Getting started with PSOC™ 4 HVMS and PSOC™ 4 HVPA MCUs in ModusToolbox™

About this document

Scope and purpose

This application note helps you explore the PSOC™ 4 High Voltage Mixed Signal (HVMS), and PSOC™ 4 High Voltage Precision Analog (HVPA) Automotive MCU architecture and development tools, and shows you how to create your first project using the Eclipse IDE for ModusToolbox™ software. This application note also guides you to more resources available online to accelerate your learning about PSOC™ 4 HVMS: CY8C41x6 and CY8C41x7, and PSOC™ 4 HVPA: CY8C41x7 MCUs.

Intended audience

This document is intended for users who are new to PSOC™ 4 HVMS, PSOC™ 4 HVPA MCU, and ModusToolbox™ software.

Associated part family

- CY8C41x6
- CY8C41x7

Software version

ModusToolbox™ software 3.7 or above.

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1 Introduction

The PSOC™ 4 HVMS and PSOC™ 4 HVPA MCU device is a microcontroller targeted at automotive applications. The PSOC™ 4 HVMS CY8C41x5, CY8C41x6 and PSOC™ 4 HVPA CY8C41x7 MCU integrates the following features on a single chip:

- CPU subsystem
  - 48 MHz, 32-bit Arm® Cortex®-M0+ CPU with the following:
    - Single-cycle multiply
    - Memory protection unit (MPU)
  - Datawire/peripheral direct memory access (DMA) controller with 8 channels
  - Integrated memories
    - Up to 64 KB of flash
    - Up to 8 KB of SRAM
- Programmable analog
  - 12-bit, 1-Msps SAR ADC with differential and single-ended modes, and channel sequencer with signal averaging
  - 16-channel SAR multiplexer with built-in diagnostics (8 I/O channels and 8 diagnostic channels)
  - Temperature sensor built into SAR ADC
  - Two low-power comparators that operate in Deep Sleep low-power mode
- Programmable digital
  - Programmable smart I/O logic blocks allowing Boolean operations to be performed on port inputs and outputs
- High-voltage subsystem
  - Regulator output voltage supports 3.3 V or 5 V selectable with ±2% trimmed accuracy
  - Regulator current: up to 60 mA
  - Thermal shutdown
  - Operates directly off 12-V/24-V battery (tolerates up to 42 V)
- CAPSENSE™ (multi-sense converter) block
  - Multi-sense converter (MSC) provides a best-in-class signal-to-noise ratio (SNR) (>5:1) and water tolerance for capacitive sensing
- Timing and pulse-width modulation
  - Five 16-bit timer/counter/pulse-width modulator (TCPWM) blocks
- Communication
  - Two independent run-time reconfigurable serial communication blocks (SCB) with reconfigurable I^2C, SPI, UART, or LIN slave functionality
  - Up to two CXPI channels with data rate up to 20 kbps

The ModusToolbox™ software environment supports PSOC™ 4 HVMS and PSOC™ 4 HVPA MCU application development with a set of tools for configuring the device, setting up the peripherals, and complementing your projects with world-class middleware. See the Infineon GitHub repo for the KIT_PSOC4-HVMS-64K_LITE BSP, KIT_PSOC4-HVMS-128K_LITE BSP, KIT_PSOC4-HVPA-144K_LITE BSP, libraries for popular functionality like device firmware upgrade (DFU) and emWin, and a comprehensive array of example applications to get you started.

Figure 1 illustrates an application-level block diagram for a Steering wheel hands-on-detection (HOD) use case using a PSOC™ 4 HVMS MCU.

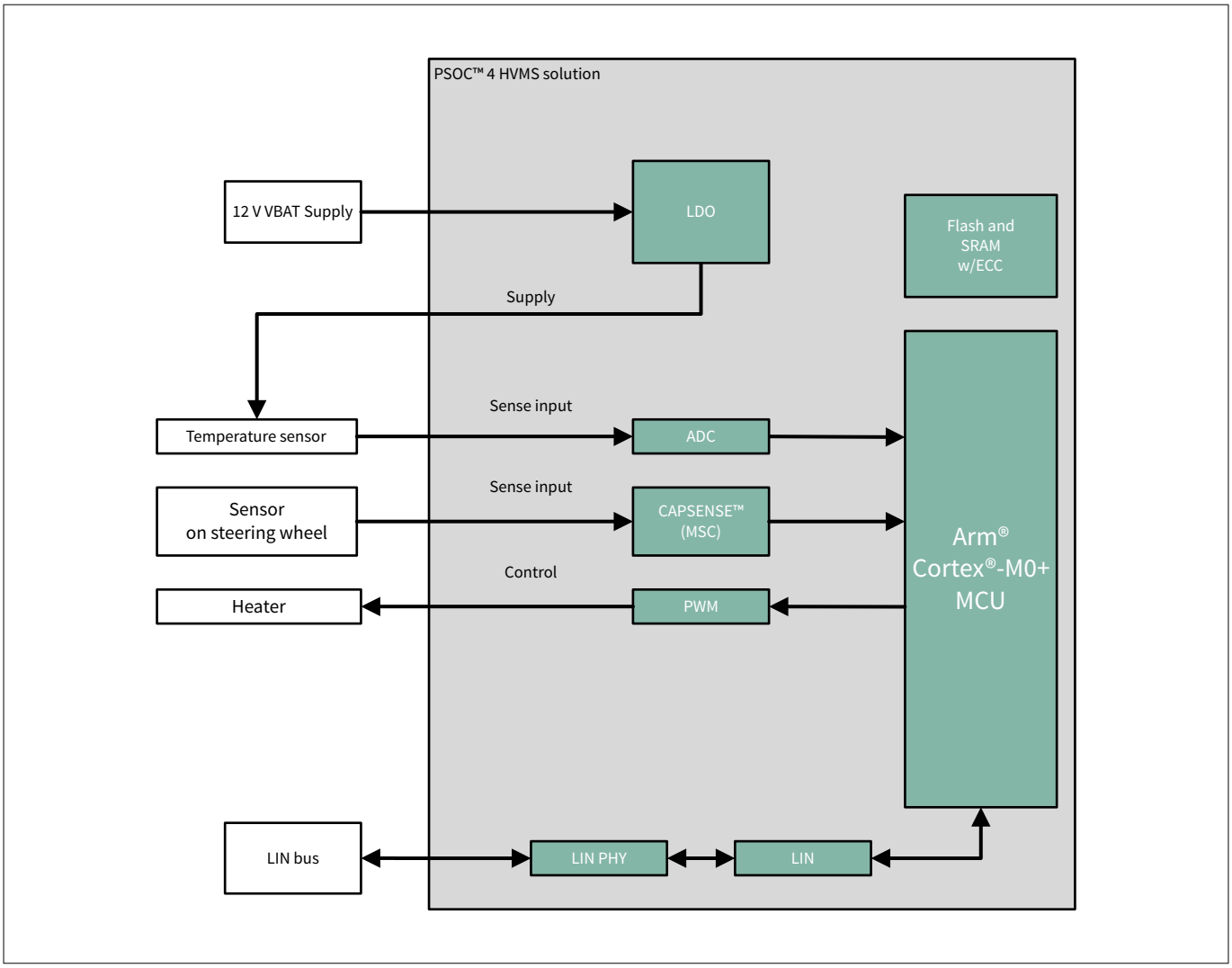


Figure 1 Application-level block diagram using PSOC™ 4 HVMS MCU

The PSOC™ 4 HVMS MCU is a highly capable and flexible solution. For example, the steering wheel hands-on-detection use case in Figure 1 has the advantage of the following features:

- MCU:
  - Arm® Cortex®-M0+ MCU with DMA and MPU
  - Up to 64 KB flash with error correcting code (ECC)
- CAPSENSE™:
  - Handles high parasitic capacitance (Cp) to support long sensors
  - Temperature compensation along with heated steering wheels
  - Supports thick overlay/steering wheel covers
  - Heating coil can be used as an HOD sensor
- ADC:
  - Monitors supply voltage
  - Measures temperature of the sensor

- PWM:
  - Controls haptic actuator
  - Controls LED lighting
- HV (LDO and LIN PHY):
  - Connects directly to a 12-V battery supply with the integrated HV regulator
  - Communicates directly to the LIN bus with an integrated LIN PHY

Table 1 provides an overview of the product line.

Table 1 PSOC™ 4 HVMS family MCU product line

Device series	Details
PSOC™ 4 HVMS CY8C4125	24 MHz Cortex®-M0+ 32 KB flash, 4 KB RAM Packages: 32/48/56 QFN
PSOC™ 4 HVMS CY8C4126	24 MHz Cortex®-M0+ 64 KB flash, 8 KB RAM Packages: 32/48/56 QFN
PSOC™ 4 HVMS CY8C4145	48 MHz Cortex®-M0+ 32 KB flash, 4 KB RAM Packages: 32/48/56 QFN
PSOC™ 4 HVMS CY8C4146	48 MHz Cortex®-M0+ 64 KB flash, 8 KB RAM Packages: 32/48/56 QFN

***Note**: All features are not available in all the devices in a product line. For more details, see the Device datasheets.*

This application note introduces you to the capabilities of the PSOC™ 4 HVMS MCU, gives an overview of the development ecosystem, and gets you started with a simple “Hello World” application wherein you learn to use the PSOC™ 4 HVMS MCU. Additionally, provides how to create the application from an empty starter application, but the completed design is available as a code example for ModusToolbox™ on GitHub.

For hardware design considerations, see [3].

2 Development ecosystem

2.1 PSOC™ 4 HVMS MCU resources

The 32-bit PSOC™ 4 HV Arm® Cortex® microcontroller webpage contains wealth of data that will assist you in selecting the right PSOC™ 4 HVMS device and quickly and effectively integrate it into your design. For a comprehensive list of PSOC™ 4 HVMS MCU resources, see How to design with PSOC™ 4 HVMS MCU. The following is an abbreviated list of resources for the PSOC™ 4 HVMS MCUs.

- **Overview:** PSOC™ 4 HV MCU webpage
- **Product selectors:** PSOC™ 4 HVMS CY8C41x5/CY8C41x6 series MCU
- Datasheets describe and provide electrical specifications for each device family
- Application notes and code examples cover a broad range of topics, from basic to advanced
- Reference manuals provide detailed descriptions of the architecture and registers in each device family
- **PSOC™ 4 HVMS MCU programming specification:** Provides the information necessary to program the nonvolatile memory of PSOC™ 4 HVMS MCU devices
- **Development tools:** KIT_PSOC4-HVMS-64K_LITE
- **Technical support:** PSOC™ 4 Developer Community forum, knowledge base articles

2.2 Firmware/application development

For application development with the PSOC™ 4 HVMS MCUs, use the ModusToolbox™ development platform. ModusToolbox™ includes configuration tools, low-level drivers, middleware libraries, operating system support, and other packages for creating MCU.

2.2.1 Choosing an IDE

ModusToolbox™, the latest-generation toolset, includes the Eclipse IDE and therefore, supports across Windows, Linux, and macOS platforms. The Eclipse IDE for ModusToolbox™ is integrated with quick launchers for tools and design configurators in the Quick Panel. Third-party IDEs supported by ModusToolbox™ include Visual Studio Code, Arm® MDK (µVision), and IAR Embedded Workbench. The associated hardware and middleware configurators also work on all three host operating systems.

