Embedded Target for Motorola® MPC555

For Use with Real-Time Workshop®

- Modeling
- Simulation
- Implementation

User's Guide

Version 2

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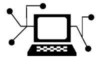

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Embedded Target for Motorola MPC555 User's Guide

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1

Getting Started

This section contains the following topics:

Introduction to the Embedded Target for Motorola MPC555 (p. 1-2)	Overview of the product and the use of the Embedded Target for Motorola® MPC555 in the development process.
Prerequisites (p. 1-8)	What you need to know before using the Embedded Target for Motorola MPC555.
Using This Guide (p. 1-9)	Suggested path through this document to get you up and running quickly with the Embedded Target for Motorola MPC555.
Installing the Embedded Target for Motorola MPC555 (p. 1-10)	Installation of the product.
Hardware and Software Requirements (p. 1-11)	Hardware platforms supported by the product; required MathWorks tools and development tools (e.g. compilers, debuggers) required for use with the product.
Setting Up and Verifying Your Installation (p. 1-13)	Overview of setting up your development tools and hardware to work with the Embedded Target for Motorola MPC555, and verifying correct operation.
Setting Target Preferences (p. 1-14)	Configuring environmental settings and preferences associated with the Embedded Target for Motorola MPC555 for use with specific development tools.

Introduction to the Embedded Target for Motorola MPC555

The Embedded Target for Motorola MPC555 is an add-on product for use with the Real-Time Workshop® Embedded Coder. It provides a complete and unified set of tools for developing embedded applications for the Motorola MPC555 and MPC565 processors.

Used in conjunction with Simulink®, Stateflow®, and the Real-Time Workshop Embedded Coder, the Embedded Target for Motorola MPC555 lets you

- Design and model your system and algorithms.
- Compile, download, run and debug generated code on the target hardware, seamlessly integrating with industry-standard compilers and development tools for the MPC555.
- Use cosimulation and rapid prototyping techniques to evaluate performance and validate results obtained from generated code running on the target hardware.
- Deploy production code on the target hardware.

Feature Summary

Production Code Generation

- The Real-Time Workshop Embedded Coder generates production code for use on the target MPC5xx microcontroller.
- The Real-Time Workshop Embedded Coder generates project or makefiles for popular cross-development systems:
  - Wind River Systems Diab cross-compiler
  - Metrowerks CodeWarrior
- Debugger support:
  - Wind River Systems SingleStep debugger
  - Metrowerks CodeWarrior debugger

Device Driver Support

- The Embedded Target for Motorola MPC555 Library provides device driver blocks that let your applications access on-chip resources. The I/O blocks support the following features of the MPC555 and MPC565:
  - Pulse width modulation (PWM) generation via the Modular Input/Output Subsystem (MIOS) PWM unit or the Time Processor Unit 3 (TPU) modules
  - Analog input via the Queued Analog-to-Digital Converter (QADC64)
  - Digital input and output via the MIOS or TPU
  - Digital input via the QADC64
  - Frequency and pulse width measurement via the MIOS Double Action Submodule (MDASM)
  - Transmit or receive Controller Area Network (CAN) messages via the MPC5xx TouCAN modules
  - Driver blocks to support other functions of the TPU modules—Fast Quadrature Decode, New Input Capture/Input Transition Counter, and Programmable Time Accumulator
  - Serial transmit and receive
  - Utility blocks such as a watchdog timer

Code and Performance Analysis

Web-viewable code generation report includes

- Analysis of RAM/ROM usage and other variables
- Analysis of code generation options used, with optimization suggestions
- Hyperlinks to all generated code files
- Hyperlinks from generated code to source model in Simulink

Applications Development and Rapid Prototyping

- Generation of real-time, stand-alone code for MPC5xx
- Scheduler and time functions for singlerate or multirate real-time operation
- CAN-based loader for download of generated code to RAM or flash memory
- CAN-based host-target communications for non-real-time retrieval of data on host computer

Simulation and Cosimulation

- Automatic S-function generation lets you validate your generated code in software-in-the-loop (SIL) simulation.
- Processor-in-the-loop (PIL) cosimulation lets you integrate generated code, running on the target processor, into your simulation.
- SIL and PIL code components are generated by the Real-Time Workshop Embedded Coder. These simulation components are in the same compact and efficient format as the production code generated for final deployment.

CAN Support

- Transmit or receive CAN messages via the MPC555 TouCAN modules.
- CAN Drivers (Vector) library provides blocks for configuring and connecting to Vector-Informatik CAN hardware and drivers. These can be used in simulation to connect to a real CAN bus.
- The CAN Message Blocks library includes blocks for transmitting, receiving, decoding, and formatting CAN messages. It also supports message specification via the Vector-Informatik CANdb standard.

Code Validation and Performance Analysis

Code Validation. Since signal data is available to Simulink during each sample interval in a PIL simulation, you can observe signal data on Scope blocks or other Simulink signal viewing blocks. You can also store signal data to MAT-files via To File blocks. To validate the results obtained by the generated code running on the target processor, you can compare these files to results obtained using a normal Simulink plant/controller simulation.

Determining Code Size. In control design it is critical to ensure that the size of the generated code does not exceed physical limitations of RAM and ROM. The Embedded Target for Motorola MPC555 can automatically produce a code generation report that displays the RAM usage and ROM size of the generated code.

This capability is useful when selecting which code generation optimizations will be used. After determining the size of the required RAM and ROM, you can consider which code generation optimizations to use, and consider modifications to the modeling style.

Applications for the Embedded Target for Motorola MPC555

The Embedded Target for Motorola MPC555 provides targets that support three application scenarios:

- Real-time (RT) execution and rapid prototyping target
- Processor-in-the-loop (PIL) cosimulation target
- Algorithm export (AE) target

In the sections that follow, we summarize typical applications and the tasks you will need to perform for each; we also provide links to the relevant documentation.

Real-Time Execution and Rapid Prototyping

The Embedded Target for Motorola MPC555 real-time target enables you to use your controller block diagram in real time to perform embedded control. With this target, you can add I/O blocks for the MPC5xx to your controller subsystem, generate and build code, download to the target, and run the generated C code.

When you first begin using the RT target, see “Tutorial: Creating a New Application” on page 2-4, which demonstrates the following topics through the use of a simple model with a device driver:

- Examining the demo model with a plant model and controller
- Adding the MPC555 Resource Configuration block to your subsystem
- Adding I/O device drivers from the Embedded Target for Motorola MPC555 library
- Selecting the RT target
- Generating code for real time
- Downloading code with
  - A BDM connector
  - CAN
- Running the generated code in real-time

You may also be interested in generating code analysis information from your RT target build. See “Code Analysis Reporting” on page 3-28 for details.

Processor-in-the-Loop

The processor-in-the-loop (PIL) target lets you run a cosimulation of a closed-loop Simulink model for the purpose of code validation and analysis. When running a PIL cosimulation, you use a closed-loop model with two major components: a plant model and a controller. The plant model may contain any Simulink blocks including a combination of continuous-time and discrete-time blocks. The controller must not include any continuous-time blocks, since this component is used for code generation in the embedded-C format of the Real-Time Workshop Embedded Coder.

To get started with the PIL target, see "Tutorial 1: Building and Running a PIL Cosimulation" on page 3-5. The tutorial covers the following topics:

- Opening the demo model and examining the plant model and controller
- Selecting the PIL target
- Generating the Embedded Real-Time (ERT) S-function and the corresponding library block
- Inserting the S-function back into the closed-loop model
- Automatic downloading of generated code with
  - SingleStep debugger and a Background Debug Mode (BDM) port connector
  - CodeWarrior and a BDM connector
- Running a PIL cosimulation

You may also be interested in generating code analysis information from your PIL target build. See "Code Analysis Reporting" on page 3-28 for details.

Algorithm Export

The Embedded Target for Motorola MPC555 algorithm export (AE) target enables you generate code for your controller subsystem and build the code as a stand-alone executable for use on the MPC555. The difference between the AE and the PIL target is that the AE target eliminates all extraneous code (such as serial communications code) used for cosimulation, and also eliminates any real-time interrupts. The AE target therefore generates code only for the basic controller subsystem (e.g. algorithm code). You can then modify or customize this code for your own special purposes.

In contrast, the RT target provides turnkey code including interrupt service routines, driver code, and underlying initialization code for the MPC555.

Depending upon your particular application, you may find it more valuable to begin with the AE target baseline, and extend this environment for your own use.

The AE target is documented in “Algorithm Export Target” on page 3-27.

Like the PIL and RT targets, the AE target supports generation of code analysis information. See “Code Analysis Reporting” on page 3-28 for details.

Prerequisites

This document assumes you are experienced with MATLAB®, Simulink, Stateflow, Real-Time Workshop, and the Real-Time Workshop Embedded Coder.

Minimally, you should read the following from the "Basic Concepts and Tutorials" section of the Real-Time Workshop documentation:

- "Basic Real-Time Workshop Concepts." This section introduces general concepts and terminology related to Real Time Workshop.
- "Quick Start Tutorials." This section provides several hands-on exercises that demonstrate the Real-Time Workshop user interface, code generation and build process, and other essential features.

You should also familiarize yourself with the Real-Time Workshop Embedded Coder documentation.

In addition, if you want to understand and use the device driver blocks in the the Embedded Target for Motorola MPC555 library, you should have at least a basic understanding of the architecture of the MPC555. The Motorola *MPC555 Users Guide* is required reading. We recommend that you read the introduction to the processor and familiarize yourself with all the major subsystems of the MPC555.You can find this document at the following URL: `http://e-www.motorola.com/webapp/sps/library/prod_lib.jsp`.

Using This Guide

We suggest the following path to get acquainted with the Embedded Target for Motorola MPC555 and gain hands-on experience with the features most relevant to your interests:

- Read Chapter 1, “Getting Started” in its entirety, paying particular attention to “Setting Up and Verifying Your Installation” on page 1-13.
- If you are interested in using the device driver blocks supplied with Embedded Target for Motorola MPC555 and in deploying stand-alone, real-time applications on the MPC555, read Chapter 2, “Generating Stand-Alone Real-Time Applications.” Work through the “Tutorial: Creating a New Application” on page 2-4.
- If you are interested in processor-in-the-loop (PIL) cosimulation, read Chapter 3, “PIL Cosimulation” to learn about the Embedded Target for Motorola MPC555 PIL target. Work through the “Tutorial 1: Building and Running a PIL Cosimulation” on page 3-5.
- Then, for in-depth information about the device drivers and other blocks supplied with Embedded Target for Motorola MPC555, see Chapter 4, “Block Reference.” It is particularly important to read “MPC555 Resource Configuration” on page 4-41, as the MPC555 Resource Configuration block is required to use most of the device driver blocks.

See also the Embedded Target for Motorola MPC555 Demos. To browse the demos, open the MPC555 Help and Demos library. You can then double click the **Help for Demos** block to go directly to information and instructions for all demos, or select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Demos**. These demos are used in the tutorials, where there are detailed explanations.

Installing the Embedded Target for Motorola MPC555

Your platform-specific MATLAB Installation guide provides all of the information you need to install the Embedded Target for Motorola MPC555.

Prior to installing the Embedded Target for Motorola MPC555, you must obtain a License File or Personal License Password from The MathWorks. The License File or Personal License Password identifies the products you are permitted to install and use.

As the installation process proceeds, it displays a dialog where you can select which products to install.

Hardware and Software Requirements

Operating System Requirements

The Embedded Target for Motorola MPC555 is a PC-Windows only product. The product has been tested on Microsoft Windows NT, 2000, and XP.

You can see the system requirements for MATLAB online at

`http://www.mathworks.com/products/system.shtml/Windows`

Hardware Requirements

Programs generated by the Embedded Target for Motorola MPC555 can run on any Electronic Control Unit (ECU) that is based on the MPC555 or MPC565 processor.

In this document, however, we assume that you are working with the Phytec phyCORE-MPC555 development board, and we document specific settings and procedures for use with the Phytec phyCORE-MPC555 board, in conjunction with specific cross-development environments.

If you use a different development board, you may need to adapt these settings and procedures for your development board.

If you want to use CAN to connect to your target you require Vector-Informatik CAN hardware and drivers. See "CAN Hardware and Drivers" on page A-13.

Software Requirements

Required and Related MathWorks Products

The Embedded Target for Motorola MPC555 *requires* these MathWorks products:

- MATLAB 7.0 (Release 14)
- Simulink 6.0 (Release 14)
- Real-Time Workshop 6.0 (Release 14)
- Real-Time Workshop Embedded Coder 4.0 (Release 14)

Optional — if you want to implement the CAN Calibration Protocol (for example, for downloading without manual processor reset) by using the CAN Calibration Protocol block, you also need

- Stateflow 6.0(Release 14) and Stateflow Coder

For more information about any of these products, see either

- The online documentation for that product, if it is installed or if you are reading the documentation from the CD
- The MathWorks Web site, at `http://www.mathworks.com`; see the "products" section

The MathWorks provides several products that are especially relevant to the kinds of tasks you can perform with the Embedded Target for Motorola MPC555. For required and related products, see:
`http://www.mathworks.com/products/target_mpc555/`

Supported Cross-Development Tools

In addition to the required MathWorks software, a supported cross-development environment is required. The Embedded Target for Motorola MPC555 currently supports the cross-development tools listed below; please read carefully the limitations noted:

- Wind River Systems Diab cross-compiler (version 5.1.2), and Wind River Systems SingleStep debugger of the following versions:
  - Version 7.7.3 (debug via Wind River Vision Probe) (for MPC5xx)
  - Version 7.6.2 (debug via Macraigor Systems Wiggler, Raven / Blackbird, On-board BDM) (for MPC555 only)
- Metrowerks CodeWarrior for Embedded PowerPC (version 8.0)

  The full feature set (PIL, RT, and AE targets) is supported for both toolchains.

Before using the Embedded Target for Motorola MPC555 with any of the above cross-development tools, please be sure to read and follow the instructions in "Setting Up and Verifying Your Installation" on page 1-13.

Setting Up and Verifying Your Installation

The next sections describe how to configure your development environment (compiler, debugger, etc.) for use with the Embedded Target for Motorola MPC555 and verify correct operation. The initial configuration steps are described in the following sections:

- You must set up your development environment and your target hardware. Information on these settings can be found in the “Toolchains and Hardware” on page A-1:
  - “Setting Up Your Target Hardware” on page A-10
  - “Setting Up Your Toolchain” on page A-2
- You must configure Embedded Target for Motorola MPC555 to work with your toolchain by specifying the locations of your compiler and debugger. This is described in the section “Setting Target Preferences” on page 1–14.
- We supply a test program to verify your installation. This confirms you have correctly set up your toolchain, target preferences and development board. See “Run Test Program” on page 1–20.
- The next step is to download boot code to the flash memory of your MPC555. See “Download Boot Code to Flash Memory” on page 1–20.

Note You must download the new boot code if you have used a previous release of Embedded Target for Motorola MPC555 with your hardware. See “Download Boot Code to Flash Memory” on page 1–20.

Once you have completed these steps we suggest you run the tutorials in subsequent sections to get started with the Embedded Target for Motorola MPC555.

Setting Target Preferences

This section describes how to set target preferences associated with the Embedded Target for Motorola MPC555. These settings persist across MATLAB sessions and different models. Target preferences let you specify the location of your MPC555 cross-compiler, the communications port to be used for downloading code, and other parameters affecting the generation, building, and downloading of code.

Configuring the Embedded Target for Motorola MPC555 for Your Cross-Development Toolchain

When you set up the Embedded Target for Motorola MPC555, you must make sure you localize the settings to suit your PC and cross-development toolchain. It is important that you set the correct path to your compiler and debugger using the **MPC555 Target Preferences** dialog box.

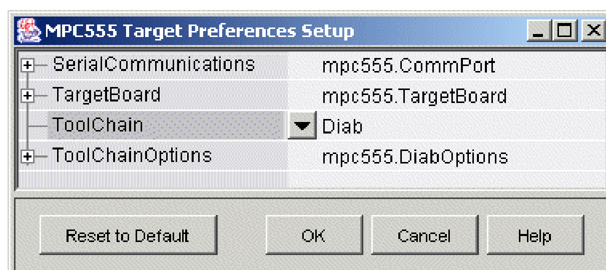
Instructions for setting up specific third-party toolchains for use with the Embedded Target for Motorola MPC555 are in "Toolchains and Hardware" on page A-1. Make sure you have followed the instructions to set up your toolchain first:

- "Setting Up Your Installation with Diab Cross-Compiler and SingleStep Debugger" on page A-3
  - "Setting Target Preferences for Diab and SingleStep" on page A-4. Note especially the settings you must change if you are not using the Vision Probe BDM device, the defaults are set up for the Vision Probe.
- "Setting Up Your Installation with Metrowerks CodeWarrior" on page A-7
  - "Set Target Preferences for CodeWarrior" on page A-9

You can modify target preference objects via the **MPC555 Target Preferences** dialog box:

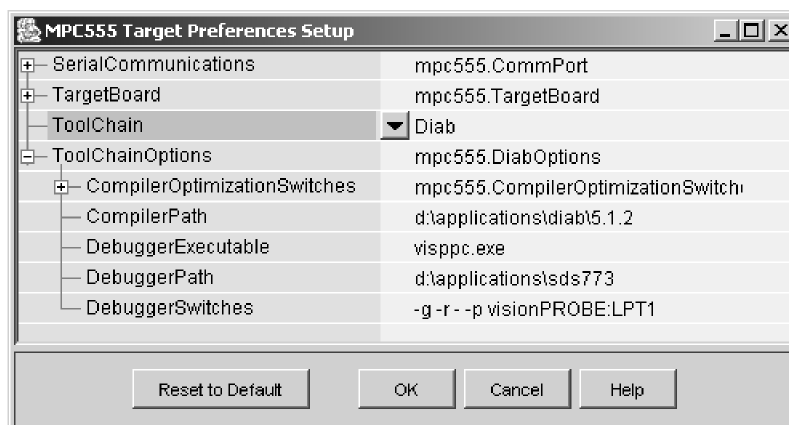
1 Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Target Preferences**.

This opens the **MPC555 Target Preferences** dialog box where you can edit the settings for your cross-development environment. When you first open the dialog the following settings are visible.

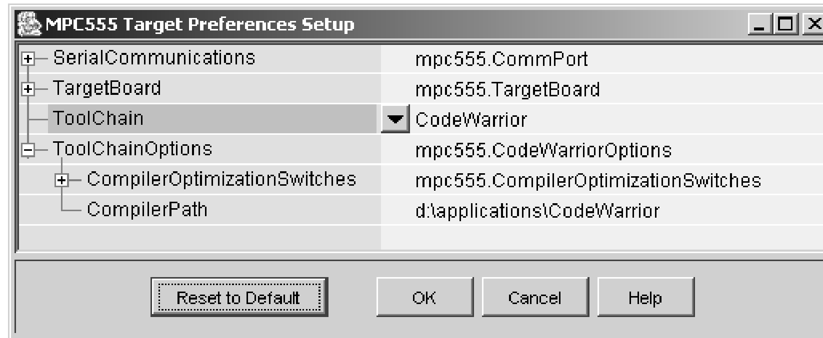


2 Select `Diab` or `CodeWarrior` from the drop-down **Toolchain** menu.

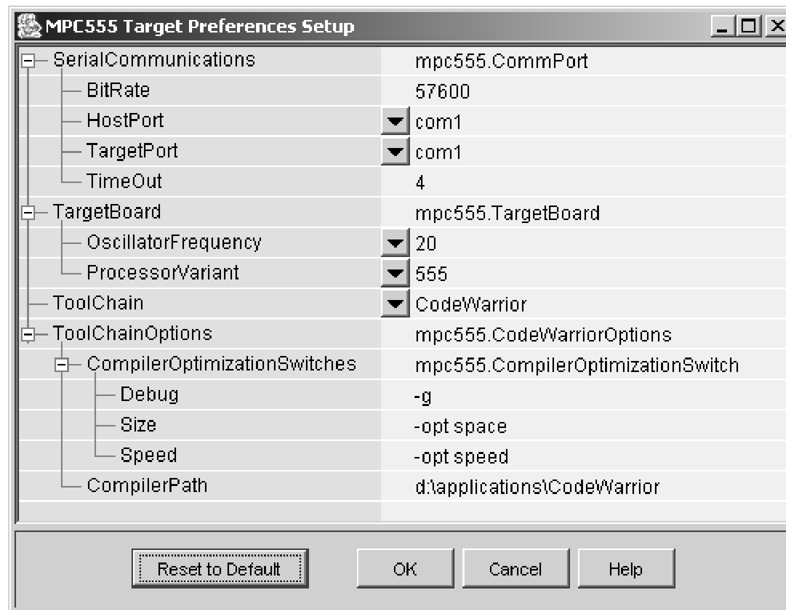
3 Expand **ToolChainOptions** as shown below (by clicking the plus sign) and type the correct path into **CompilerPath**. The following shows Diab options. Note that the defaults are set up for the Vision Probe — see the Appendix for settings to use another BDM device, described in “Setting Target Preferences for Diab and SingleStep” on page A-4.



4 For SingleStep you must also type the correct path into **Debugger Path**. This is not necessary for CodeWarrior as the compiler and debugger are integrated. The example below shows the CodeWarrior preferences.



There are other settings in the target preferences you can see by expanding all the options, as shown.



Serial Communications

These target preferences relate to Processor-in-the-Loop (PIL) cosimulation only.

SerialCommunications	mpc555.CommPort
BitRate	57600
HostPort	com1
TargetPort	com1
TimeOut	4

- `BitRate` — Bit rate (in bps) for host/target communications. The default is `57600`.
- `HostPort` — Host serial port for host/target communications. Select from `com1` to `com8`; the default is `com1`.
- TargetPort — Target board serial port for host/target communications. Select from `com1` to `com8`; the default is `com1`.
- `TimeOut` — Time-out value (in seconds) for the serial communications port. The default is `4`.

Target Board

TargetBoard	mpc555.TargetBoard
OscillatorFrequency	20
ProcessorVariant	555

- `OscillatorFrequency` — Choose either `20` MHz (the default) or `4` MHz if you are using a 4MHz board.
- `ProcessorVariant` — Here you can select from `MPC555`, `MPC561`, `MPC562`, `MPC563`, `MPC564`, `MPC565` or `MPC566` to match your target processor. The default is the MPC555.

When you install bootcode after setting target preferences the correct bootcode for your chosen target processor and oscillator frequency will be automatically installed. Note that you also need to make these settings match in your models for the non-default target processor and oscillator frequency. See “Configuration for Nondefault Hardware” on page A-14.

CompilerOptimizationSwitches

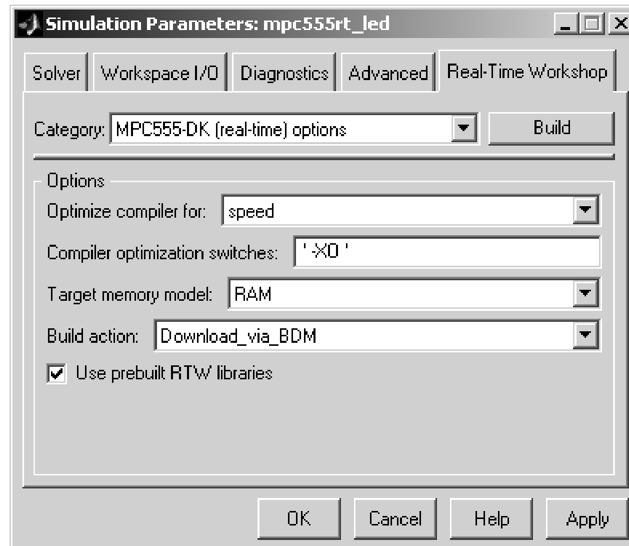
ToolChainOptions	mpc555.DiabOptions
CompilerOptimizationSwitches	mpc555.CompilerOptimizationSwitch
Debug	-g
Size	-XO -Xsize-opt
Speed	-XO
CompilerPath	d:\applications\diab\5.1.2
DebuggerExecutable	visppc.exe
DebuggerPath	d:\applications\sds773
DebuggerSwitches	-g -r - -p visionPROBE:LPT1

ToolChainOptions	mpc555.CodeWarriorOptions
CompilerOptimizationSwitches	mpc555.CompilerOptimizationSwitch
Debug	-g
Size	-opt space
Speed	-opt speed
CompilerPath	d:\applications\CodeWarrior

For both toolchains these settings configure optimizations for `speed`, `size`, and `debug`. The settings are compiler specific. These properties can be edited from the **MPC555 Target Preferences** dialog box or from the **Simulation Parameters** dialog box, described below. The defaults should be adequate for most rapid prototyping purposes.

If you want to alter these settings, consult your compiler documentation for specific optimizations. To edit the settings,

- If you want your changes to apply to many models, edit them within the **MPC555 Target Preferences** dialog box. Your settings will appear within the **Simulation Parameters** dialog box in the **Compiler optimization switches** field when you select `speed`, `size` or `debug` from the **Optimize compiler for** options in the drop-down menu. You must choose `MPC555-DK (real-time) options` from the **Category** menu on the **Real-Time Workshop** tab to reach these settings, as shown in the following example.



- If you want to customize these settings for a single model, edit them from the **Simulation Parameters** dialog box. **Optimize compiler for** will change to `custom` and the defaults for these settings will remain unchanged in the **MPC555 Target Preferences** dialog box. When you edit these settings, you must place single quotation marks at either end of the string. These settings are then applied to model code.

Use Prebuilt RTW Libraries. This check box option (selected by default) saves a considerable amount of time during the build process, as the libraries do not need to be recompiled every time. However, note this uses the defaults we have chosen for compiler optimization switches. These defaults are designed for rapid prototyping mode. If you are going to switch to production code development and want to fine tune the settings, you should clear this check box option. Then the custom optimization switches you set in the **Real-Time Workshop Simulation Parameters** dialog box will be applied to the library code as well as the model code.

DebuggerSwitches

This setting is specific to SingleStep. See “Setting Target Preferences for Diab and SingleStep” on page A-4.

Run Test Program

To verify your setup, you can download and run a simple test program on the phyCORE-MPC555 board:

1. Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Run Simple MPC555 Test Application**.

2. To answer the question `Do you want to run the application?` Type `y` at the command line.

If you have not set up your target preferences properly the process will stop and ask you to do this now.

Watch as your toolchain downloads and runs the application on your phyCORE board. Successful execution results in a blinking LED.

You have now verified your installation and are ready to begin working with the Embedded Target for Motorola MPC555.

Download Boot Code to Flash Memory

The next step is to download the boot code to flash memory, if you have not already done so. Normally, you will only need to program the boot code into flash memory once. After this is done, new application code can be downloaded as often as required without any changes to the boot code.

The first time you program the boot code into the target hardware, you must download it via the BDM port. However, if existing boot code is already programmed into flash memory and must be replaced (for example, with a newer or modified version) it is also possible to download entirely over CAN or serial. If you are upgrading from a previous release of Embedded Target for Motorola MPC555 you must download the new boot code.

If your target does not have bootcode already you can only install new bootcode with a BDM. See the next section “Installing Bootcode via BDM and Serial or CAN” on page 1–21. For existing bootcode, you can use a BDM or CAN; with bootcode from version 1.2 or later you can also download over Serial. See “Installing Bootcode Without a BDM” on page 1–22.

The first time you use Embedded Target for Motorola MPC555 you must use a toolchain to download boot code to the MPC555 flash memory. Once the boot code is loaded into flash memory, you can download code to the processor

entirely over serial or the CAN network as described in the tutorials. See “Overview of Memory Organization and the Boot Process” on page 2-20 for more information.

Installing Bootcode via BDM and Serial or CAN

To install bootcode, follow these steps:

1. Connect the BDM cable to the target, and a serial or CAN cable. If you do not have a BDM available, see “Installing Bootcode Without a BDM” on page 1-22.

2. Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Install MPC5xx Bootcode**.

   A dialog appears asking if you are connected to the target via BDM. Read the information on the dialog.

3. Click **Yes**.

   Your toolchain is launched and prepares to download.

   The **Download Control Panel** appears.

4. If you are using CAN (the default) you can proceed to step 5. If you are using serial to connect to the target, click the **Communications Options** tab in the **Download Control Panel** and select `Serial` from the **Connection type** drop-down menu.

5. On the **Download** tab, click **Start Download**.

Your development tools execute a command to install the boot code. When the process stops, the messages in the **Download Control Panel** complete, and the **Stop Download** button reverts to **Start Download**. The boot code should now be installed.

Installing Bootcode Without a BDM

If your target does not have bootcode already you can only install new bootcode with a BDM. For targets with existing bootcode, if you do not have a BDM available you can install bootcode as follows:

- For a target with R14 bootcode, you can install new bootcode using the **Start** menu exactly as described above except step 4 - click **No** when asked if you are connected via BDM. The download should complete successfully over serial or CAN.
- If existing bootcode on the target is version 1.1 (R13+SP1), you can install bootcode without a BDM if you have CAN. Use the **Start** menu bootcode installer as described above and click **No** when asked if connected by BDM. The download should complete successfully over CAN.
- If the existing bootcode is earlier than version 1.1 (if it is R12.1 or R13), you can install bootcode without a BDM if you have CAN. You cannot use the **Download Control Panel**. Instead you must use the upgrade model, `can_bootcode_upgrade.mdl`.

Once you have successfully downloaded boot code to your target, you have completed your installation and are ready to use all the features of the Embedded Target for Motorola MPC555. If necessary, please consult your toolchain documentation.

We suggest you now turn to Chapter 2, “Generating Stand-Alone Real-Time Applications” to get hands-on experience with using the Embedded Target for Motorola MPC555 and your toolchain to generate, download, and execute application code on your phyCORE-MPC555 board. You can then also work through the tutorials in Chapter 3, “PIL Cosimulation” to start using processor-in-the-loop simulation for development via the Embedded Target for Motorola MPC555.

2

Generating Stand-Alone Real-Time Applications

This section includes the following topics:

Introduction (p. 2-2)	An overview of the Embedded Target for Motorola MPC555 real-time target, other components required to generate stand-alone real-time applications, and the process of deploying generated code on target hardware.
Tutorial: Creating a New Application (p. 2-4)	A hands-on exercise in building an application from a demo model, including downloading and executing generated code on a target board.
Downloading Boot and Application Code (p. 2-19)	A detailed discussion of the process of downloading code to the MPC555 RAM and flash memory.
Generating ASAP2 Files (p. 2-30)	How to generate ASAP2 files from your model.
Execution Profiling (p. 2-35)	How to use the execution profiling utilities to generate reports and graphical displays for analyzing timer-based tasks and asynchronous Interrupt Service Routines (ISRs).
Summary of the Real-Time Target (p. 2-40)	Summary of the code generation options specific to the real-time target, and requirements and restrictions that apply to the current release.

Introduction

This section describes how to generate a stand-alone real-time application for the MPC555. The components required to generate stand-alone code are

- The Embedded Target for Motorola MPC555 real-time target
- The MPC555 Resource Configuration object provided in the Embedded Target for Motorola MPC555 library
- I/O driver blocks provided in the Embedded Target for Motorola MPC555 library
- Utilities for downloading generated code to the target hardware

Using these together with your toolchain, you can build a complete application. You do not need to hand-write any C code to integrate the generated code into a final application.

See "Before You Begin" on page 2–4 for information on supported hardware and toolchains.

The tutorial "Tutorial: Creating a New Application" on page 2-4 uses two blocks from the Embedded Target for Motorola MPC555 library. For complete information on the Embedded Target for Motorola MPC555 library blocks, see Chapter 4, "Block Reference."

Before reading this section and using the Embedded Target for Motorola MPC555 library, you should have at least a basic understanding of the architecture of the MPC555. To learn about the MPC555, we suggest that you study the *MPC555 Users Manual*. We recommend that you read the introduction to the processor and familiarize yourself with all the major subsystems of the MPC555.You can find this document at the following URL: `http://e-www.motorola.com/webby/asps/library/prod_lib.jsp`.

Deploying Generated Code

You can load a generated program into the MPC555 flash memory for permanent deployment. You can also load your code into external RAM (if available on your development hardware).

Alternatively, you can use the automatic code generation process for rapid prototyping and investigate a range of different design alternatives before making a deployment decision.

Your generated program can run on any Electronic Control Unit (ECU) that is based on the MPC555 processor. Your application can use any of the supported MPC555 on-chip I/O devices. We provide driver blocks for the MPC555's MIOS, TPU and TouCAN modules, providing you with drivers for the on-chip analog input, digital I/O, PWM, serial and CAN devices.

See Chapter 4, "Block Reference" for further information on the device driver blocks in the Embedded Target for Motorola MPC555 library).

In addition to on-chip I/O resources, an ECU typically provides additional I/O devices. If you want to access such custom I/O devices, you must write device drivers and integrate them with the automatically generated code. See the following documentation for details:

- Real-Time Workshop User's Guide
- Real-Time Workshop Embedded Coder User's Guide
- Writing S-Functions

Once the application has been programmed into memory on the target system, you may need to monitor signals or tune parameters. The Embedded Target for Motorola MPC555 supports signal monitoring and parameter tuning via the CAN Calibration Protocol (CCP). To enable CCP, you must include a CAN Calibration Protocol block in your model. The CAN Calibration Protocol block implementation of CCP has been tested against CANape from Vector-Informatik and ATI Vision. See "CAN Calibration Protocol (MPC555)" on page 4-18 for further information.

Tutorial: Creating a New Application

In this tutorial, we will build a stand-alone real-time application from a model incorporating blocks from the Embedded Target for Motorola MPC555 library. We assume that you are already familiar with Simulink and with the Real-Time Workshop code generation and build process.

In the following sections, we will

- Configure the model
- Generate code from a subsystem
- Download code by one of the following methods:
  - Download to target RAM via a serial connection, using the Download Control Panel utility (provided with the Embedded Target for Motorola MPC555)
  - Download to target RAM via a CAN connection, using the Download Control Panel utility
  - Download to target RAM via a BDM connection
- Execute the code on the target

After you complete this tutorial, you may want to learn how to deploy generated code into the MPC555 flash memory. See "Downloading Boot and Application Code" on page 2-19 for that information.

Before You Begin

This tutorial requires the following specific hardware and software in addition to the Embedded Target for Motorola MPC555:

- Phytec phyCORE-MPC555 development board

  The tutorial model utilizes two LEDs on the phyCORE-MPC555 board. These LEDs are connected to pins `MPIO32B0` and `MPIO32B1` on the MPC555 MIOS digital output pins. If you are using a different development board, you may be able to obtain the same functionality by making similar connections.

- A supported toolchain for compiling and debugging. Currently supported toolchains are
  - Diab and SingleStep from Wind River Systems
  - CodeWarrior from Metrowerks

  See “Setting Up Your Toolchain” on page A-2 for details.
- Hardware to enable downloading:
  - If you want to download generated code to the target board over serial you will need a serial cable to connect your host PC to the target board.
  - If you want to download over BDM you will need a BDM device.
  - If you want to download via CAN, you will need a supported CAN card and drivers from Vector-Informatik. See “CAN Hardware and Drivers” on page A-13.

Configuring the Embedded Target for Motorola MPC555

- Make sure that your target preferences are set correctly for your development tools. See “Setting Target Preferences” on page 1-14.
- Once your target preferences are set for your toolchain you must download bootcode to the target before you can work through this tutorial. See “Download Boot Code to Flash Memory” on page 1-20.

The Example Model

In this tutorial we will use a simple example model, `mpc555rt_led`, from the directory *`matlabroot`*`/toolbox/rtw/targets/mpc555dk/mpc555demos`.

This directory is on the default MATLAB path. The path *`matlabroot`* is the location where MATLAB is installed:

1 Open the model.

```
mpc555rt_led
```

2 Save a local copy to your working directory. We will work with this copy throughout this exercise.

Figure 2-1 shows the example model at the root level. We will only use this level in simulation.

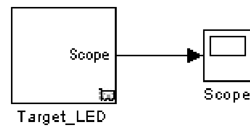


Figure 2-1: mpc555rt_led_demo Model, Root Level

3 Double-click on the `Target_LED` subsystem block.

Figure 2-2 shows the `Target_LED` subsystem, from which we will generate code.

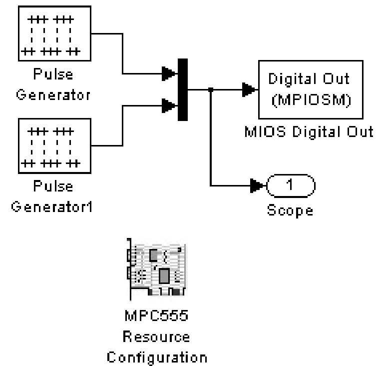
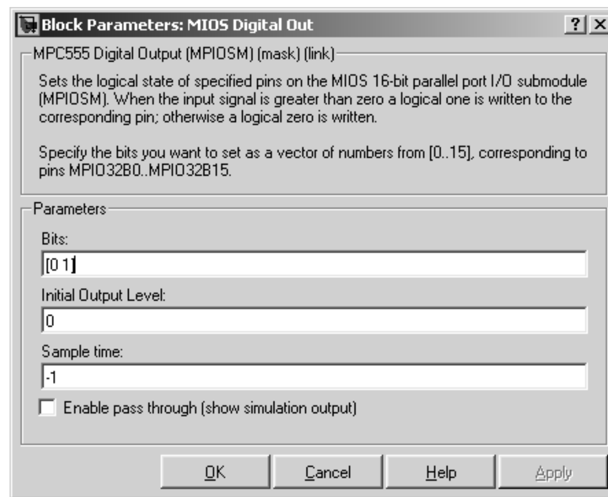


Figure 2-2: Target_LED Subsystem

In the `Target_LED` subsystem, two square wave signals are multiplexed and routed to the MIOS Digital Out block. The MIOS Digital Out block accepts a vector of numbers representing pins 0-15 on the MIOS 16-bit Parallel Port I/O Submodule (MPIOSM) on the MPC555. As the square wave signals oscillate between 0 and 1, the MIOS Digital Out block writes corresponding logic values to the appropriate pin on the port.

This figure shows the parameters of the MIOS Digital Out block.



