. Accesses to target TargetName within the block BlockName and specified address spaces [ADDR\\_SPACE](#) and read and/or write cycles [<enum READ\\_WRITE>](#) are turned off. A turned-off write access behaves exactly like a normal write access except the actual memory is not written. A turned-off read cycle behaves exactly like a regular read cycle except that the value returned is the OFF\_DATA constant defined for the entire block. The affected address spaces and read/write cycles must be subsets of the referenced memory block.

```
set_block_off_data32("TargetName", "BlockName",
 enum ADDR_SPACE, OFF_DATA);
set_block_off_data("TargetName", "BlockName",
 enum ADDR_SPACE, OFF_DATA);
```

These commands specify that read cycles to the target TargetName within the block BlockName return the data <OFF\_DATA> but only if the block is either a "non\_mem" block or a block in which the read cycles have been set to off. The affected address spaces must be a subset of the address spaces to which the referenced memory block applies. The first command sets an eight bit value, the second sets a 32-bit value.

```
set_block_to_bus_fault("TargetName", "BlockName",
 enum ADDR_SPACE, enum READ_WRITE);
```

This command results in bus faults for accesses to the target TargetName within the block BlockName for the applicable address spaces, [ADDR\\_SPACE](#), and read/write cycles [enum READ\\_WRITE](#). The effected address spaces must be a subset of the spaces to which the referenced memory block applies.

```
set_block_to_dock("FromTargetName", "BlockName",
 enum ADDR_SPACE, "ToTargetName",
```

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`AddressOffset);`

This script establishes a memory share between a docking target `FromTargetName` and a "docked-to" second target `ToTargetName`. Memory accesses for the docking target actually occur in the second target, while this command has no effect on the second target's accesses.

Docking target accesses within the block `BlockName` in the address space [`ADDR\_SPACE`](#) are projected to the "docked-to" target at an offset address `AddressOffset`.

The address range corresponds exactly to a previously defined block within the docking target. There is no such requirement for the "docked-to" target.

```
//-----
// CHANNEL 2, CORE 0
add_mem_block("Ch2_Core0", 0, MC33816_DATA_SIZE-1,
"Ch2Data", MC33816_DATA_SPACE);
//-----
// CHANNEL 2, CORE 1
add_non_mem_block("Ch2_Core1", 0, MC33816_DATA_SIZE-1,
"ch2_ram_dock_a", MC33816_DATA_SPACE);
set_block_to_dock("Ch2_Core1", "ch2_ram_dock_a",
MC33816_DATA_SPACE, "Ch2_Core0", 0);
```

In this example a memory share is setup between targets `Ch2_Core0` and `Ch2_Core1`. The memory that is shared resides in `Ch2_Core0`.

```
set_block_dock_space("TargetName", "BlockName",
enum ADDR_SPACE DockFromSpace,
enum READ_WRITE,
enum ADDR_SPACE DockToSpace);
```

This command supports an address space transformation for a docked memory access. Read and/or write cycles [`enum READ\_WRITE`](#) from target `TargetName` between within the block `BlockName` in the address spaces [`enum ADDR\_SPACE DockFromSpace`](#) are transformed to occur in address space [`enum ADDR\_SPACE DockToSpace`](#). The `DockToSpace` argument must specify a single space.

It is important to fully specify all shared memory accesses between dissimilar targets. Docks with unspecified address space transformations result in indeterminate results. For instance, a eTPU sharing memory with a CPU32 could easily result in an opcode being fetched out of data space, even though both targets have both code and data spaces. Assumptions about similarity of address spaces between dissimilar targets simply should not be made.