Use ModusToolbox™ to take advantage of the power and extensibility of an Eclipse-based IDE.

2.2.2 ModusToolbox™ software

ModusToolbox™ is a collection of tools and software that provides an immersive development experience for creating converged MCUs and allows you to integrate our devices into your existing development methodology. To achieve this goal, ModusToolbox™ leverages popular third-party ecosystems, such as FreeRTOS and Arm® Mbed OS, and adds specific features for security.

Eclipse IDE for ModusToolbox™ is a multi-platform development environment that supports application configuration and development.

Figure 2 shows a high-level view of the tools/resources included in the ModusToolbox™ software. For a more in-depth overview of the ModusToolbox™ software, see the ModusToolbox™ user guide.

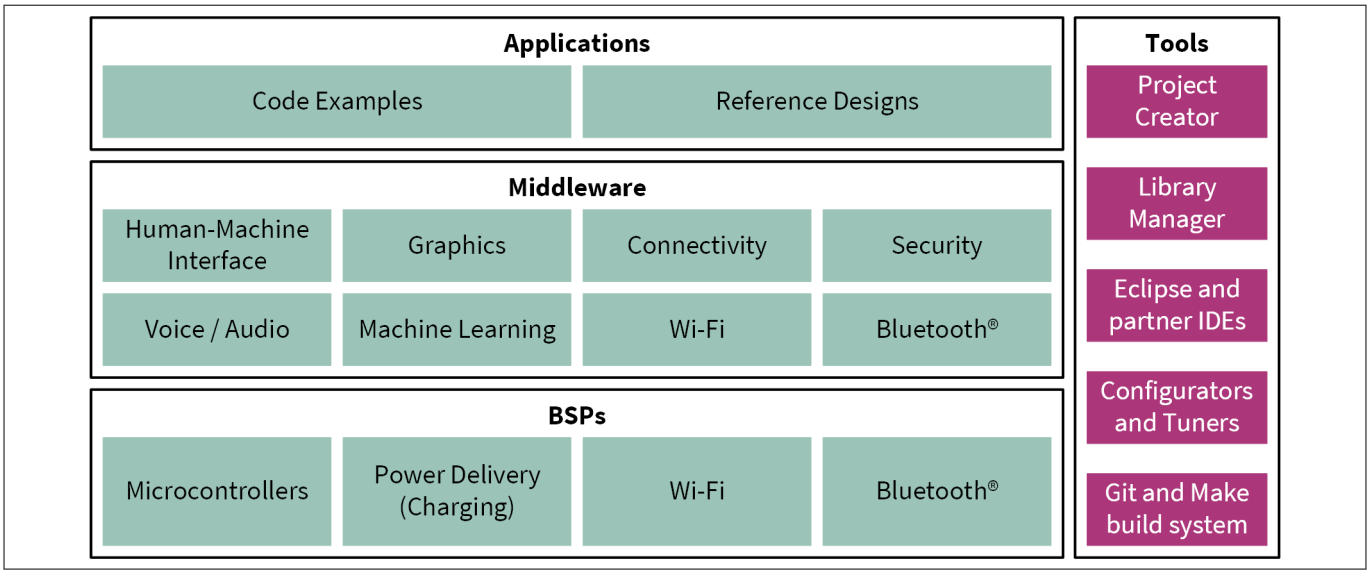


Figure 2 ModusToolbox™ software

The ModusToolbox™ installer includes the design configurators and tools, and the build system infrastructure.

The build system infrastructure includes the new project creation wizard that can be run independent of the Eclipse IDE, the make infrastructure, and other tools.

All the ModusToolbox™ development flows depend on the provided low-level resources. These include:

- Board support packages (BSP) – A BSP is the layer of firmware containing board-specific drivers and other functions. The board support package is a set of libraries that provide APIs to initialize the board and provide access to board level peripherals. It includes low-level resources such as Peripheral Driver Library (PDL) for board peripherals. It uses the HAL to configure the board. Custom BSPs can be created to enable support for end-application boards. See the “Board Support Packages” section in the ModusToolbox™ user guide for more information
- Hardware Abstraction Layer (HAL) – HAL provides a high-level interface to configure and use hardware blocks on MCUs. It is a generic interface that can be used across multiple product families. The focus on ease-of-use and portability means that the HAL does not expose all the low-level peripheral functionality. The HAL wraps the lower-level drivers (such as PSOC™ 4 HVMS PDL) and provides a high-level interface to the MCU. The interface is abstracted to work on any MCU. This helps you write application firmware independent of the target MCU

  The HAL can be combined with platform-specific libraries (such as PSOC™ 4 HVMS PDL) within a single application. You can leverage the HAL's simpler and more generic interface for most of an application, even if one portion requires finer-grained control
- Peripheral Driver Library (PDL) – The PDL integrates the device header files, startup code, and peripheral drivers into a single package. The PDL supports the PSOC™ 4 HVMS MCU device family. The drivers abstract the hardware functions into a set of easy-to-use APIs. These are fully documented in the PDL API Reference manual

  The PDL reduces the need to understand register usage and bit structures, therefore, easing software development for the extensive set of peripherals in the PSOC™ 4 HVMS MCU series. You configure the driver for your application, and then use API calls to initialize and use the peripheral
- Extensive middleware libraries that provides specific capabilities to an application. All the middleware is delivered as libraries and via GitHub repositories

2.2.3 PSOC™ 4 HVMS MCU software resources

The PSOC™ 4 HVMS MCU software includes driver and middleware configurators to get you started developing firmware with PSOC™ 4 HVMS MCU. It contains configurators, drivers, libraries, middleware, various utilities, Makefiles, and scripts. It also includes relevant drivers, middleware, and examples for use with industrial applications. You may use any or all tools in any environment you prefer.

2.2.3.1 Configurators

ModusToolbox™ software provides graphical applications called configurators that make it easier to configure a hardware block. For example, instead of having to search through all the documentation to configure a Serial Communication Block (SCB) as a UART with a desired configuration, open the appropriate configurator and set the baud rate, parity, and stop bits. After saving the hardware configuration, the tool generates the C code to initialize the hardware with the desired configuration.

Configurators are independent of each other, but they can be used together to provide flexible configuration options. They can be used standalone, in conjunction with other tools, or within a complete IDE. Configurators are used for:

- Setting options and generating code to configure drivers
- Setting up connections such as pins and clocks for a peripheral
- Setting options and generating code to configure middleware

The following configurators are available for PSOC™ 4 HVMS MCU applications:

- **Device Configurator:** Sets up the system (platform) functions and the basic peripherals (for example, UART, Timer, and PWM)
- **CAPSENSE™ Configurator:** Configures CAPSENSE™ widgets and generates code to control the application firmware
- **CAPSENSE™ Tuner:** Tune CAPSENSE™ applications
- **Smart I/O Configurator:** Configures the smart I/O

Each of these configurators creates their own files (e.g., `design.cyqspi` for QSPI). The configurator files (`design.modus` or `design.cyqspi`) are usually provided with the BSP. The files are copied into the application when an application is created based on a BSP. Additionally, you can create custom device configurator files for an application and override the BSP-provided devices.

2.2.3.2 Library management for PSOC™ 4 HVMS MCU

With the release of ModusToolbox™ v3.2, applications can optionally share board support packages (BSPs) and libraries. If needed, different applications can use different versions of the same BSP or library. The file types associated with libraries using this flow have a `.mtb` extension.

Section My first PSOC™ 4 HVMS MCU design using Eclipse IDE for ModusToolbox™ software of this document describes creating a new application using this flow.

For more information on ModusToolbox™ flow, see the Library Manager user guide located at `<install_dir>/ModusToolbox/tools_<version>/library-manager/docs/library-manager.pdf`.

2.2.3.3 Software development for PSOC™ 4 HVMS MCU

Significant source code and tools are provided to enable software development for PSOC™ 4 HVMS MCUs. You use tools to specify how you want to configure the hardware, generate code for that purpose which you use in your firmware, and include various middleware libraries for additional functionality, like FreeRTOS. This source code makes it easier to develop the firmware for supported devices. It helps you quickly customize and build firmware without the need to understand the register set.

In the ModusToolbox™ environment, you use configurators to configure either the device or a middleware library, such as QSPI functionality.

The PSOC™ 4 HVMS MCU Peripheral Driver Library code is delivered as the mtb-pdl-cat2 library. Middleware is delivered as separate libraries for each feature/function.

Whether you use the Eclipse IDE, a third-party IDE, or the command-line, firmware developers who wish to work at the register level should see the driver source code from the PDL. The PDL includes all the device-specific header files and startup code you need for your project. It also serves as a reference for each driver. Because the PDL is provided as source code, you can see how it accesses the hardware at the register level.

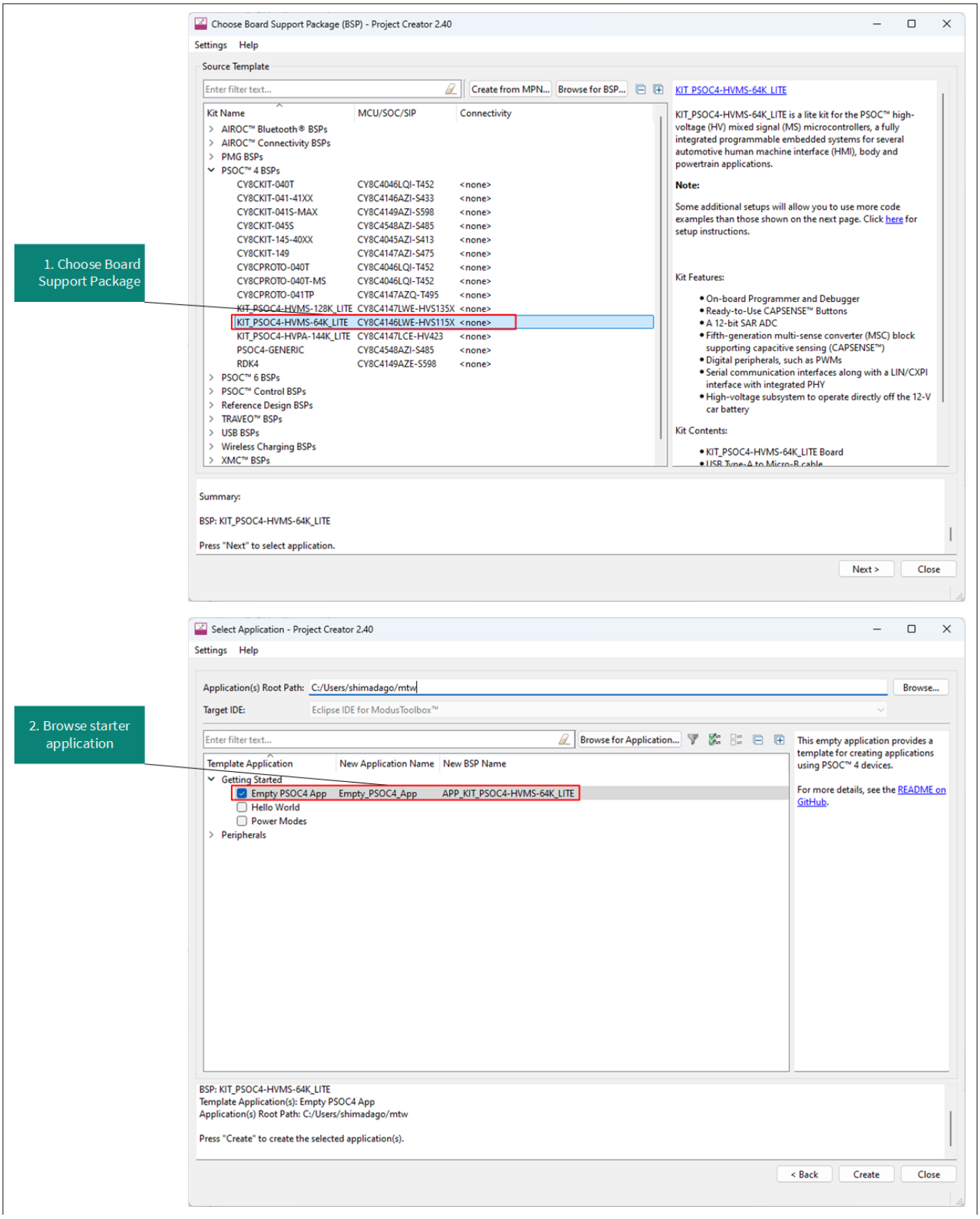
Some devices do not support particular peripherals. The PDL is a superset of all the drivers for any supported device. This superset design means:

- All API elements needed to initialize, configure, and use a peripheral are available
- The PDL is useful across various PSOC™ 4 HVMS MCU devices, regardless of available peripherals
- The PDL includes error checking to ensure that the targeted peripheral is present on the selected device

This enables the code to maintain compatibility across products of the PSOC™ 4 HVMS MCU family as long as the peripherals are available. A device header file specifies the peripherals that are available for a device. If you write the code that attempts to use an unsupported peripheral, you will get an error at compile time. Check the datasheet for the specific device to ensure that the peripheral is supported before writing the code to use that peripheral.

As shown in Figure 3, with the Eclipse IDE for ModusToolbox™ software, you can:

1. Choose a board support package (BSP)
2. Create a new application based on a list of starter applications, filtered by kit
3. Develop your application firmware using the PDL for PSOC™ 4 HVMS MCU


1. Choose Board Support Package
Choose Board Support Package (BSP) - Project Creator 2.40
Settings Help
Source Template
Enter filter text...
Create from MPN...
Browse for BSP...
Kit Name
MCU/SOC/SIP
Connectivity
AIROC™ Bluetooth® BSPs
AIROC™ Connectivity BSPs
PMG BSPs
PSOC™ 4 BSPs
CY8CKIT-040T CY8C4046LQI-T452 <none>
CY8CKIT-041-41XX CY8C4146AZI-S433 <none>
CY8CKIT-041S-MAX CY8C4149AZI-S598 <none>
CY8CKIT-045S CY8C4548AZI-S485 <none>
CY8CKIT-145-40XX CY8C4045AZI-S413 <none>
CY8CKIT-149 CY8C4147AZI-S475 <none>
CY8CPROTO-040T CY8C4046LQI-T452 <none>
CY8CPROTO-040T-MS CY8C4046LQI-T452 <none>
CY8CPROTO-041TP CY8C4147AZQ-T495 <none>
KIT_PSOC4-HVMS-128K_LITE CY8C4147LWE-HVS135X <none>
KIT_PSOC4-HVMS-64K_LITE CY8C4146LWE-HVS115X <none>
KIT_PSOC4-HVPA-144K_LITE CY8C4147LCE-HV423 <none>
PSOC4-GENERIC CY8C4548AZI-S485 <none>
RDK4 CY8C4149AZE-S598 <none>
PSOC™ 6 BSPs
PSOC™ Control BSPs
Reference Design BSPs
TRAVEO™ BSPs
USB BSPs
Wireless Charging BSPs
XMC™ BSPs
KIT_PSOC4-HVMS-64K_LITE
KIT_PSOC4-HVMS-64K_LITE is a lite kit for the PSOC™ high-voltage (HV) mixed signal (MS) microcontrollers, a fully integrated programmable embedded systems for several automotive human machine interface (HMI), body and powertrain applications.
Note:
Some additional setups will allow you to use more code examples than those shown on the next page. Click here for setup instructions.
Kit Features:
On-board Programmer and Debugger
Ready-to-Use CAPSENSE™ Buttons
A 12-bit SAR ADC
Fifth-generation multi-sense converter (MSC) block supporting capacitive sensing (CAPSENSE™)
Digital peripherals, such as PWMs
Serial communication interfaces along with a LIN/CXPI interface with integrated PHY
High-voltage subsystem to operate directly off the 12-V car battery
Kit Contents:
KIT_PSOC4-HVMS-64K_LITE Board
Summary:
BSP: KIT_PSOC4-HVMS-64K_LITE
Press "Next" to select application.
Next >
Close
2. Browse starter application
Select Application - Project Creator 2.40
Settings Help
Application(s) Root Path: C:/Users/shimadago/mtw
Browse...
Target IDE: Eclipse IDE for ModusToolbox™
Enter filter text...
Browse for Application...
Template Application
New Application Name
New BSP Name
Getting Started
Empty PSOC4 App Empty_PSOC4_App APP_KIT_PSOC4-HVMS-64K_LITE
Hello World
Power Modes
Peripherals
This empty application provides a template for creating applications using PSOC™ 4 devices.
For more details, see the README on GitHub.
BSP: KIT_PSOC4-HVMS-64K_LITE
Template Application(s): Empty PSOC4 App
Application(s) Root Path: C:/Users/shimadago/mtw
Press "Create" to create the selected application(s).
< Back
Create
Close

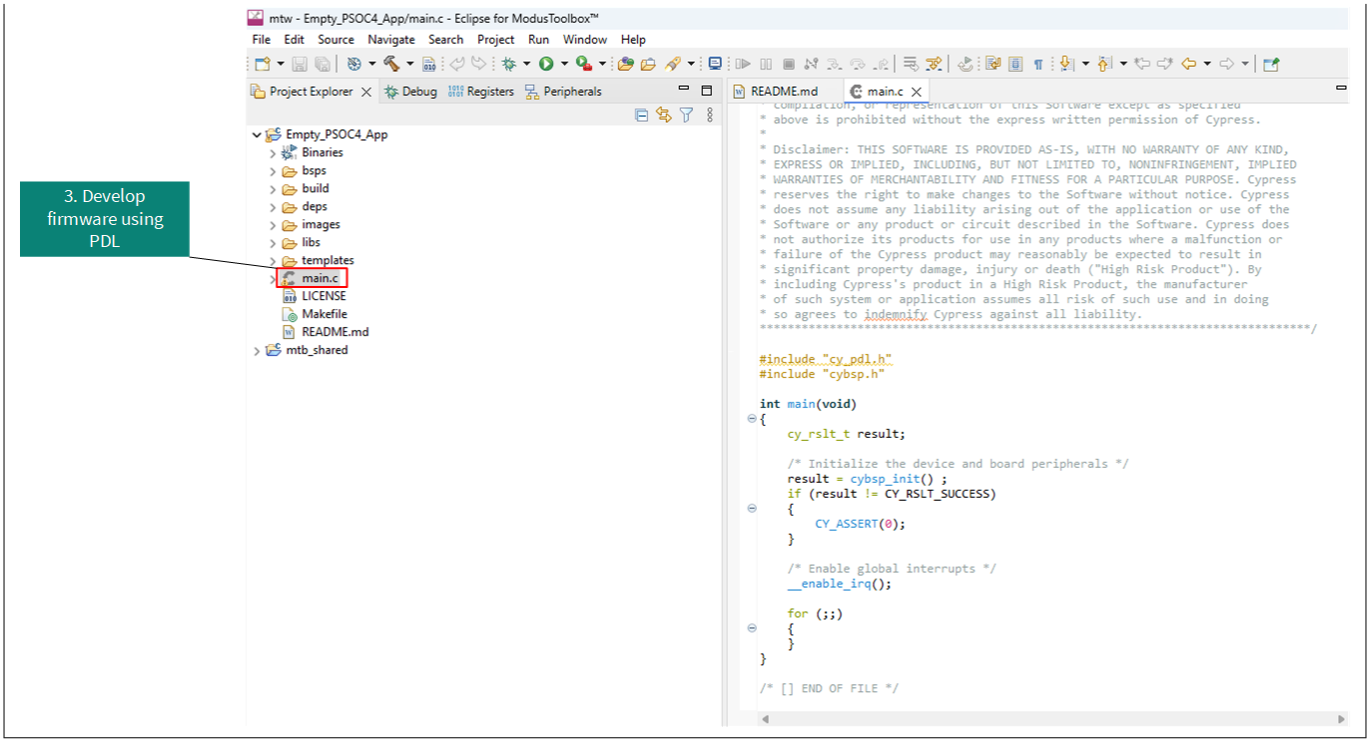


Figure 3 Eclipse IDE for ModusToolbox™ resources

Table 2 List of the BSP for PSOC™ 4 HVMS and PSOC™ 4 HVPA family

Device series	BSP
PSOC™ 4 HVMS CY8C4146LWE-HVS115X	KIT_PSOC4-HVMS-64K_LITE
PSOC™ 4 HVMS CY8C4146LWE-HVS015X	KIT_PSOC4-HVMS-64K_LITE-02
PSOC™ 4 HVMS CY8C4147LWE-HVS135X	KIT_PSOC4-HVMS-128K_LITE
PSOC™ 4 HVMS CY8C4147LWE-HVS035X	KIT_PSOC4-HVMS-128K_LITE-02
PSOC™ 4 HVPA CY8C4147LCE-HV423	KIT_PSOC4-HVPA-144K_LITE
PSOC™ 4 HVPA CY8C4147LDE-HV734	KIT_PSOC-HVPA-SPM1_LITE

2.3 Support for other IDEs

You can develop firmware for PSOC™ 4 HVMS MCUs using your favorite IDE such as IAR Embedded Workbench or Visual Studio Code.

ModusToolbox™ configurators are standalone tools that can be used to set up and configure PSOC™ 4 HVMS MCU resources and other middleware components without using the Eclipse IDE. The Device Configurator and middleware configurator use the `design.x` files within the application workspace. You can then point to the generated source code and continue developing firmware in your IDE.

If there is a change in the device configuration, edit the `design.x` files using the configurators and regenerate the code for the target IDE. It is recommended that you generate resource configurations using the configuration tools provided with ModusToolbox™ software.

2.4 FreeRTOS support with ModusToolbox™

Adding native FreeRTOS support to a ModusToolbox™ application project is like adding any library or middleware. You can import the FreeRTOS middleware into your application by using the Library Manager.

Select the application project and click the **Library Manager** link in the **Quick Panel**. Select **freertos** from the Libraries > PSOC™ 4 HVMS MCU Middleware dialog, as shown in Figure 4.

The `.mtb` file pointing to the FreeRTOS middleware is added to the application project. The middleware content is also downloaded and placed inside the corresponding folder called freertos. To continue working with FreeRTOS, follow the steps in the Quick Start section of FreeRTOS documentation.