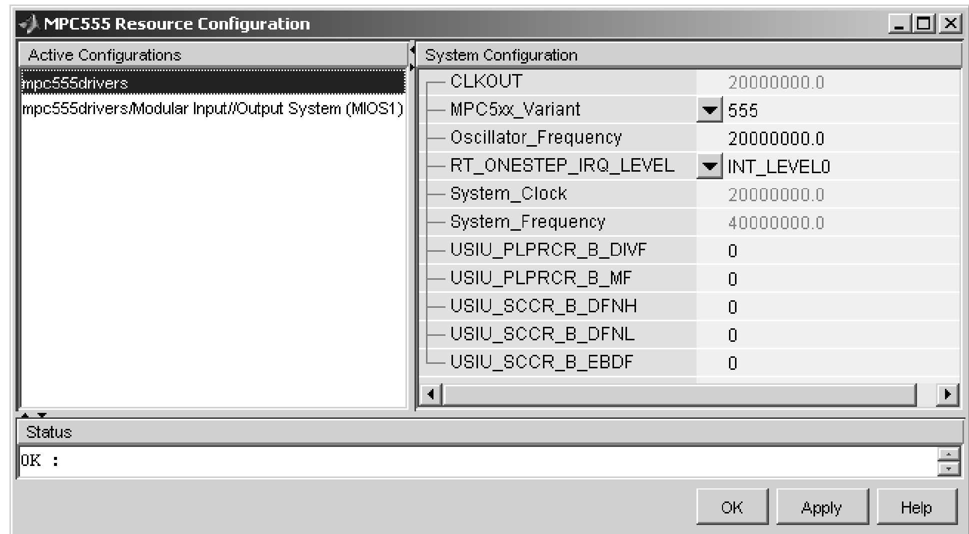
The **Bits** field is set to the vector `[0 1]`. The block maps this vector to the MPC555 MIOS digital output pins `MPIO32B0` and `MPIO32B1`. When the application runs, it will send a pulse signal to these output pins. On the phyCORE-MPC555 board, these signals are connected to two of the LEDs, which will switch on and off at the frequency set in the respective pulse generator blocks.

In addition to the Pulse Generator, Mux, MIOS Digital Out, and Output blocks, the `Target_LED` subsystem contains a MPC555 Resource Configuration object. When building a model with driver blocks from the Embedded Target for Motorola MPC555 library, you must always place a MPC555 Resource Configuration object into the model (or the subsystem from which you want to generate code) first.

The purpose of the MPC555 Resource Configuration object is to provide information to other blocks in the model. Unlike conventional blocks, the MPC555 Resource Configuration object is not connected to other blocks via input or output ports. Instead, driver blocks (such as the MIOS Digital Out block in the example model) query the MPC555 Resource Configuration object for required information.

For example, a driver block may need to find the system clock speed that is configured in the MPC555 Resource Configuration object. The MPC555 has a number of clocked subsystems; to generate correct code, driver blocks need to know the speeds at which these clock busses will run.

The MPC555 Resource Configuration window lets you examine and edit the MPC555 Resource Configuration settings. To open the MPC555 Resource Configuration window, double-click on the MPC555 Resource Configuration icon. This picture shows the **MPC555 Resource Configuration** window for the `Target_LED` subsystem.



In this tutorial, we will use the default MPC555 Resource Configuration settings. Observe, but do not change, the parameters in the MPC555 Resource Configuration window. To learn more about the MPC555 Resource Configuration object, see "MPC555 Resource Configuration" on page 4-41.

Close the **MPC555 Resource Configuration** window before proceeding.

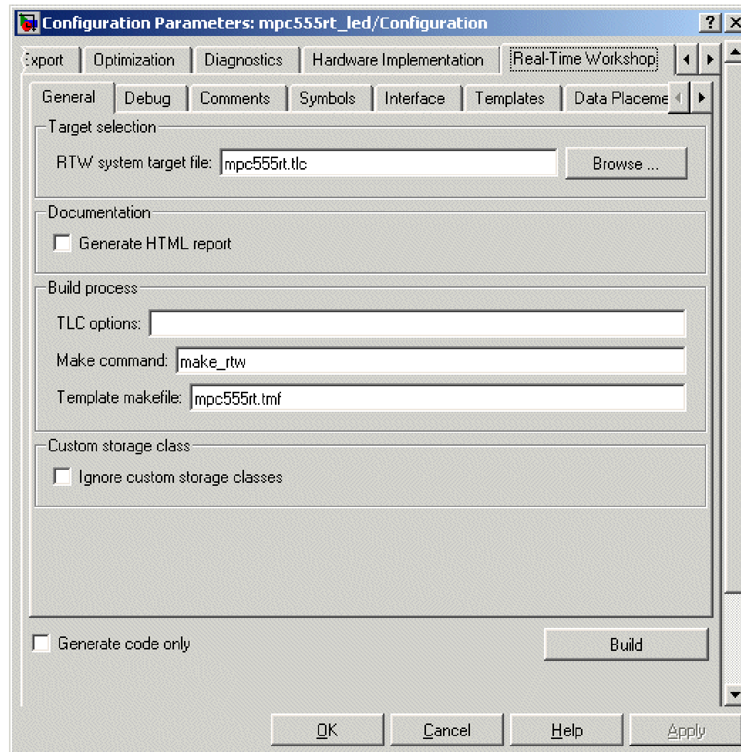
The next step in this tutorial is generating code.

Generating Code

We will now look at settings and then generate application code:

1 Select **Simulation –> Configuration Parameters**. The **Configuration Parameters** dialog opens.

2 Select the **Real-Time Workshop** tab, as shown below.



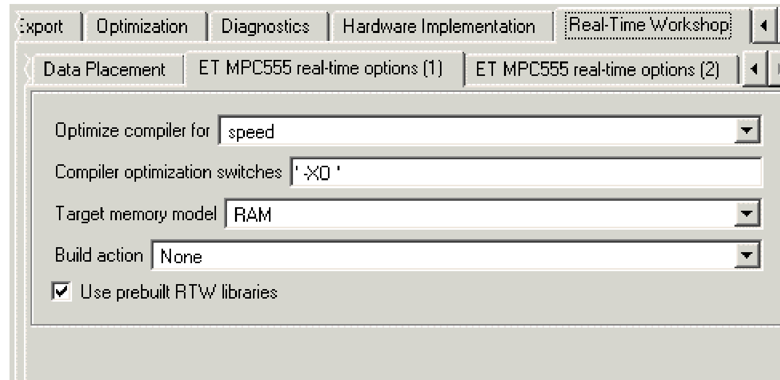
3 Notice the **RTW system target file** for real-time deployment is `mpc555rt.tlc`.

To see how to change from real-time deployment to processor-in-the-loop or algorithm export, click on the **Browse** button to open the **System Target File Browser**. In the browser, observe the three `Embedded Target for Motorola MPC555` options. Click **Cancel** to keep the default real-time setting and return to the **Real-Time Workshop** pane.

4 Select the `ET MPC555 real-time options (1)` tab (use the buttons at top right to scroll through the tabs). The `RAM` option should be selected from the **Target memory model** menu. This option directs Real-Time Workshop to

generate a code file suitable for downloading and execution in RAM. The files for both RAM and flash are in Motorola S-record format.

Leave the options set to their defaults. The code generation options should appear as shown below (though optimization switches settings vary between toolchains).



5 You are now ready to build the application. Do this by right-clicking on the `Target_LED` subsystem and selecting **Real-Time Workshop –> Build subsystem**. Then click the **Build** button in the following dialog.

6 On successful completion of the build process, two files are created in the working directory:

a `Target_LED_ram.s19`: This file is for serial or CAN download. It is code only, without symbols, suitable for execution on the target system.

b `Target_LED_ram.elf`: This file is for BDM download.

If `debug` is selected in the compiler optimization settings, the `elf` file will contain debugging symbols as well as code. These symbols are suitable for use with a symbolic debugger such as Wind River SingleStep or Metrowerks CodeWarrior. The default optimization setting is `speed`, so no symbols are included. Symbols are only generated for a `debug` build. See “CompilerOptimizationSwitches” on page 1–18.

You can download to RAM:

- Via Serial or CAN, using the Download Control Panel utility (with Vector-Informatik hardware if you are using CAN), as described in "Downloading the Application to RAM via Serial or CAN" on page 2-12.
- Via the BDM port, as described in "Downloading the Application to RAM via BDM" on page 2-16.

Downloading the Application to RAM via Serial or CAN

The Download Control Panel utility can be used to download application code to MPC555 RAM or to MPC555 flash memory.

In this section, you will use the Download Control Panel utility to download the generated `Target_LED_ram.s19` file to RAM on the target system. The `s19` file is for download over serial or CAN.

`Target_LED_ram.elf` is for BDM download, as described in the next section, "Downloading the Application to RAM via BDM" on page 2–16. Recall you can perform a debug build to include debugging symbols in the `elf` file.

Do the following before you begin:

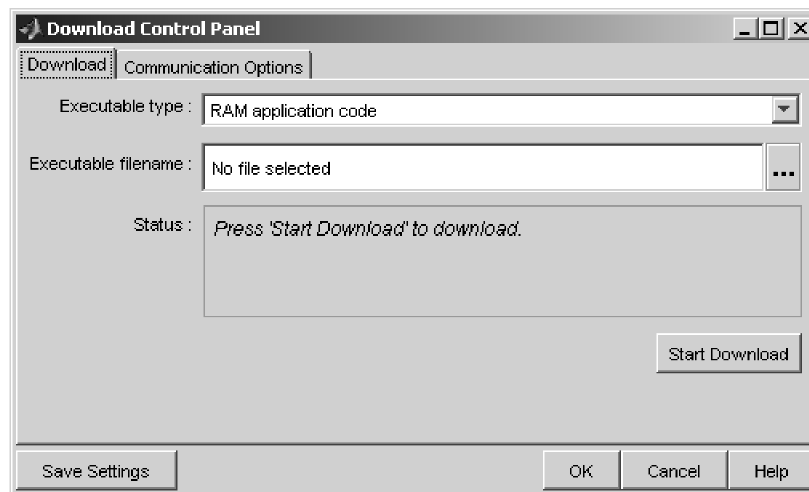
- If you are using serial, make sure you have connected the serial port on your PC to serial port 1 (RS232-1) on the target hardware.
- If you are using CAN, make sure that your Vector-Informatik CAN card and drivers are installed and configured properly. See "CAN Hardware and Drivers" on page A-13. Make sure that the desired CAN port on the PC card is connected to the CAN A port on the target hardware.
- Make sure that you have set up your toolchain as described in "Toolchains and Hardware" on page A-1, and downloaded boot code to the flash memory of the MPC555 as described in "Download Boot Code to Flash Memory" on page 1–20.
- Make sure that nothing is connected to the BDM port of your development board.
- Make sure that the jumpers on the phyCORE-MPC555 board are set as described in "Phytec Jumper Settings" on page A-10.
- Cycle the power (or perform a hard reset) on your development board, to clear the RAM.

To download the generated `Target_LED_ram.s19` file to RAM:

1 Start the **Download Control Panel** in one of the following ways:

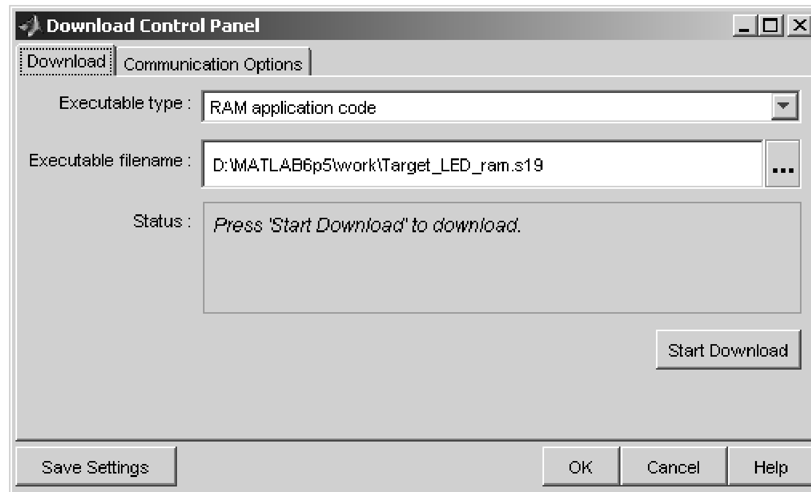
- Use the MATLAB **Start** menu. Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Launch Download Control Panel**.
- Type `embedded_target_download` at the MATLAB command prompt.
- You can also open the **Download Control Panel** automatically at the end of the build process. Before you start the build, you can select **Launch Download Control Panel** from the **Build action** options on the `ET MPC555 real-time options (1)` tab of the Model Explorer. You can see an illustration of this tab in step 4 of "Generating Code" on page 2-9.

2 After using any of these three options, the **Download Control Panel** dialog opens.



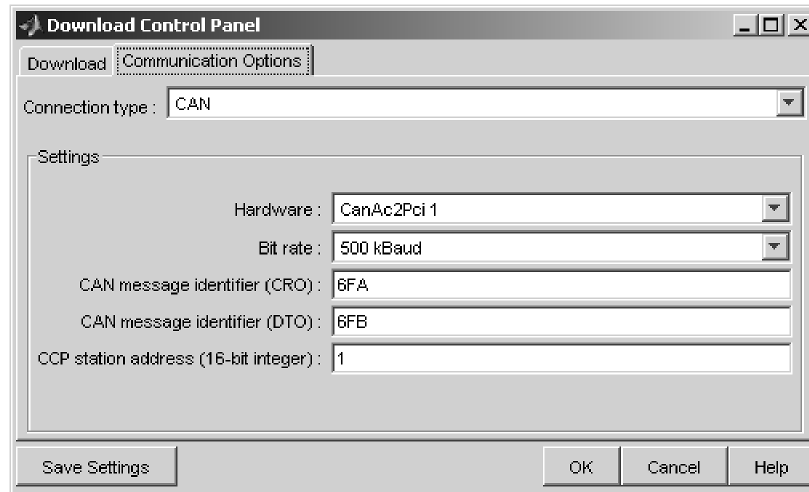
Note `RAM application code` is automatically selected in the **Download** menu. You can use exactly the same process to download application code to flash memory by changing this option to `Flash application code`. Note that you need to build a *`model`*`_flash.s19` file in order to use this option, as described in "Downloading Application Code to Flash Memory via Serial or CAN" on page 2-23. For this exercise leave the `RAM` option selected.

3 Enter the name of the file to be downloaded into the **Filename** field, in this case, `Target_LED_ram.s19`. Alternatively, you can use the browse button (right of the edit box) to navigate to the desired file. The **Download Control Panel** should now appear as shown in this picture.



4 Click on the **Communications Options** tab.

- If you are using serial, select `Serial` from the **Connection Type** drop-down menu. Select the appropriate host PC connection port from `Com1` to `Com4`. You can save your preferences by clicking the **Save Preferences** button.
- If you are using CAN, select `CAN` from the **Connection Type** drop-down menu. Select an appropriate card and port from the **CAN hardware** drop-down menu. The default settings for the other parameters are appropriate for most cases. You can save your preferences by clicking the **Save Settings** button. The following picture shows the **Communications Options** configured for a Vector-Informatik CANAC2pci card, channel 1.



5 Click the **Download** tab. Then click the **Start Download** button.

When you click **Start**, the **Download Control Panel**'s **Status** box changes to read `Press reset or power-cycle your development board to start download`.

6 Press the Reset button on your PhyCORE-MPC555 board (or cycle the power). The **Download Control Panel** changes its **Status** box to read `Connection OK. Please wait till completion or press Stop to terminate the download.`

Downloading commences, and the **Start** button caption changes to **Stop**.

7 While downloading proceeds, progress messages are displayed in the **Download Control Panel**. A dialog appears to inform you the download completed successfully. After the download, the **Stop** button caption changes back to **Start**.

If the download does not succeed, reset your development board and return to step 5.

8 Close the **Download Control Panel** dialog.

9 A few seconds after a successful download, the boot code transfers control to the application program. At this point, you should see two LEDs (red and green) blinking on the target board. This indicates that the program is operating correctly.

Note that you can monitor the progress of a CAN download using a program such as CANalyzer. Alternatively, you can use the `btest32` utility supplied with the Vector Informatik driver software. You can invoke the `btest32` utility from the PC command prompt. The following example runs `btest32` with a bit rate of 500000 (500 kbaud):

```
btest32 500000
```

Downloading the Application to RAM via BDM

You can choose to automatically download to the target over BDM on completion of the build process. Follow these steps to generate, download and execute the `Target_LED_ram.elf` file to RAM on the target system. `Target_LED_ram.elf` can contain both code and symbols for use with the debugger if you perform a debug build. You will not perform a debug build in this tutorial, so the file will contain code only.

You can use Embedded Target for Motorola MPC555 to download application code via BDM to MPC555 RAM only.

If you want to download application code to MPC555 flash you can use serial or CAN. The download process is exactly the same as described in “Downloading the Application to RAM via Serial or CAN” on page 2-12, except you change the **Download** option from `RAM` to `Flash`. Note that you also need to generate a *`model`*`_flash.s19` file to download to flash memory, as described in “Downloading Application Code to Flash Memory via Serial or CAN” on page 2-23. If you want to download the application to flash memory over BDM manually using your own tools, then the file you need to download is the S-record file `*.s19`.

Do the following before you begin:

- Make sure that you have downloaded boot code to the flash memory of the MPC555. See “Download Boot Code to Flash Memory” on page 1–20.

- Connect the BDM port of your development board to parallel port LPT1 of your host PC (or the port specified for your toolchain if different, see "Setting Up Your Toolchain" on page A-2).
- Make sure that the jumpers on the phyCORE-MPC555 board are set as described in "Phytec Jumper Settings" on page A-10.

To generate and download the `Target_LED_ram.elf` file to RAM over BDM,

1 Select **Simulation –> Simulation Parameters**.

   The **Model Explorer** window appears. Make sure `Configuration` is selected under the model name in the tree.

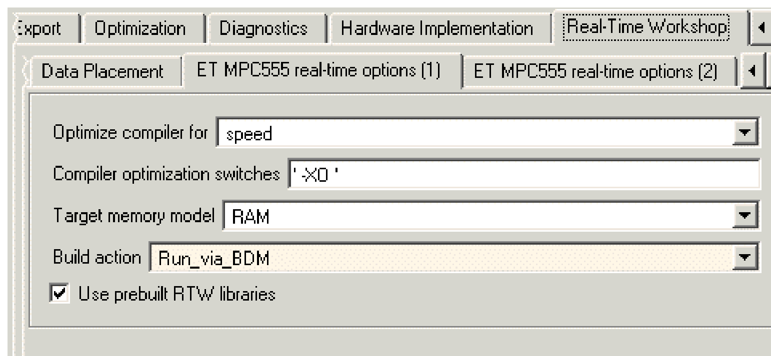
2 Click **RTW** to activate the **Real-Time Workshop** pane.

3 On the **Real-Time Workshop** pane, select the `MPC555-DK (real-time)` tab.

4 Select `Run_via_BDM` or `Debug_via_BDM` from the **Build action** drop-down menu.

5 Ensure the **Target memory model** selected is `RAM` (not `FLASH`).

   Notice the default **Optimize compiler for** setting is `speed`. If you change this setting to `debug`, the generated `elf` file will contain both code and symbols for use with a symbolic debugger. See "CompilerOptimizationSwitches" on page 1–18 for more information on these settings. For this tutorial, leave this setting at the default, as shown.



6 Right click on the `Target_LED` subsystem and select **Real-Time Workshop –> Build Subsystem**.

You will see progress messages in the MATLAB Command Window as code is generated. Your debugger will be automatically started and will download the code to the target.

Also available is the **Start** menu option **Debug RAM base application**. Use this option to select a `*.elf` file and debug over BDM as described above. You can use this option to debug a model you have already built without having to go through the build process again.

Downloading Boot and Application Code

RAM vs. Flash Memory

The Embedded Target for Motorola MPC555 creates a file containing the application executable code that must be programmed onto the MPC555. It can also write a file including symbolic information suitable for use with a debugger. The files are written to your working directory.

The format of the code and symbol files is the same for both RAM and flash memory targets, suitable for downloading into RAM or on-chip flash memory. The naming convention for these files is

- *model*_flash.s19 or *model*_ram.s19 (for serial and CAN download)
- *model*_flash.elf or *model*_ram.elf (for BDM download, can contain debugging symbols).

You can download code to RAM or flash memory via serial or CAN download, or via the MPC555's BDM port.

There are advantages and disadvantages to each memory model.

Loading the application code into RAM is faster than loading it into flash memory. In addition, by using RAM you can avoid using up the programming cycles of the flash memory; this lengthens the usable lifetime of the flash memory. Running the application from RAM is a good option for initial testing of the application.

To program applications into RAM, your target hardware must have additional RAM external to the MPC555 on-chip RAM. The Embedded Target for Motorola MPC555 does not support downloading of code to MPC5xx on-chip RAM, because the MPC555 has only 26K of on-chip RAM and the MPC565 has 36K.

For final deployment, or to load code onto a test board for use at a test site, you will generally want to program your code into the nonvolatile flash memory. 416K of flash memory is available for application code (992K on the MPC565). Code programmed into flash memory is persistent and restarts when the board is powered on.

To download code to flash memory, you must first load a binary boot code file into the flash memory. The Embedded Target for Motorola MPC555 provides the boot code file. You must load the boot code into flash memory in order to

run application code. The boot code is always required even for RAM applications.

To understand the download process, it is first necessary to review the memory organization on the MPC555 and the operation of the boot code. This is described in the next section, “Overview of Memory Organization and the Boot Process” on page 2-20:

- If you just want to know how to download application code, you can jump ahead to the section “Downloading Application Code” on page 2-22.
- If you want to know how to download boot code, see the Getting Started section “Download Boot Code to Flash Memory” on page 1-20.

Overview of Memory Organization and the Boot Process

Purpose of Flash Memory Boot Code

When reading this section, you may want to refer to the internal memory map of the MPC555 in section 1.3 of the *MPC555 User’s Guide*. You can find this document at the following URL.
`http://e-www.motorola.com/webapp/sps/library/prod_lib.jsp`

To run generated code from the flash memory, you must load the first 32K flash sector with boot code. The primary purpose of the boot code is to load and start application code when the board is powered on or reset. The boot code also acts as a download agent that downloads generated code into flash memory via CAN or serial.

The boot code manages the exception handling for the MPC555. Applications don't directly handle exceptions but receive them from the boot code. If the boot code is not installed, then applications will not work correctly.

Memory Organization

The MPC555 has a total of 448K of on-chip flash memory (1024K on the MPC565). This memory is organized into banks of 32K each. The first bank is always used to store the boot code and the remaining 416K is available for application code (992K on the MPC565). When using the Embedded Target for Motorola MPC555, the on-chip flash memory is located at absolute address `0x0000` in the MPC555 address space.

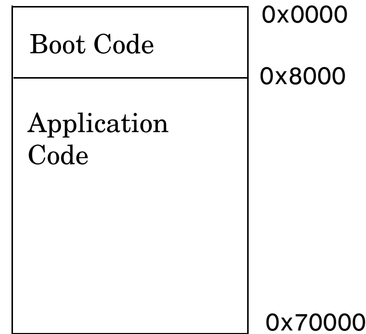


Figure 2-3: Organization of Flash Memory

To run a stand-alone application on the MPC555, it is first necessary to program the boot code into the first bank of flash memory.

The Boot Process

The boot code is executed following power on or reset (unless a probe is connected to the BDM port). Normally, the boot code performs basic hardware initialization and then branches to the application code. Once the application code is running, there is no way to return to the boot code except by performing a reset.

One of the important functions of the boot code is to serve as agent that allows program code to be downloaded over CAN or serial. There are two methods of initiating a program download over CAN or serial:

- The default method for initiating a flash download is to send a special serial or CAN message during a short window of time while the boot code is executing. In the supplied boot code, this window is set to 40ms. If this special message is received during the window while the boot code is executing, a program download sequence commences and a new application can be programmed into flash memory. See “Downloading Application Code to Flash Memory via Serial or CAN” on page 2-23 for details.
- Alternatively, it is possible to commence a flash download over CAN while application code is running on the target. To initiate a download over CAN, you must include a special block in your Simulink model. This block is the

CAN Calibration Protocol block. See “Downloading Boot or Application Code via CAN Without Manual CPU Reset” on page 2-26 for details.

Downloading Application Code

The following sections describe how to download generated image files and run generated code on the target hardware. They also describe how to download to RAM and to flash memory, via either serial, CAN, or the BDM port.

Downloading the Application Code to RAM

To download application code to RAM, you must generate a code file in Motorola S-Record format, which is suitable for downloading and execution in RAM. To do this, select the `RAM` option from the **Target memory model** menu in the **MPC555-DK (real-time) options** category of the **Real-Time Workshop** pane (of the Configuration in the Model Explorer). The build process creates two files in the working directory:

- *`model`*`_ram.s19`: For serial or CAN download. Code only, without symbols, suitable for execution on the target system.
- *`model`*`_ram.elf`: For BDM download. Can also contain symbols if you perform a debug build, suitable for use with a symbolic debugger such as Wind River SingleStep.

- You can download to RAM via serial or CAN, using the Download Control Panel utility (with Vector-Informatik CAN hardware if applicable), as described in “Downloading the Application to RAM via Serial or CAN” on page 2-12.
- You can also download to RAM via BDM, as described in “Downloading the Application to RAM via BDM” on page 2-16.

Downloading the Application Code to Flash Memory

To download application code to flash memory, you must generate a code file which is suitable for downloading and execution in flash memory. To do this, select the `FLASH` option from the **Target memory model** menu in the **MPC555-DK (real-time) options** category of the Real-Time Workshop pane. The build process creates the file *`model`*`_flash.s19` which contains an image of the executable code, in the working directory.

You can download the file to flash memory via serial or CAN, using the Download Control Panel utility (with Vector-Informatik hardware if using

CAN), as described in the following section. Note you cannot use BDM to automatically download application code to flash memory. If you want to download the application to flash memory over BDM manually using your own tools, then the file you need to download is the S-Record file `*.s19`.

Note that you can use the Download Control Panel utility separately as a stand-alone application from MATLAB. For instructions, run this command

```
!D:\matlabroot\toolbox\rtw\targets\common\general\embedded_targe
t_download.bat -help
```

where *`matlabroot`* is the full path to your `matlab` installation directory, on drive D: in this example.

Downloading Application Code to Flash Memory via Serial or CAN

You can use the Download Control Panel to download generated application code to the MPC555 flash memory. Note that except for changing the **Download** option from `RAM` to `Flash`, the process is the same as downloading to RAM.

Do the following before you begin:

- If you are using serial, make sure you have connected the serial port on your PC to serial port 1 (RS232-1) on the target hardware.
- If you are using CAN, make sure that your Vector-Informatik CAN card and drivers are installed, and are configured properly. See “CAN Hardware and Drivers” on page A-13. Make sure that the desired CAN port on the PC card is connected to the CAN A port on the target hardware.
- Make sure that you have set up your toolchain and downloaded boot code to the flash memory of the MPC555, as described in “Setting Up and Verifying Your Installation” on page 1–13.
- Make sure that nothing is connected to the BDM port of your development board.
- Make sure that the jumpers on the phyCORE-MPC555 board are set as described in “Phytec Jumper Settings” on page A-10.

To download the generated *`model`*`_flash.s19` file to flash:

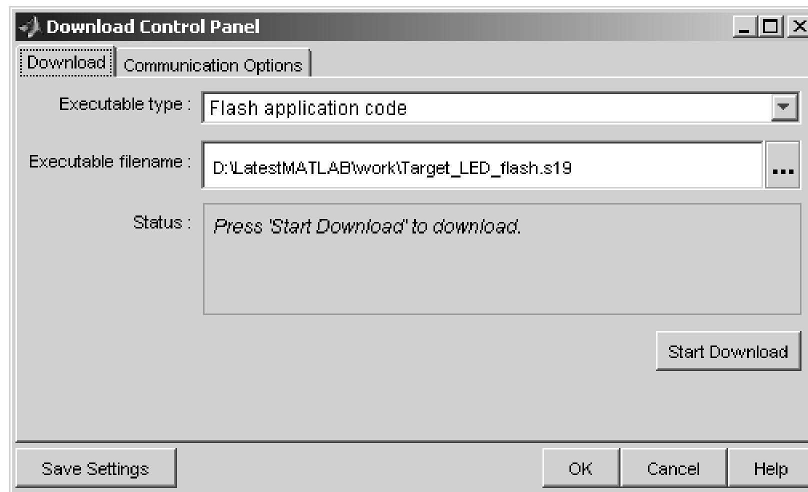
1 Open the Download Control Panel in one of the following ways:

- Use the MATLAB **Start** menu. Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Launch Download Control Panel**.
- Type `embedded_target_download` at the MATLAB command prompt.
- You can also open the **Download Control Panel** automatically at the end of the build process. Before you start the build process, you can select **Launch Download Control Panel** from the **Build action** options on the `ET MPC555 real-time options (1)` tab of the Model Explorer. You can see an illustration of this tab in step 4 of “Generating Code” on page 2-9.

After using any of these three options, the **Download Control Panel** window opens.

2 Select `Flash application code` from the **Executable type** menu.

3 Enter the name of the file to be downloaded into the **Executable filename** field. Alternatively, you can use the browse button to navigate to the desired file. Remember the *`model`*`_flash.s19` files are for serial or CAN download to flash. The **Download Control Panel** should now appear as shown in this picture.



4 Click on the **Communications Options** tab. If you have not saved your preferences already, select `Serial` or `CAN` from the **Connection Type** drop-down menu. If necessary, select an appropriate card/port. The default

settings for the other parameters are appropriate for the default boot process. You can save your preferences by clicking the **Save Preferences** button. The **Communications Options** configured for a Vector-Informatik CAN-AC2-PCI card, channel 1, are shown in the section “Downloading the Application to RAM via Serial or CAN” on page 2-12.

5. The next step is to download code. Click the **Download** tab, and then click the **Start** button.
   - If there is an application currently running on the target that contains a CAN Calibration Protocol (CCP) kernel, the download proceeds automatically. For more details see “Downloading Boot or Application Code via CAN Without Manual CPU Reset” on page 2-26.
   - If the CCP condition is not met, you must immediately press the reset button on your PhyCORE-MPC555 board after clicking the **Start** button. You will see a message prompt in the **Status** box: `Press reset or power-cycle your development board to start download`.

     When you press the Reset button on your PhyCORE-MPC555 board (or cycle the power), the **Download Control Panel** changes its **Status** box to read `CCP Connection OK. Please wait till completion or press Stop to terminate the download.`

   Downloading commences, and the **Start** button caption changes to **Stop**. While downloading proceeds, progress messages are displayed in the **Download Control Panel**. A successful download ends with an information dialog and the **Stop** button caption changes back to **Start**.

6. If the download does not succeed, reset the board and return to step 5.

   You can monitor the progress of the flash download over CAN by using a program such as CANalyzer. Alternatively, you can use the `btest32` utility supplied with the Vector Informatik driver software. You can invoke the `btest32` utility from the PC command prompt. The following example runs `btest32` with a bit rate of 500000 (500kbaud):

   ```
   btest32 500000
   ```

7. Close the **Download Control Panel** window.

Once the download process is complete, the application starts running immediately on the target hardware.

Downloading Boot or Application Code via CAN Without Manual CPU Reset

The default method for download over CAN requires that the target processor be manually reset in order for the download process to begin. This requirement may be problematic if the target hardware is not physically accessible or if it cannot be individually reset or powered down/up.

It is possible to remove this requirement for manual reset if a suitably prepared application is already running on the target. To do this, include a CAN Calibration Protocol block within the model (See “CAN Calibration Protocol (MPC555)” on page 4-18).

Note To use the CAN Calibration Protocol block you need Stateflow and Stateflow Coder.

When the currently running application includes the CAN Calibration Protocol block, the download process begins when you click on the **Start** button of the **Download Control Panel**; it is not necessary to manually reset the target hardware to initiate the download. A reset of the processor is triggered by a CCP Program Prepare message. After the Program Prepare message is received at the target, there will be a short delay until the processor resets and continues the download process by transmitting a response to the Program Prepare message.

The length of the delay will be the watchdog timeout period of the application. By default, for a 20MHz application, this will be approximately 7 seconds; for a 40MHz application, this will be approximately 3 seconds.

It is possible to explicitly set the timeout period of the watchdog timer, by using the Watchdog block in the MPC555 device driver library. See “Watchdog” on page 4-115.

The **Download Control Panel** is configured to allow a maximum delay of 10 seconds between sending the Program Prepare message and receiving a response from the target. If this delay is exceeded, an error will be reported by the download tool.

When using the CAN Calibration Protocol block, you must specify

- CAN message identifier for Command Receive Objects

- CAN message identifier for Data Transmit Objects
- Can Calibration Protocol Station Address

Note that the values specified may differ from the default values for these parameters that are programmed in the boot code. When performing the download procedure using the Download Control Panel, you must ensure that the parameters specified on the **Communications Options** tab match those specified in the currently running application.

For an example of how to use the CAN Calibration Protocol block for signal monitoring, parameter tuning and automatic download, see the demo model `mpc555rt_ccp`. For instructions, click the link “MPC555 CCP Demo” or to see information on all demos, at the command line enter

```
demo simulink 'Embedded Target for Motorolaﬁ MPC555'
```

Boot Code Parameters for CAN Download

The boot code parameters for download over CAN determine

- CAN bit rate
- CAN message identifier for Command Receive Objects (CRO)
- CAN message identifier for Data Transmit Objects (DTO)
- CAN Calibration Protocol Station Address
- The duration of the window during which the boot code listens for a download command message

Table 2-1 shows the default values for these parameters. These defaults should be suitable for most applications.

Table 2-1: Default Boot Code Parameters

Parameter	Default Value
CAN bit rate	500000
CCP station address	1
CAN message identifier (CRO)	6FA

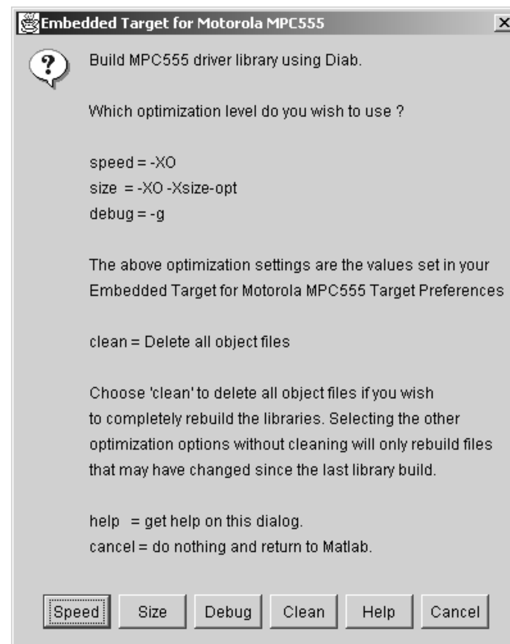
Table 2-1: Default Boot Code Parameters

Parameter	Default Value
CAN message identifier (DTO)	6FB
Duration of listening window	40 ms

You cannot change the default boot code parameter values except by modifying and recompiling the boot code. If it is absolutely necessary to do this, you can recompile the boot code as follows:

1 Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Build MPC555 Driver Library**.

The **Build Driver Libraries** dialog opens.



2 Select the compiler optimization setting you want to use for the build (from `speed`, `size`, `debug`, or `clean`).

- See “CompilerOptimizationSwitches” on page 1–18 for more information on the `speed`, `size` and `debug` settings, which are compiler-specific. You can edit these settings in the **Target Preferences** dialog.
- The `clean` option deletes all object files. Note that to ensure a rebuild of all files you should run a `clean` build followed by a build using your required optimization setting. Otherwise only files which have changed since last library build will be rebuilt.

Embedded Target for Motorola MPC555 automatically recompiles the code, using your settings in target preferences.

Note You should not make changes to the boot code without fully understanding the effect of your changes. Note also that the boot code may be changed without notice in future releases of this product.

Generating ASAP2 Files

ASAP2 is a data definition standard proposed by the Association for Standardization of Automation and Measuring Systems (ASAM). ASAP2 is a standard description you use for data measurement, calibration, and diagnostic systems. The Embedded Target for Motorola MPC555 real-time target lets you export an ASAP2 file containing information about your model during the code generation process.

Before you begin generating ASAP2 files with the Embedded Target for Motorola MPC555 real-time target, you should read the "Generating ASAP2 Files" section of the Real-Time Workshop Embedded Coder documentation. That section describes how to define the signal and parameter information required by the ASAP2 file generation process.

The process of generating an ASAP2 file from your model with Embedded Target for Motorola MPC555 real-time target is similar to that described in the Real-Time Workshop Embedded Coder documentation.

The `mpc555rt_ccp` demo provides an example of the Embedded Target for Motorola MPC555 ASAP2 file generation feature.

How the Process Works

The Embedded Target for Motorola MPC555 generates an initial ASAP2 file during the code generation process. At this point, the addresses of signals and parameters on the target system are unavailable, since the code has not been compiled and linked. The initial ASAP2 file contains placeholders for the unresolved addresses.

To supply the required memory addresses, the generated code must be compiled and the compiler must generate a MAP file.

After the build process, if the Embedded Target for Motorola MPC555 real-time target detects the presence of the ASAP2 file and a MAP file in the required format, it performs a post-processing phase. During this phase, the MAP file is used to propagate the required address information back into the ASAP2 file.

MAP file formats differ between compilers, so the post processing phase is compiler-specific. The Embedded Target for Motorola MPC555 provides the post-processing mechanism for both supported toolchains (Diab and CodeWarrior).

To use the Embedded Target for Motorola MPC555 ASAP2 file generation feature, you simply need to select the **Generate ASAP2** file option in Real-Time Workshop. as described in the following section "ASAP2 File Generation Procedure" on page 2–31. If it is appropriate to back propagate addresses from the MAP file into the ASAP2 file, then this will also be done automatically. No other steps are necessary to ensure that the generated MAP and ASAP2 files are automatically post processed.

The names of the ASAP2 file and the MAP file derive from the source model. The MAP file is generated in the same directory as the source model. The ASAP2 file is written to the build directory.

ASAP2 File Generation Procedure

1 Create the desired model. Use appropriate parameter names and signal labels to refer to ASAP2 `CHARACTERISTICS` and `MEASUREMENTS` respectively.

2 Define the corresponding `ASAP2.Parameter` and `ASAP2.Signal` objects in the MATLAB workspace.

3 Configure the data objects to generate unstructured global storage declarations in the generated code by assigning one of the following storage classes to the `RTWInfo.StorageClass` property for each object:

   - `ExportedGlobal`
   - `ImportedExtern`
   - `ImportedExternPointer`

   `ExportedGlobal` is the default storage class.

4 Configure the other data object properties such as `LongID_ASAP2`, `PhysicalMin_ASAP2`, etc., for each object.

5 In your model window, select the menu item **Simulation –> Configuration Parameters**.

   The **Configuration Parameters** dialog appears.

6 Select the **Optimization** tab.

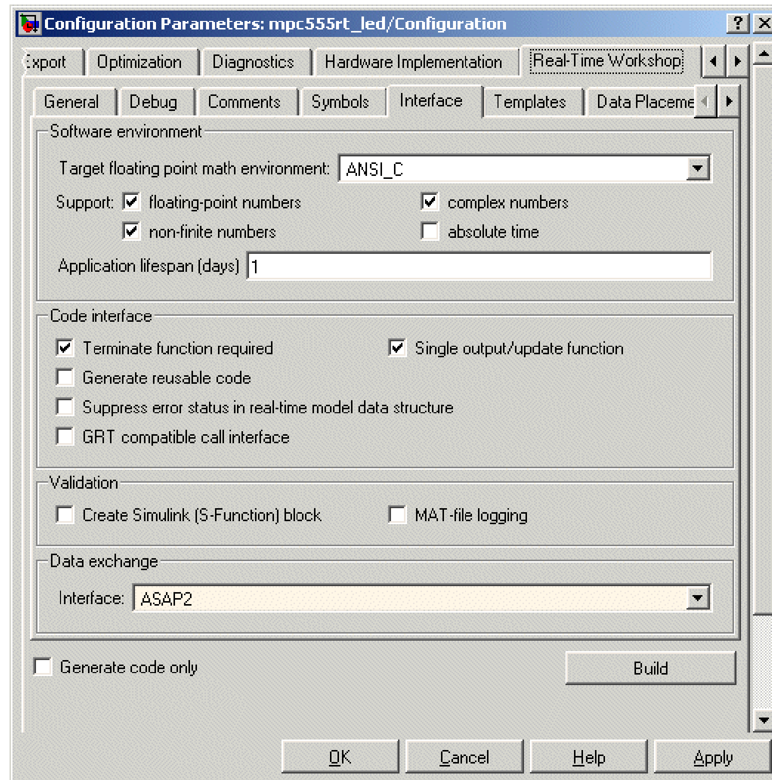
7 Select the **Inline parameters** option.

   Note that you should *not* configure the parameters associated with your data objects in the **Model Parameter Configuration** dialog box (reached via the **Configure** button). If a parameter that resolves to a Simulink data object is configured using the **Model Parameter Configuration** dialog box, the dialog box configuration is ignored. You can, however, use the **Model Parameter Configuration** dialog to configure other parameters in your model.

8 Select the **Real-Time Workshop** tab.

9 Select the **Interface** tab (use the buttons at top right to scroll through the Real-Time Workshop tabs).

10 Select the **ASAP2** option from the **Interface** drop-down menu, in the `Data exchange` frame, as shown following.



11 Click **Apply**.

12 Click **Build**.

The ASAP2 file is generated as part of the build process.

Data Acquisition (DAQ) List Configuration

The Embedded Target for Motorola MPC555 supports the Data Acquisition (DAQ) List feature of the CAN Calibration Protocol (CCP). DAQ lists allow efficient synchronous signal monitoring. The CCP block provided with the Embedded Target for Motorola MPC555 supports DAQ lists (see “CAN Calibration Protocol (MPC555)” on page 4-18 for details).

ASAP2.Signal objects are used for monitoring a signal in the CCP polling mode of operation. To monitor a signal in a DAQ list, however, you must configure the signal somewhat differently. The differences are as follows:

- Instead of defining an ASAP2.Signal in the MATLAB workspace (and associated signal in the Simulink model), define a canlib.Signal object instead.
- There is no need to set the RTWInfo.StorageClass property of the canlib.Signal object. By default, the storage class is set to Custom.
- You should enter data in the other fields of the canlib.Signal object in the same way you would do for an ASAP2.Signal object.

During code generation, the Embedded Target for Motorola MPC555 automatically determines how to configure the DAQ lists in the generated code. For each distinct sample rate (of the set of canlib.Signal objects assigned by the user) one DAQ list in the model is created. The CCP DAQ List Object Descriptor Tables (ODTs) are shared equally between the created DAQ lists.

The sample rates of the canlib.Signal objects are mapped to CCP event channels in an extra file, DAQ_LIST_EVENT_MAPPINGS, that is generated in the build directory. This shows how to assign event channels to MEASUREMENT signals in a calibration package.

The event channels periodically transmit events that are used to trigger the sending of DAQ data to the host. By assigning event channels as defined in DAQ_LIST_EVENT_MAPPINGS, consistent and efficient transmission of DAQ data is achieved.

It is the responsibility of the calibration tool (see “Compatibility with Calibration Packages” on page 4-23) to assign an event channel and data to the available DAQ lists using CCP commands, and to interpret the synchronous response.

It is the responsibility of the user to make sure the calibration tool is set up correctly and that the event channels assigned to MEASUREMENT signals correspond to those defined in the file DAQ_LIST_EVENT_MAPPINGS.

Execution Profiling

The Embedded Target for Motorola MPC555 provides a set of utilities for recording, uploading and analyzing execution profile data for timer-based tasks and asynchronous Interrupt Service Routines (ISRs). With these utilities, you can

- Generate a graphical display that shows when timer-based tasks and interrupt service routines are activated, preempted, resumed and completed.
- Generate a report with information on
  - Maximum number of overruns for each timer-based task since model execution began
  - Maximum turnaround time for each timer-based task since model execution began
  - Analysis of profiling data for timer-based tasks and asynchronous interrupts over a period of time

You can use the demo model `mpc555_multitasking` to see an example. This demo model illustrates both execution profiling and the preemptive multitasking scheduler with configurable overrun handling. For instructions, click the link "MPC555 Multitasking Demo", or to see information on all demos, at the command line enter

```
demo simulink 'Embedded Target for Motorolafi MPC555'
```

To perform execution-profiling analysis on a model, you must perform the following steps:

1. Depending on whether you are using serial or CAN, place a copy of the appropriate execution profiling block in your model (MPC555 Execution Profiling via SCI1 or MPC555 Execution Profiling via CAN A).

2. Connect a serial or CAN cable between the target processor and your host PC.

3. Check the box to enable Execution profiling in Real-Time Workshop options. See "Real Time Workshop Options for Execution Profiling" on page 2–37.

4. Build, download and run the model.

5. Initiate execution profiling by running one of the following commands:

- `profile_mpc555 serial`
- `profile_mpc555 can`

Two forms of execution profiling are provided:

1. The worst-case values for task turnaround times and number of task overruns since model execution began are updated whenever a previous worst-case value is exceeded.

2. A snapshot of task and ISR activity may be recorded over a period of time; the length of this period depends on how much memory is available to log the data.

Execution Profiling Definitions

Task turnaround time is the elapsed time between start and finish of a task. If the task is not preempted then the task turnaround time is equal to the task execution time.

Task execution time is that part of the time between task start and finish when the task is actually running and not preempted by another task. Note that the task execution time cannot be measured directly, but is inferred from the task start and finish time and the intervening periods during which it was preempted by another task. Note that, in performing these calculations, no account is taken of processor time consumed by the scheduler while switching tasks: this means that, in cases where preemption has occurred, the reported task execution times will overestimate the true values.

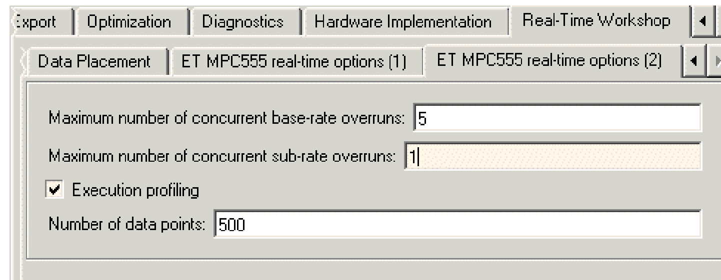
Task overruns occur when a timer task does not complete before that same task is next scheduled to run. Depending on how the real-time scheduler is configured, a task overrun may be handled as a real-time failure. Alternatively, a small number of concurrent task overruns may be allowed in order to accommodate cases where a task occasionally takes longer than normal to complete.

The Execution Profiling Block

See the Block Reference section “MPC555 Execution Profiling via SCI1” on page 4-39 or “MPC555 Execution Profiling via CAN A” on page 4-36.

Real Time Workshop Options for Execution Profiling

You can see these options on the **ET MPC555 real-time options (2)** tab of the **Real-Time-Workshop** tab in the **Configuration Parameters** dialog.



Execution profiling

If this option is checked then the generated code for the model will be "instrumented" with function calls at the beginning and end of each task or ISR to be profiled. These function calls read a timer (on MPC555 it is the decrementer timer) and log this reading along with a task identifier.

When code for the model is generated, these functions will update data on the worst-case turnaround time for each timer-based task as well as the worst-case number of concurrent task overruns, whenever a previous worst case value is exceeded. Additionally, when a trigger is provided, data will be logged over a period of time to record all task start and task finish times. The trigger signal can be supplied, for example, by the execution profiling blocks. See "MPC555 Execution Profiling via SCI1" on page 4-39 and "MPC555 Execution Profiling via CAN A" on page 4-36.

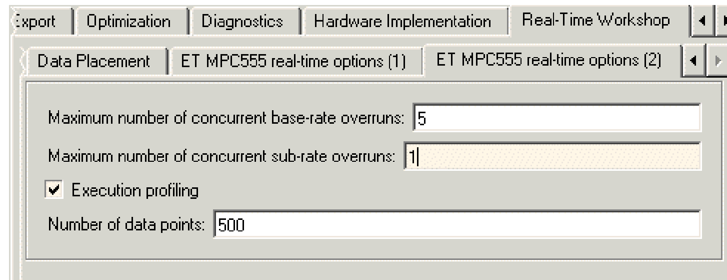
Number of data points

When a snapshot of task and ISR activity is logged this data is stored in memory that is statically allocated at build time. Each data point requires 8 bytes on the MPC555. The larger the number of data points to be stored, the more RAM that must be reserved for this purpose. At the end of a logging run, the data must be uploaded to the host computer for analysis; this is typically achieved by using the execution profiling blocks.

Note For MPC555, it is necessary to build the driver libraries with flag DPROFILING_ENABLED=1. If this is not done, then no profiling information will be recorded for CAN or TPU ISRs.

Real Time Workshop Overrun Options

These Real-Time Workshop options configure the allowable number of task overruns. You can see these options on the **ET MPC555 real-time options (2)** tab of the **Real-Time-Workshop** pane in the **Model Explorer**.



You can use the options **Maximum number of concurrent base-rate overruns** and **Maximum number of concurrent sub-rate overruns** to configure the behavior of the scheduler when any of the timer based tasks do not complete within their allowed sample time. It is useful to allow task overruns in the case where a task may occasionally take longer than usual to complete (e.g. if extra processing is required when a special event occurs); if the task overrun is only occasional then it is possible for the scheduler to 'catch up' after the extra processing has been completed.

If the maximum number of concurrent overruns for any task is exceeded, this is deemed to be a failure and the real-time application is stopped. This in turn will result in a watchdog timer timeout (provided the watchdog timer is enabled) and the processor will be reset.

As an example, if the base rate is 1 ms and the maximum number of concurrent base-rate overruns is set to 5 then it is possible for the base rate task to run for almost 6 ms before failure occurs. Once the overrun has occurred, it is necessary for subsequent executions of the base rate to complete in less than 1 ms in order that the lost time is recovered.

The occurrence of base-rate overruns does not affect the numerical behavior of the algorithm (although reading/writing external devices will of course be delayed).

If sub-rate overruns are allowed then the transfer of data between different rates (via rate-transition blocks) in the model may be affected; this causes the numerical behavior in real-time to differ from the behavior in simulation. To see an illustration of this effect try running the demo model mpc555rt_multitasking. To disallow sub-rate overruns and ensure that this effect does not occur, you should set **Maximum number of concurrent sub-rate overruns** to zero.

Summary of the Real-Time Target

The following sections summarize the features of the Real-Time Target:

- "Code Generation Options" on page 2–40
- "Requirements and Restrictions" on page 2–42

Code Generation Options

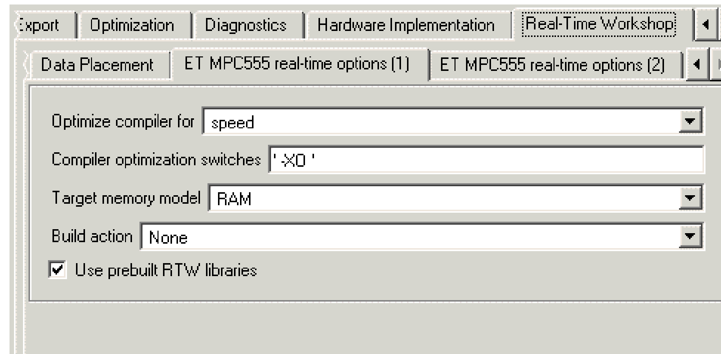
The real-time target is an extension of the Real-Time Workshop Embedded Coder embedded real-time (ERT) target configuration. The real-time target inherits the code generation options of the ERT target, as well as the general code generation options of the Real-Time Workshop. These options are available via the **Real-Time Workshop** pane of the **Configuration Parameters** dialog; they are documented in the Real-Time Workshop documentation and the Real-Time Workshop Embedded Coder documentation.

Some code generation options of the ERT target are not relevant to the real-time target, and are either unsupported, or restricted in their operation. See "Requirements and Restrictions" on page 2-42 for details.

Note Do not attempt to build code in directories with spaces in the name. This may cause the build to fail as we cannot guarantee that third party toolchains will accept this.

Target-Specific Options

The real-time target has several target-specific code generation options. To view or change the setting of these options, select the **ET MPC555 real-time options(1)** tab of the **Real-Time-Workshop** tab in the **Configuration Parameters** dialog. This picture shows the options at their default settings.



- **Optimize compiler for** — Select `speed`, `size`, `debug`, or `custom`.

  This option controls compiler optimization switches used during the build process. The exact effect of the optimization switches depends on whether you are using the Diab or CodeWarrior compiler. You can optimize for performance by choosing the `speed`, `size`, or `debug` options, or define your own (the `custom` option). You can edit these preferences here in the **Compiler optimization switches** edit box if you want to apply changes to the current model (**Optimize compiler for:** will change to `custom`). You can also edit the defaults for these settings in the **Target Preferences** dialog if you want to apply these changes to several models. See "CompilerOptimizationSwitches" on page 1-18 for more information.

- **Target memory model** Select either `FLASH` or `RAM`.

  If you select the `FLASH` option, files in a format suitable for downloading into the MPC555 on-chip flash memory are written. If you select the `RAM` option, files in a format suitable for downloading into RAM are generated.

In both cases these two files are generated, with this naming convention:

- *model*_flash.s19 or *model*_ram.s19 — code only, for CAN download
- *model*_flash.elf or *model*_ram.elf — for BDM download, containing code and optional debugging symbols if you choose a debug build in the **Optimize compiler for** settings

• **Build action**

- None— code generation only.
- Launch_Download_Control_Panel —on completion of code generation the Download Control Panel utility is opened.
- Run_Via_BDM—on completion of code generation download over BDM connection automatically starts and on completion the code is run.
- Debug_Via_BDM—on completion of code generation download over BDM connection automatically starts. When the download is complete the code stops at the first line in debug mode, so you can step through the code.

• **Use prebuilt RTW libraries**

This check box option (selected by default) saves a considerable amount of time during the build process, as the libraries do not need to be recompiled every time. However, note this uses the defaults we have chosen for compiler optimization switches. These defaults are designed for rapid prototyping mode. If you are going to switch to production code development and want to fine tune the settings, you should clear this option. Then the custom optimization switches you set here will be applied to the library code as well as the model code.

Requirements and Restrictions

MPC555 Resource Configuration Block Required

To generate code from a model using the Embedded Target for Motorola MPC555 real-time target, an MPC555 Resource Configuration block must be included in the model. The MPC555 Resource Configuration block is required even for models that do not contain any MPC555 device driver blocks.

Note When using device driver blocks from the Embedded Target for Motorola MPC555 libraries in conjunction with the MPC555 Resource Configuration block, do not disable or break library links on the driver blocks. If library links are disabled or broken, the MPC555 Resource Configuration block will operate incorrectly. See "MPC555 Resource Configuration" on page 4-41 for further information.

Certain ERT code generation options are not supported by the real-time target. If these options are selected, the real-time target either ignores the option or issues an error message during the build process. Table 2-2 summarizes these restricted options.

Table 2-2: Real-Time Target Restricted Code Generation Options

Option	Restriction
MAT-file logging	Ignored if selected; build process proceeds
Create Simulink (S-function) block	Error if selected; build process terminates
External mode	Error if selected; build process terminates
Generate an example main program	This option should not be selected for the real-time target. The real-time target supplies a target-specific main program, `mpc555dk_main.c`. Ignored if selected; build proceeds with a warning.
Generate reusable code	Error if selected; build process terminates

3

PIL Cosimulation

This section includes the following topics:

Overview of PIL Cosimulation (p. 3-2)	Basic concepts you will need to know to use cosimulation effectively in your design process.
Tutorial 1: Building and Running a PIL Cosimulation (p. 3-5)	A hands-on, step-by-step introduction to cosimulation with the PIL target, using a plant/controller demonstration model.
Tutorial 2: Modifying and Rebuilding the Controller (p. 3-17)	This tutorial shows you how to use the PIL target to make iterative changes to a controller subsystem.
Tutorial 3: Using the Demo Model In Simulation (p. 3-21)	In addition to building code suitable for cosimulation, the PIL target builds components you can use in closed-loop and software-in-the-loop (SIL) simulations. This tutorial shows you how to use these components.
PIL Target Summary (p. 3-22)	Summary of code generation options of the PIL target; restrictions and limitations of the PIL target.
Algorithm Export Target (p. 3-27)	The Algorithm Export (AE) target generates only the code that implements the algorithm of your model or subsystem. This is useful for code analysis and interfacing to hand-written or legacy code.
Code Analysis Reporting (p. 3-28)	This section describes the extended HTML code generation report.
Algorithm Export Target Summary (p. 3-30)	Summary of code generation options and restrictions for algorithm export.

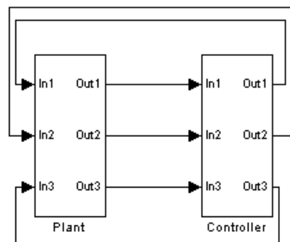
Overview of PIL Cosimulation

The Embedded Target for Motorola MPC555 supports *processor-in-the-loop* (PIL) *cosimulation*, a technique that is designed to help you evaluate how well a candidate control system operates on the actual target processor selected for the application.

The Embedded Target for Motorola MPC555 (processor-in-the-loop) target is an extended version of the embedded real-time (ERT) target configuration, designed specifically for PIL cosimulation. We will refer to this target as the *PIL target*.

Why Use Cosimulation?

PIL cosimulation is particularly useful for simulating, testing and validating a controller algorithm in a system comprising a *plant* and a *controller*. In classic closed-loop simulation, Simulink and Stateflow model such a system as two subsystems and the signals transmitted between them, as shown in this block diagram.



Your starting point in developing a plant/controller system is to model the system as two subsystems in closed-loop simulation. As your design progresses, you can use Simulink external mode with standard Real-Time Workshop targets (such as GRT or ERT) to help you model the control system separately from the plant.

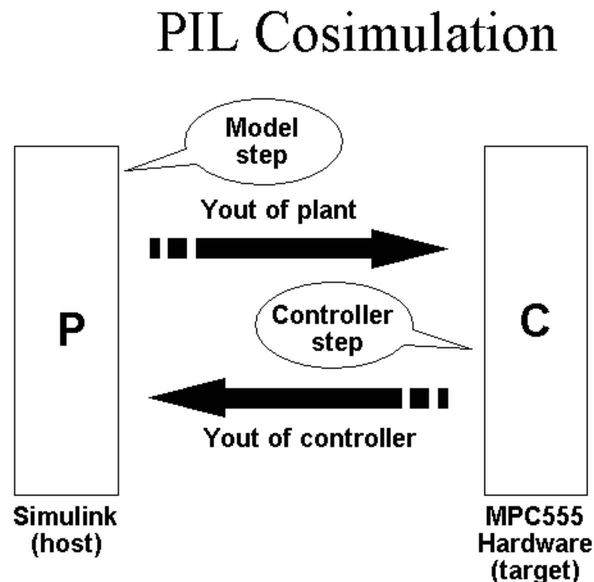
However, these simulation techniques do not help you to account for restrictions and requirements imposed by the hardware. When you finally reach the stage of deploying controller code on the target hardware, you may need to make extensive adjustments to the controller system. Once these

adjustments are made, your deployed system may diverge significantly from the original model. Such discrepancies can create difficulties if you need to return to the original model and change it.

PIL cosimulation addresses these issues by providing an intermediate stage between simulation and deployment. The term “cosimulation” reflects a division of labor in which Simulink models the plant, while code generated from the controller subsystem runs on the actual target hardware. In a PIL cosimulation, the target processor participates fully in the simulation loop—hence the term “processor-in-the-loop.”

How Cosimulation Works

This figure illustrates how the plant (P) and controller (C) components interact in a PIL cosimulation



In a PIL cosimulation, Real-Time Workshop Embedded Coder generates efficient code for the control system. This code runs (in simulated time) on a target board using the intended microcontroller. The plant model remains in Simulink without the use of code generation.

During PIL cosimulation, Simulink simulates the plant model for one sample interval and exports the output signals (`Yout` of the plant) to the target board via a communications link. When the target processor receives signals from the plant model, it executes the controller code for one sample step. The controller returns its output signals (`Yout` of the controller) computed during this step to Simulink, via the same communications link. At this point one sample cycle of the simulation is complete and the plant model proceeds to the next sample interval. The process repeats and the simulation progresses.

To learn about PIL cosimulation though hands-on experience, see "Tutorial 1: Building and Running a PIL Cosimulation" on page 3-5.

Tutorial 1: Building and Running a PIL Cosimulation

In this tutorial, you will use a subsystem in a Simulink model as a component in simulations on your host computer, and also in a PIL cosimulation running on your phyCORE-MPC555 board.

Before You Begin

Before working with this tutorial, you should read and follow the procedures in "Setting Up and Verifying Your Installation" on page 1-13. Make sure that the target preferences are set up appropriately for your development system (CodeWarrior or Diab) as described in "Setting Target Preferences" on page 1-14

Hardware Connections

The PIL target requires that you have a serial cable connection. You can also use serial and CAN, or serial with a BDM connection.

Serial cable is required for host/target PIL communications whilst the model is running, and downloads can occur over serial or CAN so the minimal requirement is a single serial cable. BDM is not required but can be used if desired; it is not recommended.

We assume that you have made the following connection, as described in the "Interfacing the phyCORE-MPC555 to a Host PC" section of the *phyCORE-MPC555 Quickstart Instructions* manual: Host PC serial (COM1) port to the RS232-1 (P2) connector on the phyCORE-MPC555 board.

The Demo Model

We have provided a demo model for your use. The Fault-Tolerant Fuel Control System model, shown in Figure 3-1, consists of a plant model with a controller subsystem, the `fuel rate controller` subsystem.

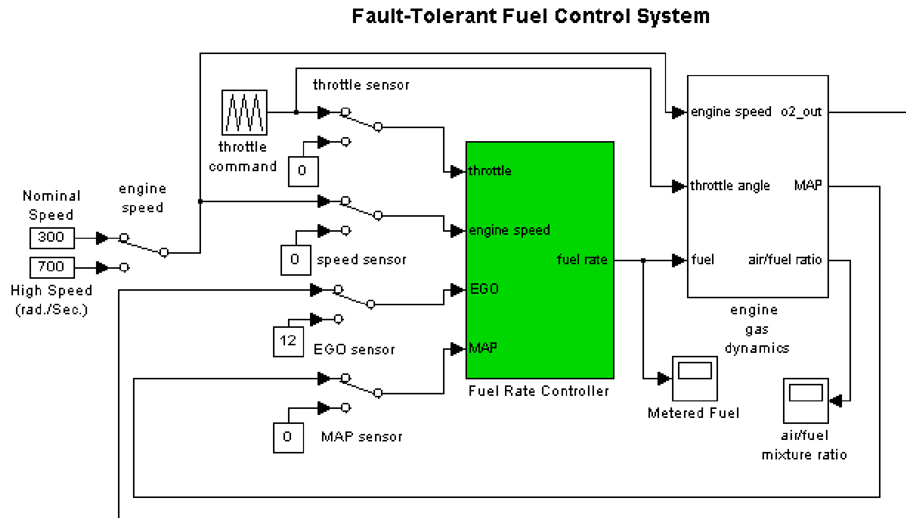
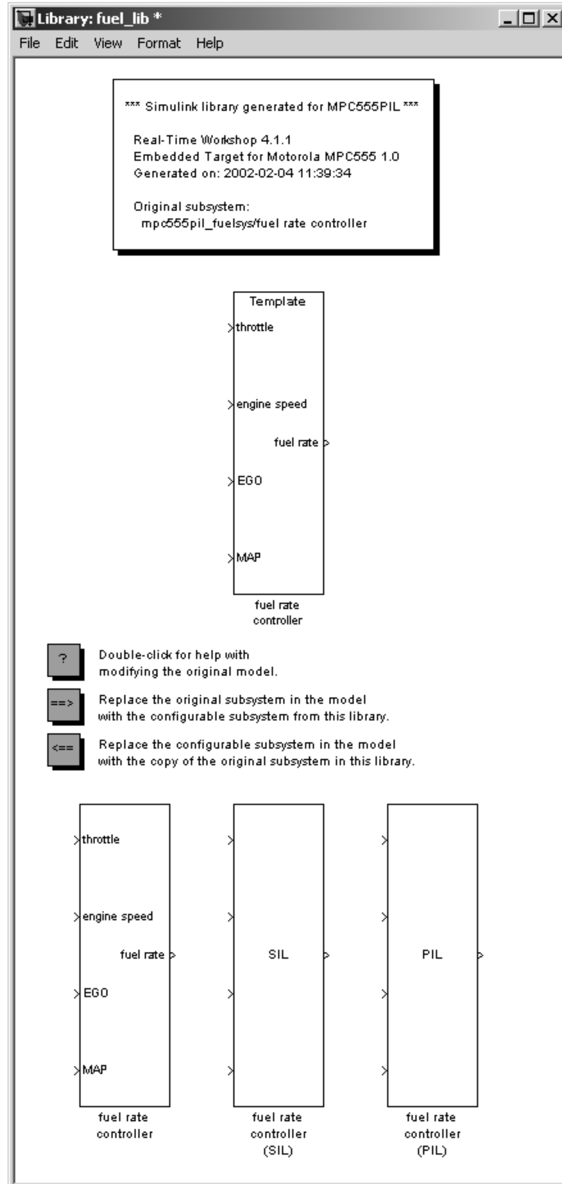


Figure 3-1: Fault-Tolerant Fuel Control System Model

In the following sections, you will use the demo model and the PIL target to generate the following:

- PIL code to run on the target board. The PIL target automatically invokes the appropriate cross-development tools to compile, link, and (optionally) download and run a target executable.
- A library containing
  - The original `fuel rate controller` subsystem block for use in simulation.
  - An S-function wrapper block, generated by Real-Time Workshop Embedded Coder, that implements the `fuel rate controller` subsystem for use in software-in-the-loop (SIL) simulation.
  - A subsystem block that implements the `fuel rate controller` subsystem on the host side during cosimulation. This subsystem communicates with generated PIL code running on the target board.
  - A master configurable subsystem block that represents the above three components. You will plug this block into a plant model and select each of the three components in turn for use in a simulation.

This figure shows a library generated by the PIL target.



Once you start the build process, there is almost no manual intervention required to build all these components.

After building the components, you will use them in normal simulation, SIL simulation, and PIL cosimulation. You will monitor the results of each simulation via the Scope blocks in the model.

Setting Up the Model

In this section you will make a local copy of the demo model and configure the model as required by this exercise:

1. Open the demo model by clicking the link or typing at the command line:

   ```
   mpc555_fuelsys
   ```

   Alternatively you can access the whole MPC555 demo suite by selecting **Start –> Demos** and browsing under Simulink, or **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Demos**. The model is located in the directory `matlabroot/toolbox/rtw/targets/mpc555dk/mpc555demos`.

   The path *`matlabroot`* should be the location where MATLAB is installed.

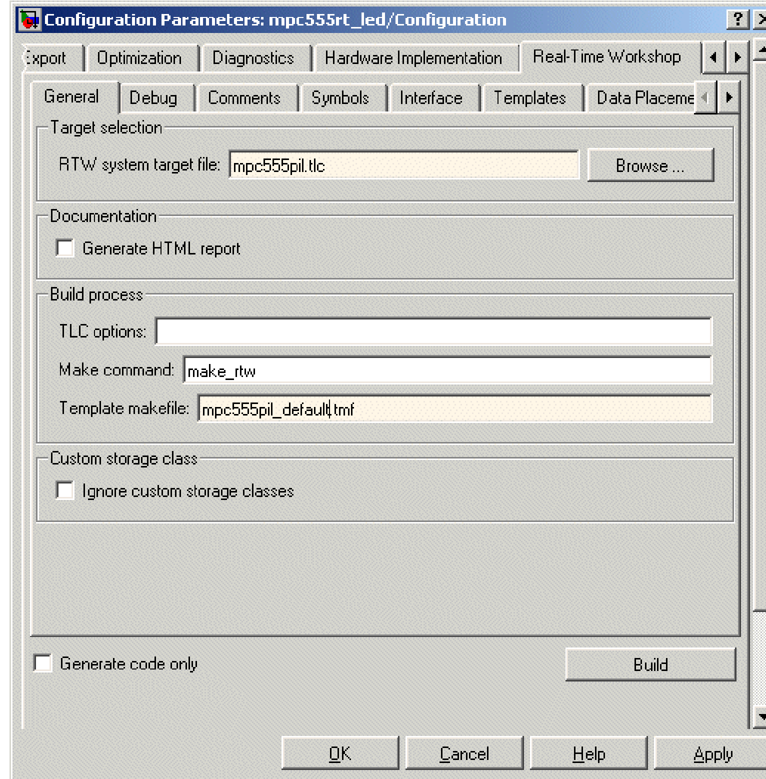
2. Save a copy of the demo model, `mpc555_fuelsys.mdl` to your working directory.

Next, check that the model is correctly configured for use with the Embedded Target for Motorola MPC555.

3. Click on the `Fuel Rate Controller` subsystem, then choose **Configuration Parameters** from the **Simulation** menu. The **Configuration Parameters** dialog opens.

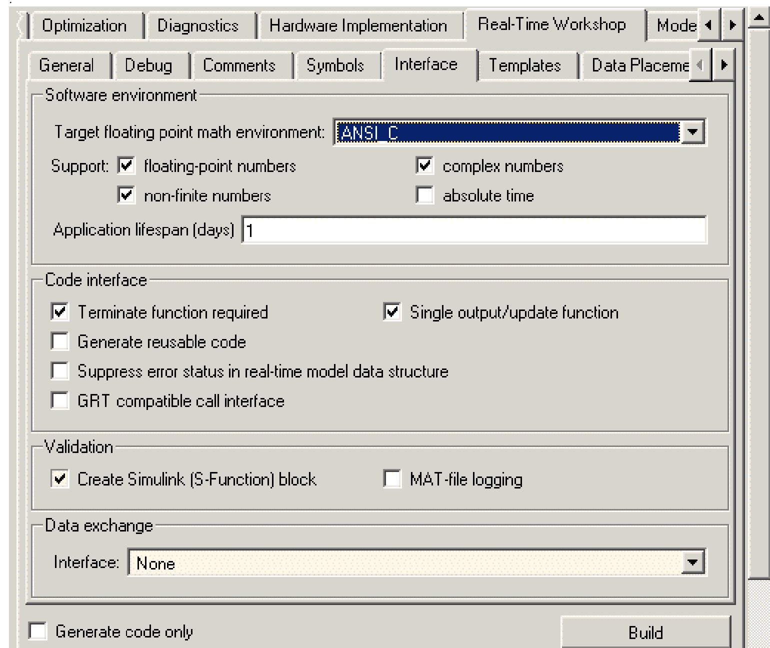
4. Select the **Real-Time Workshop** tab.

5 Observe the `RTW system target file` setting on the **General** tab. The target configuration should be as shown in this figure.

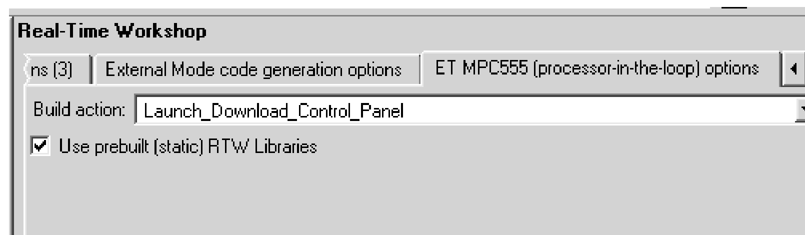


6 To see how to change target configuration settings, click the **Browse** button to open the System Target File Browser, and observe the available **Embedded Target for Motorola MPC555** targets — algorithm export, processor-in-the-loop, and real-time target. Leave the selected target at `mpc555pil.tlc`. Click **Cancel** to close the Browser and return to the **Real-Time Workshop** pane.

7 Select the **Interface** tab. Make sure that the options are set as shown in the following figure. Note that the **Create Simulink (S-Function) block** option is selected. This is required to generate a Real-Time Workshop Embedded Coder S-function wrapper block.



8 Select the **ET MPC555 (processor-in-the-loop) options** tab.



9 Select `Launch_Download_Control_Panel` from the **Build action** drop-down menu. This option automatically invokes the appropriate downloading/debugging utility for your development environment, as specified in your target preferences.

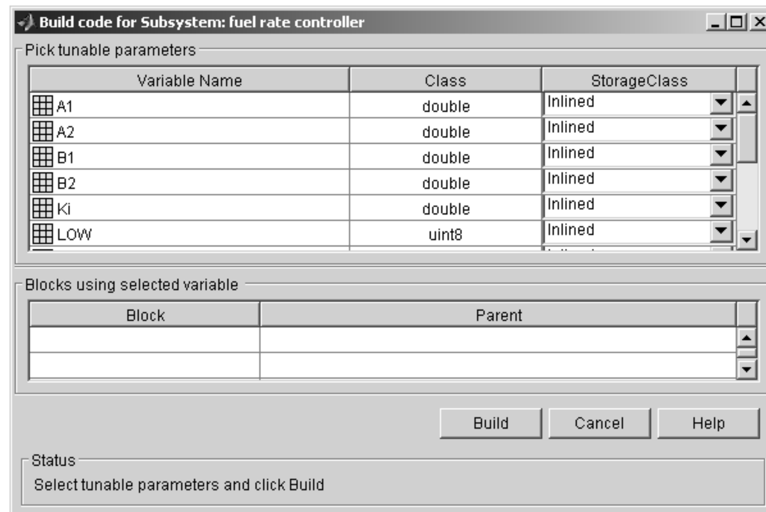
10 Click **Apply** if you have changed any parameters. Then close the **Configuration Parameters** dialog box. If needed, save the model to preserve any changes you have made.

Building PIL and Simulation Components

In this section, you will build a library of simulation, SIL, and PIL components from the `fuel rate controller` subsystem:

1 Right-click on the `fuel rate controller` subsystem. A context menu appears. Select **Build Subsystem** from the **Real-Time Workshop** submenu of the context menu.

2 The **Build code for Subsystem** window opens. This window displays information about each variable (or data object) that is referenced as a block parameter in the subsystem. The window lets you inline or set the storage class of individual parameters. We will not be concerned with these features in this exercise. Click the **Build** button to continue the code generation and build process.



3 The build process displays status messages in the MATLAB command window. Intermediate Simulink windows are displayed as the build process creates various components.

4 When the code generation process completes, the PIL target automates the process of compiling, downloading, and executing the generated PIL code

that is to run on the target hardware. To accomplish this, the PIL target launches your cross-development system (Diab or CodeWarrior), compiles and makes the executable, and invokes the **Download Control Panel** to download the code to the target. Click **Start Download** in the **Download Control Panel** to complete the process.

5. At this point, the generated program is running on the target hardware and waiting for communication to be established with Simulink on the host PC.

6. The build process has created and opened a library named `fuel_lib`, as shown in this figure.

Library: fuel_lib *
File Edit View Format Help
*** Simulink library generated for MPC555PIL ***
Real-Time Workshop 4.1.1
Embedded Target for Motorola MPC555 1.0
Generated on: 2002-02-04 11:39:34
Original subsystem:
mpc555pil_fuelsys/fuel rate controller
Template
throttle
engine speed
fuel rate
EGO
MAP
fuel rate controller
?
Double-click for help with modifying the original model.
==>
Replace the original subsystem in the model with the configurable subsystem from this library.
<==
Replace the configurable subsystem in the model with the copy of the original subsystem in this library.
throttle
engine speed
fuel rate
EGO
MAP
fuel rate controller
SIL
fuel rate controller (SIL)
PIL
fuel rate controller (PIL)

The library contains

- A copy of the original `fuel rate controller` subsystem.
- A Real-Time Workshop Embedded Coder generated S-function, labeled `fuel rate controller (SIL)`.
- A subsystem block that communicates with generated PIL code running on the target board during cosimulation, labeled `fuel rate controller (PIL)`.
- A master configurable subsystem block referencing the other three blocks. The default block choice for this subsystem is the original `fuel rate controller` subsystem.

The configurable subsystem, when plugged into the model, lets you choose which of the three library components will perform the controller functions in the model. We will use the configurable subsystem in the following sections.

The library window also contains the following controls:

- A **Help** button that displays PIL target documentation in the MATLAB Help browser.
- A button that lets you replace the original (generating) subsystem in the model with the generated configurable subsystem.
- A button that lets you do the inverse, i.e., remove the configurable subsystem from the model from the original model and replace it with the original (generating) subsystem from the library.

The library window documents the name of the original model/subsystem from which the library was generated,

Using the Demo Model In a PIL Cosimulation

In this section, we will plug the configurable subsystem into the demo model, select the PIL component, and use it in a PIL cosimulation:

1. Click on the `fuel_lib` library window to activate it. Double-click on the button labeled **Replace the original subsystem in the model with the configurable subsystem from this library**.

2. The `mpc555pil_fuelsys` model window is now the active window. The original `fuel rate controller` subsystem has been deleted from the model. It has been replaced by the configurable subsystem from the `fuel_lib`

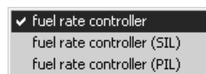
library. The configurable subsystem is automatically connected to the same signals that the original `fuel rate controller` subsystem was connected to.

Note It is important to be aware that the insertion of the configurable subsystem into the containing model establishes a link between the model, `mpc555pil_fuelsys`, and the library, `fuel_lib`. The library has information about the model and subsystem from which it was generated. The model, in turn, has information about the library from which the configurable subsystem comes. This linkage is based on the names of the library and the model, and will be broken if either is renamed. To avoid errors, treat the model and library as a single unit, and do not rename either.

---

3 Save the model.

4 Right-click on the configurable subsystem in the model. A context menu appears. Select the **Block choice** menu item and observe the block choice submenu. This figure shows the default block choice selection.



5 From the **Block choice** submenu of the context menu, select `fuel rate controller (PIL)`.

6 Open the model's two Scope blocks, if they are not already opened.

7 Make sure that Simulink is in `Normal` mode.

8 You are now ready to run the cosimulation. To start the cosimulation, click the **Start simulation** button in the Simulink toolbar.

   The target system now starts executing the controller code. Observe that the output signals computed on the target are displayed on the scopes. The updating of the Scope blocks is slow, relative to a normal simulation, because data is transmitted over the serial line on every model step.