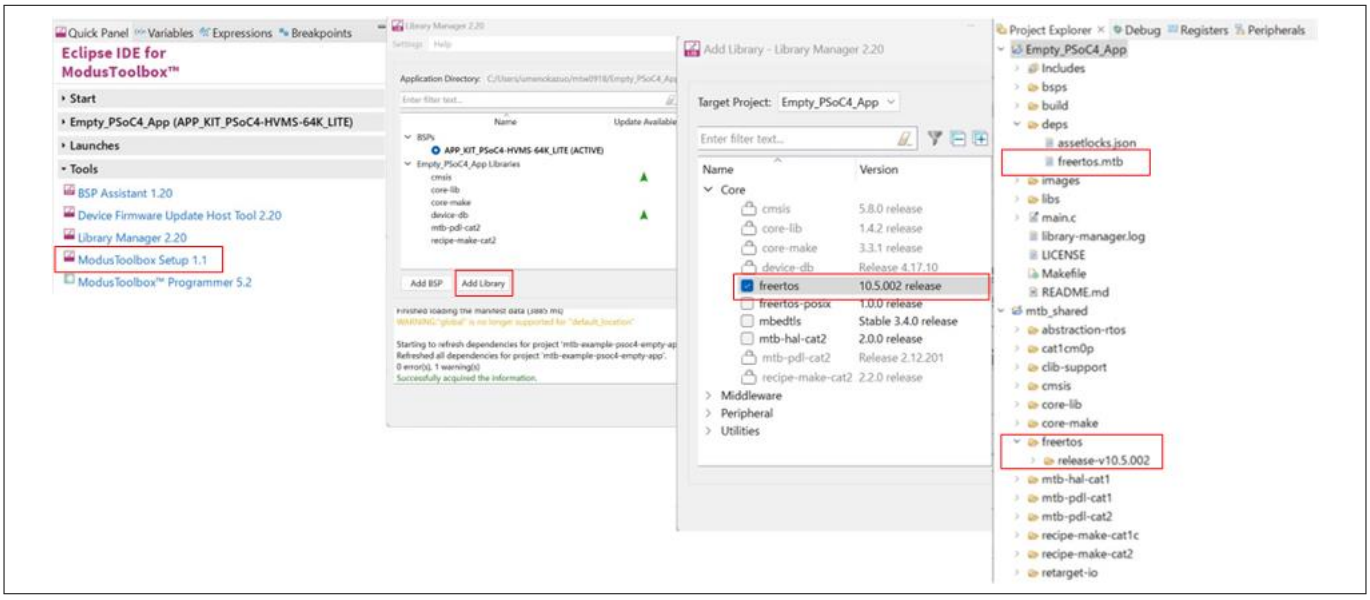


Figure 4 Import FreeRTOS middleware in ModusToolbox™ application

2.5 Programming/debugging

All PSOC™ 4 HVMS MCU kits have a KitProg3 onboard programmer or debugger. It supports Cortex® microcontroller Software Interface Standard - Debug Access Port (CMSIS-DAP). See the KitProg3 user guide for details.

The Eclipse IDE requires KitProg3 and uses the OpenOCD protocol for debugging PSOC™ 4 HVMS MCU applications. Additionally, it supports GDB debugging using industry-standard probes like the Segger J-Link.

ModusToolbox™ includes the **fw-loader** command-line tool to update and switch the KitProg firmware from KitProg2 to KitProg3.

For more details, see the “Program and debug” section in the Eclipse IDE for ModusToolbox™ user guide.

2.6 PSOC™ 4 HVMS MCU development kits

- **Development kits**
  - PSOC™ 4 HVMS 64K Lite Kit (PSOC4_HVMS_LITE_KIT)

3 Device features

PSOC™ 4 HVMS MCU product lines have extensive feature sets. For other products, see References.

3.1 CY8C41x6

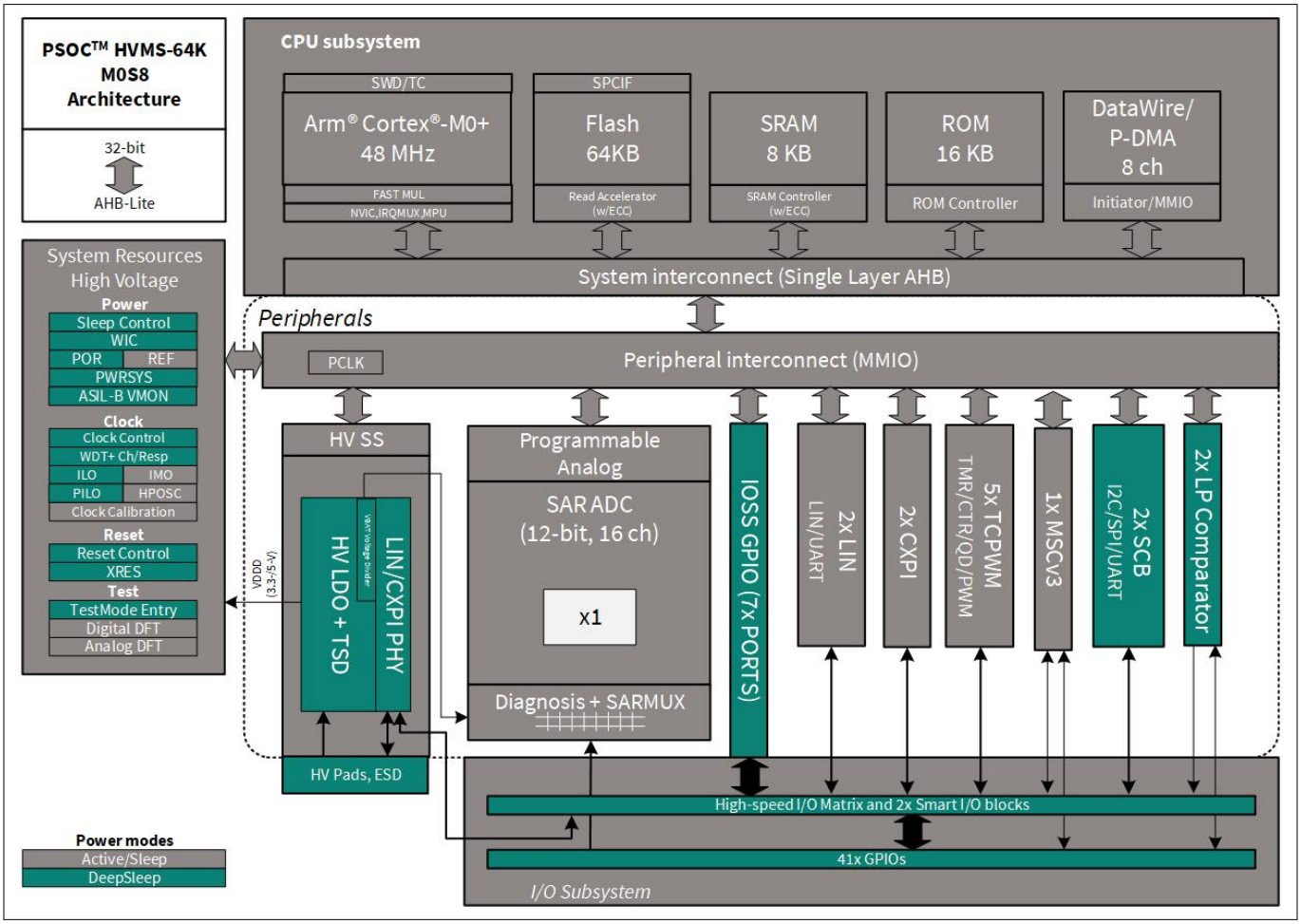


Figure 5 PSOC™ 4 HVMS-64K MCU block diagram

- **CPU subsystem**
  - 48 MHz Arm® Cortex®-M0+ CPU
  - Three DMA controllers
- **Integrated memories**
  - Up to 64 KB of code flash
  - Up to 8 KB of SRAM
- **Programmable analog**
  - 12-bit, 1-Msps SAR ADC with differential and single-ended modes, and channel sequencer with signal averaging
  - 16-channel SAR multiplexer with in-built diagnostics (8 I/O channels and 8 diagnostic channels)
  - Temperature sensor built into SAR ADC
  - Two low-power comparators that operate in Deep Sleep low-power mode

- **Programmable digital**
  - Programmable smart I/O logic blocks allowing Boolean operations to be performed on port inputs and outputs
- **High-voltage subsystem**
  - Regulator output voltage supports 3.3 V or 5 V selectable with ±2% trimmed accuracy
  - Regulator current: up to 60 mA
  - Thermal shutdown
  - Operates directly off 12-V/24-V battery (tolerates up to 42 V)
  - Integrated local interconnect network (LIN)/clock extension peripheral interface (CXPI) transceiver
- **CAPSENSE™ (multi-sense converter) block**
  - Multi-sense converter (MSC) provides a best-in-class signal-to-noise ratio (SNR) (>5:1) and water tolerance for capacitive sensing
  - One MSC converter supported
  - Autonomous channel scanning without CPU assistance
- **Functional safety for ASIL-B**
  - The device will be developed according to the development process of ISO 26262 for ASIL-B as a Safety Element out of Context (SEooC) (according to ISO 26262-10:2018E, clause 9)
  - Memory protection unit (MPU)
  - Window watchdog timer (WDT) with challenge-response functionality
  - Supply monitoring; detection of overvoltage and brownout events for 3.3 V or 5 V, and 1.8 V supplies
  - Hardware error detection and correction (SECDED ECC) on all safety-critical memories (SRAM, flash)
- **Timing and pulse-width modulation**
  - Five 16-bit timer, counter, pulse-width modulator (TCPWM) blocks
  - Center-aligned, edge, and pseudo-random modes
  - Memory protection unit (MPU)
  - Comparator-based triggering of Kill signals for motor drive and other high-reliability digital logic applications
  - Quadrature decoder
- **Clock sources**
  - ±2% 24 MHz to 48 MHz internal main oscillator (IMO)
  - ±1% 2 MHz high-precision oscillator (HPOSC)
  - ±5% 32 kHz precision internal low-power oscillator (PILO)
  - ±1% accuracy on IMO and PILO when software calibrated to the HPOSC
  - 40 kHz internal low-speed oscillator (ILO)
- **Communication**
  - Two independent run-time reconfigurable Serial Communication Blocks (SCBs) with reconfigurable I^2C, SPI, UART, or LIN slave functionality
  - Up to two independent Local interconnect network (LIN) channels
    - LIN protocol compliant with LIN 2.2A and ISO 17987
  - Up to two CXPI channels with data rate up to 20 kbps
- **I/O**
  - Up to 41 GPIOs

  - Any GPIO pin can be CAPSENSE™, analog, or digital
  - Drive modes, strengths, and slew rates are programmable
- **Packages**
  - 32-lead QFN with wettable flanks (6 mm × 6 mm)
  - 48-lead QFN with wettable flanks (7 mm × 7 mm)
  - 56-lead QFN with wettable flanks (8 mm × 8 mm)

4 My first PSOC™ 4 HVMS MCU design using Eclipse IDE for ModusToolbox™ software

This section provides the following:

- Demonstrates how to build a simple design based on PSOC™ 4 HVMS MCU and program it on to the development kit
- Provides detailed steps that make it easy to learn PSOC™ 4 HVMS MCU design techniques and how to use the Eclipse IDE for ModusToolbox™ software

4.1 Prerequisites

Before you get started, ensure that you have the appropriate development kit for your PSOC™ 4 HVMS MCU product line, and have installed the required software. You also need Internet access to the GitHub repositories during project creation.