9 When the simulation completes, the signals displayed on the scopes should appear as shown in Figure 3-2.

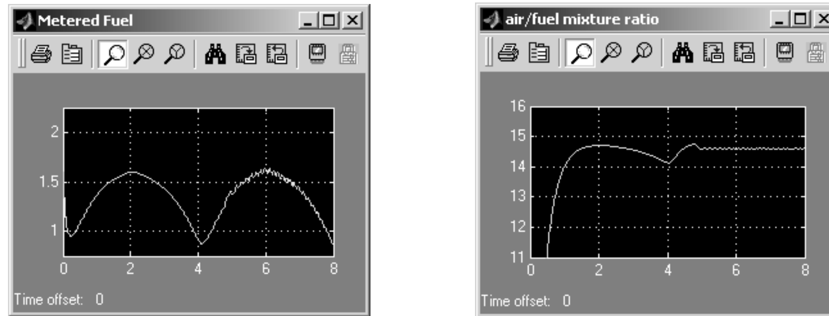


Figure 3-2: Signals Displayed at End of Simulation or Cosimulation

10 When the cosimulation has completed, or has stopped or paused, the target code enters a wait state until it receives a command to start (or resume) from the host. Restart the cosimulation by clicking the **Start simulation** button again. You can start, stop, restart, pause, or continue a cosimulation exactly as you would a normal simulation. Try each of these operations a few times.

11 Stop the cosimulation (or let it complete) and activate your cross-development system. Terminate the program on the target system, and exit your cross-development system.

You can reload and run the target code created by the PIL target for your cross-development system, and run another cosimulation by using the **Download Control Panel** from the **Start** menu. Select the `*.s19` file. In this case it will be `fuel_ram.s19`.

See "Build Process Files and Directories" on page 3-24 for information on the files and directories created by the build process.

Tutorial 2: Modifying and Rebuilding the Controller

In this section, we will continue to use the configurable subsystem we built in "Tutorial 1: Building and Running a PIL Cosimulation" on page 3-5.

In this tutorial, we will make a simple change to the original `fuel rate controller` subsystem in our generated library, `fuel_lib`. We will then rebuild the library components, and run another cosimulation, observing the behavior of our modified controller. All of these steps will be accomplished within the same model/library pair.

Note Before you begin the procedure below, make sure that you have stopped the target program and exited your cross-development system.

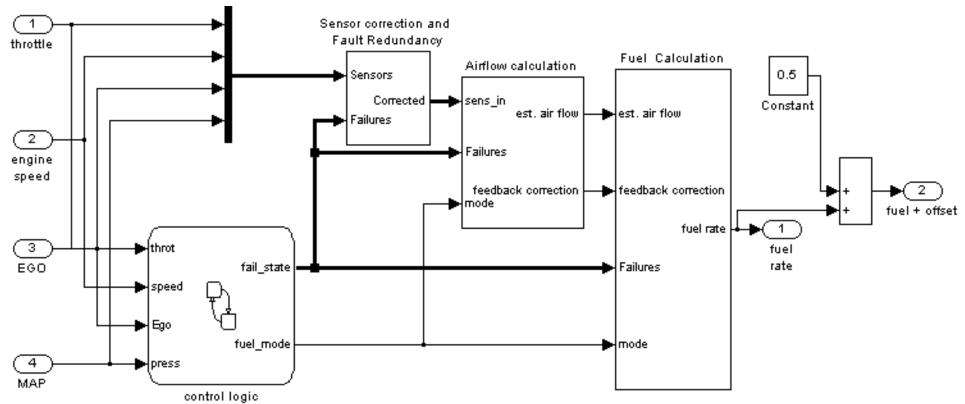
Modifying the Controller

In this section, we add an output signal and port to the controller subsystem. The changes we make to the controller subsystem in this section are for demonstration purposes; they do not add useful functionality to the model:

1 Activate the `fuel_lib` library, and double-click on the original `fuel rate controller` subsystem.

2 Add a Sum block, a Constant block, and an outport to the `fuel rate controller` subsystem. Configure them such that an offset of 0.5 is summed with the fuel rate signal.

3 Route the Sum block output to the new outport, and label the outport `fuel + offset`. The `fuel rate controller` subsystem should now resemble this block diagram.



4 Close the `fuel rate controller` subsystem. Observe that, in the library window, the `fuel rate controller` subsystem now has two outputs, but the SIL and PIL blocks in the library do not. These components will not be updated until the library is rebuilt.

Note You do not need to remove the configurable subsystem from the model to rebuild the code for the SIL and PIL components.

---

5 Activate the `mpc555pil_fuelsys` model. Right-click on the configurable subsystem in the model. A context menu appears. From the **Block choice** submenu of the context menu, select `fuel rate controller`. Observe that the configurable subsystem reflects the change in the corresponding component of the library, showing two outports.

6 Add a Scope block to the model and connect it to the new `fuel + offset` outport of the configurable subsystem. Label the scope `fuel with offset`.

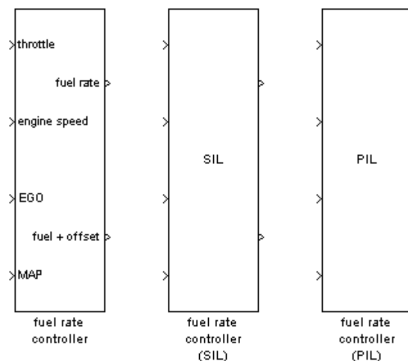
Rebuilding the Controller and Cosimulating

You are now ready to rebuild the PIL code and library components. This time, however, you will build from the configurable subsystem, which must be linked back to the `fuel rate controller` subsystem in the library. Before continuing, right-click on the configurable subsystem and make sure that, in the **Block choice** submenu of the context menu, `fuel rate controller` is selected. *Do not select* `fuel rate controller (SIL)` *or* `fuel rate controller (PIL)`.

To rebuild the PIL code and library components:

1 Right-click on the configurable subsystem, and select **Build Subsystem** from the **Real-Time Workshop** submenu of the context menu.

2 The build process proceeds as described in the previous tutorial (see "Building PIL and Simulation Components" on page 3-11 if necessary). At the end of the build process, the `fuel_lib` library is again activated. Observe that the rebuilt SIL and PIL components now have two outports, like the original subsystem from which they were generated, as shown in this figure.



3 The PIL code has been downloaded to the target; you can now cosimulate again with the rebuilt PIL code. As before, right-click on the configurable subsystem in the model, and select `fuel rate controller (PIL)` from the **Block choice** submenu of the context menu.

4 Open all the model's Scope blocks, if they are not already opened.

5 Make sure that Simulink is in `Normal` mode.

6. Click the **Start simulation** button in the Simulink toolbar.

   Observe the signals displayed on the scopes. The `fuel with offset` scope and the `Metered Fuel` scope should display signals that are identical except for their offsets. Otherwise, all signals should be identical to the signals generated by the previous cosimulation.

7. Clean up by terminating the program on the target system, and exiting your cross-development system. Save the model if desired.

In the next section, you will use the other components of the `fuel_lib` library in simulations.

Tutorial 3: Using the Demo Model In Simulation

In this section, we will continue to use the configurable subsystem in the demo model, using it first in a normal closed-loop simulation and then in a SIL simulation.

Closed-Loop Simulation

1 Right-click on the configurable subsystem and select `fuel rate controller` from the **Block choice** submenu of the context menu. This selects the controller subsystem that was used in the original model.

2 Open the Scope blocks and start the simulation. When the simulation completes (simulation time is set to 8 seconds), the signals displayed on the scopes should appear identical to those displayed during the previous cosimulation (see Figure 3-2 on page 3-16).

SIL Simulation

1 Right-click on the configurable subsystem and select `fuel rate controller (SIL)` from the **Block choice** submenu of the context menu.

   Selecting this option directs Simulink to call a generated wrapper S-function that implements the controller algorithm in highly efficient Real-Time Workshop Embedded Coder generated code. You can now run a SIL simulation.

2 Start the simulation. You will notice that the simulation completes much more quickly, due to the efficiency of the generated code. Also, observe that the generated code displays results, on the scopes, that are identical to the previous simulation and cosimulation (see Figure 3-2 on page 3-16).

PIL Target Summary

The following sections summarize the features of the PIL target:

- "Code Generation Options" on page 3-22
- "Build Process Files and Directories" on page 3-24
- "Restrictions" on page 3-25

Code Generation Options

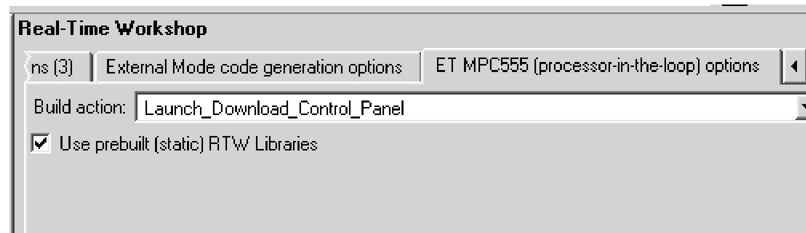
The PIL target is an extension of the Real-Time Workshop Embedded Coder embedded real-time (ERT) target configuration. The PIL target inherits the code generation options of the ERT target, as well as the general code generation options of Real-Time Workshop. These options are available via the **Category** menu of the **Real-Time Workshop** pane of the **Simulation Parameters** dialog box; they are documented in the Real-Time Workshop documentation and the Real-Time Workshop Embedded Coder documentation.

Some code generation options of the ERT target are not relevant to the PIL target, and are either unsupported, or restricted in their operation, by the PIL target. See "Restrictions" on page 3-25 for details.

Note Do not attempt to build code in directories with spaces in the name. This may cause the build to fail as we cannot guarantee that third-party toolchains will accept this.

Target-Specific Options

The PIL target has two target-specific code generation options: **Build action** and **Use prebuilt (static) RTW libraries**. To view or change the setting of these options, select the `ET MPC555 (processor-in-the-loop) options` tab on the **Real-Time Workshop** pane of the **Model Explorer** window.



- The **Build action** menu has two options that control what action the PIL target takes after completing the code generation process:
  - `Launch_Download_Control_Panel`: When this option is selected, the PIL target automatically invokes the **Download Control Panel**. When you click **Start Download** the PIL target downloads the generated code to the target board and begins execution of the code.

    Before using this option, make sure that the target preferences (Compiler and Debugger paths) are set correctly.
  - `None`: When this option is selected, the PIL target does not take any action after code generation completes. To download and run your application, you must do so manually, using your development tools.
- **Use prebuilt (static) RTW libraries**

  This check box option (selected by default) saves a considerable amount of time during the build process, as the libraries do not need to be recompiled every time.

Manual Download

Once a subsystem has been built using the PIL target, it is possible to use the **Download Control Panel** to manually download the generated code to the target without repeating the entire build process. To do this, use the following procedure:

1. Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Launch Download Control Panel**.
2. Select the required `*.s19` file, and click **Start Download**.

Build Process Files and Directories

The PIL target creates the following in your working directory:

- A build directory, containing generated source code, object files in their own directory, and a makefile and other control files. The build directory also may contain subdirectories used by Stateflow and by the HTML code generation report generator (see "Code Analysis Reporting" on page 3-28).

  The naming convention for the build directory is `*source*_mpc555pil`, where *source* is the first word of the generating subsystem or model. For example, the `fuel rate controller` subsystem used in the PIL tutorials generates the build directory `fuel_mpc555pil`.
- The generated library, *source*`_lib.mdl`, and the`.dll` components that are bound to the generated PIL and SIL blocks in the library. Note that if you rebuild *source*`_lib.mdl` in the same working directory, a revision number is appended to the *source* string. For example, building from the `fuel rate controller` subsystem used in the PIL tutorials generates `fuel_lib.mdl`, `fuel1_lib.mdl`, `fuel2_lib.mdl`... `fuel`*n*`_lib.mdl`.
- Executable PIL code in a format suitable for downloading to the target and execution by your development system (Diab or Metrowerks).
- Project files, debugging symbol files, link maps, and other files specific to your development system (Diab and Metrowerks).

If you do not select the `Launch_Download_Control_Panel` option when you generate code (or if you want to rerun PIL code after it is built), you can use the **Download Control Panel** to manually download and run the generated executable. To do this, see "Manual Download" on page 3-23.

Restrictions

Please note the following restrictions on the use of the PIL target:

- The PIL target does not support code generation from device driver blocks from the Embedded Target for Motorola MPC555 block libraries. Do not include device driver blocks in your PIL models.
- In a plant/controller simulation where the controller is built via the PIL target, the plant model can contain any Simulink blocks, including a combination of continuous-time and discrete-time blocks. However, the controller subsystem must not include any continuous-time blocks. This component is used for code generation in the Embedded-C format of Real-Time Workshop Embedded Coder; the Embedded-C format does not support continuous blocks.
- If you change the cross-compiler you use with the PIL target (from Diab to CodeWarrior or vice versa), you should rebuild your PIL models in a clean directory, or delete all files from the models' code generation directories. The PIL build process expects to start with a clean directory, or a directory created in the process of building with the same compiler. Leftover components built by a different compiler cause errors.
- Certain ERT code generation options are not supported by the PIL target. If these options are selected, the PIL target either ignores the option or issues an error message during the build process. Table 3-1 summarizes these restricted options.

Table 3-1: PIL Target Restricted Code Generation Options

Option	Restriction
MAT-file logging	Ignored if selected; build process proceeds
Generate ASAP2 file	Ignored if selected; build process proceeds
External mode	Error if selected; build process terminates

Table 3-1: PIL Target Restricted Code Generation Options (Continued)

Option	Restriction
Generate an example main program	This option should not be selected for the PIL target. The PIL target supplies a target-specific main program, `mpc555dk_main.c`.
Generate reusable code	Error if selected; build process terminates
Target floating-point math environment	Error if `ISO_C` menu option is selected. Use only the `ANSI_C` option (default).

Algorithm Export Target

The Embedded Target for Motorola MPC555 Algorithm Export (AE) target is an aid to code analysis and interfacing. The target generates only the code that implements the algorithm of your model or subsystem, without any overhead for PIL host/target communications or other operations extraneous to the model. Such purely algorithmic code is easier to interface to your hand-written or legacy code than code generated by the PIL or RT targets.

Another application of the AE target is to use it to produce a code generation report. Since only model code is included, you can more easily analyze the code generated from your model.

The AE target supports both the CodeWarrior and Diab cross-compilers, as specified in your target preferences (see "Setting Target Preferences" on page 1-14).

To use the AE target,

3. Select **Configuration Parameters** from the **Simulation** menu. The **Configuration Parameters** dialog opens.
4. Select the R**eal-Time Workshop** tab.
5. On the **General** tab, click on the **Browse** button to open the **System Target File Browser**. In the browser, select `Embedded Target for Motorola MPC555 (algorithm export)` target. Click **OK** to close the browser and return to the **Real-Time Workshop** pane.
6. Select the **Templates** tab and make sure **Generate an example main program** is selected.
7. Follow the usual procedure for generating code from your model or subsystem.

We recommend using the AE target in conjunction with the Embedded Target for Motorola MPC555 HTML code generation report (see "Code Analysis Reporting" on page 3-28). If you select the **Generate HTML report** option as described in the next section, you can view a profiling report that includes detailed itemization of RAM and ROM usage for all code and data sections, and a complete memory map of the generated code. You can also easily examine the generated code via hyperlinks in the code generation report.

Code Analysis Reporting

The Embedded Target for Motorola MPC555 supports an extended version of the Real-Time Workshop Embedded Coder HTML code generation report.

The extended code generation report consists of several sections:

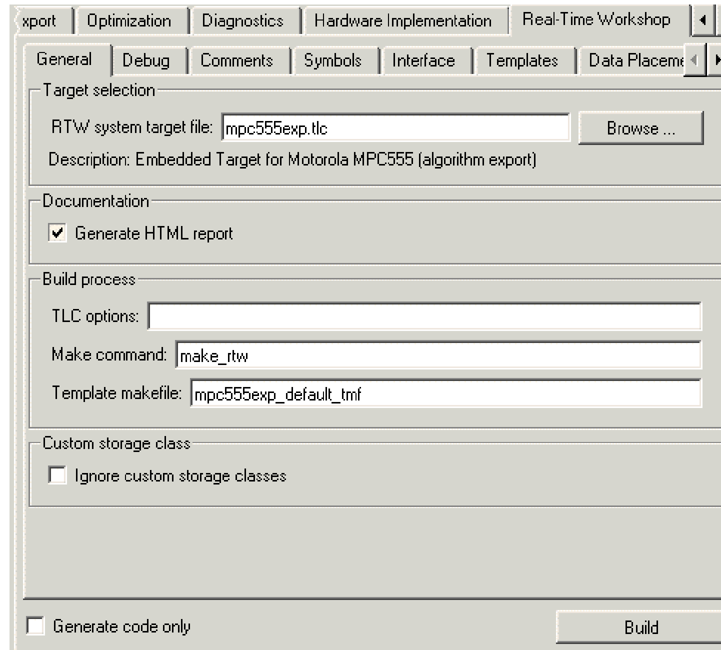
- The **Generated Source Files** section of the **Contents** pane contains a table of source code files generated from your model. You can view the source code in the MATLAB Help browser. Hyperlinks within the displayed source code let you view the blocks or subsystems from which the code was generated. Click on the hyperlinks to view the relevant blocks or subsystems in a Simulink model window.
- The **Summary** section lists version and date information, TLC options used in code generation, and Simulink model settings.
- The **Optimizations** section lists the optimizations used during the build, and also those that are available. If you chose options that generated less than optimal code, they are marked in red. This section can help you select options that will better optimize your code.
- The report also includes information on other code generation options, code dependencies, and links to relevant documentation.
- The code profile report section includes a detailed itemization of RAM and ROM usage for all code and data sections, and a complete memory map of the generated code.

To generate a code generation report and view the profiling report,

1. On the **General** tab of the **Real-Time Workshop** pane of the **Model Explorer**, make sure that the **Generate code only** option is not selected.

   The reason for this step is that the Embedded Target for Motorola MPC55 extended code generation report obtains information from MAP files that are created by your cross-compiler during the build process. If the **Generate code only** option is on, these files are not generated, which prevents the generation of the code generation report.

2 Select **Generate HTML report**, as shown in this picture.



3 Follow the usual procedure for generating code from your model or subsystem.

4 Real-Time Workshop writes the code generation report file in the build directory. The file is named `model_codegen_rpt.html` or `subsystem_codegen_rpt.html`.

5 Real-Time Workshop automatically opens the MATLAB Help browser and displays the code generation report.

6 To view the profiling report, click on the **Code profile report** link in the **Contents** pane of the report.

Alternatively, you can view the code generation report in your Web browser.

Algorithm Export Target Summary

The following sections summarize the features of the Algorithm Export (AE) target:

- “Code Generation Options” on page 3-22
- “Restrictions” on page 3-30

Code Generation Options

The AE target is an extension of the Real-Time Workshop Embedded Coder embedded real-time (ERT) target configuration. The AE target inherits the code generation options of the ERT target, as well as the general code generation options of Real-Time Workshop. These options are available via the **General** tab of the **Real-Time Workshop** tab of the **Configuration Parameters** dialog; they are documented in the Real-Time Workshop documentation and the Real-Time Workshop Embedded Coder documentation.

Some code generation options of the ERT target are not relevant to the AE target, and are either unsupported, or restricted in their operation, by the AE target. See “Restrictions” below for details.

Note Do not attempt to build code in directories with spaces in the name. This may cause the build to fail as we cannot guarantee that third party toolchains will accept this.

The only target-specific option for AE target is **Use prebuilt (static) RTW libraries**. This check box option (selected by default) saves a considerable amount of time during the build process, as the libraries do not need to be recompiled every time.

Restrictions

Certain ERT code generation options are not supported by the AE target. If these options are selected, the AE target either ignores the option or issues an error message during the build process. Table 3-2 summarizes these restricted options.

Table 3-2: AE Target Restricted Code Generation Options

Option	Restriction
MAT-file logging	Ignored if selected; build process proceeds
Create Simulink (S-function) block	Error if selected; build process terminates
Generate ASAP2 file	Ignored if selected; build process proceeds
External mode	Error if selected; build process terminates

You must not include driver blocks in your model for Algorithm Export. The AE target is designed to generate only the code that implements the algorithm of your model or subsystem, without any overhead for PIL host/target communications or other operations extraneous to the model, so you should not be including driver blocks.

4

Block Reference

This section contains the following topics:

The Embedded Target for Motorola MPC555 Block Libraries (p. 4-2)	Overview of the block libraries provided by the Embedded Target for Motorola MPC555.
Blocks Organized by Libraries (p. 4-4)	Block summaries and links to the block reference documentation, grouped by block library.
Blocks — Alphabetical List (p. 4-16)	Block summaries and links to the block reference documentation, in alphabetical order.

The Embedded Target for Motorola MPC555 Block Libraries

The Embedded Target for Motorola MPC555 provides three block libraries:

- The Embedded Target for Motorola MPC555 library (`mpc555drivers.mdl`) provides device driver blocks that let your applications access on-chip resources. The I/O blocks support the following features of the MPC555:
  - Pulse width modulation (PWM) generation or digital output via the Modular Input/Output Subsystem (MIOS) PWM unit or the Time Processor Unit 3 (TPU) modules
  - Analog input via the Queued Analog-to-Digital Converter (QADC64)
  - Digital input and output via the MIOS or TPU
  - Digital input via the QADC
  - Frequency and pulse width measurement via the MIOS Double Action Submodule (MDASM)
  - Driver blocks to support other functions of the TPU modules – Fast Quadrature Decode, New Input Capture/Input Transition Counter, and Programmable Time Accumulator
  - Serial transmit and receive
  - Transmission or reception of Controller Area Network (CAN) messages via the MPC555 TouCAN modules
- The CAN Message Blocks library (`canblks.mdl`) provides device driver and utility blocks that support the Controller Area Network (CAN) protocol. CAN is an industry standard protocol used in automotive electronics and many other embedded environments where dispersed components require sharing of information. The CAN Message Blocks library includes blocks for transmitting, receiving, decoding, and formatting CAN messages. The CAN Message Blocks library also supports message specification via the Vector-Informatik CANdb standard.
- The CAN Drivers (Vector) library (`vector_candrivers.mdl`) provides blocks for configuring and connecting to Vector-Informatik CAN hardware and drivers.

The following sections provide complete information on each block in the Embedded Target for Motorola MPC555 block libraries, in a structured format.

Refer to these pages when you need details about a specific block. Click **Help** on the **Block Parameters** dialog box for the block, or access the block reference page through Help.

Using Block Reference Pages

Block reference pages are listed in alphabetical order by the block name. Each entry contains the following information:

- **Purpose—**Describes why you use the block or function.
- **Library—**Identifies the block library where you find the block.
- **Description—**Describes what the block does.
- **Dialog Box—**Shows the block parameters dialog and describes the parameters and options contained in the dialog. Each parameter or option appears with the appropriate choices and effects.
- **Examples—**Optional section that provides demonstration models to highlight block features.

In addition, block reference pages provide pictures of the Simulink model icon for the blocks.

Blocks Organized by Libraries

The blocks in the Embedded Target for Motorola MPC555 libraries are organized into sublibraries that support different functions. The tables below reflect the organization of the following libraries:

- “MPC555 Driver Library” on page 4-5
  - “CAN 2.0B Controller Module (TouCAN) Sublibrary” on page 4-6
  - “Enhanced Queued Analog-To-Digital Converter Module-64 Sublibrary” on page 4-7
  - “Execution Profiling Sublibrary” on page 4-7
  - “Interrupts Sublibrary” on page 4-7
  - “Modular Input/Output System (MIOS1) Sublibrary” on page 4-8
  - “Queued Analog-to-Digital Converter Module-64 Sublibrary” on page 4-8
  - “Serial Communications Interface (SCI) Sublibrary” on page 4-9
  - “Time Processor Unit (TPU3) Sublibrary” on page 4-9
- “CAN Message Blocks” on page 4-11
- “CAN Drivers (Vector)” on page 4-11

- MPC555 Help and Demos — Open this library to access the demo suite. You can double-click the **Help for Demos** block to go directly to information and instructions for all demos, or select **Start –> Simulink –> Embedded Target for Motorola® MPC555 –> Demos**, or at the command line enter

```
demo simulink 'Embedded Target for Motorolafi MPC555'
```

MPC555 Driver Library

Top Level Library

Block Name	Purpose
MPC555 Resource Configuration	Support driver configuration for MPC555 and MIOS, QADC, and TouCAN submodules.
Watchdog	In event of application failure, time out and reset processor.

Note To generate code from a model using the Embedded Target for Motorola MPC555 real-time target, an MPC555 Resource Configuration block must be included in the model. The MPC555 Resource Configuration block is required even for models that do not contain any MPC555 device driver blocks.

Note When using device driver blocks from the Embedded Target for Motorola MPC555 libraries in conjunction with the MPC555 Resource Configuration block, do not disable or break library links on the driver blocks. If library links are disabled or broken, the MPC555 Resource Configuration block will operate incorrectly. See “MPC555 Resource Configuration” on page 4-41 for further information.

CAN 2.0B Controller Module (TouCAN) Sublibrary

Block Name	Purpose
CAN Calibration Protocol (MPC555)	Implement the CAN Calibration Protocol (CCP) standard.
TouCAN Error Count	Count transmit and/or receive errors detected on selected TouCAN modules.
TouCAN Fault Confinement State	Indicate the state of a TouCAN module.
TouCAN Interrupt Generator	Generate an interrupt subsystem for CAN interrupt sources.
TouCAN Receive	Receive CAN messages from a TouCAN module on the MPC555.
TouCAN Soft Reset	Reset a TouCAN module.
TouCAN Transmit	Transmit a CAN message via a TouCAN module on the MPC555.
TouCAN Warnings	Flag excessively high transmit or receive error counts on TouCAN modules.

For CAN message blocks see “CAN Message Blocks” on page 4-11.

Enhanced Queued Analog-To-Digital Converter Module-64 Sublibrary

Block Name	Purpose
QADCE Analog In	Input driver enables use of Queued Analog-Digital Converter (QADC64) in continuous scan mode for the MPC565.
QADCE Digital In	Input driver enables use of Queued Analog-Digital Converter (QADC64) pins as digital inputs for the MPC565.

Execution Profiling Sublibrary

Block Name	Purpose
MPC555 Execution Profiling via SCI1	Provides a serial interface to the execution profiling engine.
MPC555 Execution Profiling via CAN A	Provides a CAN interface to the execution profiling engine via CAN channel A.

Interrupts Sublibrary

Block Name	Purpose
Asynchronous Rate Transition	Converts rate of input signal to specified sample time whilst disabling interrupts.

Modular Input/Output System (MIOS1) Sublibrary

Block Name	Purpose
MIOS Digital In	Input driver for MIOS 16-bit Parallel Port I/O Submodule (MPIOSM).
MIOS Digital Out	Output driver for MIOS 16-bit Parallel Port I/O Submodule (MPIOSM).
MIOS Digital Out (MPWMSM)	Digital output via the MIOS Pulse Width Modulation Submodule (MPWMSM).
MIOS Pulse Width Modulation Out	Output driver for MIOS Pulse Width Modulation Submodule (MPWMSM).
MIOS Waveform Measurement	Support pulse width and pulse period measurement via MIOS Double Action Submodule.

Queued Analog-to-Digital Converter Module-64 Sublibrary

Block Name	Purpose
QADC Analog In	Input driver enables use of Queued Analog-Digital Converter (QADC64) in continuous scan mode for the MPC555.
QADC Digital In	Input driver enables use of QADC64 pins as digital inputs for the MPC555.

Time Processor Unit (TPU3) Sublibrary

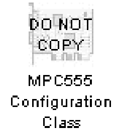
Block Name	Purpose
TPU3 Digital In	Input driver for TPU3 channel.
TPU3 Digital Out	Output driver for TPU3 channel.
TPU3 Fast Quadrature Decode	Input driver for a pair of TPU3 channels for Fast Quadrature Decode (FQD)
TPU3 New Input Capture/Input Transition Counter	Input driver for TPU3 channel New Input Capture/Input Transition Counter (NITC)
TPU3 Programmable Time Accumulator	Input driver for TPU3 channel Programmable Time Accumulator (PTA)
TPU3 Pulse Width Modulation Out	Output driver for TPU3 channel Pulse Width Modulation.

Serial Communications Interface (SCI) Sublibrary

Block Name	Purpose
Serial Transmit	Configure serial output.
Serial Receive	Configures serial input.

Configuration Class Blocks

Each sublibrary of the Embedded Target for Motorola MPC555 library contains a *configuration class block* that has an icon similar to the one shown in this picture.



Configuration class blocks exist only to provide information to other blocks. *Do not copy these objects into a model under any circumstances.*

CAN Message Blocks and CAN Drivers Libraries

See the CAN Blockset Reference for the following blocks:

CAN Message Blocks

Block Name	Purpose
CAN Message Packing	Map Simulink signals to CAN messages.
CAN Message Packing (CANdb)	Pack Simulink double signals into CAN messages.
CAN Message Filter	Dispatch message processing based on message ID.
CAN Message Unpacking	Inspect and unpack the individual fields in a CAN message.
CAN Message Unpacking (CANdb)	Decompose a CAN frame into its constituent signals.

CAN Drivers (Vector)

Block Name	Purpose
Vector CAN Configuration	Configure a CAN channel (either hardware or virtual) for use with Vector-Informatik drivers.
Vector CAN Receive	Read CAN frames from a Vector CAN channel.
Vector CAN Transmit	Transmit CAN frames on a Vector CAN channel.

Data Type Support and Scaling for Device Driver Blocks

The following table summarizes the input and output data types supported by the device driver blocks in the Embedded Target for Motorola MPC555 library, and the scaling applied to block inputs and outputs.

I/O Data Types and Scaling for MPC555 Device Driver Blocks

Block	Input Data Type	Input Scaling	Output Data Type	Output Scaling/ Units
MIOS Digital In			`Boolean`	0 or 1 only
MIOS Digital Out	Any Simulink supported data type	logic 1 if input > 0, logic 0 if input <= 0		
MIOS Digital Out (MPWMSM)	Any Simulink supported data type	logic 1 if input > 0, logic 0 if input <= 0		
MIOS Pulse Width Modulation Out	`double` or `single`	0 to 1		
MIOS Waveform Measurement			`double` or `single` (must be same as input data type)	Seconds
QADC Analog In			`uint16` or `int16` (defined by **Justification** parameter)	(defined by **Justification** parameter)

I/O Data Types and Scaling for MPC555 Device Driver Blocks (Continued)

Block	Input Data Type	Input Scaling	Output Data Type	Output Scaling/ Units
QADC Digital In			`Boolean`	0 or 1 only
TouCAN Receive			`CAN_MESSAGE_STANDARD` or `CAN_MESSAGE_EXTENDED`	N/A
TouCAN Transmit	`CAN_MESSAGE_STANDARD` or `CAN_MESSAGE_EXTENDED`	N/A		
TouCAN Warnings			`Boolean`	N/A
TouCAN Error Count			`uint8`	N/A
TouCAN Fault Confinement State			`uint16`	N/A
TPU3 Digital In			`Boolean`	0 or 1 only
TPU3 Digital Out	Any Simulink supported data type	Logic 1 if input > 0, logic 0 if input <= 0		
TPU3 Fast Quadrature Decode	Fast Mode input `Boolean`		`uint16`	N/A

I/O Data Types and Scaling for MPC555 Device Driver Blocks (Continued)

Block	Input Data Type	Input Scaling	Output Data Type	Output Scaling/ Units
TPU3 New Input Capture/Input Transition Counter			`uint16`	N/A

TPU3 Programmable Time Accumulator			Time Accumulation
			`uint32`
			Period Count
			`uint8`
				N/A

TPU3 Pulse Width Modulation Out	Duty cycle input (top if 2 inputs): double or single	0 to 1		
	Pulse period register input — `uint16`	Saturated to be in the range 0 to 32768		

I/O Data Types and Scaling for MPC555 Device Driver Blocks (Continued)

Block	Input Data Type	Input Scaling	Output Data Type	Output Scaling/ Units
Serial Transmit	Data: `uint8` (vector or scalar) Byte number: `uint32` (scalar)	N/A	Number of bytes: `uint32`	0-16 (for SCI1); 0 or 1 (for SCI2)
Serial Receive	Byte number: `uint32` Reset: `Boolean`	N/A 0 or 1	Data: `uint8` Actual byte number: `uint32` Framing and parity error: `Boolean` Overrun flag: `Boolean`	N/A N/A 0 or 1 0 or 1

Blocks — Alphabetical List

This section contains function reference pages listed alphabetically.

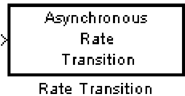
Purpose

Convert rate of input signal to specified sample time while disabling interrupts

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/ Interrupts

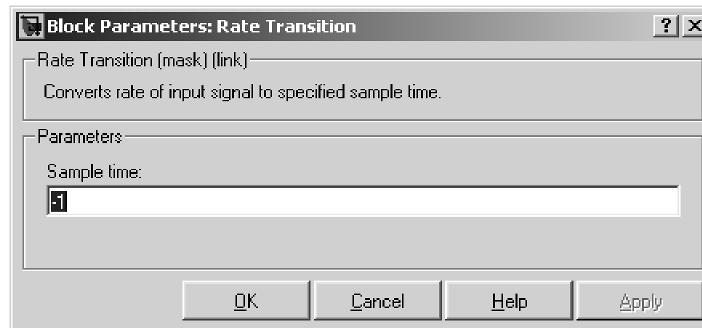
Description



The Asynchronous Rate Transition block is used when reading or writing signals attached to an Asynchronous subsystem. An Asynchronous subsystem is one which is driven by an interrupt function call trigger. The subsystem is run in the context of an interrupt and not in the context of the model. The Asynchronous Rate Transition block should be placed outside the Asynchronous subsystem and attached to either input ports or output ports of the Asynchronous subsystem.

TheAsynchronous Rate Transition block copies the signal from input to output while disabling interrupts. This ensures that blocks outside the subsystem that want access to the signal do not get interrupted while reading or writing a signal and end up with corrupt data.

Dialog Box



Sample time

The sample time of the block.

CAN Calibration Protocol (MPC555)

Purpose

Implement the CAN Calibration Protocol (CCP) standard

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
CAN 2.0B Controller Module

Description

The CAN Calibration Protocol (MPC555) block provides an implementation of a subset of the CAN Calibration Protocol (CCP) Version 2.1. CCP is a protocol for communicating between the target processor and the host machine over CAN. In particular, a calibration tool (see “Compatibility with Calibration Packages” on page 4-23) running on the host can communicate with the target, allowing remote signal monitoring and parameter tuning.

This block processes Command Receive Object (CRO) messages and outputs the resulting Data Transmission Object (DTO) and Data Acquisition (DAQ) messages.

Note To use the CAN Calibration Protocol block, you need Stateflow 5.0(Release 13) and Stateflow Coder

---

For more information on CCP, refer to *ASAM Standards: ASAM MCD: MCD 1a* on the Association for Standardization of Automation and Measuring Systems (ASAM) Web site at `http://www.asam.de`.

You can see an example illustrating how to use the CAN Calibration Protocol (MPC555) block in the `mpc555rt_ccp` demo.

Note this block is entirely CAN triggered, and so is only designed for the Real-Time Target .(CAN is disabled during PIL and SIL cosimulation.)

Using the DAQ Output

The DAQ output is the output for any CCP DAQ lists that have been set up. You can use the ASAP2 file generation feature of the RT target to

- Set up signals to be transmitted using CCP DAQ lists.
- Assign signals in your model to a CCP event channel automatically (see “Generating ASAP2 Files” on page 2-30).

Once these signals are set up, event channels then periodically fire events that trigger the transmission of DAQ data to the host. When this occurs, CAN messages with the appropriate CCP/DAQ data appear on the DAQ output, along with an associated function call trigger.

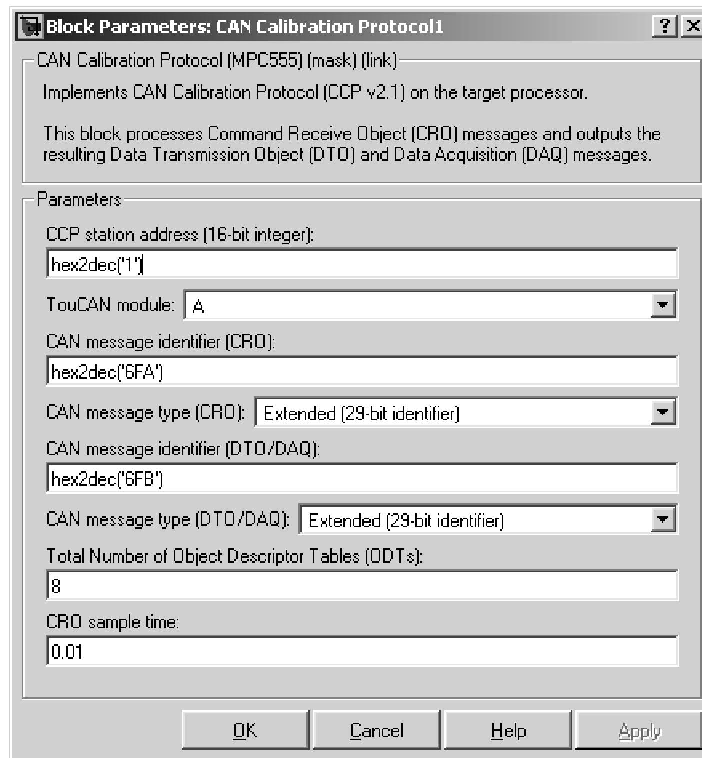
It is the responsibility of the calibration tool (see "Compatibility with Calibration Packages" on page 4-23) to use CCP commands to assign an event channel and data to the available DAQ lists, and to interpret the synchronous response.

Using DAQ lists for signal monitoring has the following advantages over the polling method:

- There is no need for the host to poll for the data. Network traffic is halved.
- The data is transmitted at the correct update rate for the signal. Therefore there is no unnecessary network traffic generated.
- Data is guaranteed to be consistent. The transmission takes place after the signals have been updated, so there is no risk of interruptions while sampling the signal.

Note The Embedded Target for Motorola MPC555 does not currently support event channel prescalers.

Dialog Box



CAN station address (16 bit integer)

The station address of the target. The station address is interpreted as a `uint16`. It is used to distinguish between different targets. By assigning unique station addresses to targets sharing the same CAN bus, it is possible for a single host to communicate with multiple targets.

TouCAN module

Choose A or B.

CAN message identifier (CRO)

Specify the CAN message identifier for the incoming Command Receive Object (CRO) message you want to process.

CAN message type (CRO)

The incoming message type. Select either `Standard(11-bit identifier)` or `Extended(29-bit identifier)`.

CAN message identifier (DTO/DAQ)

The message identifier is the CAN message ID used for Data Transmission Object (DTO) and Data Acquisition (DAQ) message outputs. It is also used for transmitting messages to the host during the software-induced CAN download (soft boot). See "Extended Functionality" on page 4-23.

CAN message type (DTO/DAQ)

The message type to be transmitted by the DTO and DAQ outputs. Select either `Standard(11-bit identifier)` or `Extended(29-bit identifier)`.