4.1.1 Hardware

- The design is developed for **PSOC™ 4 HVMS Evaluation Kit**. However, you can build the projects for other development kits. See the Using these instructions section

4.1.2 Software

- ModusToolbox™ 3.7 or above

After installing the software, see the ModusToolbox™ user guide to get an overview of the software.

***Note**: For a list of known issues, see `mt_release_notes.pdf` included with the ModusToolbox™ installation. The default location of this file is `<user-home>/ModusToolbox/docs_<version>`.*

4.2 Using these instructions

These instructions are grouped into several sections. Each section is devoted to a phase of the application development workflow. The major sections are:

- Part 1: Create a new application
- Part 2: View and modify the design
- Part 3: Write firmware
- Part 4: Build the application
- Part 5: Program the device
- Part 6: Test your design

This design is developed for the **PSOC™ 4 HVMS MCU Evaluation Kit**. You can use other supported kits to test this example by selecting the appropriate kit while creating the application.

4.3 About the design

This design uses the PSOC™ 4 HVMS MCU to execute two tasks: UART communication and LED control.

After device reset, this code example uses the UART to print a “Hello World” message to the serial port stream, and starts blinking the user LED on the kit. When you press the **Enter** key on the serial console, the blinking is paused or resumed.

4.4 Part 1: Create a new application

This section takes you on a step-by-step guided tour of the new application process. It uses the '**Empty App**' starter application and guides you through the design development stages, and programming.

If you are familiar with developing projects with ModusToolbox™, you can use the '**Hello World**' starter application directly. It is a complete design, with all the firmware written for the supported kits. You can walk through the instructions and observe how the steps are implemented in the code example.

If you start from scratch and follow all the instructions in this application note, you can use the code example as a reference while following the instructions.

Launch Eclipse IDE for ModusToolbox™ to get started. Note that Eclipse IDE for ModusToolbox™ software needs access to the internet to successfully clone the starter application onto your machine. The following shows the CYT4BF project as an example.

1. **Select a new workspace**

   At launch, Eclipse IDE for ModusToolbox™ presents a dialog to choose a directory for use as the workspace directory. The workspace directory is used to store workspace preferences and development artifacts. You can choose an existing empty directory by clicking the **Browse** button, as Figure 6 shows. Alternatively, you can type in a directory name to be used as the workspace directory along with the complete path, and the Eclipse IDE will create the directory for you

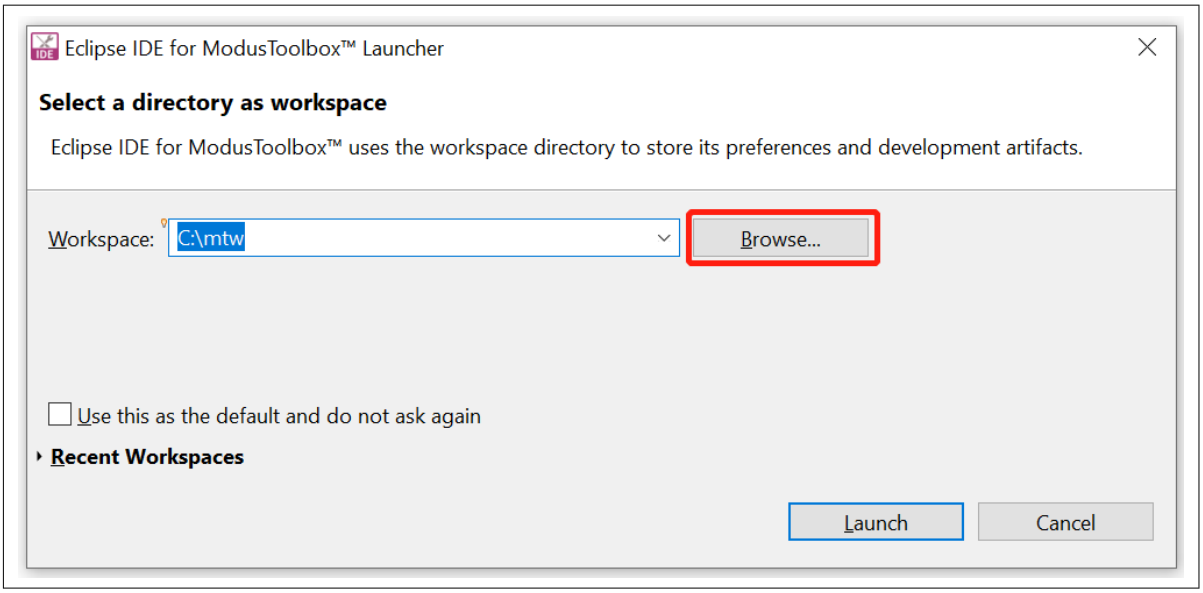


Figure 6 Select a directory as the workspace

2. **Create a new ModusToolbox™ application**

   a. Click **New Application** in the Start group of the Quick Panel

   b. Alternatively, you can choose **File** > **New** > **ModusToolbox™ Application**, as shown in Figure 7

   The Eclipse IDE for ModusToolbox™ Application window appears

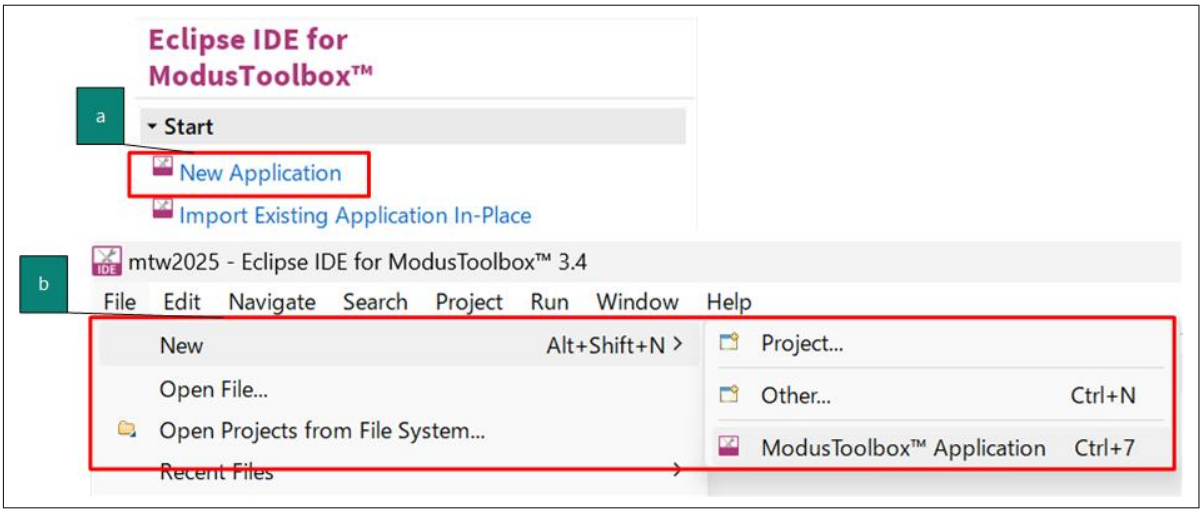


Figure 7 Create a new ModusToolbox™ application

3. Select a target PSOC™ 4 HVMS MCU Evaluation Kit

ModusToolbox™ speeds up the development process by providing BSPs that set various workspace/ project options for the specified development kit in the new application dialog.

a. In the **Choose Board Support Package (BSP)** dialog, choose the **Kit Name** that you have. The steps that follow use **KIT_PSOC4-HVMS-64K_LITE**. See Figure 8 for help with this step

b. Click **Next**

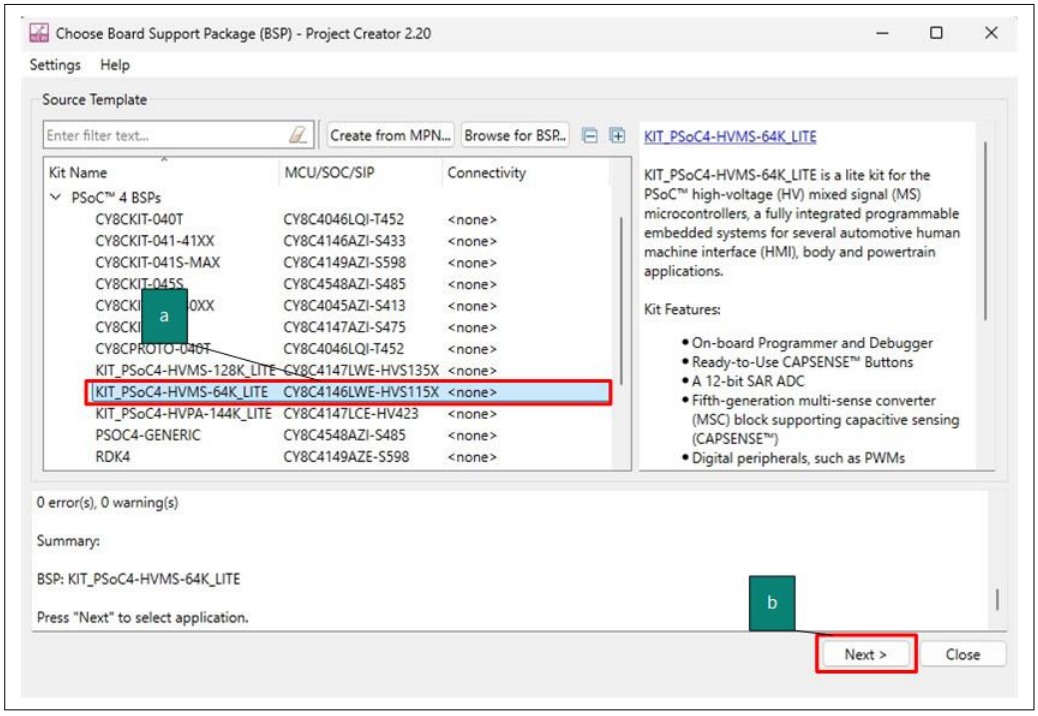


Figure 8 Choose the target hardware

c. In the Starter Application dialog, select **Getting Started** > **Empty App starter application**, as Figure 9 shows

d. In the **Name** field, type in a name for the application, such as **Hello_World**. You can choose to leave the default name if you prefer

e. Click **Create** to create the application, as shown in Figure 9. Wait for the Project Creator to automatically close once the project is successfully created

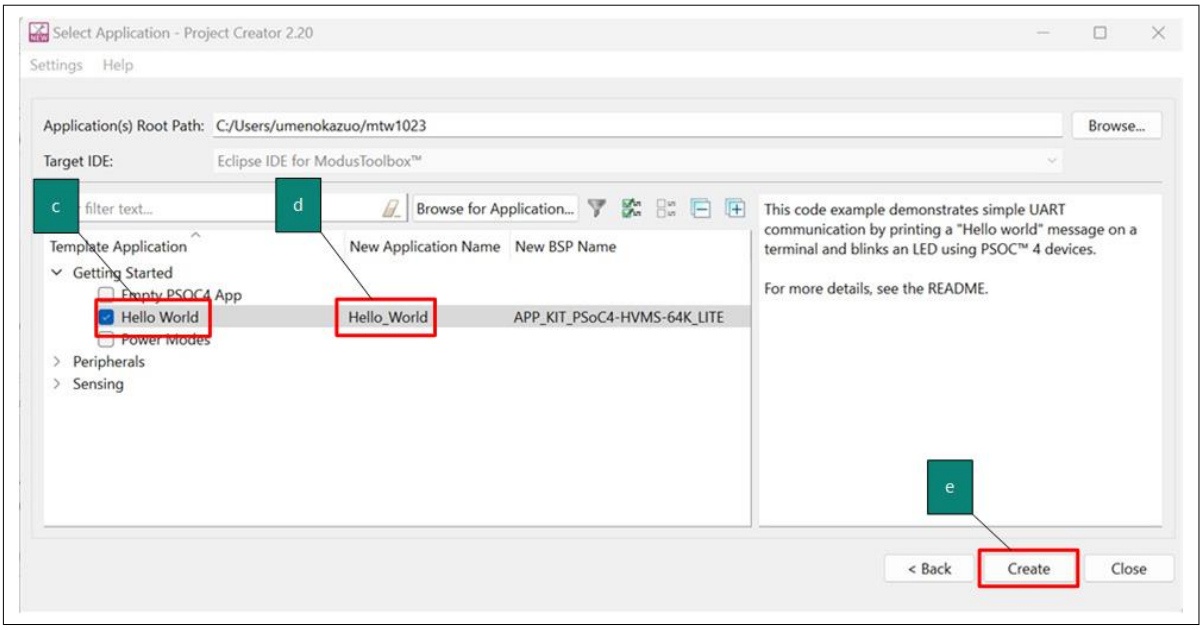


Figure 9 Choose the starter application

You have successfully created a new ModusToolbox™ application for a PSOC™ 4 HVMS MCU.

The BSP uses CY8C4146 as the default device that is mounted on the PSOC™ 4 HVMS MCU Evaluation Kit.

If you are using custom hardware based on a PSOC™ 4 HVMS MCU, or a different PSOC™ 4 HVMS MCU part number, see the “Creating your Own BSP” section in the ModusToolbox™ user guide. The guide is also available under the `ide_3.2>docs` folder of the ModusToolbox™ installation directory.

4.5 Part 2: View and modify the design

Figure 10 shows the ModusToolbox™ Project Explorer interface displaying the structure of the application project.

PSOC™ 4 HVMS MCU consist of one CM0+ core. This application note shows an example code for the firmware development using ModusToolbox™ software.

A project folder consists of various subfolders – each denoting a specific aspect of the project.

1. An application project contains a Makefile which is typically at the root folder. It has instructions on how to recreate the project. This file also contains the set of directives that the *make* tool uses to compile and link the application project. There can be more than one project in an application and each dependent project usually resides within its own folder within the application folder and contains its own *Makefile*
2. The *bsps* folder contains all the configuration files that are generated by the device and peripheral configurators, and are included in the `GeneratedSource` folder of the BSP. These files are prefixed with *cycfg_*. These files contain the design configuration as defined by the BSP. You can view and modify the design configuration by clicking the **Device Configurator** link in the **Quick Panel**. However, note that if you upgrade the BSP library to a newer version, the manual edits done to the design.x files are lost. You can also create custom Device Configurator files for an application and override the ones provided by the BSP. See the “Modifying the BSP configuration for a single application” section in the ModusToolbox™ user guide for more details. The BSP folder also contains the linker scripts and the startup code for the PSOC™ 4 HVMS MCU used on the board
3. The *build* folder contains all the artifacts resulting from the *make* build of the project. The output files are organized by target BSPs

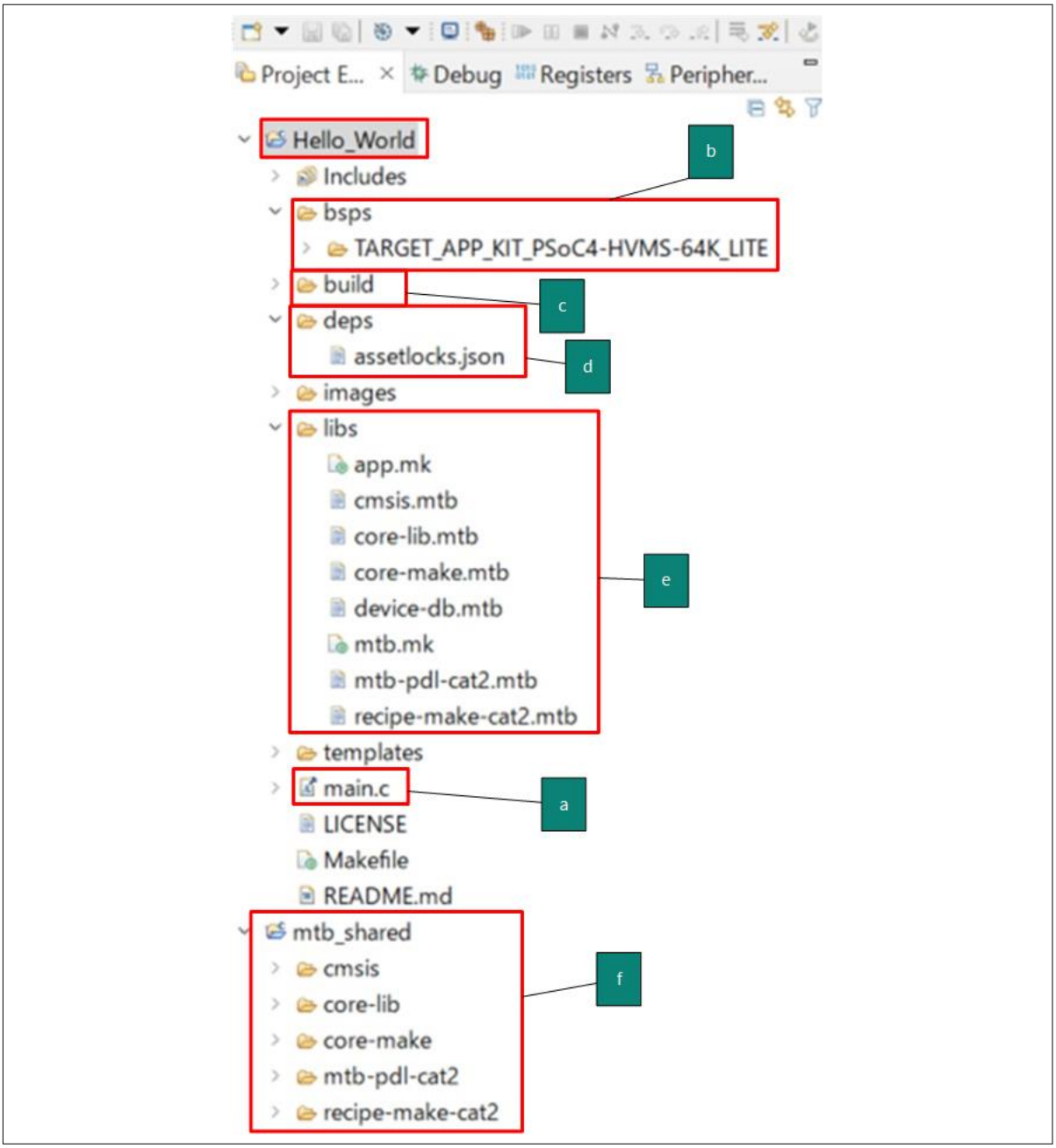


Figure 10 Project explorer view

4. The *deps* folder contains `.mtb` files, which provide the location from which ModusToolbox™ software pulls the BSP/library that is directly referenced by the application. These files typically contain the GitHub location of the entire library. The `.mtb` files also contains a git commit hash or tag that tells which version of the library is to be fetched and a path as to where the library should be stored

   The *latest-v1.X* tag in the link denotes the specific release of the BSP. The `$$ASSET_REPO$$` variable points to the root of the shared location. If the library has to be local to the application instead of shared, use `$$LOCAL$$` instead of `$$ASSET_REPO$$`

5. The *libs* folder also contains `.mtb` files; these point to libraries that are included indirectly as a dependency of a BSP or another library. For each indirect dependency, the Library Manager places an `.mtb` file in this folder. These files have been populated based on the targets available in the *deps* folder

For example, using the BSP lib file, *TARGET_PSOC4-HVMS-64K_LITE.mtb* populates the *libs* folder with the following `.mtb` files: cmsis.mtb, core- lib.mtb, core- make.mtb, device - db .mtb, mtb-pdl-cat 2 .mtb, recipe-make-cat 2 .mtb

The *libs* folder contains the `mtb.mk` file, which stores the relative paths of all the libraries required by the application. The build system uses this file to find all the libraries required by the application

6. By default, when creating a new application or adding a BSP/library to an existing application and specifying it as 'shared', all BSPs/libraries are placed in an `mtb_shared` directory adjacent to the application directories

   The `mtb_shared` folder is shared between different applications that use the same versions of the BSP/library

Of interest are the configuration files that are in the `COMPONENT_BSP_x` folder. Click on the **Device Configurator** link in the **Quick Panel**. Figure 11 shows the resulting window called the **Device Configurator** window. You can also double-click open the other `design.x` files to open them in their respective configurators or click the corresponding links in the **Quick Panel**.

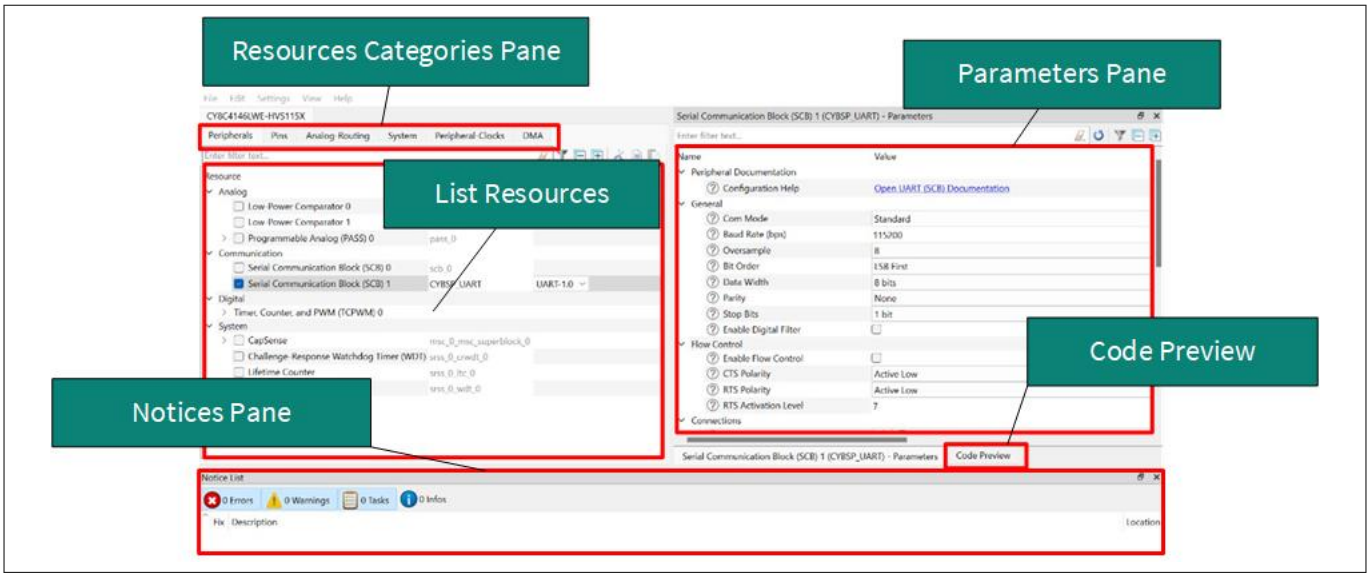


Figure 11 Device Configurators overview

The **Device Configurator** window provides a **Resources Categories** pane. Here you can choose between different resources available in the device such as peripherals, pins, and clocks from the **List of Resources**.