Total number of Object Descriptor Tables (ODTs)

The default number of Object Descriptor Tables (ODTs) is 8. These ODTs are shared equally between all available DAQ lists. You can choose a value between 0 and 254, depending on how many signals you want to log simultaneously. You must make sure you allocate at least 1 ODT per DAQ list, or your build will fail. The calibration tool will give an error message if there are too few ODTs for the number of signals you specify for monitoring. Be aware that too many ODTs can make the sample time overrun. If you choose more than the maximum number of ODTs (254), the build will fail.

A single ODT uses 56 bytes of memory. Using all 254 ODTs would require over 14 KB of memory, a large proportion of the available memory on the target. To conserve memory on the target the default number is low, allowing DAQ list signal monitoring with reduced memory overhead and processing power.

As an example, if you have five different rates in a model, and you are using three rates for DAQ, then this will create three DAQ lists and you must make sure you have at least three ODTs. ODTs are shared equally among DAQ lists, and therefore you will end up with one ODT per DAQ list. With less than three ODTs you get zero ODTs per DAQ list and the behavior is undefined.

Taking this example further, say you have three DAQ lists with one ODT each, and start trying to monitor signals in a calibration tool. If you try to

assign too many signals to a particular DAQ list (that is, signals requiring more space than seven bytes (one ODT) in this case), then the calibration tool will report this as an error.

For more information on DAQ lists, see "Data Acquisition (DAQ) List Configuration" on page 2-33.

CRO sample time

Sample time for incoming Command Receive Object (CRO) messages.

Supported CCP Commands

The following CCP commands are supported by the CAN Calibration Protocol (MPC555) block:

- `CONNECT`
- `DISCONNECT`
- `DNLOAD`
- `DNLOAD_6`
- `EXCHANGE_ID`
- `GET_CCP_VERSION`
- `GET_DAQ_SIZE`
- `GET_S_STATUS`
- `SET_DAQ_PTR`
- `SET_MTA`
- `SET_S_STATUS`
- `SHORT_UP`
- `START_STOP`
- `START_STOP_ALL`
- `TEST`
- `UPLOAD`
- `WRITE_DAQ`

Compatibility with Calibration Packages

The above commands support

- Synchronous signal monitoring via calibration packages that use DAQ lists
- Asynchronous signal monitoring via calibration packages that poll the target
- Asynchronous parameter tuning via CCP memory programming

This CCP implementation has been tested successfully with the Vector-Informatik CANape calibration package running in both DAQ list and polling mode, and with the Accurate Technologies Inc. Vision calibration package running in DAQ list mode. (Note that Accurate Technologies Inc. Vision does not support the polling mechanism for signal monitoring.)

Extended Functionality

The CAN Calibration Protocol (MPC555) block also supports the `PROGRAM_PREPARE` command. This command is an extension of CCP that allows the automatic download of new code into the target memory. This removes the requirement for a manual reset of the processor. On receipt of the `PROGRAM_PREPARE` command, the target will reboot and begin the CAN download process. This lets you download new application code to RAM or flash memory, or download new boot code to flash memory. See "Downloading Boot or Application Code via CAN Without Manual CPU Reset" on page 2-26.

Note The CAN message identifiers of the CCP messages incoming to the target (Command Receive Object (CRO) messages) and the messages outgoing from the target (Data Transmission Object (DTO) or DAQ) are specified in the block mask for the CAN Calibration Protocol (MPC555) block. These message identifiers are used as the CAN identifiers for the download process after a `PROGRAM_PREPARE` reboot. The type of CAN message used for this `PROGRAM_PREPARE` download process is always `Extended (29-bit identifier)`.

MIOS Digital In

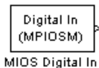
Purpose

Input driver for MIOS 16-bit Parallel Port I/O Submodule (MPIOSM)

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Modular Input/Output System (MIOS1)

Description



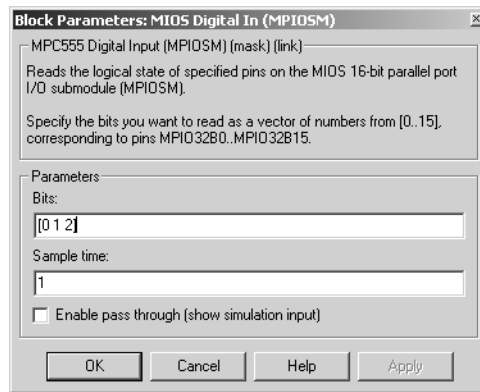
The MIOS Digital In block reads the state of selected pins (bits) on the MIOS 16-bit Parallel Port I/O Submodule (MPIOSM) of the MPC555. The **Bits** field specifies a vector of numbers in the range `0..15`, corresponding to pins `MPIO32B0..MPIO32B15` on the MPIOSM.

The output of the block is a wide vector representing the logic state of the pins referenced in the **Bits** field. When the signal on a given pin is a logical 1, the block output element will be equal to 1; otherwise the block output element will equal zero.

Refer to section 15.13, "MIOS 16-bit Parallel Port I/O Sub module (MPIOSM)," in the *MPC555 Users Manual* for further information.

Note You are responsible for ensuring that pin assignments of MIOS Digital In and MIOS Digital Out blocks in your model do not conflict. No error checking is performed to detect conditions where the same pin is referenced by both an input and an output block. If such a condition occurs, the behavior of the system is undefined.

Dialog Box



Bits

A vector of numbers in the range `0..15`. Each number corresponds to a pin (`MPIO32B0..MPIO32B15`) on the MPIOSM.

Sample time

Sample time of the block.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

MIOS Digital Out

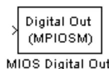
Purpose

Output driver for MIOS 16-bit Parallel Port I/O Submodule (MPIOSM)

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Modular Input/Output System (MIOS1)

Description



The MIOS Digital Out block sets the state of selected pins (bits) on the MIOS 16-bit Parallel Port I/O Submodule (MPIOSM) of the MPC555. The **Bits** field specifies a vector of numbers in the range `0..15`, corresponding to pins `MPIO32B0..MPIO32B15` on the MPIOSM.

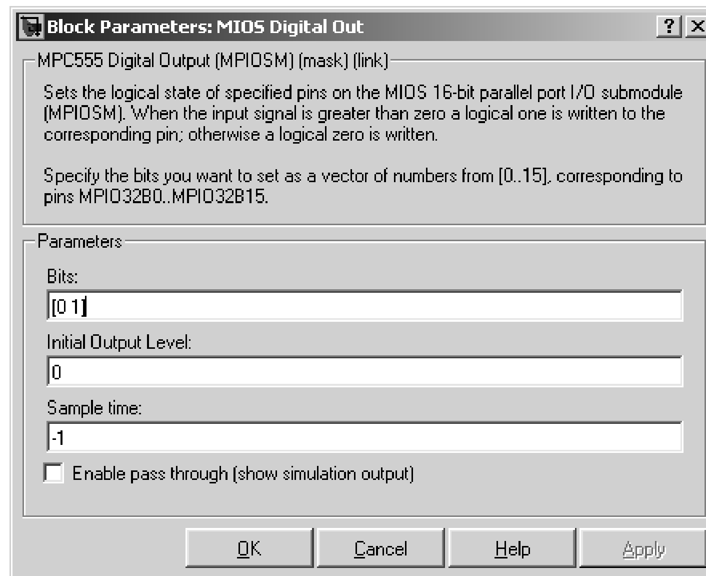
The input to the block is a wide vector with one signal element per pin. When the input signal is greater than zero, a logical 1 is written to the corresponding pin. When the input signal is less than or equal to zero, a logical zero is written to the corresponding pin.

If you want to write to several digital output pins at the same sample rate, using a single MIOS Digital Out block with a vector input signal will result in more efficient code. However, if you want to update different output pins at different sample rates, you must use a separate MIOS Digital Out block for each rate.

Refer to section 15.13, "MIOS 16-bit Parallel Port I/O Sub module (MPIOSM)," in the *MPC555 Users Manual* for further information.

Note You are responsible for ensuring that pin assignments of MIOS Digital In and MIOS Digital Out blocks in your model do not conflict. No error checking is performed to detect conditions where the same pin is referenced by both an input and an output block. If such a condition occurs, the behavior of the system is undefined.

Dialog Box



Bits

A vector of numbers in the range `0..15`. Each number corresponds to a pin (`MPIO32B0..MPIO32B15`) on the MPIOSM.

Initial output level

The value to be placed on the output pins at initialization. This ensures the starting level is always known.

Sample time

The sample time of this block.

Enable pass through (show simulation input)

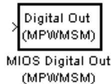
Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

MIOS Digital Out (MPWMSM)

Purpose Digital output via the MIOS Pulse Width Modulation Submodule (MPWMSM)

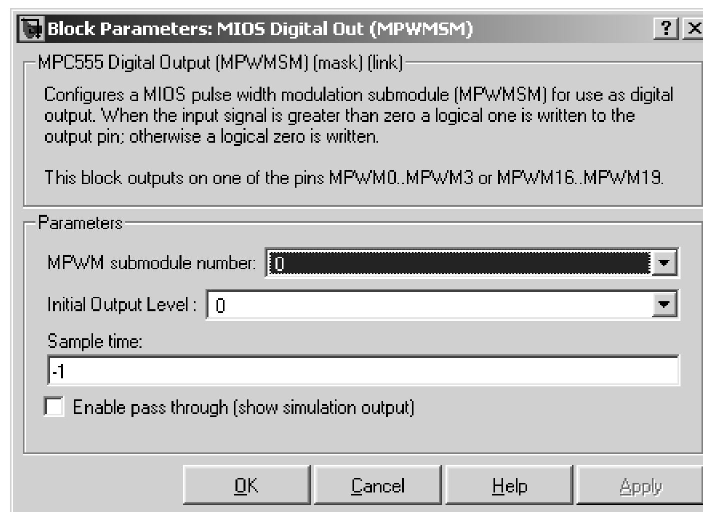
Library Embedded Target for Motorola MPC555/ MPC555 Driver Library/ Modular Input/Output System (MIOS1)

Description The MIOS Digital Out (MPWMSM) block is a device driver that lets you use the MIOS Pulse Width Modulation Submodule (MPWMSM) in *digital output mode*. In digital output mode, the Pulse Width Modulation (PWM) feature of the MPWMSM is turned off. When the input signal is greater than zero, a logical 1 is written to the output pin; otherwise a logical zero is written.



Refer to section 15.12, "MIOS Pulse Width Modulation Submodule (MPWMSM)," in the *MPC555 Users Manual* for further information on the parameters described below.

Dialog Box



MPWM submodule number
Select a PWM submodule for output. Note that modules 4, 5, 20 and 21 are for the MPC56x (561-6) only. If you select one of these modules and MPC555 is the processor selected in the Resource Configuration block, then an error will be thrown on updating the model.

Initial output level

The value to be placed on the output pins at initialization. This ensures the starting level is always known.

Sample time

Sample time of the block.

Invert output polarity

Switches the output level for logic one and zero.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

MIOS Pulse Width Modulation Out

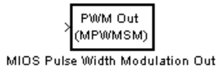
Purpose

Output driver for MIOS Pulse Width Modulation Submodule (MPWMSM)

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Modular Input/Output System (MIOS1)

Description



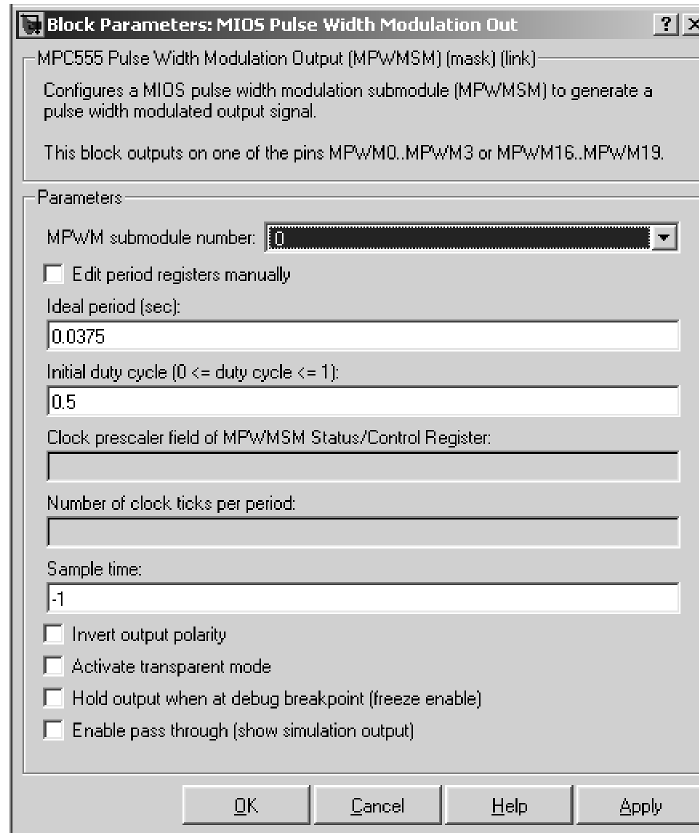
The MIOS Pulse Width Modulation Out block is used for Pulse Width Modulation (PWM) output from the MIOS Pulse Width Modulation Submodule (MPWMSM). A PWM signal is a rectangular waveform whose period is constant but whose duty cycle can be varied, under control of a modulator signal, between 0% and 100%.

The MIOS Pulse Width Modulation block input signal acts as the modulator, controlling the duty cycle of the signal on the output pin. The input signal is multiplied by the period register value, and saturates if outside 0-1. When the input signal value is 0, the output signal's duty cycle is 0%. When the input signal value is 1, the output signal's duty cycle is 100%.

There are two possible methods for calculating the period of the waveform. You can either control the scaling registers directly, or enter the desired (ideal) period and the mask will solve for the best values for the scaling registers.

Refer to section 15.12, "MIOS Pulse Width Modulation Submodule (MPWMSM)," in the *MPC555 Users Manual* for further information on the parameters described below.

Dialog Box



MPWM submodule number

Select a PWM submodule for output. Note that modules 4, 5, 20 and 21 are for the MPC56x (561-6) only. If you select one of these modules and MPC555 is the processor selected in the Resource Configuration block, then an error will be thrown on updating the model.

Edit period registers manually

When this option is selected, the **Clock prescaler field of MPWM Status/Control Register** and **Number of clock ticks per period** edit fields are activated. You can then set the PWM period by setting these values.

When this option is not selected, use the **Ideal period (sec)** field to set the PWM period parameters.

Ideal period (sec)
Specifies the desired period of the pulse signal. The mask then solves for the clock prescaler and the pulse period.

Initial duty cycle
Enter an initial value for the duty cycle (0 <= duty cycle <= 1). This ensures the initial value is always known.

Clock prescaler field of MPWM Status/Control Register
Divides the counter clock to get the clock signal used to drive the PWM output. Note that the counter clock itself is derived from the MPC555 system clock as configured by the MPC555 Resource Configuration block (see “MPC555 Resource Configuration” on page 4-41).

Number of clock ticks per period
Determines the number of PWM counter ticks per pulse period. Valid values are `1 - 65535`.

Sample time
Sample time of the block.

Invert output polarity
Switches the output level for logic one and zero.

Activate transparent mode
Bypasses the register double buffers. When transparent mode is active, a software write to the Next Pulse Width Register is immediately transferred to the Pulse Width Register. When transparent mode is inactive, the updated value only takes effect at the start of the next period.

Hold output when at debug break point (freeze enable)
Stops the PWM counters when a breakpoint is hit during debug mode, and holds the current output values.

Enable pass through (show simulation input)
Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

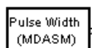
Purpose

Support pulse width and pulse period measurement via MIOS Double Action Submodule (MDASM)

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Modular Input/Output System (MIOS1)

Description



MIOS Waveform Measurement

Waveform measurement is a feature of the MIOS Double Action Submodule (MDASM) on the MPC555. The MIOS Waveform Measurement block currently implements the following features of the MDASM:

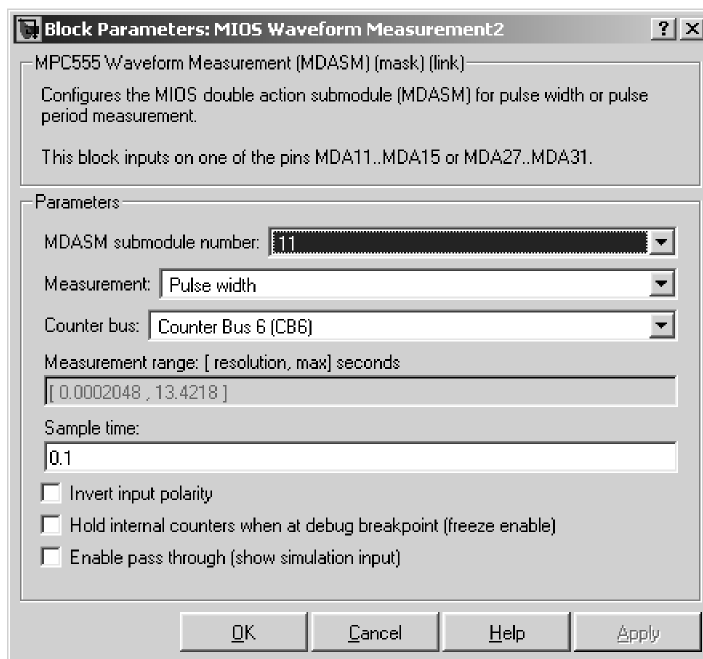
- *Pulse width measurement*: the MIOS Waveform Measurement block outputs the time from the leading edge of a pulse to the trailing edge of the same pulse.
- *Pulse period measurement*: the MIOS Waveform Measurement block outputs the time from the leading edge of a pulse to the next leading edge of a pulse.

Note that the minimum and maximum measurable pulse periods and pulse widths are dependent on the selected clock sources and their configurations.

You must configure the clock sources via the MPC555 Resource Configuration object. There are only two clock sources (assigned via the **Counter bus** parameter) assignable to the 10 MDASM modules. More than one MDASM can be assigned to a single clock source.

Refer to section 15.11, “MIOS Double Action Submodule (MDASM) Registers” in the *MPC555 Users Manual* for further information on the parameters described below.

Dialog Box



MDASM submodule number

Select one of the 10 MIOS Double Action Submodules (MDASM) in the MPC555.

Measurement

Select the mode of operation of the block: either pulse width measurement or pulse period measurement.

Counter bus

Select one of the two counters that can be used as sources to drive the MDASM module.The counters must be configured via the MPC555 Resource Configuration object. See “MIOS1 Configuration Parameters” on page 4-51.

Measurement range: [resolution, max] seconds

This read only field displays the measurement range of the pulse width or pulse period. The example shown is from the MPC555 real-time I/O demo model (`mpc555rt_io`).

Sample time

The period at which Simulink reads the pulse width or period. The measurements are performed in hardware so it is not necessary to set the sample time to suit the expected period of the incoming signal.

Invert output polarity

Changes the sense of the leading edge of the pulse. When **Invert output polarity** is selected, the leading edge is rising. Otherwise, the leading edge is falling.

Hold output when at debug break point (freeze enable)

Stops the clocks of the MDASM module when a breakpoint is hit during debug mode.

Enable pass through (show simulation input)

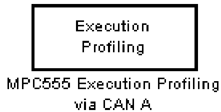
Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

MPC555 Execution Profiling via CAN A

Purpose Provide a CAN interface to the execution profiling engine via CAN channel A

Library Embedded Target for Motorola MPC555/ MPC555 Driver Library/ Utilities

Description



MPC555 Execution Profiling via CAN A

Provides a CAN interface to the execution profiling engine. On receipt of a start command message, logging of execution profile data is commenced. On completion of a logging run, the recorded data is automatically returned via CAN. You must specify the message identifiers for the start command and the returned data. These identifiers must be compatible with the values used by the host-side part of the execution profiling utility. See also MATLAB command `profile_mpc555`.

`profile_mpc555(connection)` collects and displays execution profiling data from an MPC555 target microcontroller that is running a suitably configured application generated by Embedded Target for Motorola MPC555. The `connection` may be set to `'CAN'` in order to collect data via a CAN connection between the target and the host computer. To use the CAN connection, you must have suitable CAN hardware installed on the host computer. This function will test for availability of CanCardX 1 or CanAc2Pci1 and defaults to a bit rate of 500k bits per second. If you need to use a different configuration, you should make a copy of this file and change the configuration data as required. The data collected is unpacked then displayed in a summary HTML report and as MATLAB graphic.

```
profdata = profile_mpc555(connection)
```

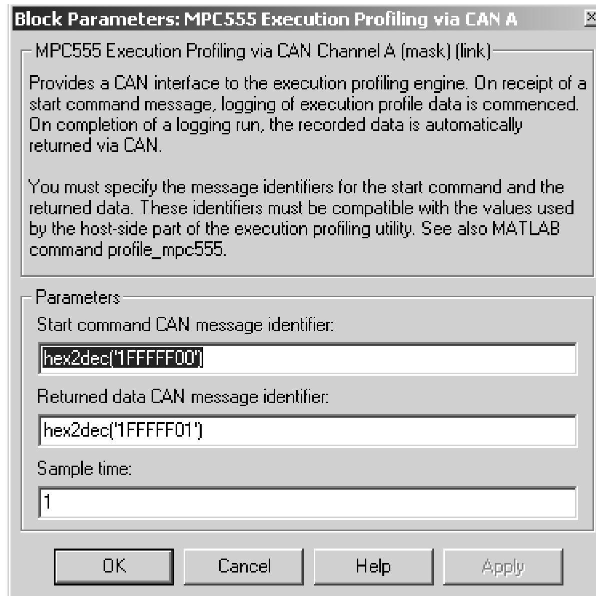
returns the execution profiling data in the format documented by `exprofile_unpack`.

To configure a model for use with execution profiling, you must perform the following steps:

1. Check the appropriate option in the Target Specific Options tab of the Real-Time Workshop Options dialog.
2. Make sure the model includes an MPC555 Execution Profiling block that provides an interface between the target-side profiling engine, and the host-side computer from which this command is run.

For more information see“Execution Profiling” on page 2-35 which includes links to instructions for the example demo `mpc555_multitasking.mdl`.

Dialog Box



Start command CAN message identifier

Set the identifier of the message to start logging execution profiling data. You should use the default unless you have modified `profile_mpc555`. This identifier must be compatible with the values used by the host-side part of the execution profiling utility (`profile_mpc555`).

The utility `profile_mpc555` provides a mechanism for initiating an execution profiling run and for uploading the recorded data to the host machine. To perform this procedure using a CAN connection between host and target, `profile_mpc555` first sends a CAN message that is a command to start an execution profiling run. The CAN identifier for this message must be specified as the same value on the target as on the host. The host-side values are hard-coded in `profile_mpc555`. If you are using an un-modified version of the host side utility, you should use the default value for this CAN message identifier. These are visible to help you avoid using the same identifier for other tasks.

Returned data CAN message identifier

Set the message identifier for the returned data. As with the message identifier for the start command, the value specified here must be the same as the hard-coded value in profile_mpc555.

Sample time

The sample time of the block.The faster the sample time of the block, the faster data will be uploaded at the end of the execution profiling run. You may want to run this block slower than the fastest rate in the system because the execution profiling itself imposes some loading on the processor. You can minimize this extra loading by not running it at the fastest rate.

Purpose

Provide a serial interface to the execution profiling engine

Library

Embedded Target for Motorola MPC555/
MPC555 Driver Library/ Execution Profiling

Description

Execution Profiling
via Serial

MPC555 Execution Profiling
via SCI1

Provides a CAN interface to the execution profiling engine. On receipt of a start command message, logging of execution profile data is commenced. On completion of a logging run, the recorded data is automatically returned via serial. See also MATLAB command `profile_c166`.

`profile_mpc555(connection)` collects and displays execution profiling data from an MPC555 target microcontroller that is running a suitably configured application generated by Embedded Target for Motorola MPC555. The `connection` may be set to `'serial'` in order to collect data via a serial connection between the target and the host computer.

The data collected is unpacked then displayed in a summary HTML report and as MATLAB graphic.

```
profdata = profile_mpc555(connection)
```

returns the execution profiling data in the format documented by `exprofile_unpack`.

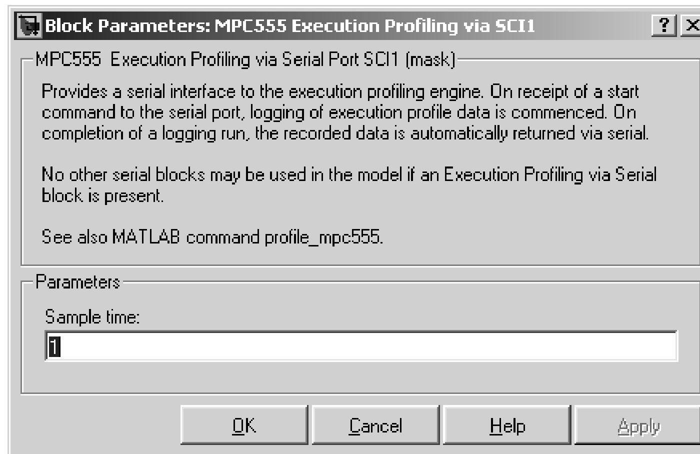
To configure a model for use with execution profiling, you must perform the following steps:

1. Check the execution profiling option in the Target Specific Options tab of the Real-Time Workshop Options dialog.
2. Make sure the model includes an MPC555 Execution Profiling block that provides an interface between the target-side profiling engine, and the host-side computer from which this command is run.

For more information see “Execution Profiling” on page 2-35 which includes instructions for the example demo `mpc555_multitasking.mdl`.

MPC555 Execution Profiling via SCI1

Dialog Box



Sample time

The sample time of the block. The faster the sample time of the block, the faster data will be uploaded at the end of the execution profiling run. You may want to run this block slower than the fastest rate in the system because the execution profiling itself imposes some loading on the processor. You can minimize this extra loading by not running it at the fastest rate.

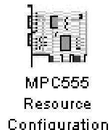
Purpose

Support device configuration for MPC555 CPU and MIOS, QADC, and TouCAN submodules

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library

Description



The MPC555 Resource Configuration block differs in function and behavior from conventional blocks. Therefore, we refer to this block as the MPC555 Resource Configuration *object*.

The MPC555 Resource Configuration object maintains configuration settings that apply to the MPC555 CPU and its MIOS, QADC, and TouCAN subsystems. Although the MPC555 Resource Configuration object resembles a conventional block in appearance, it is not connected to other blocks via input or output ports. This is because the purpose of the MPC555 Resource Configuration object is to provide information to other blocks in the model. MPC555 device driver blocks register their presence with the MPC555 Resource Configuration object when they are added to a model or subsystem; they can then query the MPC555 Resource Configuration object for required information.

To install a MPC555 Resource Configuration object in a model or subsystem, open the top-level Embedded Target for Motorola MPC555 library and select the MPC555 Resource Configuration icon. Then drag and drop it into your model or subsystem, like a conventional block.

Having installed a MPC555 Resource Configuration object into your model or subsystem, you can then select and edit configuration settings in the MPC555 Resource Configuration window. See “Using the MPC555 Resource Configuration Window” on page 4-45 for further information.

Note Any model or subsystem using device driver blocks from the Embedded Target for Motorola MPC555 library *must* contain an MPC555 Resource Configuration object. You should place an MPC555 Resource Configuration object at the top level system for which you are going to generate code. If your whole model is going to run on the target processor, put the MPC555 Resource Configuration object at the root level of the model. If you are going to generate code from separate subsystems (to run specific subsystems on the target), place an MPC555 Resource Configuration object at the top level of each subsystem. You should not have more than one MPC555 Resource

Configuration object in the same branch of the model hierarchy. Errors will result if these conditions are not met.

Types of Configurations

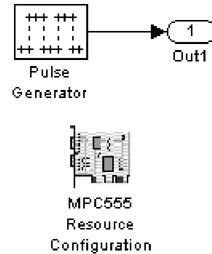
A *configuration* is a collection of parameter values affecting the operation of a group of device driver blocks in one of the Embedded Target for Motorola MPC555 libraries, such as the MIOS1, QADC64 or TouCAN libraries. The MPC555 Resource Configuration object currently supports the following types of configurations:

- "System Configuration Parameters" on page 4-47: MPC555 clocks and other CPU-related parameters.
- "QADC64 Configuration Parameters" on page 4-48: parameters related to the Queued Analog-to-Digital Converter module (QADC).
- "QADC64E Configuration Parameters" on page 4-50: parameters related to the QADC for the MPC565.
- "MIOS1 Configuration Parameters" on page 4-51: parameters related to the Modular Input/Output System (MIOS).
- "TouCAN Configuration Parameters" on page 4-52: parameters related to the CAN 2.0B Controller Module (TouCAN).
- "Time Processor Unit (TPU3) Configuration Parameters" on page 4-55TPU3 Configuration: parameters related to the Time Processor Unit module.
- "Serial Communications Interface (SCI) Configuration Parameters" on page 4-56: parameters related to the Serial Communications Interface.

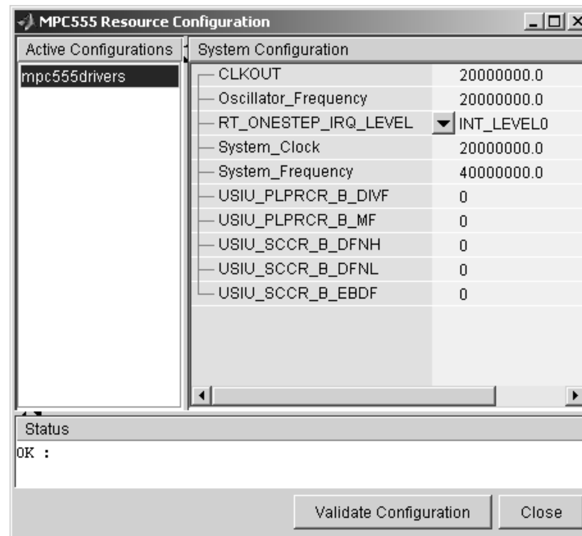
Active and Inactive Configurations

An *active* configuration is a configuration associated with blocks of the model or subsystem in which the MPC555 Resource Configuration object is installed. There is always an active MPC555 configuration. For any other configuration type (e.g., QADC, MIOS, or TouCAN), there is at most one active configuration.

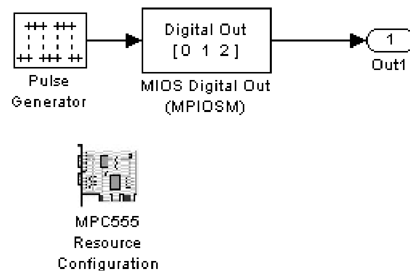
Consider this model, which contains a MPC555 Resource Configuration object but no MPC555 device driver blocks.



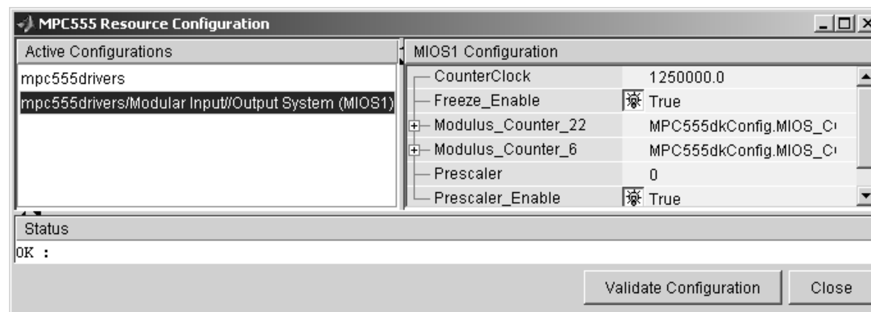
This model has only one active configuration, for the MPC555 itself, as shown in the MPC555 Resource Configuration window.



When a device driver block is added to the model, an appropriate configuration is created and activated. The following figure shows an MIOS Digital Out block added to the model.



The addition of the MIOS Digital Out block causes an MIOS configuration to be added to the list of active configurations, as shown in this figure.

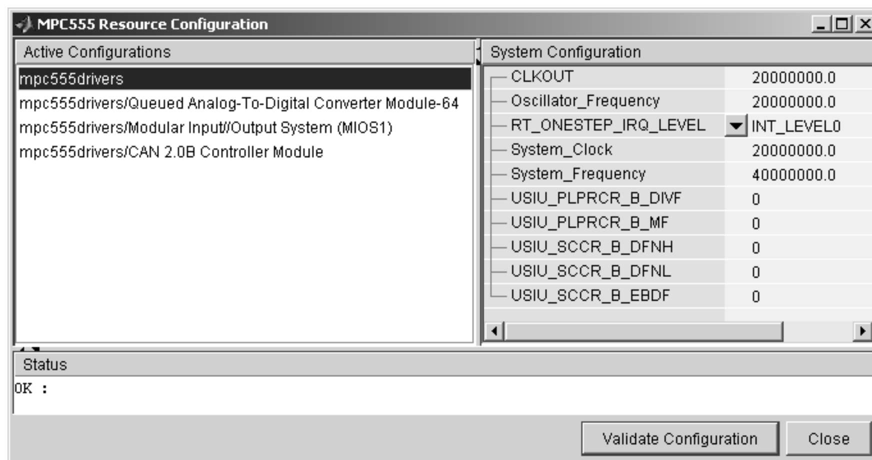


A configuration remains active until all blocks associated with it are removed from the model or subsystem. At that point, the configuration is in an *inactive* state. Inactive configurations are not shown in the MPC555 Resource Configuration window. You can reactivate a configuration by simply adding an appropriate block into the model.

Note When using device driver blocks from the Embedded Target for Motorola MPC555 libraries in conjunction with the MPC555 Resource Configuration block, do not disable or break library links on the driver blocks. If library links are disabled or broken, the MPC555 Resource Configuration block will operate incorrectly.

Using the MPC555 Resource Configuration Window

To open the **MPC555 Resource Configuration** window, install a MPC555 Resource Configuration object in your model or subsystem, and double-click on the MPC555 Resource Configuration icon. The **MPC555 Resource Configuration** window then opens.



MPC555 Resource Configuration Window

This figure shows the MPC555 Resource Configuration window for a model that has active configurations for MPC555, MIOS1, QADC, and TouCAN.

The MPC555 Resource Configuration window consists of the following elements:

- **Active Configurations** panel: This panel displays a list of currently active configurations. To edit a configuration, click on its entry in the list. The parameters for the selected configuration then appear in the **System configuration** panel.

  To link back to the library associated with an active configuration, right-click on its entry in the list. From the pop-up menu that appears, select **Go to library**.

  To see documentation associated with an active configuration, right-click on its entry in the list. From the popup menu that appears, select **Help**.

- **System configuration** panel: This panel lets you edit the parameters of the selected configuration. The parameters of each configuration type are detailed in "MPC555 Resource Configuration Window Parameters" on page 4-46.

Note There is no **Apply** or **Undo** functionality in the **System configuration** panel. All parameter changes are applied immediately.

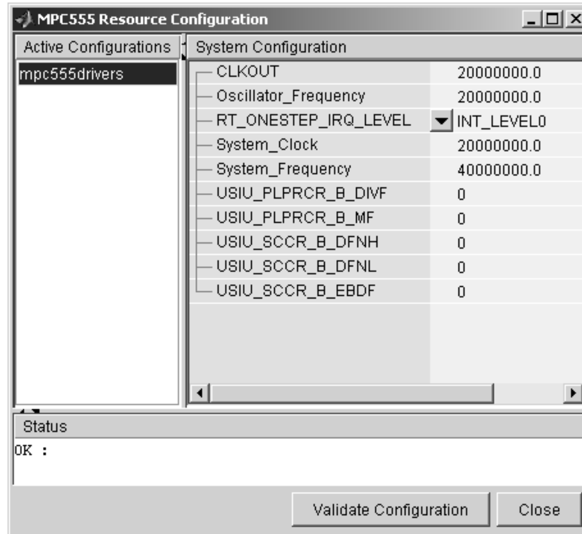
- **Status** panel: The **Status** panel displays error messages that may arise if resource allocation conflicts are detected in the configuration.
- **Validate Configuration** button: After you edit a configuration, you should always click the **Validate Configuration** button to check for resource allocation conflicts. For example, if both TouCAN modules A and B are assigned to interrupt level IRQ 1, the **Validate Configuration** process will detect the conflict and display a warning in the **Status** panel.

  Note that the **Validate Configuration** button does not validate the entire model; it only checks for resource allocation conflicts related to the selected configuration. To detect problems related to the model as a whole, select **Update diagram** (**Ctrl+D**) from the Simulink Edit menu.
- **Close** button: Dismisses the window.

MPC555 Resource Configuration Window Parameters

The sections below describe the parameters for each type of configuration in the MPC555 Resource Configuration window. The default parameter settings are optimal for most purposes. If you want to change the settings, we suggest you read the sections of the *MPC555 Users Manual* referenced below. You can find this document at the URL `http://e-www.motorola.com`.

System Configuration Parameters



RT_ONESTEP_IRQ_LEVEL

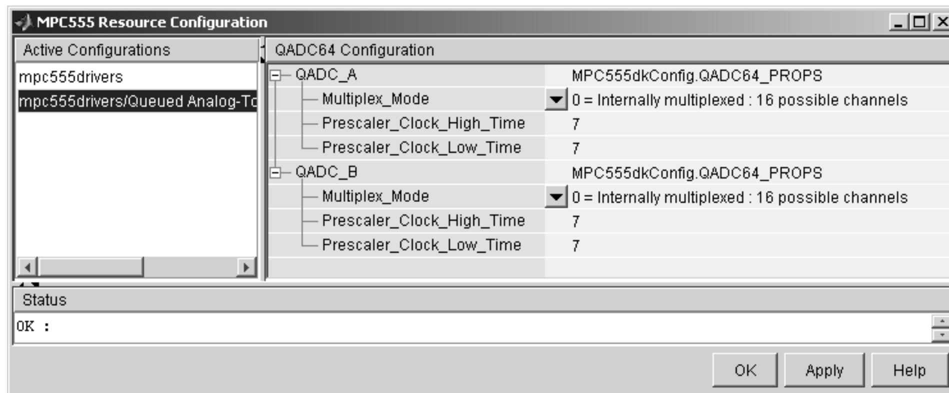
The `rt_OneStep` function is the basic execution driver of all programs generated by the Embedded Target for Motorola MPC555. `rt_OneStep` is installed as a timer interrupt service routine; it sequences calls to the *`model`*`_step` function. The **RT_ONESTEP_IRQ_LEVEL** parameter lets you associate `rt_OneStep` with any of the available IRQ levels `(0..7)`. Do not select `Interrupts Disabled`, or the model will not work.

See the “Data Structures and Program Execution” section in the Real-Time Workshop Embedded Coder documentation for a detailed description of the `rt_OneStep` function.

System Clock Parameters

The other parameters in the MPC555 group alter the speed of three of the main clocks in the MPC555. Note we only support 4MHz or 20 MHz clock speeds. Refer to section 8, “Clocks and Power Control,” in the *MPC555 Users Manual* for information on these settings.

QADC64 Configuration Parameters



The Queued Analog-To-Digital Converter Module 64 (QADC64) Configuration parameters configure the QADC64 operational mode and supports the blocks in the QADC sublibrary.

The QADC64 performs 10 bit analog to digital conversion on an input signal. Currently the blocks in this library support only the *continuous scan* mode of operation. In continuous scan mode, the QADC64 is set to run, and then continuously acquires data into its result buffer. Input is double buffered, so the model can read the result buffer at any time to get the latest available signal data.

The MPC555 has two QADC modules, QADC_A and QADC_B. You can program these individually. By default each QADC module has 16 input channels. By attaching an external multiplexer to three of the analog input pins, you can increase the number of possible channels to 41. These pins become outputs from the processor and can act as inputs to an analog multiplexer. The **Multiplex Mode** parameter determines whether the QADC64 operates in internally or externally multiplexed mode.

Refer to section 13, “Queued Analog-to-Digital Converter Module-64,” in the *MPC555 Users Manual* for detailed information about the QADC64.

In general, you should not need to change any of the settings of the parameters described below from their defaults. The other parameters are advanced settings. Refer to section 13, “Queued Analog-to-Digital Converter Module-64,” in the *MPC555 Users Manual* for information on these settings.

Multiplex Mode

Configures the QADC64 for internally or externally multiplexed mode by setting the MUX bit. The MUX bit determines the interpretation of the channel numbers and forces the MA[2:0] pins to be outputs. Valid settings are

- `0 = Internally multiplexed : 16 possible channels`
- `1 = Externally multiplexed : 41 possible channels`

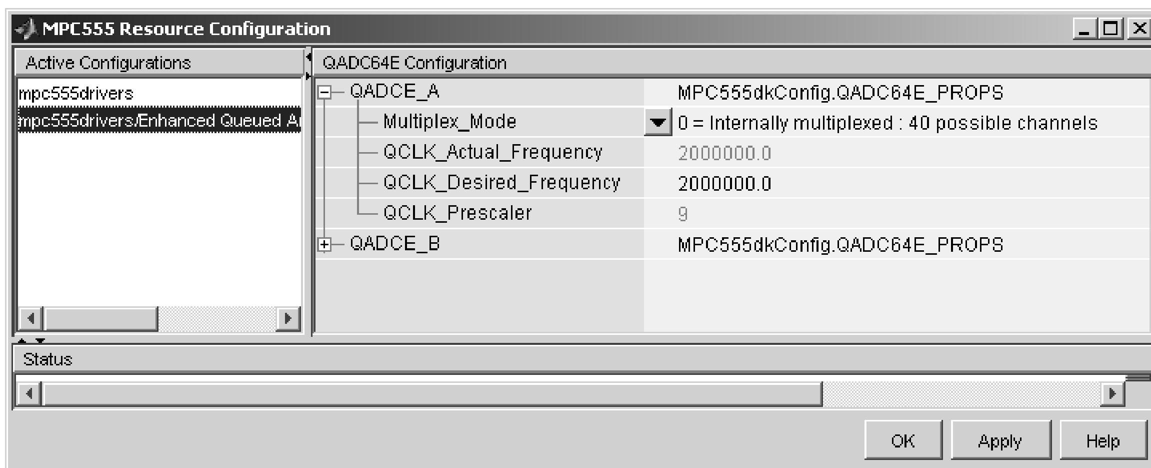
Prescaler Clock High Time

Prescaler clock high (PSH) time. The default is `7`. The PSH field selects the QCLK high time in the prescaler. PSH value plus 1 represents the high time in IMB clocks.

Prescaler Clock Low Time

Prescaler clock low (PSL) time. The default is `7`. The PSL field selects the QCLK low time in the prescaler. PSL value plus 1 represents the low time in IMB clocks.

QADC64E Configuration Parameters



The Enhanced QADC functions are for MPC56x processors – you will see an error message if you try to configure these for an MPC555. Use QADC blocks for an MPC555; for an MPC56x set your target processor accordingly in the Target Preferences and then you can use the QADCE blocks.

The Enhanced Queued Analog-To-Digital Converter Module 64 (QADC64E) Configuration parameters configure the QADC64E operational mode and supports the blocks in the Enhanced QADC sublibrary.

Multiplex Mode

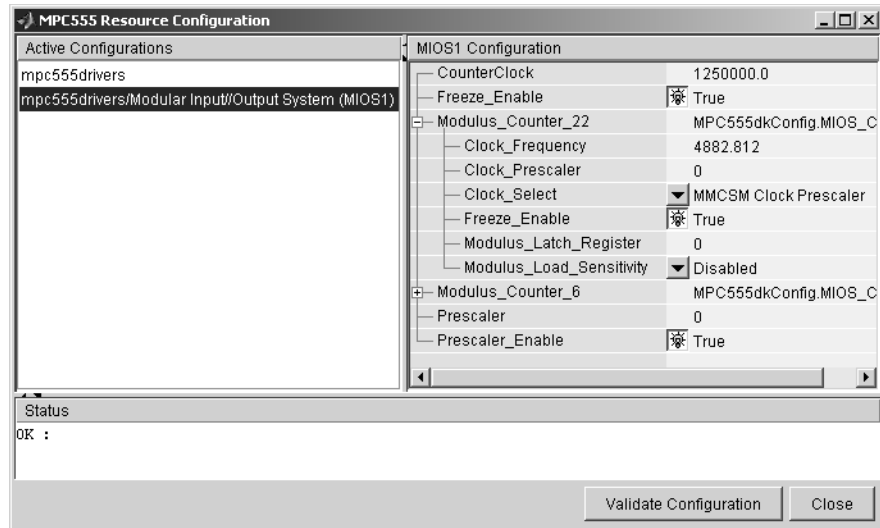
Configures the QADC64 for internally or externally multiplexed mode by setting the MUX bit. The MUX bit determines the interpretation of the channel numbers and forces the MA[2:0] pins to be outputs. Valid settings are

- `0 = Internally multiplexed : 40 possible channels`
- `1 = Externally multiplexed : 65 possible channels`

QCLK_Desired_Frequency

Set the Q clock frequency you want here. The `QCLK_Actual_Frequency` field displays the true value achieved. `QCLK_Actual_Frequency` and `QCLK_Prescalar` are read only fields for information.

MIOS1 Configuration Parameters



CounterClock

The MIOS counter clock is generated by the MIOS counter prescaler submodule. The MIOS counter clock drives the other MIOS1 submodules. The value shown for the counter clock is calculated automatically as the system clock frequency divided by the prescaler value.

Freeze Enable

This allows all counters on the MIOS1 to be frozen when the processor is stopped in debug mode. Note that this is in addition to the **Freeze Enable** setting for individual submodules on the MIOS1. To allow the counters on a particular submodule to be stopped, select Freeze enable here, and select **Hold output when at debug break point (freeze enable)** in the block parameters associated with the submodule (e.g., MIOS Pulse Width Modulation block or MIOS Waveform Measurement block).

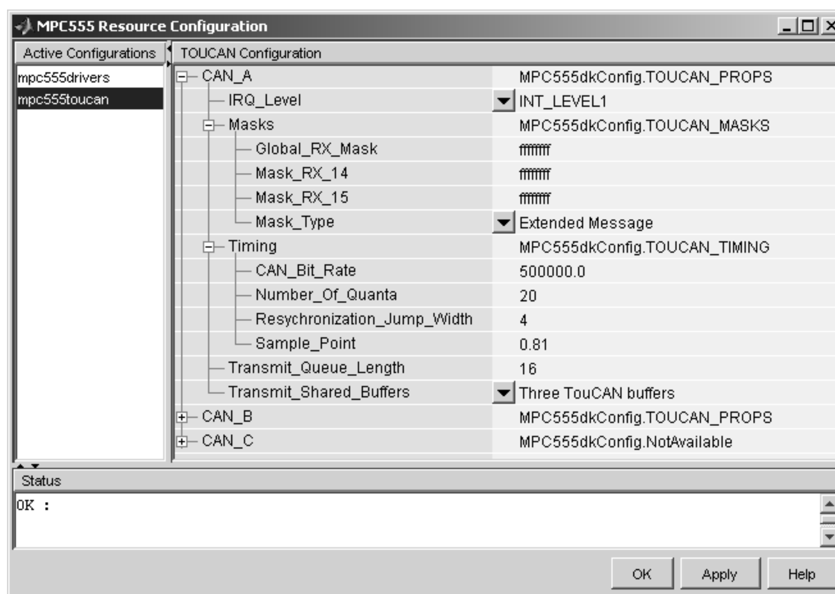
Modulus Counter 6 and 22

These two counters provide reference clocks to submodules such as the MIOS Pulse Width Modulation Submodule and the MIOS Double Action Submodule (Frequency / Period measurement) subsystems. If you change the **Clock select** to anything other than `MMCSM Clock Prescaler`, the

MIOS Pulse Width Modulation and MIOS Waveform Measurement blocks will not work as expected. To change the clock frequency and hence the available resolution of pulse width modulation and waveform measurement, change the **Clock Prescaler** to a value between 0 and 255.

Refer to section 15.10, “MIOS Modulus Counter Submodule (MMCSM),” in the *MPC555 Users Manual* for information on these settings.

TouCAN Configuration Parameters



The parameters listed below are the same for TouCAN modules A and B. Consult Section 16 of the *MPC555 User's Manual* before editing the TouCAN configuration parameter defaults.

IRQ Level

The transmit queue for each TouCAN module requires a processor interrupt to run. Select an interrupt level (0-31) that is not used by any other device. Use the **Validate Configuration** button to make sure you do not select an interrupt level that is already in use. Do not disable

interrupts, this will stop the TouCAN Transmit block from working correctly.

Mask Configuration Parameters

Global RX Mask

Buffers 0-13 use this mask. Setting a bit to `1` in the mask causes the corresponding bits in the message to be masked out (i.e., ignored).

Mask RX 14

Same as **Global RX Mask**, but the mask applies only to buffer 14.

Mask RX 15

Same as **Global RX Mask**, but the mask applies only to buffer 15.

Mask Type

Specify whether the buffer masks are Standard or Extended frame IDs. If you want to receive Extended Frames in your model, you should set the **Mask Type** to **Extended Message**. The mask type option tells the compiler how to map the bits specified in the mask options to the bits in the hardware. The decision as to whether a message is a Standard or Extended frame is defined on a per message buffer basis.

Timing Configuration Parameters

CAN Bit Rate

Enter the desired bit rate. The default bit rate is `500000.0`.

Number of Quanta

The number of TouCAN clock ticks per message bit.

Resynchronization Jump Width

The maximum number of clock ticks that the TouCAN device can resynchronize over when it detects that it is losing message synchronization.

Sample Point

The point in the message where the TouCAN tries to sample the value of the message bit.

Transmission Configuration Parameters

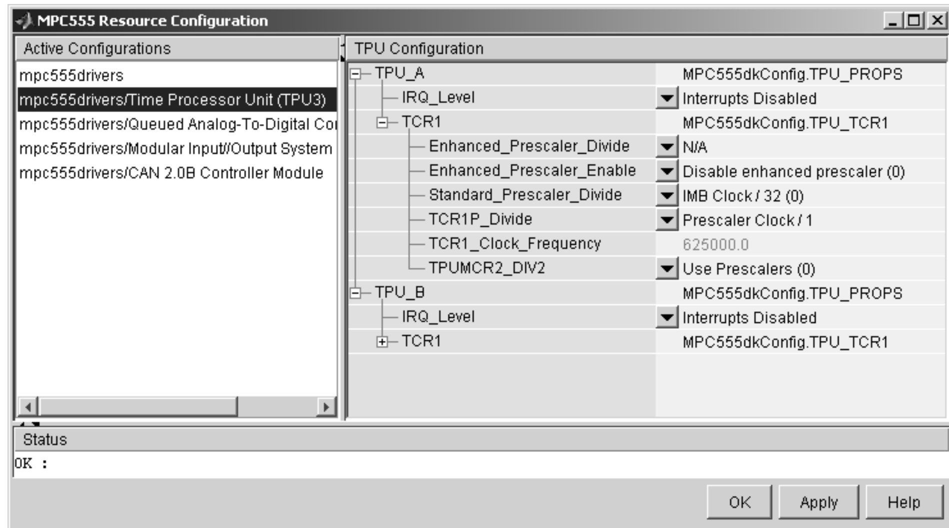
Transmit Queue Length

Length (number of messages) of the transmit queue. The transmit queue holds messages that are waiting to be transmitted. An increase in performance can be achieved by reducing the queue length. However, if the queue's length is too small it may become full, causing messages to be lost.

Transmit Shared Buffers

Choose either `Single TouCAN Buffer` or `Three TouCAN Buffers`. This parameter is used in conjunction with all TouCAN Transmit blocks in the model that are operating in `Queued transmission with shared buffer` mode. If you select `Single TouCAN Buffer`, then all messages that are queued will be transmitted via a single hardware buffer; in this case, it is possible that a low priority message in the transmit buffer will block higher priority messages that are in the queue. To avoid this problem, use the option `Three TouCAN Buffers`. When three buffers are used, the driver ensures that the message entered into arbitration to be transmitted via the CAN bus is always the highest priority message available; furthermore in this mode the TouCAN module is able to transmit messages continuously by re-loading hardware buffers that become empty while another buffer is active transmitting.

Time Processor Unit (TPU3) Configuration Parameters



The TCR1 timebase is configurable for TPU Channels A, B and C. The parameters under the TCR1 tree allow you full control to specify the clock speed of the TCR1 timebase. Consult Section 17 of the *MPC555 User's Manual* before editing the TPU configuration parameter defaults. The parameters listed below are the same for TPU modules A, B and C.

TPUMCR2_DIV2

TPUMCR2_DIV2 (the last setting under the tree) allows you to choose to use a set of prescalers to divide the IMB clock down further (`Use Prescalers (0)`), or to just divide the IMB clock by two (`IMB Clock / 2 (1)`). If you choose the divide by two option then none of the other settings are applicable and are marked `N/A`. Note this is the last setting purely because the parameters are laid out in alphabetical order.

Enhanced_Prescaler_Enable

Here you can choose whether you use the Standard Prescaler (set by `Standard_Prescaler_Divide`) or the Enhanced Prescaler (set by `Enhanced_Prescaler_Divide`) to derive the Prescaler Clock.

Standard_Prescaler_Divide

If you choose to use the Standard_Prescaler_Divide then you can choose to divide the IMB clock down by either 32 or 4.

Enhanced_Prescaler_Divide

If you choose to use the Enhanced_Prescaler_Divide, then you can choose to divide the IMB clock down by either 2, 4, 6, 8, .. , 60, 62, 64.

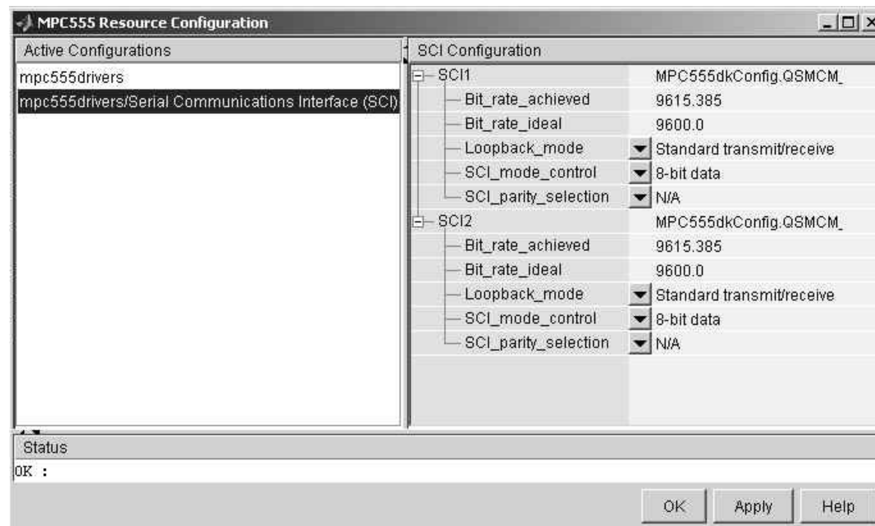
TCR1P_Divide

Whichever type of prescaler you choose (standard or extended), there is a further prescaler that is applied to the clock. TCR1P_Divide divides the Prescaler Clock by 1, 2, 4, or 8. The resulting clock is the TCR1 timebase.

IRQ_Level

This enables TPU interrupts. The default is disabled. If your model contains any TPU3 Programmable Time Accumulator blocks, you will need to choose an interrupt level.

Serial Communications Interface (SCI) Configuration Parameters



Bit_rate_achieved

This read-only field shows the achieved serial interface bit rate. In general this value differs slightly from the requested bit rate, but is the closest value that can be achieved by setting allowed values in the MPC555 registers SCC1R0 and SCC2R0 for QSMCM submodules SCI1 and SCI2 respectively.

Bit_rate_ideal

Enter the desired bit rate for serial communications in this field. Appropriate register settings will be calculated automatically. You can check the actual bit rate in the **Bit_rate_achieved** field.

Loopback_mode_enable

Select either `Standard transmit/receive` or `Loopback mode enabled`. The loopback mode may be useful for test purposes where the serial interface is required to receive data that it transmitted itself.

SCI_mode_control

Select the desired combination of word length and parity/no parity.

Parity_selection

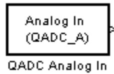
If parity is enabled, you must select `Odd parity` or `Even parity`.

QADC Analog In

Purpose Input driver enables use of Queued Analog-Digital Converter (QADC64) in continuous scan mode

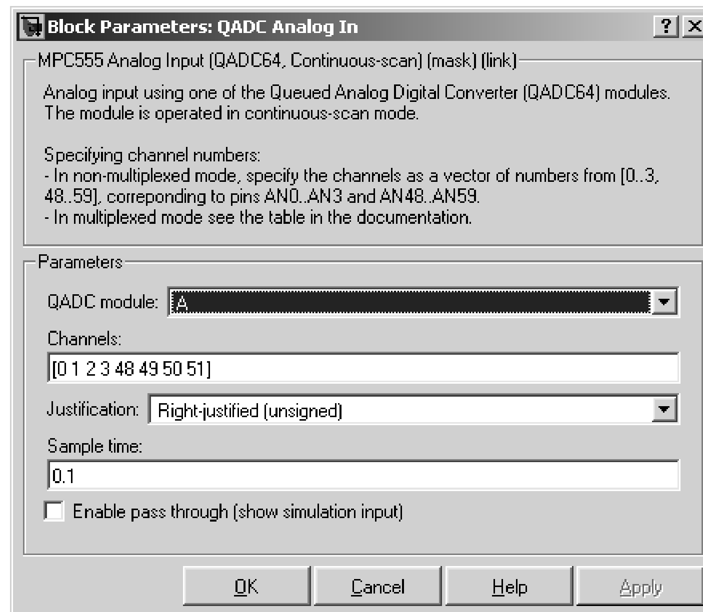
Library Embedded Target for Motorola MPC555/ MPC555 Driver Library/ Queued Analog-To-Digital Converter Module-64

Description The QADC Analog In block sets the QADC64 into continuous scan mode. It then samples the specified channels at the specified rate. In continuous scan mode, the analog-to-digital converter is scanned as fast as possible, at a rate much faster than the sample rate of the model. Using continuous scan mode ensures that your application will obtain the latest signal value.



The MPC555 has two QADC modules, A and B. You can program these individually. You can place only one instance of the QADC Analog In block per module in your model or subsystem.

Dialog Box



QADC module

Select module A or B.

Channels

A vector of numbers representing channels to be scanned. See "Channel Number Selection" below.

Justification

Converted data is read from the 10-bit wide QADC64 result word table into a 16-bit word. Data from the result word table can be accessed in three different formats. The **Justification** menu selects from the following formats:

- `Right-justified (unsigned)`: with zeros in the higher order unused bits.
- `Left-justified (signed)`: with the most significant bit inverted to form a sign bit, and zeros in the unused lower order bits. In this mode, zero is treated as the half scale of the input range.
- `Left-justified (unsigned)`: with zeros in the unused lower order bits.

Refer to section 13.13, in the "Queued Analog-to-Digital Converter Module-64" section of the *MPC555 Users Manual* for further information.

Sample time

Block sample time; determines sample rate at which the port is monitored.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

Channel Number Selection

A channel number in the **Channels** vector selects the input channel number corresponding to the analog input pin to be sampled and converted. The analog input pin channel number assignments and the pin definitions vary, depending on whether the QADC64 is operating in multiplexed or nonmultiplexed mode. The queue scan mechanism makes no distinction between an internally or externally multiplexed analog input.

The following two tables show the mapping between the channel numbers and the hardware pins for the two scanning modes (multiplexed and nonmultiplexed).

For example, in nonmultiplexed mode, to scan all 16 channels of the QADC64 you would specify the following vector in the **Channels** field:

```
[ 0 1 2 3 48 49 50 51 52 53 54 55 56 57 58 59 ]
```

Nonmultiplexed Scan Mode

Port Pin Name	Analog Pin Name	Other Functions	Pin Type (I/O)	Channel Number
PQB0	A_AD0 / AN0	-	I	0
PQB1	A_AD1 / AN1	-	I	1
PQB2	A_AD2 / AN2	-	I	2
PQB3	A_AD3 /AN3	-	I	3
PQB4	A_AD4 / AN48	-	I	48
PQB5	A_AD5 / AN49	-	I	49
PQB6	A_AD6 / AN50	-	I I	50
PQB7	A_AD7 / AN51	-	I	51
PQA0	A_AD8 / AN52	-	I/O	52
PQA1	A_AD9 / AN53	-	I/O	53
PQA2	A_AD10 / AN54	-	I/O	54
PQA3	A_AD11 / AN55	-	I/O	55
PQA4	A_AD12 / AN56	-	I/O	56
PQA5	A_AD13 / AN57	-	I/O	57
PQA6	A_AD14 / AN58	-	I/O	58
PQA7	A_AD15 / AN59	-	I/O	59

Multiplexed Scan Mode

Port Pin Name	Analog Pin Name	Other Functions	Pin Type (I/O)	Channel Number
PQB0 PQB1 PQB2 PQB3	A_AD0 / ANw A_AD1 / ANx A_AD2 / ANy A_AD3 / Anz	- - - -	I I I I	0-14 even 1-15 odd 16-30 even 17-31 odd
PQB4 PQB5 PQB6	A_AD4 / AN48 A_AD5 / AN49 A_AD6 / AN50	- - -	I I I	48 49 50
PQB7	A_AD7 / AN51	-	I I	51
PQA3 PQA4 PQA5 PQA6	A_AD11 / AN55 A_AD12 / AN56 A_AD13 / AN57 A_AD14 / AN58	- - - -	I/O I/O I/O I/O	55 56 57 58
PQA7	A_AD15 / AN59	-	I/O	59

Note that PQA0, PQA1 and PQA2 (corresponding to channels 52-54) are used as output pins (MA0, MA1, and MA2) to drive an external demultiplexer.

QADC Digital In

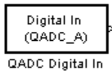
Purpose

Input driver enables use of Queued Analog-Digital Converter (QADC64) pins as digital inputs

Library

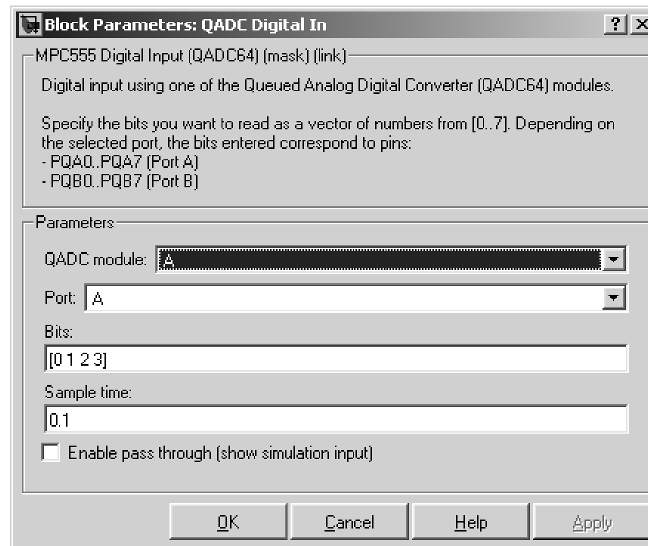
Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Queued Analog-To-Digital Converter Module-64

Description



The QADC Digital In block allows you to treat the QADC64 pins as digital inputs. Each QADC64 module has two 8-bit ports, A and B. You can use any bit on either port as a digital input.

Dialog Box



QADC module

Select module A or B.

Port

Select an 8 bit port (A or B) on the module.

Bits

A vector of bits (numbered 0-7) to read. The vector should not be longer than eight elements.

Sample time

Block sample time; determines sample rate at which the port is monitored.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

Mapping Bits To Hardware Pins

Use this table to work out how the block ports and bits map to processor pins on the MPC555.

Relationship of Port/Bit Parameters to Hardware Pins

Port	Bit	Hardware Pin
B	0	A_AD0 / PQB0
B	1	A_AD1 / PQB1
B	2	A_AD2 / PQB2
B	3	A_AD3 / PQB3
B	4	A_AD4 / PQB4
B	5	A_AD5 / PQB5
B	6	A_AD6 / PQB6
B	7	A_AD7 / PQB7
A	0	A_AD8 / PQA0
A	1	A_AD9 / PQA1
A	2	A_AD10 / PQA2

Relationship of Port/Bit Parameters to Hardware Pins (Continued)

Port	Bit	Hardware Pin
A	3	A_AD11 / PQA3
A	4	A_AD12 / PQA4
A	5	A_AD13 / PQA5
A	6	A_AD14 / PQA6
A	7	A_AD15 / PQA7

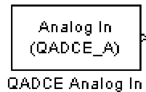
Purpose

Input driver enables use of Queued Analog-Digital Converter (QADC64) in continuous scan mode on an MPC565

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/ Enhanced Queued Analog-To-Digital Converter Module-64

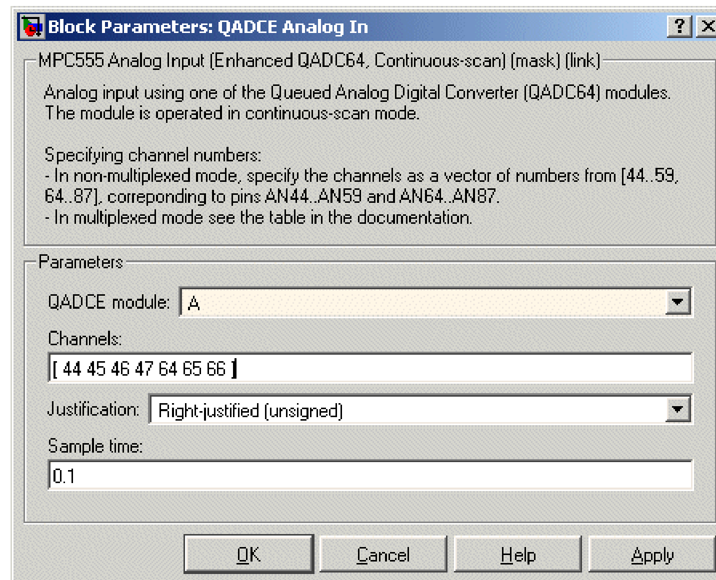
Description



The QADCE Analog In block sets the QADC64E into continuous scan mode. It then samples the specified channels at the specified rate. In continuous scan mode, the analog-to-digital converter is scanned as fast as possible, at a rate much faster than the sample rate of the model. Using continuous scan mode ensures that your application will obtain the latest signal value.

The MPC565 has two QADC64E modules, A and B. You can program these individually. You can place only one instance of the QADC Analog In block per module in your model or subsystem.

Dialog Box



QADC module

Select module A or B.

Channels

A vector of numbers representing channels to be scanned. A channel number in the **Channels** vector selects the input channel number corresponding to the analog input pin to be sampled and converted.

The analog input pin channel number assignments and the pin definitions vary, depending on whether the QADC64 is operating in multiplexed or nonmultiplexed mode. The queue scan mechanism makes no distinction between an internally or externally multiplexed analog input.

In nonmultiplexed mode, specify a vector of numbers from [44..59 64..87] corresponding to pins AN44..AN59 and AN64..AN87.

See the table following for the mapping in multiplexed mode between the channel numbers and the hardware pins.

Justification

Converted data is read from the 10-bit wide QADC64 result word table into a 16-bit word. Data from the result word table can be accessed in three different formats. The **Justification** menu selects from the following formats:

`Right-justified (unsigned)`: with zeros in the higher order unused bits.

`Left-justified (signed)`: with the most significant bit inverted to form a sign bit, and zeros in the unused lower order bits. In this mode, zero is treated as the half scale of the input range.

`Left-justified (unsigned)`: with zeros in the unused lower order bits.

Sample time

Block sample time; determines sample rate at which the port is monitored

Mapping Bits To Hardware Pins

Use the following table to work out how the block ports and bits map to processor pins on the MPC565 in multiplexed mode.

In summary

- No multiplexing:
  channels available 44-59 and 64-87
- A only multiplexing:
  channels available 0-31; 48-51; 55-59; 64-87
- B only multiplexing:
  channels available 0-31; 48-59; 64-71; 75-87
- A and B multiplexing:
  channels available 0-31; 48-51; 55-59; 64-71; 75-87

Multiplexed Scan Mode

Port Pin Name	Analog Pin Name	Other Functions	Pin Type (I/O)	Channel Number
ANw/A_PQB(0)	AN(00) to AN(07)	-	Input	0 to 7
ANx/A_PQB(1)	AN(08) to AN(15)	-	Input	8 to 15
ANy/A_PQB(2)	AN(16) to AN(23)	-	Input	16 to 23
ANz/A_PQB(3)	AN(24) to AN(31)	-	Input	24 to 31
A_PQB(0)	AN(44)	ANw	Input/Output	44
A_PQB(1)	AN(45)	ANx	Input/Output	45
A_PQB(2)	AN(46)	ANy	Input/Output	46
A_PQB(3)	AN(47)	ANz	Input/Output	47
A_PQB(4)	AN(48)	-	Input/Output	48
A_PQB(5)	AN(49)	-	Input/Output	49
A_PQB(6)	AN(50)	-	Input/Output	50

Multiplexed Scan Mode (Continued)

Port Pin Name	Analog Pin Name	Other Functions	Pin Type (I/O)	Channel Number
A_PQB(7)	AN(51)	-	Input/Output	51
A_PQA(0)	AN(52)	MA(0)	Input/Output	52
A_PQA(1)	AN(53)	MA(1)	Input/Output	53
A_PQA(2)	AN(54)	MA(2)	Input/Output	54
A_PQA(3)	AN(55)	-	Input/Output	55
A_PQA(4)	AN(56)	-	Input/Output	56
A_PQA(5)	AN(57)	-	Input/Output	57
A_PQA(6)	AN(58)	-	Input/Output	58
A_PQA(7)	AN(59)	-	Input/Output	59
B_PQB(0)	AN(64)	-	AMUX Input	64
B_PQB(1)	AN(65)	-	AMUX Input	65
B_PQB(2)	AN(66)	-	AMUX Input	66
B_PQB(3)	AN(67)	-	AMUX Input	67
B_PQB(4)	AN(68)	-	AMUX Input	68
B_PQB(5)	AN(69)	-	AMUX Input	69
B_PQB(6)	AN(70)	-	AMUX Input	70
B_PQB(7)	AN(71)	-	AMUX Input	71
B_PQA(0)	AN(72)	MA(0)	AMUX Input	72
B_PQA(1)	AN(73)	MA(1)	AMUX Input	73
B_PQA(2)	AN(74)	MA(2)	AMUX Input	74
B_PQA(3)	AN(75)	-	AMUX Input	75

Multiplexed Scan Mode (Continued)

Port Pin Name	Analog Pin Name	Other Functions	Pin Type (I/O)	Channel Number
B_PQA(4)	AN(76)	-	AMUX Input	76
A_PQA(5)	AN(77)	-	AMUX Input	77
A_PQA(6)	AN(78)	-	AMUX Input	78
A_PQA(7)	AN(79)	-	AMUX Input	79
-	AN(80)	-		80
-	AN(81)	-		81
-	AN(82)	-		82
-	AN(83)	-		83
-	AN(84)	-		84
-	AN(85)	-		85
-	AN(86)	-		86
-	AN(87)	-		87

In this table, MA(0) to MA(2) indicates these pins (A_ and B_PQA(0)-(2)) are used as output pins to drive an external demultiplexer.

QADCE Digital In

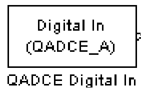
Purpose

Input driver enables use of Queued Analog-Digital Converter (QADC64) pins as digital inputs on an MPC565

Library

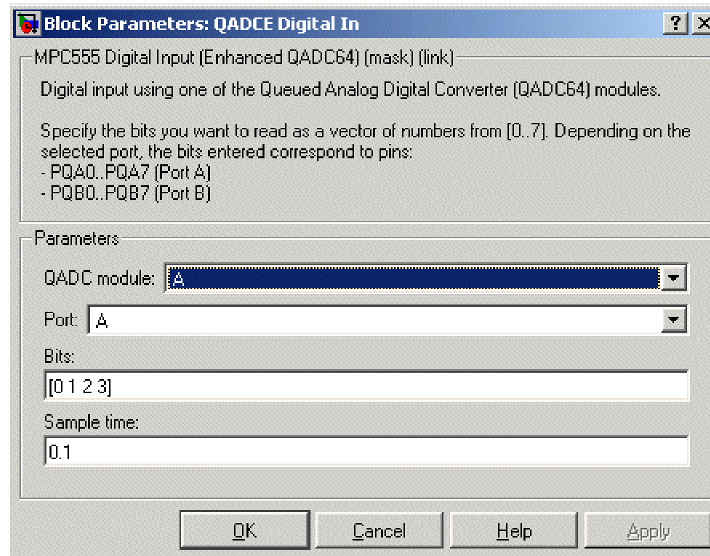
Embedded Target for Motorola MPC555/ MPC555 Driver Library/ Enhanced Queued Analog-To-Digital Converter Module-64

Description



The QADC Digital In block allows you to treat the QADC64E pins as digital inputs. Each QADC64E module has two 8-bit ports, A and B. You can use any bit on either port as a digital input.

Dialog Box



QADC module

Select module A or B.

Port

Select an 8 bit port (A or B) on the module.

Bits

Specify a vector of bits (numbered 0-7) to read. The vector should not be longer than eight elements. Depending on the selected port, the bits entered correspond to pins PQA0 to PQA7 (port A) or PQB0 to PQB7.

Sample time

Block sample time; determines sample rate at which the port is monitored

Serial Receive

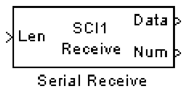
Purpose

Configure MPC555 for serial receive on either of the QSMCM submodules SCI1 or SCI2.

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Serial Communications Interface (SCI)

Description



The Serial Receive block receives bytes via either of the MPC555 QSMCM submodules SCI1 or SCI2. It requests either a fixed number of bytes to be received, or, by enabling the first input, a variable number of bytes can be requested each time this block is called. When the block is called, the requested number of bytes are retrieved from a hardware buffer provided by the submodule SCI1 or SCI2. On SCI1, the size of this buffer is 1 byte. On SCI2, the total size of the buffer is 16 bytes; note however that the effective capacity is reduced due to the hardware behavior and the circular mode of buffer operation used by the software driver. You should design your application on the basis of 9 bytes for the maximum buffer size for SCI2.

If the buffer contains fewer bytes than the number requested, these bytes are pulled from the buffer and made available at the block output. The number of bytes actually retrieved from the buffer is made available at the second output. This block will only retrieve bytes that have already been received and placed in the hardware buffer; it will never wait for additional data to be received.

To configure the serial interface bit rate and data format, see “Serial Communications Interface (SCI) Configuration Parameters” on page 4-56.

The device driver used for the Serial Receive block does not require the use of CPU interrupts.

Block Inputs and Outputs

The first input can be enabled so a variable number of bytes can be requested each time.

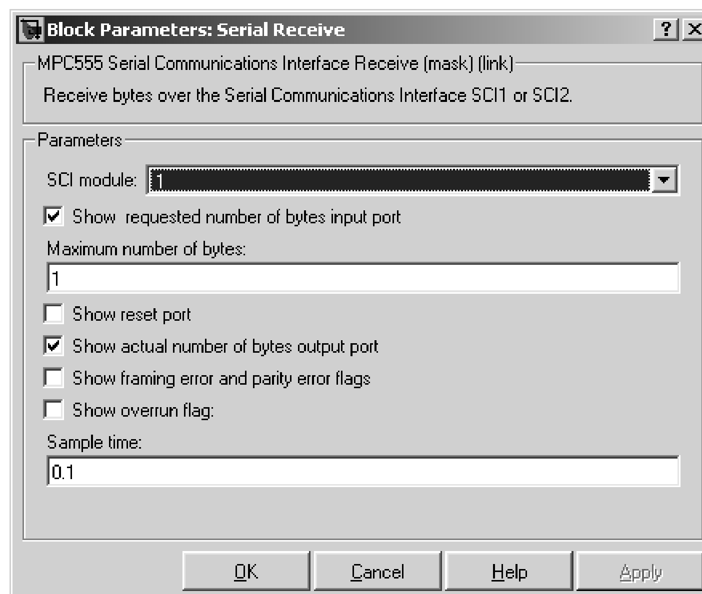
The second input, if enabled, is a reset signal, which must have a Boolean data type. You must reset the SCI1 module if an overrun error or framing or parity error occurs. No reset is required for SCI2.

The first output (marked `Data`) pulls bytes from the buffer — either the number requested or the number available, whichever is the lower. Note that the number requested is the value of the first input signal if supplied, or the width of output signal otherwise.

The second output (marked `Num`) is the number of bytes actually retrieved from the buffer. Up to four outputs can be enabled — the third showing framing error and parity error flags, and the fourth showing overrun flags.

See "Data Type Support and Scaling for Device Driver Blocks" on page 4-12 for information on supported input/output data types and scaling of input/output signals.

Dialog Box



SCI module

Select either 1 or 2 (to choose module SCI1 or SCI2).

Show requested number of bytes input port

Enables an inport (the top one if there are two) where you can input the number of bytes to request.

Maximum number of bytes

Maximum number of bytes to receive (this is only visible if the requested number of bytes input port is enabled). This sets an upper limit on the number of bytes that will be read each time the block is called.

Show reset port

Enables the reset input (the lower inport).

Show actual number of bytes output port

Enables another output that shows the number of bytes actually read from the SCI buffer.

Show framing error and parity error flags

Enables another output. This output is zero if no framing or parity error occurred during the current read; it is true (1) otherwise. Note that for SCI1 only, a reset is required once a data overrun has occurred.

Show overrun flag

Enables another output. This output is true (1) if a data overrun occurred. Note that for SCI1 only, a reset is required once a data overrun has occurred.

Sample time

The time interval between samples. To inherit the sample time, set this parameter to `-1`. See "Specifying Sample Time" in the Simulink documentation for more information.