You can choose how a resource behaves by choosing a **Personality** for the resource. For example, a **Serial Communication Block (SCB)** resource can have **EZI2C**, **I2C**, **SPI**, or **UART** personalities. The **Alias** is your name for the resource, which is used in firmware development. One or more aliases can be specified by using a comma to separate them (with no spaces).

The **Parameters** pane is where you enter the configuration parameters for each enabled resource and the selected personality. The **Code Preview** pane shows the configuration code generated per the configuration parameters selected. This code is populated in the `cycfg_` files in the `GeneratedSource` folder. Any errors, warnings, and information messages arising out of the configuration are displayed in the **Notices** pane.

The application project contains relevant files that help you create an application for the M0+ CPU (`main.c`).

Configuration of UART, timer peripherals, pins, and system clocks

The configuration of the debug UART peripheral, timer peripheral, pins, and system clocks can be done directly in the code using the function APIs provided by the BSP. See Part 3: Write firmware.

4.6 Part 3: Write firmware

At this point in the development process, in this part, you write the firmware that implements the design functionality.

If you are working from scratch using the empty PSOC™ 4 HVMS starter application, you can copy the respective source code to the `main.c` of the application project from the code snippet provided in this section. If you are using the Hello World code example, all the required files are already in the application.

4.6.1 Firmware flow

Now, examine the code in the `main.c` file of the application. Figure 12 shows the firmware flowchart.

After reset, this code example initializes and configures the system clocks, pins, clock to peripheral connections, and other platform resources.

After reset, the clocks, system resources, the debug UART, and the user LED are initialized by the BSP initialization function. The debug UART prints a “Hello World!” message on the terminal emulator – the onboard KitProg3 acts the USB-to-UART bridge to create the virtual COM port, CPU toggles the LED state on the kit.

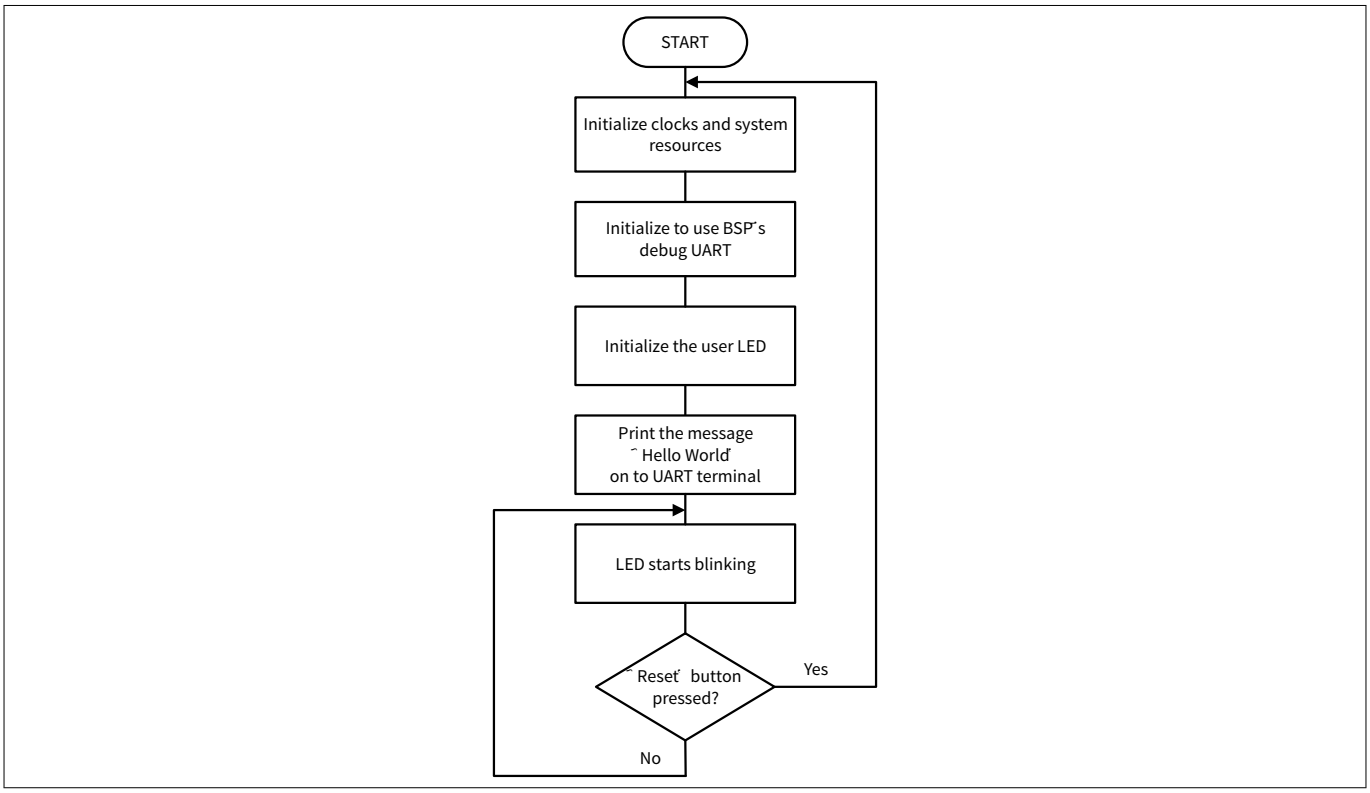


Figure 12 Firmware flowchart

This completes the summary of how the firmware works in the code example. See the source files for more information.

Table 3 List of ‘Hello World’ configuration functions

Function	Description
`cybsp_init()`	This BSP function sets up the HAL hardware manager and initializes all the system resources of the device including but not limited to the system clocks and power regulators.

Copy the following code snippet to the `main.c` of your application project.

Example code for the 'Hello World' application

```
#include "cy_pdl.h"
#include "cybsp.h"
/*******************************************************************************
*****
* Macros
*******************************************************************************
****/
#define LED_DELAY_MS (500u)
#define CY_ASSERT_FAILED (0u)
/*******************************************************************************
*****
* Function Name: main
*******************************************************************************
*****
* Summary:
* System entrance point. This function performs
* - initial setup of device
* - configure the SCB block as UART interface
* - prints out "Hello World" via UART interface
* - Blinks an LED under firmware control at 1 Hz
*
* Parameters:
* none
*
* Return:
* int
*
*******************************************************************************
****/
int main(void)
{
cy_rslt_t result;
cy_stc_scb_uart_context_t CYBSP_UART_context;
/* Initialize the device and board peripherals */
result = cybsp_init();
/* Board init failed. Stop program execution */
if (result != CY_RSLT_SUCCESS)
{
CY_ASSERT(CY_ASSERT_FAILED);
}
/* Configure and enable the UART peripheral */
Cy_SCB_UART_Init(CYBSP_UART_HW, &CYBSP_UART_config,
&CYBSP_UART_context);
Cy_SCB_UART_Enable(CYBSP_UART_HW);s
/* Enable global interrupts */
__enable_irq();
/* Send a string over serial terminal */
Cy_SCB_UART_PutString(CYBSP_UART_HW, "Hello world\r\n");
for(;;)
{
/* Toggle the user LED state */
```

```
Cy_GPIO_Inv(CYBSP_USER_LED1_PORT, CYBSP_USER_LED1_PIN);
/* Wait for 0.5 seconds */
Cy_SysLib_Delay(LED_DELAY_MS);
}
}
```

4.7 Part 4: Build the application

This section shows how to build the application.

1. **Build the application.**
   a. Select the application project in the Project Explorer window and click on the **Build <name> Application** shortcut under the **<name>** group in the Quick Panel. It selects the **Debug** build configuration and compiles/links all projects that constitute the application
   b. The **Console** view lists the results of the build operation (see Figure 13)

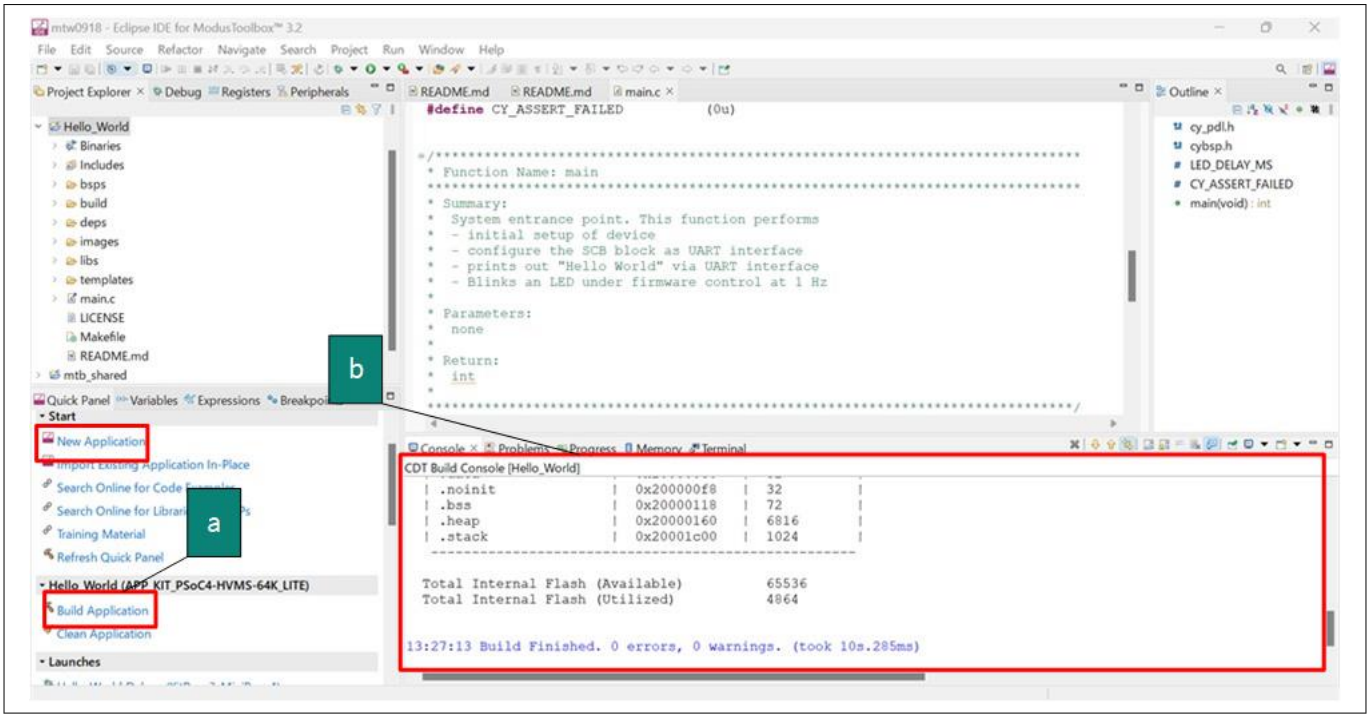


Figure 13 Build the application

If you encounter errors, revisit before steps to ensure that you accomplished all the required tasks.