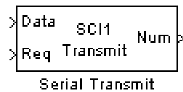
Purpose

Configure MPC555 for serial transmit, using one of the QSMCM submodules SCI1 or SCI2

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Serial Communications Interface (SCI)

Description



The Serial Transmit block transmits bytes via either of the MPC555 QSMCM submodules SCI1 or SCI2. You can use it either to transmit a fixed number of bytes, or, by enabling the second input, transmit a variable number of bytes each time this block is called. With SCI1, a hardware buffer is used that allows up to 16 bytes to be queued for transmission. With SCI2, the buffer allows only up to one byte to be queued each time the block is called. Once bytes are queued for transmit, they will be sent as fast as possible by the serial interface hardware with no further intervention required by the rest of the application.

If the hardware buffer is not empty when the block is called, i.e., the previous transmission is not yet complete, then no new bytes will be queued for transmit. This condition can be identified from the “actual number of bytes” block output; if no bytes were queued for transmit, this output returns zero.

To configure the serial interface bit rate and data format, see “Serial Communications Interface (SCI) Configuration Parameters” on page 4-56.

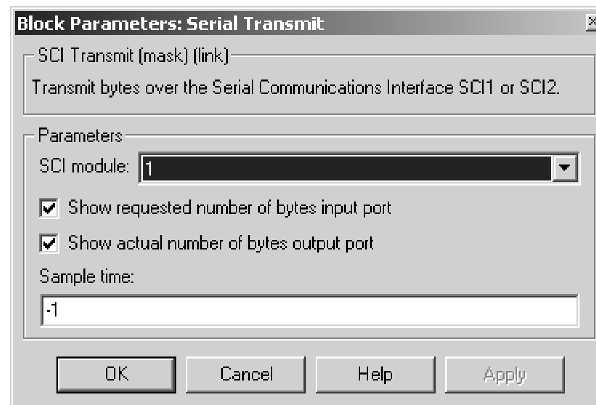
The device driver used for the Serial Transmit block does not require the use of CPU interrupts.

Block Inputs and Outputs

The first input contains the data to be transmitted; this input signal may be either a vector or scalar with data type `uint8`. The optional second input must be a scalar and may be used to control the number of bytes transmitted. The number of bytes to transmit should not be greater than the width of the first input signal.

The block output port “actual number of bytes output” gives the number of bytes queued for transmit. If the previous transmission was complete, this number will be equal to the requested number of bytes to transmit, provided that this was less or equal to 16 in the case of SCI1, or 1 in the case of SCI2. See “Data Type Support and Scaling for Device Driver Blocks” on page 4-12 for information on supported input/output data types and scaling of input/output signals.

Dialog Box



SCI module

Select either 1 or 2 (to choose module SCI1 or SCI2).

Show requested number of bytes input port

Enable/disable the input for number of bytes to send. If cleared, the number of bytes sent is just the width of the first inport; if selected, the second input is enabled, which controls the number of bytes to send.

Show number of bytes output port

Enable/disable the output port for number of bytes actually sent. If selected, this value is available from the first output.

Sample time

The time interval between samples. To inherit the sample time, leave this parameter at the default `-1`. See "Specifying Sample Time" in the Simulink documentation for more information.

TouCAN Error Count

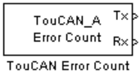
Purpose

Count transmit and/or receive errors detected on selected TouCAN modules

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
CAN 2.0B Controller Module

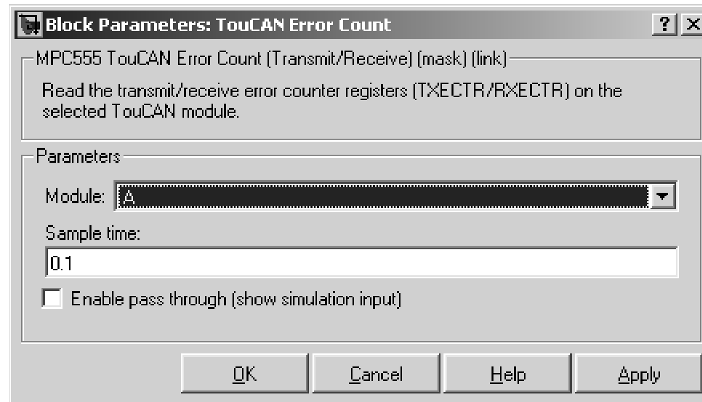
Description



The TouCAN Error Count block maintains and reports a count of errors detected by the selected TouCAN module during receive and transmit. The receive and transmit error counts are output to the `RX` and `TX` outputs of the block, respectively.

The error counts also drive the TouCAN Warnings block outputs. (See “TouCAN Warnings” on page 4-92.)

Dialog Box



Module

Select TouCAN module `A`, `B` or `C`. Note that the MPC555 only has modules A and B. MPC56x (561-6) also have module C. An error will be thrown if you select C and your target processor does not support this.

Sample time

Sample time of the block.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in

a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

TouCAN Fault Confinement State

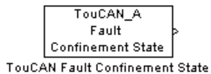
Purpose

Indicate the state of a TouCAN module

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
CAN 2.0B Controller Module

Description



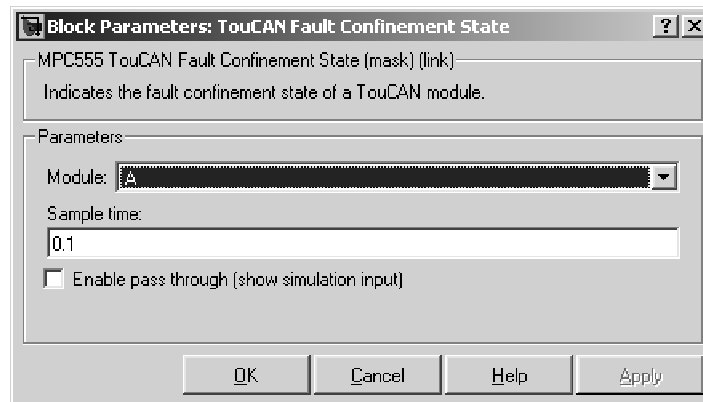
The TouCAN Fault Confinement State block provides an indicator for the state of the selected TouCAN module. The block obtains and outputs a field of two bits from the TouCAN module's Error and Status (ESTAT) register. The possible states are shown in the table below.

Refer to section 16, "CAN 2.0B Controller Module," in the *MPC555 Users Manual* for further information.

FCS State Values

State	Value	Description
Error Active	00	Normal operation
Error Passive	01	Listening only mode. The device cannot transmit.
Bus Off	1x	The device is not allowed to transmit or receive and is effectively cut off from the bus.

Dialog Box



Module

Select TouCAN module `A`, `B` or `C`. Note that the MPC555 only has modules A and B. MPC56x (561-6) also have module C. An error will be thrown if you select C and your target processor does not support this.

Sample time

Sample time of the block.

Enable pass through (show simulation input)

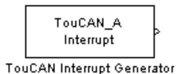
Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

TouCAN Interrupt Generator

Purpose Generate an asynchronous function-call trigger when a CAN interrupt occurs.

Library Embedded Target for Motorola MPC555/ MPC555 Driver Library/ CAN 2.0B Controller Module

Description The TouCAN Interrupt Generator block generates a function-call trigger within the context of a TouCAN interrupt service routine, which can be used to asynchronously execute a function-call subsystem in the model.



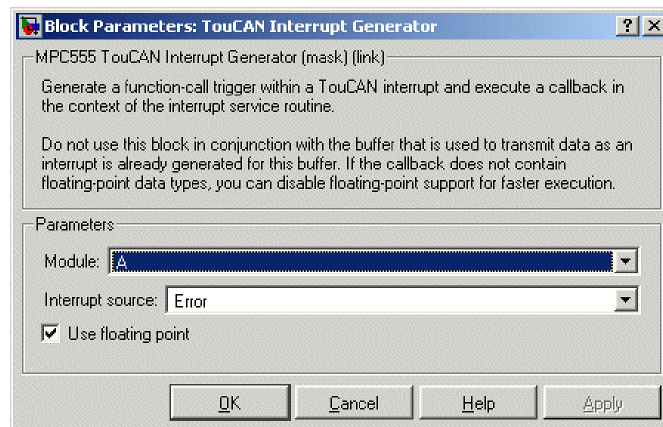
TouCAN Interrupt Generator

This block may be used to execute a function-call subsystem on occurrence of Bus Off, Error, Wake, or buffer 0-15 interrupts.

Do not use this block unless you are aware of the dangers of using asynchronous interrupts in the model. Unpredictable data loss or model behavior may result unless extreme caution is taken.

For faster interrupts, you can disable floating-point support via the **Use floating point** option. However, if you disable floating-point support, do not use blocks that require floating-point operations in your model. Use of such blocks will cause a floating-point exception at run-time.

Dialog Box



Module

Select TouCAN module `A`, `B` or `C`. Note that the MPC555 only has modules A and B. MPC56x (561-6) also have module C. An error will be thrown if you select C and your target processor does not support this.

Interrupt source

Choose the interrupt source (Bus Off, Error, Wake or Buffer 0-15) for your ISR generator.

Use floating point

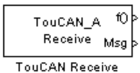
Enable or disable floating-point support.

TouCAN Receive

Purpose Receive CAN messages from the TouCAN module on the MPC555

Library Embedded Target for Motorola MPC555/ MPC555 Driver Library/ CAN 2.0B Controller Module

Description The TouCAN Receive block receives CAN messages from the TouCAN module.



The TouCAN Receive block can reserve any of the 16 buffers on the TouCAN module. Alternatively, you can instruct the TouCAN Receive block to select a hardware buffer automatically from the available buffers.

The TouCAN Receive block has two outputs in default mode: a data output and a function call trigger output. You should use a function call subsystem, activated by the trigger, to decode the message available at the TouCAN Receive block data output. Alternatively you can use the block with an interrupt driven queue, and in this mode the block has only one output, as described below.

The default mode of operation is that the TouCAN Receive block polls its message buffer at a rate determined by the block's sample time. When the TouCAN Receive block detects that a message has arrived, the function call trigger is activated.

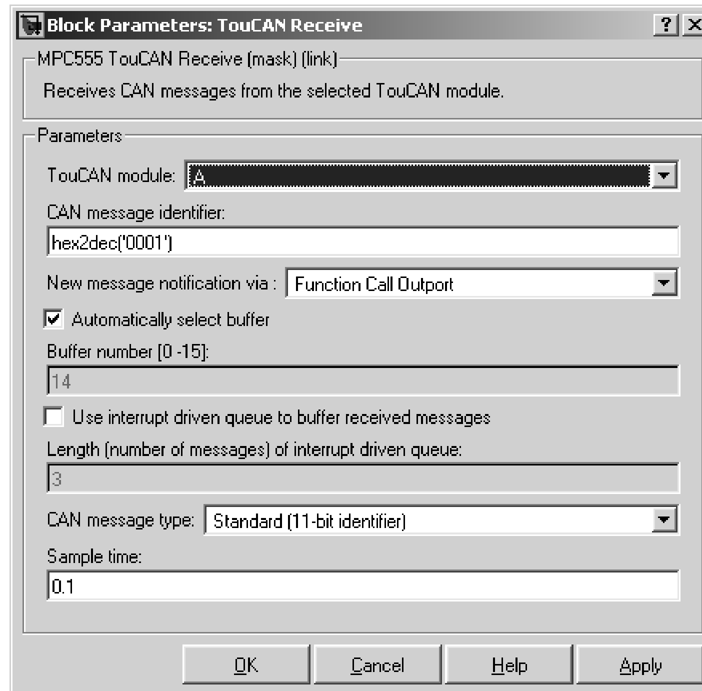
Alternatively, the TouCAN Receive block may be used with an interrupt driven queue. In this case, you can use the TouCAN Interrupt Generator block to trigger an interrupt each time a message is received in the hardware buffer allocated to the block. Place the TouCAN Receive block inside the interrupt subsystem. The function that services this interrupt then moves the contents of the hardware buffer into a FIFO queue. In this mode, instead of polling the hardware buffer directly, the block polls the FIFO. On each block update, it clears the FIFO by processing the messages in turn; a separate function call is generated for each message that is extracted from the FIFO.

If it is known that the sample time is smaller than the minimum time between messages that the block must receive then you should use the standard mode of operation where the hardware buffer is polled directly. However, if the messages may be arriving faster than the block is polling the buffer, you should use the FIFO mode.

Tip: if you need to receive several different messages with different identifiers, arriving at irregular intervals, into a single buffer, you can use one of the

dedicated receive masks for buffers 14 or 15 along with a CAN Message Filter block, and a TouCAN Receive block operating in FIFO mode. See the Masks parameters in “TouCAN Configuration Parameters” on page 4-52.

Dialog Box



TouCAN module

Select one of the two TouCAN modules (A or B) on the MPC555. MPC56x (561-6) also have module C. The TouCAN modules can receive messages independently. Note that an error will be thrown if you select C and your target processor does not support this.

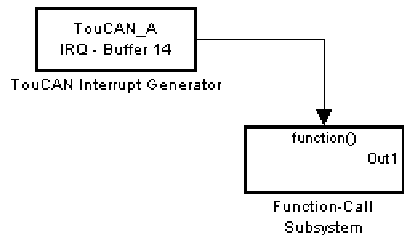
CAN message identifier

The identifier of the message you want to receive. Note that if you have set the TouCAN configuration parameters (see “MPC555 Resource Configuration” on page 4-41) in your model to mask out certain bits (e.g., the message identifier field) you may receive messages with identifiers other than the identifier specified here.

New message notification via:

`Function Call Output` — Synchronous notification that a new message has arrived.

`TouCAN Interrupt Generator' block` — If you select this option you must place the TouCAN Receive block in a function-call subsystem that is asynchronously triggered by a TouCAN Interrupt Generator block (as shown below). When you select this option, the function call output is no longer required, and disappears. Make sure you select the same receive buffer within the TouCAN Interrupt Generator and the TouCAN Receive block. When a message is received in the specified buffer the TouCAN Interrupt Generator block generates a function-call trigger (within the context of a TouCAN interrupt service routine), which can be used to asynchronously execute the function-call subsystem containing the TouCAN Receive block. See “TouCAN Interrupt Generator” on page 4-82 for details.



Automatically select buffer

When this option is selected, the TouCAN Receive block automatically selects a receive buffer from the available buffers. We recommend that you use this automatic buffer selection, unless you want to use buffer 14 or 15, which can be masked, to receive multiple CAN message identifiers in a single buffer. See the Mask parameters in “TouCAN Configuration Parameters” on page 4-52.

Buffer number [0..15]

This field is enabled if the **Automatically select buffer** option is cleared. **Buffer number** specifies the identifier of the receive buffer for this block.

We recommend that you select **Automatically select buffer** instead of manually specifying the buffer, unless you want to use buffer 14 or 15, which can be masked, to receive multiple CAN message IDs in a single buffer. See the Mask parameters in “TouCAN Configuration Parameters” on page 4-52.

Use interrupt driven queue to buffer received messages

Use the FIFO mode if the messages may be arriving faster than the block is polling the buffer. Do not use this option if the sample time may be shorter than the minimum time between messages.

Length (number of messages) of interrupt driven queue

This field is enabled if you select the interrupt driven queue option, then you can specify a number of messages.

CAN message type

The type of message you want to receive. Select either `Standard(11-bit identifier)` or `Extended(29-bit identifier)`.

Sample time

Determines the rate at which to sample the buffer to see if a new message has arrived. Set to `-1` (inherited) if using this block in a function-call subsystem triggered by the TouCAN Interrupt Generator block.

Note The TouCAN Receive block sample time should be set to a value that is smaller than the minimum time between CAN messages that will be received into the corresponding buffer. If the minimum time between messages may be shorter, use the FIFO mode (select interrupt driven queue). Otherwise if more than one message is received into a buffer during a single sample interval, the older message will be overwritten.

TouCAN Soft Reset

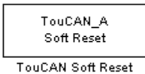
Purpose

Reset a TouCAN module

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
CAN 2.0B Controller Module

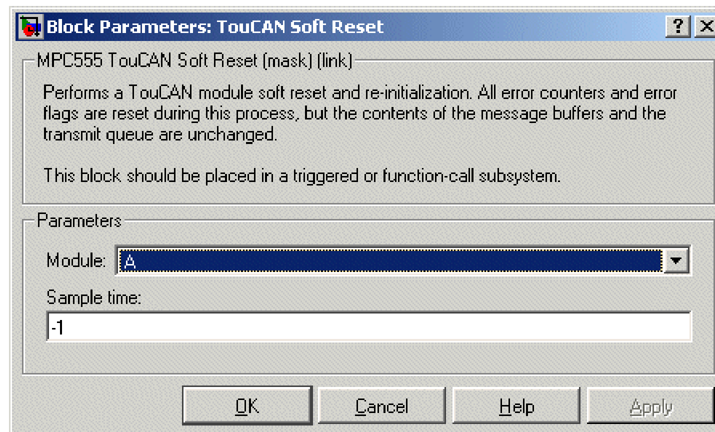
Description



When the TouCAN Soft Reset block executes, the TouCAN module resets its internal state. The TouCAN error counters will be reset. The Fault Confinement State will be reset to the Error Active state, provided the TouCAN module has not reached the Bus Off state. See “TouCAN Fault Confinement State” on page 4-80.

We recommend that you place this block in a triggered subsystem, with a sample time of -1 (inherited).

Dialog Box



Module

Select TouCAN module `A`, `B` or `C`. Note that the MPC555 only has modules A and B. MPC56x (561-6) also have module C. An error will be thrown if you select C and your target processor does not support this.

Sample time

Sample time of the block.

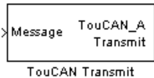
Purpose

Transmit a CAN message via a TouCAN module on the MPC555

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
CAN 2.0B Controller Module

Description



The TouCAN Transmit block transmits a CAN message onto the CAN bus. The TouCAN Transmit block uses the queue set up by the MPC555 Resource Configuration object (see "MPC555 Resource Configuration" on page 4-41). The block should be connected to CAN Message Packing/Unpacking blocks. Do not ground the block or leave it unconnected. See the demos `mpc555rt_io` and `mpc555rt_candb` for an example.

The TouCAN Transmit block provides three different transmission modes. You should choose which transmission mode to use depending on the requirements of your application. The properties of each transmission mode are summarized in the following table.

Transmit Modes

	Priority queued transmission with shared buffer	**Direct transmission with dedicated buffer**	**FIFO queued transmission with dedicated buffer**
Uses Interrupts	Yes	No	Yes
Configurable queue size	Yes	No	Yes
Order of message transmission	Messages transmitted in order of priority; a new message will overwrite any existing message that is in the queue and has the same identifier and type (standard or extended)	Most recent message overwrites any unsent message in the buffer	Messages transmitted in the order that they were placed in the queue

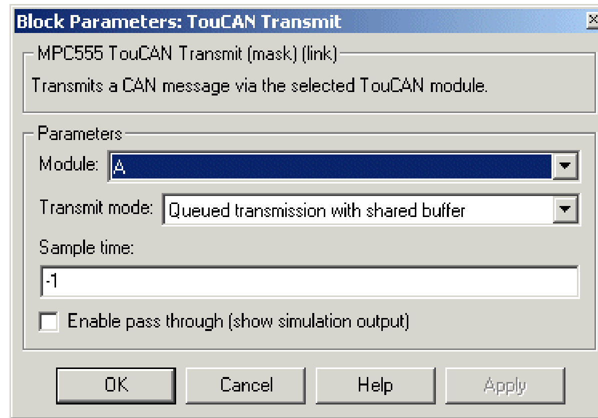
Transmit Modes

	Priority queued transmission with shared buffer	Direct transmission with dedicated buffer	FIFO queued transmission with dedicated buffer
Hardware buffers consumed	Either one or three hardware buffers are shared by many CAN Transmit blocks	One hardware buffer required for each CAN Transmit block	One hardware buffer required for each CAN Transmit block
CPU time required	Generally more than the other modes; interrupts used but time required to service interrupts is longer because it takes account of message priorities and increases with queue length	Very little; no interrupts used	Little; interrupts used but very simple interrupt service routine

For applications where the message contains time-sensitive (e.g. real-time sensor readings) information, it is recommended to use one of the `Priority queued transmission with shared buffer` or `Direct transmission with dedicated buffer` modes. For applications where it is more important that messages are received in the order that they were queued for transmission (e.g. a data logging protocol), it is recommended to use the `FIFO queued transmission with dedicated buffer` mode.

Note that the `Queued transmission with shared buffer` mode can use one or three shared buffers depending upon the setting in the Resource Configuration block. When three buffers are used, the driver ensures that the message entered into arbitration to be transmitted via the CAN bus is always the highest priority message available; furthermore in this mode the TouCAN module is able to transmit messages continuously by re-loading hardware buffers that become empty while another buffer is active transmitting.

Dialog Box



Module

Select TouCAN module `A`, `B` or `C`. Note that the MPC555 only has modules A and B. MPC56x (561-6) also have module C. An error will be thrown if you select C and your target processor does not support this.

Transmit mode

Select one of the transmit modes described in the table.

Length (number of messages) of FIFO queue

If you select the FIFO transmit mode, you can set the number of messages in the FIFO queue here. Note this is only for the FIFO queue and is not the same as the `Transmit_Queue_Length` Resource Configuration parameter in "TouCAN Configuration Parameters" on page 4-52, which only applies to shared queues.

Sample time

Choose -1 to inherit the sample time from the driving blocks. The TouCAN Transmit block does not inherit constant sample times and runs at the base rate of the model if driven by invariant signals.

Enable pass through (show simulation input)

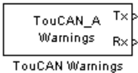
Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

TouCAN Warnings

Purpose Flag excessively high transmit or receive error counts on TouCAN modules

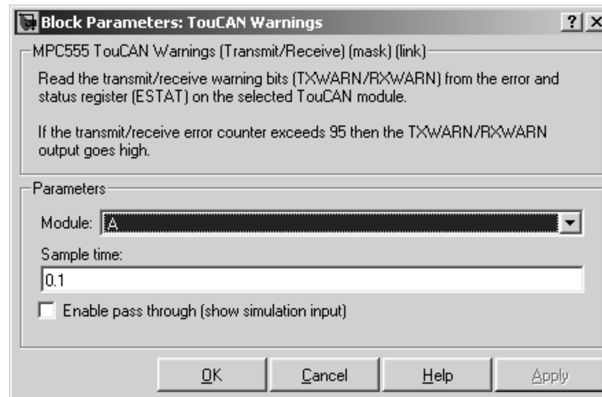
Library Embedded Target for Motorola MPC555/ MPC555 Driver Library/ CAN 2.0B Controller Module

Description The TouCAN Warnings block has two logical outputs, `RX` and `TX`. If the transmit error counter is over 95, then the `TX` output goes high. If the receive error counter is over 95, then the `RX` output goes high.



Use this block, in conjunction with a TouCAN Error Count block, to monitor error conditions on a selected TouCAN module.

Dialog Box



Module

Select TouCAN module `A`, `B` or `C`. Note that the MPC555 only has modules A and B. MPC56x (561-6) also have module C. An error will be thrown if you select C and your target processor does not support this.

Sample time

Sample time of the block.

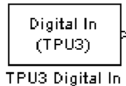
Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

Purpose Configure a Time Processor Unit (TPU3) channel for digital input

Library Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Time Processor Unit (TPU3)

Description



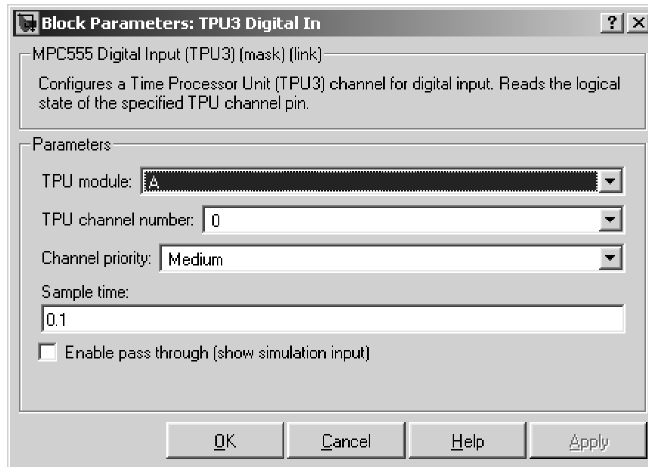
The TPU3 Digital In block reads the logical state of the selected pin (channel) on the TPU3 submodules of the MPC555 or MPC56x. You can use this block in the same way as the MIOS Digital In block. You might need to use this block instead of the MIOS Digital In block, for example, if TPU is available but not MIOS. The Channel priority field specifies a number in the range 0..15, corresponding to 16 independent timer channels on each of the modules of the TPU3. The output of the block represents the logic state of the pin referenced in the module and channels fields. When the signal on a given pin is a logical 1, the block output signal will be equal to 1; otherwise the block output element will equal zero.

The TPU has 16 channels on each module A and B (MPC565 and 566 also have module C). You can use each of these channels independently, so for an MPC555 you could use up to 32 of these blocks, specifying different channels, at once.

Refer to Section 17, “Time Processor Unit 3,” in the *MPC555 Users Manual* for further information, and the TPU3 Digital I/O Application Programming Note (search for “TPUPN18/D”).

For an example showing how to use this block see the `mpc555rt_io` demo.

Dialog Box



TPU module

Select TPU module A, B or C; each has 16 channels. Note that the MPC555 only has modules A and B. MPC565 and MPC566 also have module C. An error will be thrown if you select C and your target processor does not support this.

TPU channel number

Choose 0-15.

Channel priority

Choose `Low`, `Medium` or `High`

The host CPU makes a channel active by assigning it one of the three priorities. You choose the order in which channels are serviced by setting the channel number and assigned priority. The order in which channels are serviced is determined by assigned priority first, followed by channel number (lowest number first).

Sample time

The default is always `0.1` for input driver blocks, but you will need to change this to suit the frequency of your input signals.

Enable pass through (show simulation input)

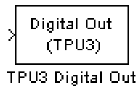
Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

TPU3 Digital Out

Purpose Configure a Time Processor Unit (TPU3) channel for digital output

Library Embedded Target for Motorola MPC555/ MPC555 Driver Library/ Time Processor Unit (TPU3)

Description



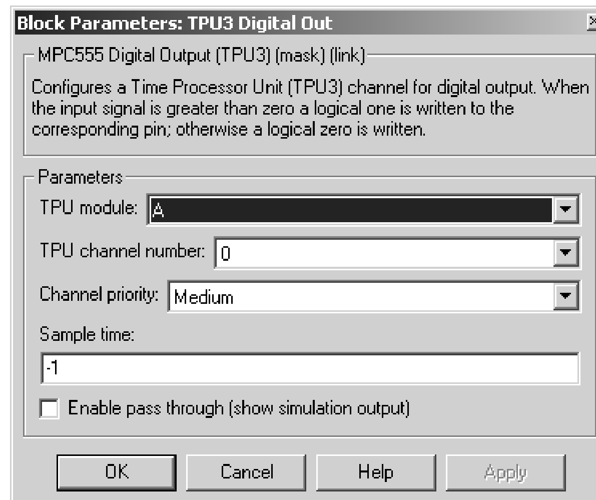
The TPU3 Digital Out block sets the state of the selected pin (channel) on the TPU3 submodule of the MPC555 (or MPC565 or MPC566). The Channel priority field specifies a number in the range 0..15, corresponding to the 16 independent channels on each TPU3 module (A, B or C). You can use each of these channels independently, so you could use up to 32 of these blocks (48 for an MPC565 or MPC566) specifying different channels at once.

When the input signal is greater than zero, a logical 1 is written to the corresponding pin. When the input signal is less than or equal to zero, a logical zero is written to the corresponding channel.

Refer to Section 17, "Time Processor Unit 3", in the *MPC555 Users Manual* and the TPU3 Digital I/O Application Programming Note (search for "TPUPN18/D") for further information about the TPU3.

For an example showing how to use this block see the `mpc555rt_io` demo.

Dialog Box



TPU Module

Select TPU module A, B or C; each has 16 channels. Note that the MPC555 only has modules A and B. MPC565 and MPC566 also have module C. An error will be thrown if you select C and your target processor does not support this.

TPU channel number

Choose 0-15.

Channel priority

Choose `Low`, `Medium` or `High`.

The host CPU makes a channel active by assigning it one of the three priorities. You choose the order in which channels are serviced by setting the channel number and assigned priority. The order in which channels are serviced is determined by assigned priority first, followed by channel number (lowest first).

Sample time

Default `-1`: this setting specifies that the block inherits its sample time from the block connected to its input (inheritance) (unless it is in a triggered subsystem). It makes no sense to sample faster than your input is changing, so normally you leave this at the default.

TPU Digital Out doesn't use a timebase. The output pin is written to at the rate specified by the block sample time. See "Time Processor Unit (TPU3) Configuration Parameters" on page 4-55 for details on settings for the TCR1 clock. See also the TPU3 Digital In Application Programming Note (search for "TPUPN18/D").

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

TPU3 Fast Quadrature Decode

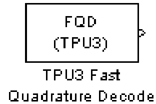
Purpose

Configure a pair of TPU3 channels for Fast Quadrature Decode (FQD)

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Time Processor Unit (TPU3)

Description



The TPU3 Fast Quadrature Decode block decodes position information from quadrature encoder hardware. The relative phase of a pair of input signals is used to determine direction of movement. The signals are decoded to increment or decrement the position counter (block output). You can derive a speed from the position information. It is particularly useful for decoding position and direction information from a slotted encoder in motion control systems.

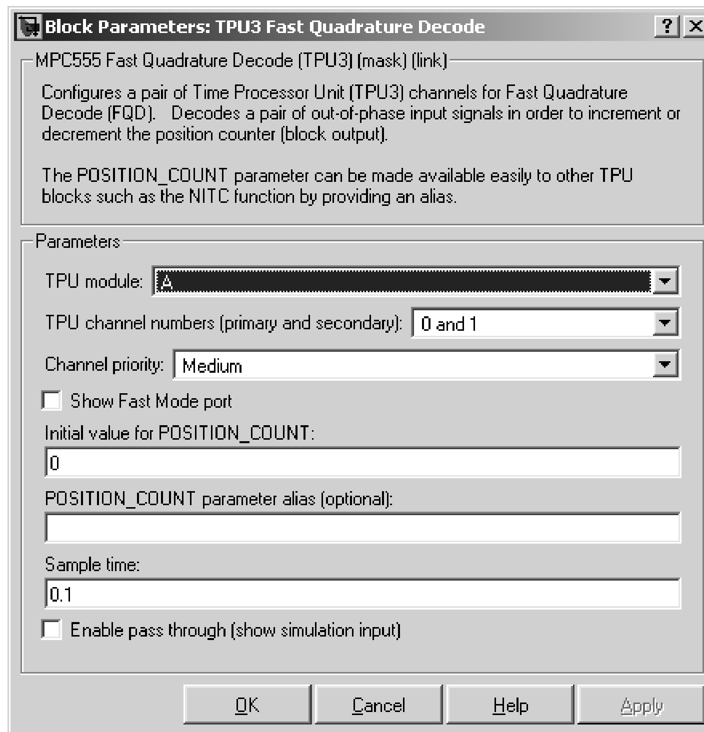
In normal mode (the default), the position counter is incremented or decremented for each valid transition on either channel. The counter increments when the primary channel is ahead and decrements when the primary channel lags. A switch in the phase relationship indicates a change of direction.

At certain speeds you may want to switch to fast mode. You can supply an input to tell the block to switch to fast mode under specified conditions. In fast mode only one of the two input signals is read. The position counter increments or decrements by 4 for each rising transition on the primary channel only (instead of once for each transition in each signal). This reduces the TPU processing load; you can also decode at more than four times the maximum count rate of normal mode.

The counter is 16 bit and free flowing (that is, it overflows to 0, and underflows to 0xFFFF). You must take care when calculating speed derived from the counter, as it may be necessary to use two's complement arithmetic. A useful document is the *TPU Fast Quadrature Decode Programming Note*—search for "*TPUPN02/D.*"

It is possible to overload the TPU processor; if you observe unexpected behavior you should consult the TPU documentation. Refer to Section 17, "Time Processor Unit 3," in the *MPC555 Users Manual* for further information.

Dialog Box



TPU module

Select TPU module A, B or C; each has 16 channels. Note that the MPC555 only has modules A and B. MPC565 and MPC566 also have module C. An error will be thrown if you select C and your target processor does not support this.

TPU channel numbers (primary and secondary)

Select a pair of consecutive channels from (0 and 1) to (14 and 15). The primary channel is always the lower channel number.

Channel priority:

Choose `Low`, `Medium`, or `High`

The order in which channels are serviced is determined by assigned priority first, followed by channel number (lowest number first).

Show Fast Mode port

This option is unselected by default. Left unselected, the block always operates in `Normal` mode. If you select this option, an inport appears where you can input a Boolean signal to control the mode of operation (for example, from a Stateflow subsystem): 0 or false =Normal Mode; 1 or true =Fast Mode.

Fast mode conserves TPU activity by only reading one of the two signals. This also allows you to decode at more than four times the maximum count rate of `Normal` mode. This may be appropriate at some speeds where you can assume the behavior of the second sign—instantaneous direction change is assumed to be impossible. The counter is updated in the same direction as when the last transition was serviced in Normal Mode. The position counter is incremented or decremented by 4 for every rising transition read on the primary channel, instead of having to read all four transitions in the two signals.

Initial value for POSITION_COUNT

Set an initial value. Range checking is applied (must be 16 bit).

POSITION_COUNT parameter alias (optional)

Provide a name that blocks such as the TPU3 New Input Capture/Input Transition Counter can use to refer to the `POSITION_COUNT` Fast Quadrature Decode parameter. Using a name is clearer than using absolute channel and parameter indices to refer to the position count from another TPU block.

Sample time

The default is always `0.1` for input driver blocks, but you will need to change this to suit the frequency of your input signals.

This block uses TCR1 as a timebase, but the functionality of the TPU Fast Quadrature Decode (FQD) function used by the block is not changed by changing the speed of the TCR1 clock. The Position Count output is incremented at a rate entirely controlled by the rising and falling edges of the pair of input waveforms, (and the Fast mode input). See "Time Processor Unit (TPU3) Configuration Parameters" on page 4-55 for more information on the TCR1 timebase settings.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

TPU3 New Input Capture/Input Transition Counter

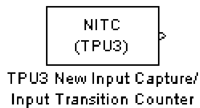
Purpose

Configure a Time Processor Unit (TPU3) channel for New Input Capture/Input Transition Counter (NITC)

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Time Processor Unit (TPU3)

Description



TPU3 New Input Capture/
Input Transition Counter

The TPU3 New Input Capture/Input Transition Counter block counts transitions on the input pin and/or captures a TCR timebase value or a TPU parameter RAM value after a certain number of transitions. You can select the number of transitions and whether to capture on rising or falling transitions or both.

You can select up to three outputs to display. Each will have a separate outport:

- `FINAL_TRANS_TIME` shows the captured value each time the maximum number of transitions (`MAX_COUNT`) is reached
- `TRANS_COUNT` shows the number of transitions counted (resets each time `MAX_COUNT` is reached)
- `LAST_TRANS_TIME` shows the captured value at the most recent transition, updated at every transition (except final transitions). At the final transition `LAST_TRANS_TIME` shows the captured value at the previous transition.

You can choose whether to capture the TCR1 timebase value each time the `MAX_COUNT` number of transitions is reached, or you can specify the address of a TPU parameter in RAM to capture at that moment. Note this block always operates in continuous mode, not single-shot—transitions are counted up to `MAX_COUNT` and then the block resets and continues counting from zero.

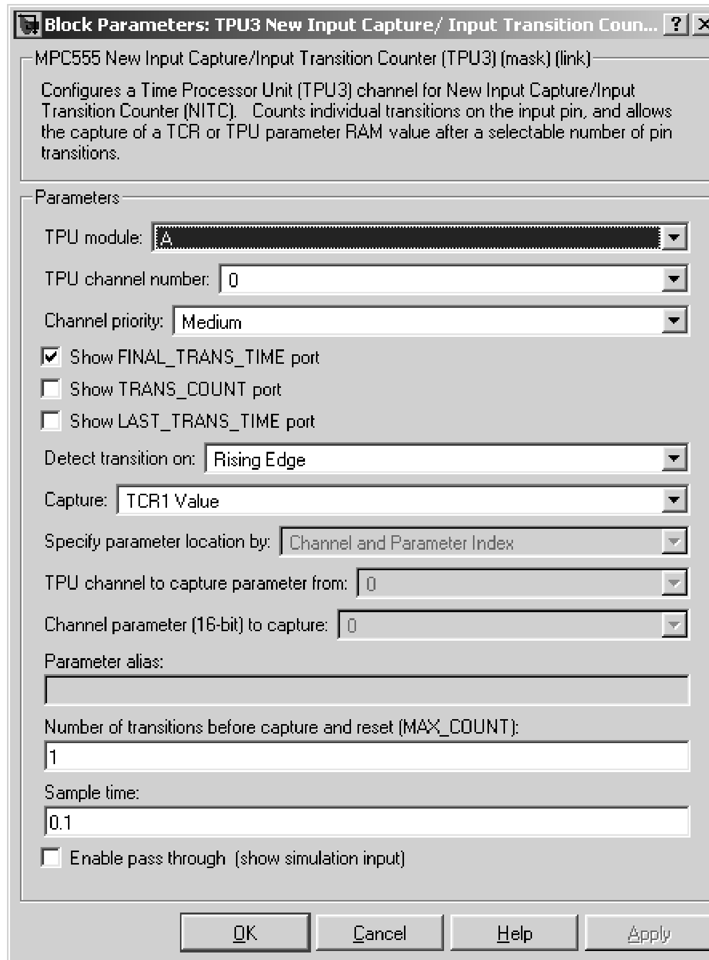
We cannot guarantee that the three outputs are read coherently. They are read one after another, and it is possible that while the memory is accessed for one parameter the next to be read may have changed value. This depends on the speed of your input signal. This should not be important for most purposes because only `TRANS_COUNT` or `FINAL_TRANS_TIME` will be the outputs of interest.

As an example, you could use this block in conjunction with the TPU3 Fast Quadrature Decode block for calibration purposes. Quadrature encoders often generate an index signal in addition to the pair of signals whose relative phase contains the position information. You could put this index signal into an NITC input to count pulses in order to calibrate the position of the encoder.

Refer to Section 17, "Time Processor Unit 3," in the *MPC555 Users Manual* for further information. A particularly useful document is the *TPU New Input Capture/Input Transition Capture Programming Note*—search for "*TPUPN08/D*." Look in the appropriate TPU programming note to look up parameter addresses if you want to capture TPU Parameters instead of TCR1 clock ticks.

As an example of using TPU parameters, if you wanted to use this block to capture the position count from a TPU Fast Quadrature Decode block, you need to set the correct channel number and parameter address. You must set the channel number to the primary FQD channel (FQD blocks use a pair of channels, the first is primary). Each TPU channel can have up to eight parameters (0 through 7), in this case you must choose parameter 1 (`POSITION_COUNT`).

Dialog Box



TPU module

Select TPU module A, B or C; each has 16 channels. Note that the MPC555 only has modules A and B. MPC565 and MPC566 also have module C. An error will be thrown if you select C and your target processor does not support this.

TPU channel number

Choose 0-15.

Channel priority:

Choose `Low`, `Medium`, or `High`

The host CPU makes a channel active by assigning it one of the three priorities. You choose the order in which channels are serviced by setting the channel number and assigned priority. The order in which channels are serviced is determined by assigned priority first, followed by channel number (lowest number first).

Show FINAL_TRANS_TIME port

Outputs the value captured each time the maximum number of transitions (`MAX_COUNT`) is reached. This value is only captured when `MAX_COUNT` is reached.

Show TRANS_COUNT port

Outputs the number of transitions counted. Resets to zero each time `MAX_COUNT` is reached.

Show LAST_TRANS_TIME port

Outputs the captured value at the latest transition. This is updated at every transition except the final one.

Detect transition on:

Choose from `Rising Edge, Falling Edge or Either Edge`.

Capture:

`TCR1 Value` — captures the value of the TCR1 timebase. See "Time Processor Unit (TPU3) Configuration Parameters" on page 4-55 for information on setting the TCR1 timebase.

`Parameter RAM Value` — captures the value of a TPU parameter in RAM. If you select this option you enable the parameters to choose the TPU channel number and parameter address, or to specify a parameter alias.

Specify parameter location by

`Channel and Parameter Index` — if you select this option you enable the two parameters to specify which TPU channel (from 0-15) and which parameter index (out of up to eight parameters per TPU channel) you want.

`Parameter Alias` — If you select this option you enable the **Parameter alias** edit box. For example you can specify a parameter alias for the

POSITION_COUNT parameter in the TPU3 Fast Quadrature Decode block. See “TPU3 Fast Quadrature Decode” on page 4-98.

Note that you cannot set the parameter location unless you have chosen `Parameter RAM Value` for the **Capture** parameter.

TPU channel to capture parameter from

Specify which TPU channel (from 0-15) you want. This option is enabled when you choose to specify parameter location by `Channel and Parameter Index`.

Channel parameter (16-bit) to capture

Specify which parameter index (out of up to eight parameters per TPU channel) you want. This option is enabled when you choose to specify parameter location by `Channel and Parameter Index`.

Parameter alias

This option is enabled when you choose to specify parameter location by `Parameter Alias`. Enter the required alias in the edit box. For example you can specify a parameter alias for the POSITION_COUNT parameter in the TPU3 Fast Quadrature Decode block. See “TPU3 Fast Quadrature Decode” on page 4-98.

Number of transitions before capture and reset (MAX_COUNT)

This must be a 16-bit number specifying how many transitions to count before capturing and then resetting. A zero will be equivalent to 1 (you cannot count zero transitions) and you must not exceed the maximum of a uint16 number. The range of an unsigned 16-bit number is 0-65535 (because 65535 = (2^16) - 1).

Range checking is applied; you will receive a warning if you input an unsuitable number.

Sample time

Be sure to set sample time fast enough not to miss any transitions. This will depend on the frequency of your input signal.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in

a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

TPU3 Programmable Time Accumulator

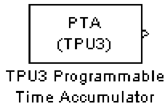
Purpose

Configure a Time Processor Unit (TPU3) channel for Programmable Time Accumulator (PTA).

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Time Processor Unit (TPU3)

Description

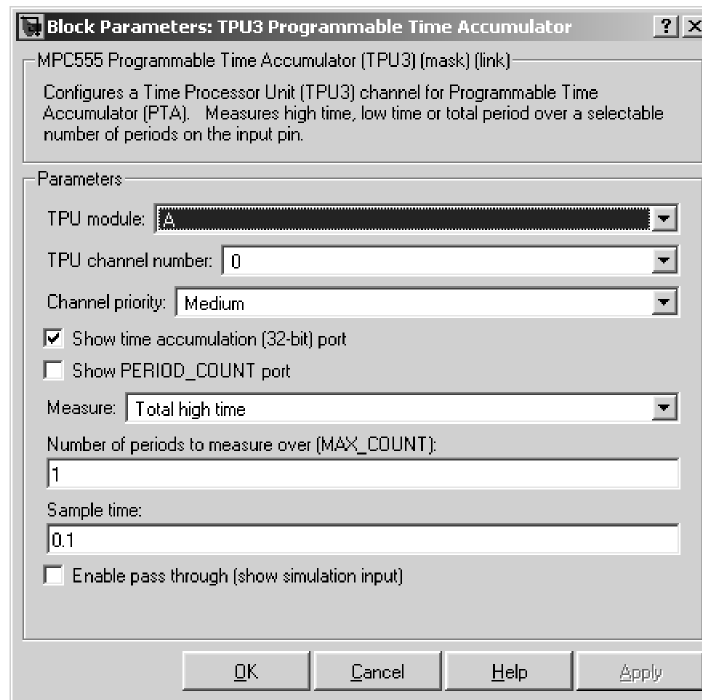


The TPU3 Programmable Time Accumulator block reads an input pin and measures an accumulation of time over a specified number of periods - either high time, low time, or the total time. You can output the accumulated time, or the number of periods or both. You can choose whether to start counting total period on a rising or falling edge.

The accumulated time value will be read at most once between any two model steps. TPU interrupts are used to ensure the 32-bit output is updated only when an accumulation is complete. This ensures that the values of the parameters `HW` and `LW` combined to create the 32-bit output are coherent. This block is under MPC555 Resource Configuration object control, and you will receive a warning if you have not enabled TPU interrupts. If your model contains any PTA blocks, you must change the TPU IRQ settings to enable interrupts. See "Time Processor Unit (TPU3) Configuration Parameters" on page 4-55.

Refer to Section 17, "Time Processor Unit 3," in the *MPC555 Users Manual* for further information. A particularly useful document is the *Programmable Time Accumulator TPU Function (PTA) Programming Note*—search for "TPUPN06/D."

Dialog Box



TPU module

Select TPU module A, B or C; each has 16 channels. Note that the MPC555 only has modules A and B. MPC565 and MPC566 also have module C. An error will be thrown if you select C and your target processor does not support this.

TPU channel number

Choose 0-15

Channel priority:

Choose `Low`, `Medium`, or `High`

The host CPU makes a channel active by assigning it one of the three priorities. You choose the order in which channels are serviced by setting the channel number and assigned priority. The order in which channels are

serviced is determined by assigned priority first, followed by channel number (lowest number first).

Show time accumulation (32-bit) port

Outputs the 32-bit time accumulation value (in TCR1 clock ticks) each time `MAX_COUNT` is reached. Whether the accumulation measures high time, low time or total time depends on the **Measure** setting.

Show PERIOD_COUNT port

Outputs the number of periods counted.

Measure:

Choose from `Total high time`, `Total low time`, `Total period (starting on rising edge)`, `Total period (starting on falling edge)`

Number of periods to measure over (MAX_COUNT):

Set the number of periods to accumulate time over, up to a maximum of 255. The value is read each time `MAX_COUNT` is reached. Note that `MAX_COUNT` is 8-bit here (it is 16-bit in the TPU3 New Input Capture/Input Transition Counter block).

Sample time:

Make sure you set a sample time fast enough not to miss any periods, depending on the frequency of your input signal.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

TPU3 Pulse Width Modulation Out

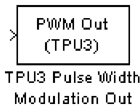
Purpose

Configure a Time Processor Unit (TPU3) channel for pulse width modulation (PWM) output

Library

Embedded Target for Motorola MPC555/ MPC555 Driver Library/
Time Processor Unit (TPU3)

Description



TPU3 Pulse Width Modulation Out

The TPU3 Pulse Width Modulation Out block is used for Pulse Width Modulation (PWM) output from the TPU3 modules. You can use this block in the same way as the MIOS PWM Out block, and with the TPU block you can also vary the period dynamically using a block inport. You can modulate up to 16 of these for each module (A, B or C) using any of the independent TPU channels.

A PWM signal is a rectangular waveform whose period may or may not be constant, and whose duty cycle can be varied, under control of a modulator signal, between 0% and 100%. You can either control the period register directly, or enter the desired (ideal) period and the mask will solve for the best values for the period register. Note for the MIOS Pulse Width Modulation Out block the period is constant, but with the TPU Pulse Width Modulation Out block you can also vary the period of the PWM signal (using the `Show PWMPER` port option you can supply the period as an input).

The TPU3 Pulse Width Modulation Out block acts as the modulator, controlling the duty cycle and period of the signal on the output channel. There can be one or two inputs. Input one (top) is always the duty cycle. Here an input signal in the range 0 to 1 generates a PWM output with corresponding duty cycle. Input signals outside this range cause the duty cycle to saturate at 0% or 100%.

You can specify the period register manually in the mask. If you select the `Show PWMPER` port option, input two appears. Here you can supply the period as an input, instead of specifying the period in the mask. PWMPER input (either block input or specified as a mask variable) must be 16 bit values with saturation applied to be in the range 0 <= PWM Period Register Value <= 32768 (0x8000).

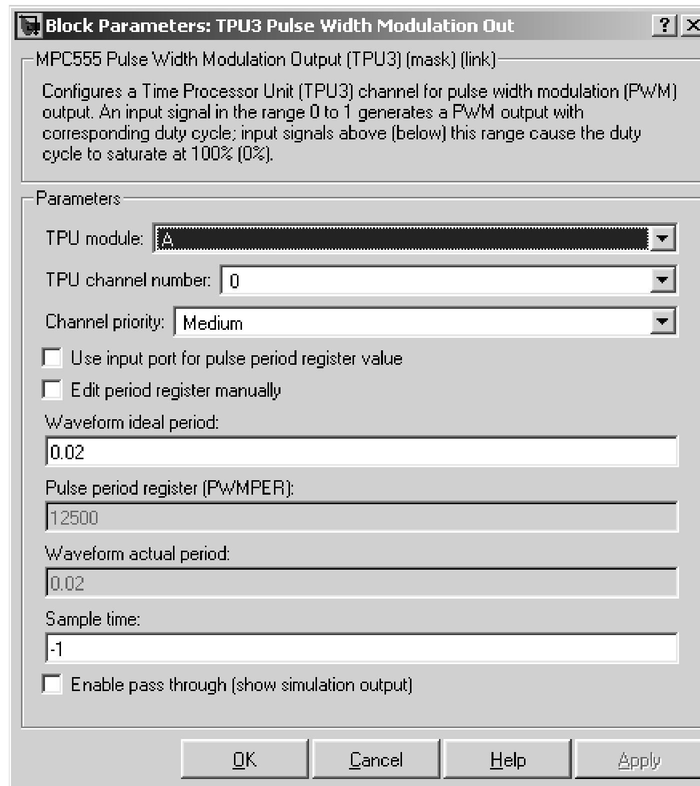
This saturation means that the block will not allow you to enter a value for PWMPER > 0x8000, or a value for ideal period that makes the PWMPER register go outside this range.

The TPU Pulse Width Modulation Out block uses TCR1 as a timebase for creating the output waveform. By changing the speed of the TCR1 clock, the range of available PWM periods changes. See "Time Processor Unit (TPU3) Configuration Parameters" on page 4-55 for more information on settings for the TCR1 clock.

Refer to Section 17, "Time Processor Unit 3," in the *MPC555 Users Manual* for further information. See also the relevant TPU3 Application Programming Note (search for "TPUPN17/D").

For an example showing both ways to use this block (specifying the period, and using the PWMPER port to input the period), see the `mpc555rt_io` demo.

Dialog Box



TPU Module

Select TPU module A, B or C; each has 16 channels. Note that the MPC555 only has modules A and B. MPC565 and MPC566 also have module C. An error will be thrown if you select C and your target processor does not support this.

TPU channel number

Choose 0-15

Channel priority

Choose `Low`, `Medium`, or `High`

The host CPU makes a channel active by assigning it one of the three priorities. You choose the order in which channels are serviced by setting the channel number and assigned priority. The order in which channels are serviced is determined by assigned priority first, followed by channel number (lowest number first).

Use input port for pulse period register value

If you select this box, the parameters relating to setting the period register disappear because they are no longer used.

A new inport appears on the block when you select this option. Here you can input the period register value. Saturation is applied: 0 <= x <= 32768 (0x8000). You can see an example of the block in the demo model `mpc555rt_io`.

Edit period register manually

If you select this check box, you can set the **Pulse period register** parameter.

Waveform ideal period

The default is `0.02`. You can enter the waveform period you want by typing in this edit box. From this the period register is calculated and appears in the **Pulse period register (PWMPER)** edit box. The actual waveform period is also calculated and displayed, see below.

Pulse period register (PWMPER)

The default is `12500`. You can enter a value for the period register here (0<= x <= 32768 (0x8000)) only if you select **Edit period register manually**. The actual waveform period is calculated and displayed in the

actual period field. If **Edit period register manually** is not selected, this edit box is gray.

Waveform actual period

You can never enter anything in this box (so it is always gray) —it is there purely to inform you, and does not affect the model code. You might find this information useful because actual and ideal waveform period are not always the same—the ideal period you enter may not always be possible.

Sample time

The default is `-1`: This setting specifies that the block inherits its sample time from the block connected to its input (inheritance) (unless it is in a triggered subsystem). It makes no sense to sample faster than your input is changing, so normally you leave this at the default.

Enable pass through (show simulation input)

Driver block-based pass through is being deprecated in Release 14 and you will see a warning if you select this option. This feature will be removed in a future release. Please use the replacement mechanism as shown in the demo model, `mpc555_fuelsys_project`.

Purpose In the event of an application failure, time out and reset processor

Library Embedded Target for Motorola MPC555/ MPC555 Driver Library

Description The Watchdog block lets you set the time-out period for the watchdog timer. The watchdog timer is a safety feature that is used to monitor correct behavior of the application. The timer is loaded with an initial value and counts down from this value. If the timer ever reaches zero, a watchdog time-out occurs, forcing a processor reset.

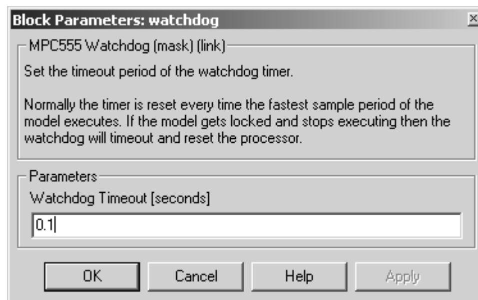
In normal operation, the watchdog timer is serviced at a regular interval (each model step) by the application code; this occurs at a higher frequency than the **Watchdog Timeout** parameter period. Therefore the counter never reaches zero and a processor reset is never triggered.

In the event of a software failure that causes the application to lock up, the watchdog timer will not be serviced. Therefore, it will time out when the counter reaches zero. This in turn causes a processor reset, which restarts the application.

You do not need to include a Watchdog block in your model unless you want to change the **Watchdog Timeout** parameter period to a value other than the default. By default, the watchdog timer is enabled and the time-out period is set to the largest possible value, which is several seconds, depending on system frequency.

Note that the Watchdog block has neither input nor output connections.

Dialog Box



Watchdog Timeout

The **Watchdog Timeout** period must be set to a value that is larger than the fastest sample rate in the system, because this is the rate at which the watchdog timer is serviced. To set the **Watchdog Timeout** period, place a Watchdog block anywhere in the model and open its dialog box.

A

Toolchains and Hardware

This section discusses specific settings for different cross-development environments:

Setting Up Your Installation with Diab Cross-Compiler and SingleStep Debugger (p. A-3)	Configuring the Embedded Target for Motorola MPC555 for use with the Diab development tools.
Setting Up Your Installation with Metrowerks CodeWarrior (p. A-7)	Configuring the Embedded Target for Motorola MPC555 for use with the Metrowerks CodeWarrior development tools
Setting Up Your Target Hardware (p. A-10)	Configuring the required connections and jumper settings for the Phytec phyCORE-MPC555 development board
CAN Hardware and Drivers (p. A-13)	Configuring supported CAN hardware and software.
Configuration for Nondefault Hardware (p. A-14)	Manual configuration for different MPC555 hardware, including altering boot code and tool configurations for different hardware clock speeds, ports, and boards.
Integrating External Blocksets (p. A-17)	How to configure the makefile to integrate custom precompiled block libraries with the MPC555 build process.

Setting Up Your Toolchain

The currently supported toolchains are WindRiver (Diab and SingleStep) and CodeWarrior. You must first install and configure your toolchain to work with the Embedded Target for Motorola MPC555. The necessary steps are described in the following sections:

- "Setting Up Your Installation with Diab Cross-Compiler and SingleStep Debugger" on page A-3
- "Setting Up Your Installation with Metrowerks CodeWarrior" on page A-7

Note Do not install your toolchain in a directory with spaces in the name. This may cause build failures.

Setting Up Your Installation with Diab Cross-Compiler and SingleStep Debugger

To use the Embedded Target for Motorola MPC555 with the Diab cross-compiler, you need the following:

- An MPC555 development board (such as the phyCORE-MPC555 development board, or the Axiom board) and a debugger connector (such as the WindRiver Vision Probe or the BDM Wiggler from Macraigor Systems). Note the phyCORE-MPC555 board comes with built-in debugger connector into which you can directly plug a parallel port connector, in which case you may not require a BDM connector.
- Wind River Systems Diab cross-compiler (version 5.1.2 or later)
- Wind River Systems SingleStep debugger
  - Version 7.7.3 (debug via Vision Probe BDM connector only)
  - Version 7.6.2 (MPC555 only) (debug via Wiggler, Raven / Blackbird, On-board BDM). Note to use these BDM devices you must set up nondefault target preferences, as detailed below.

Install Diab Cross-Compiler

If you have not already done so, install the Diab cross-compiler, following the installation instructions provided by Wind River Systems. When the installer prompts for **Components**, select `Diab C Compiler`. When the installer prompts for a **Target**, select `PowerPC` and all related components.

You do not need to set a default processor or other compiler defaults. During the code generation and build process, the Embedded Target for Motorola MPC555 will generate a makefile that sets the correct options.

You will need to note the path to the installed compiler in order to configure your target preferences (see "Setting Target Preferences for Diab and SingleStep" on page A-4).

Install SingleStep Debugger

The SingleStep debugger, in conjunction with the Embedded Target for Motorola MPC555, lets you download, run and debug generated code.

Follow the instructions of the SingleStep installer. During installation you should select the `SStep Professional Suite (MPC5xx)` option.

For SingleStep 7.6.2, you may want to obtain the following files from Wind River Systems and apply the updates they contain:

- `pcflash11_29_00.zip`

  Apply this update first. See the accompanying file, `pcflash11_29_00.txt`.
- `pcflash3_15_01.zip`

  Apply this update second. See the accompanying file, `pcflash3_15_01.txt`.

This document describes use of SingleStep version 7.6.2 or 7.7.3 and this may differ from your installed version of SingleStep, or with future versions of SingleStep. To resolve questions or difficulties with SingleStep, refer to the SingleStep documentation, or contact Wind River Systems.

You will need to note the path to the installed SingleStep debugger in order to configure your target preferences (see “Setting Target Preferences for Diab and SingleStep” on page A-4).

Setting Target Preferences for Diab and SingleStep

After installing your development tools, the next step is to configure your target preferences for the Diab cross-compiler and SingleStep debugger. (Please read “Setting Target Preferences” on page 1-14, if you have not yet done so.)

1. Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Target Preferences**.

   This opens the Target Preferences GUI where you can edit the settings for your cross-development environment.

2. Select `Diab` from the **Toolchain** menu

3. Expand the `ToolChainOptions` by clicking the plus sign, and type the correct path into **CompilerPath**. For example “`d:\applications\diab\4.3g`”.

4. For SingleStep you must also type the correct path into **DebuggerPath**. This is not necessary for CodeWarrior as the compiler and debugger are integrated. For example “`d:\applications\sds`”.

5. The defaults for **DebuggerSwitches** and **DebuggerExecutable** are set up for use of SingleStep 7.6.3 (using a Vision Probe BDM connection). You may need to change `LPT1` to whatever port you connect to.

6 To use any other BDM device than the Vision Probe (such as the Wiggler, Raven/Blackbird or OnBoard BDM with version 7.7.2 of SingleStep), you must change two target preferences from the defaults:

a Change the **DebuggerSwitches** target preference to the following:

```
-g -V mpc555  r    p LPT1=1
```

If necessary you can change `LPT1` to whatever port you connect the probe to.

b Change the **DebuggerExecutable** from the default to:

```
bdmp58.exe
```

ToolChainOptions	mpc555.DiabOptions
CompilerOptimizationSwitches	mpc555.CompilerOptimizationSwitches
Debug	-g
Size	-XO -Xsize-opt
Speed	-XO
CompilerPath	d:\applications\diab\4.3g
DebuggerExecutable	bdmp58.exe
DebuggerPath	d:\applications\sds
DebuggerSwitches	-g -V mpc555 -r - -p LPT1=1

The **DebuggerSwitches** target preference is specific to SingleStep. If you want to change the default debug settings, type

```
help debug
```

at the SingleStep command line to see the options available. For example you can change parallel port here. The default is `-p LPT1=1` which specifies port 1 on your host PC at speed 1. You could change it to `-p LPT2=2` to specify port 2 at speed 2.

Other debugger executables are supplied with SingleStep — if you want to change the defaults to use a different connection device and different debug settings, consult the SingleStep documentation.

Note that the path to the SingleStep debugger, specified in `DebuggerPath` in the Target Preference GUI, is the root directory of your SingleStep installation, on either an actual hard drive on your PC, or a mapped drive. Do not use a Universal Naming Convention (UNC) path. For most purposes, the other target preferences fields can be left at their defaults. Once you have set these

target preferences, the build process will automatically invoke your compiler and debugger when required for downloading code to flash memory and RAM.

Configure phyCORE-MPC555 Jumpers

Make sure that the jumpers on the phyCORE-MPC555 board are set as described in "Phytec Jumper Settings" on page –10. The correct jumper configuration is required when downloading to flash memory via the BDM port. Any other jumper settings may cause downloading to flash memory to fail, or cause other problems when operating with the Embedded Target for Motorola MPC555. For additional information on jumper settings, consult the phyCORE-MPC555 documentation and the SingleStep manual.

The next step is to verify your installation:

1. You can download and run the test program supplied. See "Run Test Program" on page 1–20.

2. You must then follow the instructions to download boot code ("Download Boot Code to Flash Memory" on page 1–20). Once you have completed these steps, you can begin working with the Embedded Target for Motorola MPC555.

Setting Up Your Installation with Metrowerks CodeWarrior

To use the Embedded Target for Motorola MPC555 with Metrowerks CodeWarrior, you need the following:

- An MPC555 development board (such as the phyCORE-MPC555 development board) and a debugger connector (such as the BDM Wiggler from Macraigor Systems). Note the phyCORE-MPC555 board comes with built-in debugger connector which you can plug a parallel port connector into directly, in which case you may not require a BDM connector.
- Metrowerks CodeWarrior for Embedded PowerPC (Version 8.0) CD (or network access to the Metrowerks CodeWarrior for Embedded PowerPC installer).

Install Metrowerks CodeWarrior IDE

The first step is to install the Metrowerks CodeWarrior IDE:

1. If you have previously installed a version of Metrowerks CodeWarrior for Embedded PowerPC that is earlier than version 8.0, uninstall it.

2. Install CodeWarrior for Embedded PowerPC version 8.0 using the setup program provided on your Metrowerks CodeWarrior CD (or on your network). Run `Setup.exe` and follow the prompts.

3. Open CodeWarrior IDE. You can use the Windows Start menu (**Start –> Programs –> CodeWarrior –> CodeWarrior IDE**).

4. Select **Edit –> Preferences –> Build Settings –> Build Before Running**

5. Select the option **Never** and click **Apply**.

   It is vital you set this to avoid errors when building and automatically downloading code with Embedded Target for Motorola MPC555.

Configure Metrowerks CodeWarrior Debugger

The next step is to configure the CodeWarrior debugger to communicate with the phyCORE-MPC555 board over the parallel port:

1 From the Metrowerks CodeWarrior IDE, select the **Edit** menu, and open the **IDE Preferences** dialog box. In the **IDE Preference Panels** pane, click on the plus sign next to **Debugger**.

2 A list of choices opens below **Debugger**. Select `Remote Connections`. The **Remote Connections** panel is displayed on the right.

3 If you are using a Raven or Blackbird BDM device, select `MSI BDM Raven` from the list in the **Remote Connections** panel.

4 If you are using a Wiggler, Select `MPC555DK Wiggler` from the list in the **Remote Connections** panel.

   If no `MPC555DK Wiggler` configuration exists, create one as follows:

   a Click the **Add...** button. The **New Connection** configuration dialog box opens.

   b Set the **Name** property to `MPC555DK Wiggler`.

   c Set the **Debugger** property to `EPPC MSI Wiggler`.

   d Set the **Connection Type** property to `Parallel`.

   e Set the **Connection Port** property to match the port to which you have connected your phyCORE-MPC555 board (the default is `LPT1`).

   f Set the **Speed** property to `1`.

   g Set the **FPU Buffer Address** property to 0x3f9800.

   h Click **OK** and skip to step 5.

5 If a `MPC555DK Wiggler` exists, click the **Change...** button. The `MPC555DK Wiggler` configuration dialog box opens. By default, the **Parallel Port** property is set to `LPT1`. If you have connected your phyCORE-MPC555 board to a different port, change the **Parallel Port** setting accordingly. Then click **OK** to close the **MSI Wiggler** configuration dialog box.

6 Click **Apply** and close the **IDE Preferences** dialog box.

Set Target Preferences for CodeWarrior

The next step is to configure your target preferences for Metrowerks CodeWarrior. (Please read "Setting Target Preferences" on page 1-14, if you have not yet done so). Follow these steps:

1 Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Target Preferences**.

   This opens the Target Preferences GUI where you can edit the settings for your cross-development environment.

2 Select `CodeWarrior` from the **Toolchain** menu.

3 Expand the `ToolChainOptions` by clicking the plus sign, and type the correct path into **CompilerPath**.

Note that when using CodeWarrior, you do not also have to specify the `DebuggerPath`, as the compiler and debugger are integrated. When required, the build process will automatically invoke the CodeWarrior debugger.

For most purposes, the other target preferences fields can be left at their defaults.

The next step is to verify your installation.

1 You can download and run the test program supplied. See "Run Test Program" on page 1-20.

2 You must then follow the instructions to download boot code ("Download Boot Code to Flash Memory" on page 1–20). Once you have completed these steps, you can begin working with Embedded Target for Motorola MPC555.

Setting Up Your Target Hardware

In this document, we assume that you are working with the Phytec phyCORE-MPC555 development board. This section describes the required connections and jumper settings for the board.

If you are not using the phyCORE-MPC555 development board see "Configuration for Nondefault Hardware" on page A-14.

Phytec Communications Ports

Before you begin working with the Embedded Target for Motorola MPC555, you should set up your phyCORE-MPC555 board and connect it to your host computer. The hardware setup is described in the *phyCORE-MPC555 Quickstart Instructions* manual on your Phytec Spectrum CD. See the "Interfacing the phyCORE-MPC555 to a Host PC" section of the "Getting Started" chapter.

In this document, we assume that you have connected your phyCORE-MPC555 board to the same serial (COM1) and parallel (LPT1) ports described in the *phyCORE-MPC555 Quickstart Instructions*.

Phytec Jumper Settings

The Embedded Target for Motorola MPC555 has been tested by the MathWorks with the Phytec phyCORE-MPC555 board, using the jumper settings indicated in the table below.

For jumper locations and pin numbers, see Jumper Layout section of the *Development Board for phyCORE-MPC555 Hardware Manual*, "`L-525E.pdf`" found at

`http://www.phytec.de/manuals`

Note that when using the On-Board BDM connection, if you then want to run the target standalone (disconnected from the debugger) you must also disconnect (open) jumper 6. This only affects the on-Board BDM, all other configurations always have jumper 6 open. Use the On-Board BDM settings in

the table if you are using the BDM connection for debugging, but remember you must make this change to run standalone:

- For debugging: Jumper 6 must be closed (target stops always in debug mode after reset); connect parallel cable to target.
- For standalone: Jumper 6 must be open (target runs in normal mode after reset); disconnect parallel cable from target.

The following table summarizes the correct jumper settings to use when your host PC is connected to the on-board BDM port, or via Vision Probe, Wiggler, Raven, or Blackbird devices.

Jumper	Description	Vision Probe, Raven or Blackbird	Wiggler	On-Board BDM
JP13	CAN A bus termination	Closed (apply 120 Ohm termination)	as Raven	as Raven
JP14	CAN B bus termination	Closed (apply 120 Ohm termination)	as Raven	as Raven
JP15	Select boot memory	1+2 (boot from internal flash memory)	as Raven	as Raven
JP3	Connect push button to different reset signals	1+2 (/HRESIN connected to push button)	as Raven	as Raven
JP18	Connect interrupt to push button	Default 1+2	as Raven	as Raven
JP17	Connect /HRESET or /SRESET to external BDM interface logic	1+2 (/HRESET connected to BDM interface logic)	as Raven	as Raven
JP1	On-board BDM reset signal connection	Open	as Raven	3+4 closed

Jumper	Description	Vision Probe, Raven or Blackbird	Wiggler	On-Board BDM
JP5,JP6,JP7, JP8,JP9	Jumpers relating to on-board BDM	Open	as Raven	All closed
JP2	Power supply for external BDM	Open (unless BDM device requires supply voltage from development board)	1+2 closed	1+2 closed
JP10	Connect one of the LEDs to supply voltage	Closed	as Raven	as Raven
JP11	Connect 5V supply voltage	Closed	as Raven	as Raven
JP12	Connect 3V3 supply voltage	Closed	as Raven	as Raven
JP4	Programming of Internal MPC555 Flash internal memory enabled	Closed	as Raven	as Raven
JP16	Use J5 as source of Hard-Reset-Configuration	Open	as Raven	as Raven

Note The MPC555 flash memory has a limited lifetime, which is shortened each time the flash memory is programmed. To extend product life, Motorola recommends using flash programming only when necessary.

CAN Hardware and Drivers

If you want to download generated code to the target board via CAN, you will need one of the following supported CAN cards, and the drivers supplied by the manufacturer:

- Vector-Informatik CanAC2PCI
- Vector-Informatik CanAC2
- Vector-Informatik CanCardX
- Vector-Informatik CanPari

The blocks in the CAN Drivers (Vector) blockset, and using the Download Control Panel utility over CAN, require correct installation of a CAN card and drivers from Vector-Informatik. See your Vector-Informatik documentation for instructions on installation and verification. This product has been tested with the following hardware / driver combinations:

- CAN-AC2-PCI - Plug & Play Driver V3.4 for Windows 98 / 2000 / XP
- CANcardX - Plug & Play Driver V3.4 for Windows 98 / 2000 / XP

Older Vector CAN drivers should also work without any major problems, however we recommend you install the most recent drivers so that you have the latest improvements and bug fixes.

Note Please check the Vector Informatik Web site at `http://www.vector-informatik.com` to make sure you have drivers suitable for your PC operating system version. Note that serious system problems can arise if you use drivers for the wrong PC operating system version (e.g., installing drivers for Windows NT on a Windows 2000 system).

In addition, after installing the drivers for your hardware, you must also download the CANdriver Library (Programming Library V3.2) from Vector-Informatik, and make sure that the library, `vcand32.dll` is placed in a location on the Windows system path. We recommend placing `vcand32.dll` in the Windows `system32` directory, which will save you having to change the path environment variable itself. If these configuration steps are not followed then errors in the use of the CAN Drivers (Vector) blockset and downloading over CAN will occur.

Configuration for Nondefault Hardware

The Embedded Target for Motorola MPC555 has been developed and fully tested using Phytec phyCORE-MPC555 development board. We strongly recommend the use of this board for getting started with the Embedded Target for Motorola MPC555. If you are using different MPC555 hardware, it may be necessary to perform some additional manual configuration.

The next section describes how to configure the Embedded Target for Motorola MPC555 real-time target for use on hardware with 4MHz crystal frequency (the default is 20 MHz).

The following sections give additional information about where to make changes for other hardware-specific configurations.

Hardware Clock Configuration

The Embedded Target for Motorola MPC555 uses the Periodic Interrupt Timer (PIT) to support a range of sample times. Note that the PIT is driven by the crystal frequency. This results in the following possible sample time ranges:

For a crystal frequency of 20Mhz:

- Fastest sample time = 1.28e-5 seconds.
- Slowest sample time = 0.8388 s.

For a crystal frequency of 4 Mhz:

- Fastest sample time = 6.4e-5 s.
- Slowest sample time = 4.1942 s.

Note that if you select a sample time slower than the slowest possible for your clock frequency, Simulink issues a warning message.

Also note that the fastest sample time may not be achievable because timer overruns may occur, depending on your model.

Configuring the Embedded Target for Motorola MPC555 for a crystal frequency other than 20 MHz

The MPC555 can operate with a crystal frequency of either 4 MHz or 20 MHz. By default, the Embedded Target for Motorola MPC555 is configured for a crystal frequency of 20 MHz.

You can use the Target Preferences to change to a 4MHz oscillator frequency.

1 Use the **Start** button to open the Target Preferences: **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Target Preferences**.

2 Use the drop-down menu for `OscillatorFrequency` to change from `20` (the default) to `4`.

3 Now install the appropriate bootcode for your hardware. Select **Start –> Simulink –> Embedded Target for Motorola MPC555 –> Install MPC5xx Bootcode**

The correct bootcode is installed for the oscillator frequency and processor variant that you have selected in the Target Preferences.

Note that you must also change the oscillator frequency in your models. Use the Resource Configuration block. The oscillator frequency set here must match the Target Preferences.

The default value for `Oscillator_Frequency` is `20000000`. If you are using 4MHz hardware, you must change the value for `Oscillator_Frequency` to `4000000` in every model.

Other Configuration Changes for Nondefault Hardware

Depending on your target hardware, it may be necessary to make changes to configure settings such as the size and type of external memory.

If you are downloading using the Metrowerks CodeWarrior development environment, the relevant hardware configuration settings are contained in *matlabroot*`\toolbox\rtw\targets\mpc555dk\mpc555dk\:`

```
@codewarrior_tgtaction\mpc5xx_osc20.cfg
@codewarrior_tgtaction\mpc5xx_osc4.cfg
```

If you are downloading using the Diab and SingleStep development environment, the configuration settings are contained in *matlabroot*`\toolbox\rtw\targets\mpc555dk\mpc555dk\:`

```
@diab_tgtaction\mpc5xx_osc20.cfg
@diab_tgtaction\mpc5xx_osc4.cfg
@diab_tgtaction\mpc555.wsp
```

Note that there is now only one SingleStep workspace file for RAM and flash memory.

The necessary changes to these files depend on the hardware that you are using. Depending on your hardware, you may also need to configure switches and jumper settings. Consult the documentation for your development board.

If you are generating standalone real-time applications, you may also need to make changes to settings that are contained in the startup code. These are contained in

```
matlabroot\toolbox\rtw\targets\mpc555dk\drivers\src\applications
\bootcode\bootcode_init.s
```

Note that after making any changes to `bootcode_init.s`, you must recompile the boot code as described in “Boot Code Parameters for CAN Download” on page 2-27.

Integrating External Blocksets

You can configure a `rtwmakecfg.m` file to seamlessly integrate custom third-party Simulink blocks with the Embedded Target for Motorola MPC555. You must provide the `rtwmakecfg.m` file along with the third party S-function block `.dll`s and associated files. `rtwmakecfg.m` files are widely used throughout Real-Time Workshop Embedded Coder and they allow you to:

- Specify include paths to add to the list of includes used in the generated makefiles.
- Specify precompiled libraries to add to the list of libraries used in the generated makefiles.
- Specify TLC include paths to be searched for block TLC files during code generation.

For a general explanation of how to use `rtwmakecfg.m` files, please see the section "Customizing and Creating Template Makefiles" in the documentation for Developing Embedded Targets for Real-Time Workshop Embedded Coder.

The next section contains a detailed explanatory example for the MPC555 build process.

These steps are required:

- Add the location of the `rtwmakecfg.m` file to the MATLAB path.
- Make sure this file is located in the same directory as the S-function `.dll`s.

Example External Blockset Directory Structure and rtwmakecfg.m

To understand how the `rtwmakecfg.m` file works, imagine a set of S-functions, comprising a Simulink library, provided by an external supplier, and how they can be integrated into the MPC555 build process.

Example directory structure for an external (plugin) blockset:

```
C:\externalblocks
C:\externalblocks\tlc_c
C:\externalblocks\include
C:\externalblocks\lib
```

Note: Only the root directory `C:\externalblocks` needs to be on the MATLAB path.

C:\externalblocks will contain files such as:

- Rtwmakecfg.m — rtwmakecfg.m defining MPC555 Plugins
- Blocklibrary.mdl — Simulink block library containing Sfun_a and Sun_b
- Sfun_a.dll — S-function member of Blocklibrary.mdl
- Sfun_b.dll — S-function member of Blocklibrary.mdl

C:\externalblocks\tlc_c will contain files such as:

- Sfun_a.c — S-function source for simulation.
- Sfun_b.c — S-function source for simulation.
- Sfun_a.tlc — S-function TLC for code generation
- Sfun_b.tlc — S-function TLC for code generation

Note: tlc_c directories in the same directory as the S-function .dlls are automatically added to the TLC include path.

C:\externalblocks\include will contain files such as:

- Blocksetheader.h — Header file used in the generated code

C:\externalblocks\lib will contain files such as:

- Blocksetlibrary.a — Library file linked with the generated code

An example rtwmakecfg.m that will add the Blocksetheader.h parent directory to the list of include paths and Blocksetlibrary.a to the list of libraries follows:

```
function makeInfo=rtwmakecfg()
%RTWMAKECFG Add include and source directories to RTW make files.
%  makeInfo=RTWMAKECFG returns a structured array containing
%  following fields:

%     makeInfo.includePath - cell array containing additional
include directories. Those directories will be expanded into
include instructions of rtw generated make files.

%     makeInfo.sourcePath  - cell array containing additional
source directories. Those directories will be expanded into rules
of rtw generated make files.
```

```
% makeInfo.library     - structure containing additional runtime
library names and module objects.  This information will be
expanded into rules of rtw generated make files.

% Get hold of the fullpath to this file, without the filename
itself

rootpath = fileparts(mfilename('fullpath'));

% External blocks need the following include path added

makeInfo.includePath = { fullfile(rootpath, 'include') };

% External blocks reference the following precompiled library

makeInfo.precompile = 1;
makeInfo.library(1).Name = 'Blocksetlibrary';
makeInfo.library(1).Location = fullfile(rootpath, 'lib');

% Note: the 'dummy' module must be specified for the process to
% work correctly - the library will not be rebuilt

makeInfo.library(1).Modules = { 'dummy' };
```

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