***Note**: You can also use the command-line interface (CLI) to build the application. See the "Using the command-line" section in the ModusToolbox™ user guide. This document is located in the/ide_<version>/docs/folder in the ModusToolbox™ installation.*

4.8 Part 5: Program the device

This section shows how to program the PSOC™ 4 HVMS MCU device.

ModusToolbox™ software uses the OpenOCD protocol to program and debug applications on PSOC™ 4 HVMS MCU devices. For ModusToolbox™ software to identify the device on the kit, the kit must be running KitProg3. See Programming/debugging for details.

If you are using a development kit with a built-in programmer, connect the board to your computer using the USB cable.

If you are developing on your own hardware, you may need a hardware programmer/debugger; for example, a CY8CKIT-005 MiniProg4.

1. **Program the application**
   a. Connect to the board and perform the following step
   b. Select the application project and click on the **<application name> Program (KitProg3_MiniProg4)** shortcut under the **Launches** group in the **Quick Panel**, as Figure 14 shows. The IDE will select and run the appropriate run configuration. Note that this step will also perform a build if any files have been modified since the last build

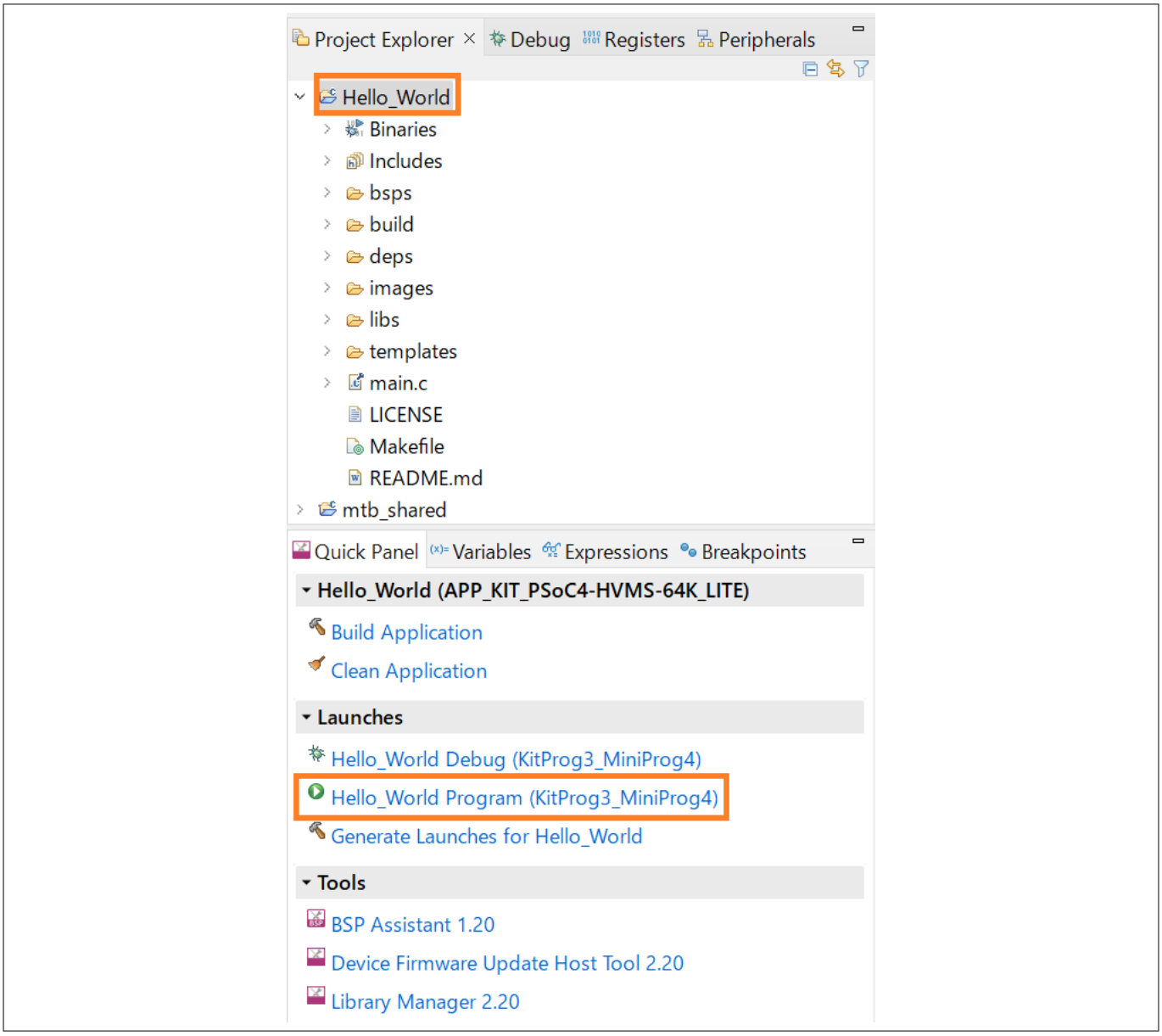


Figure 14 Programming an application to a device

The **Console** view lists the results of the programming operation, as Figure 15 shows.

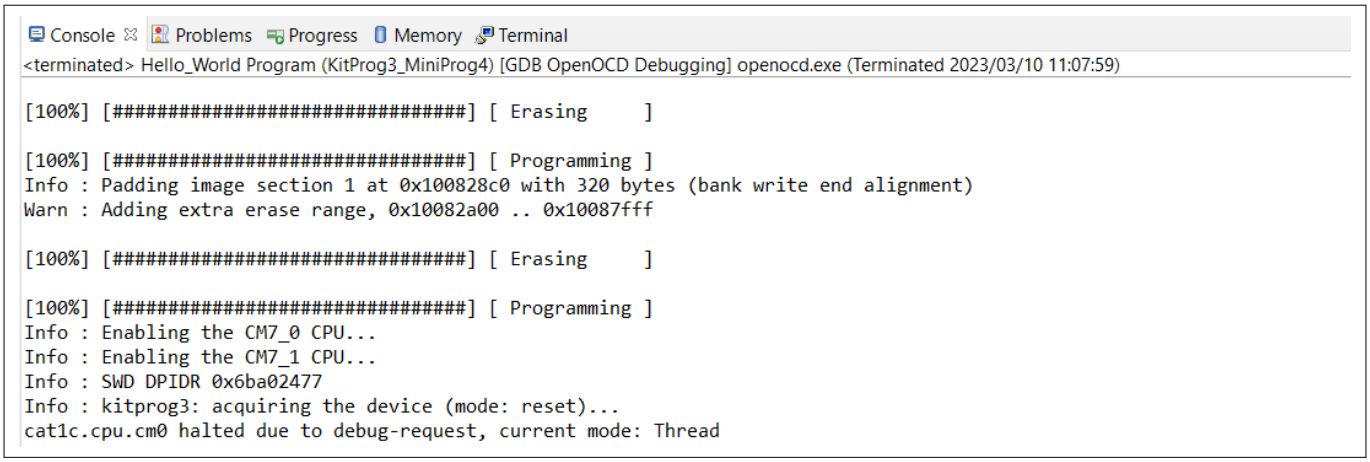


Figure 15 Console – programming results

4.9 Part 6: Test your design

This application note uses Tera Term as the UART terminal emulator to view the results. You can use any terminal of your choice to view the output. Follow these steps to observe the output of your design:

1. **Select the serial port**

   Launch Tera Term and select the USB-UART COM port as shown in Figure 16. Note that your COM port number may be different

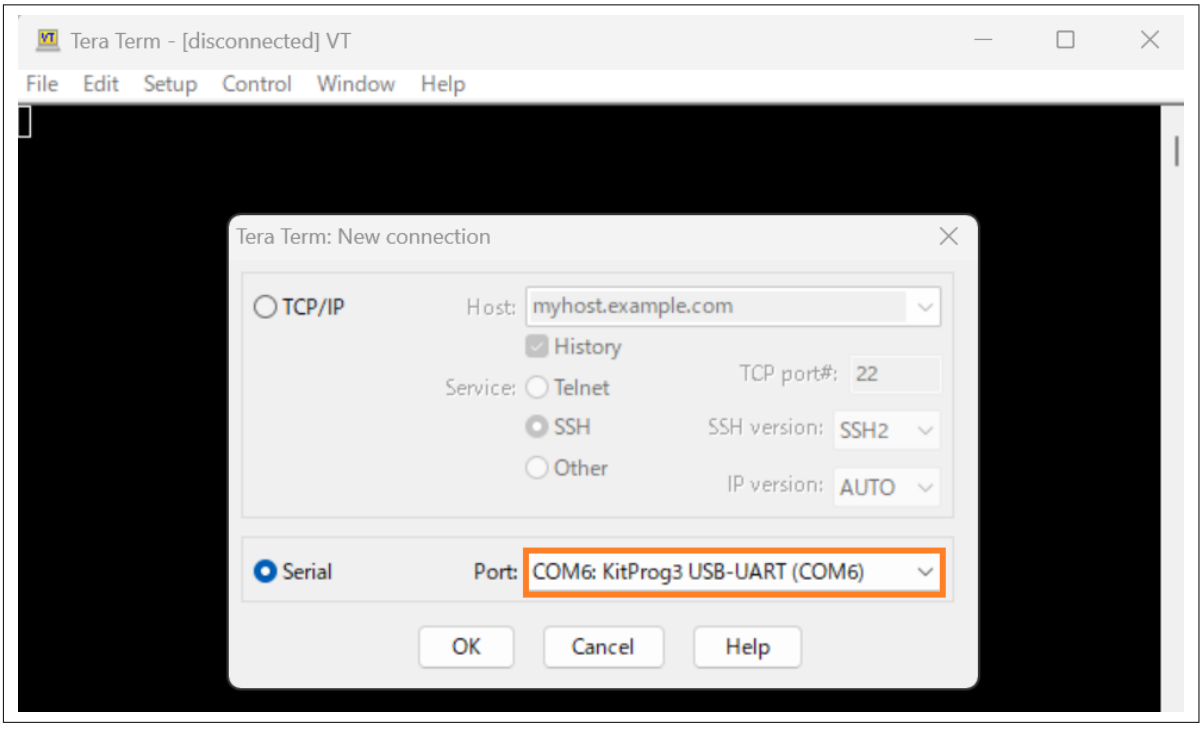


Figure 16 Selecting the KitProg3 COM port in Tera Term

2. **Set the baud rate**

   Set the baud rate to 115200 under **Setup** > **Serial port** as shown in Figure 17

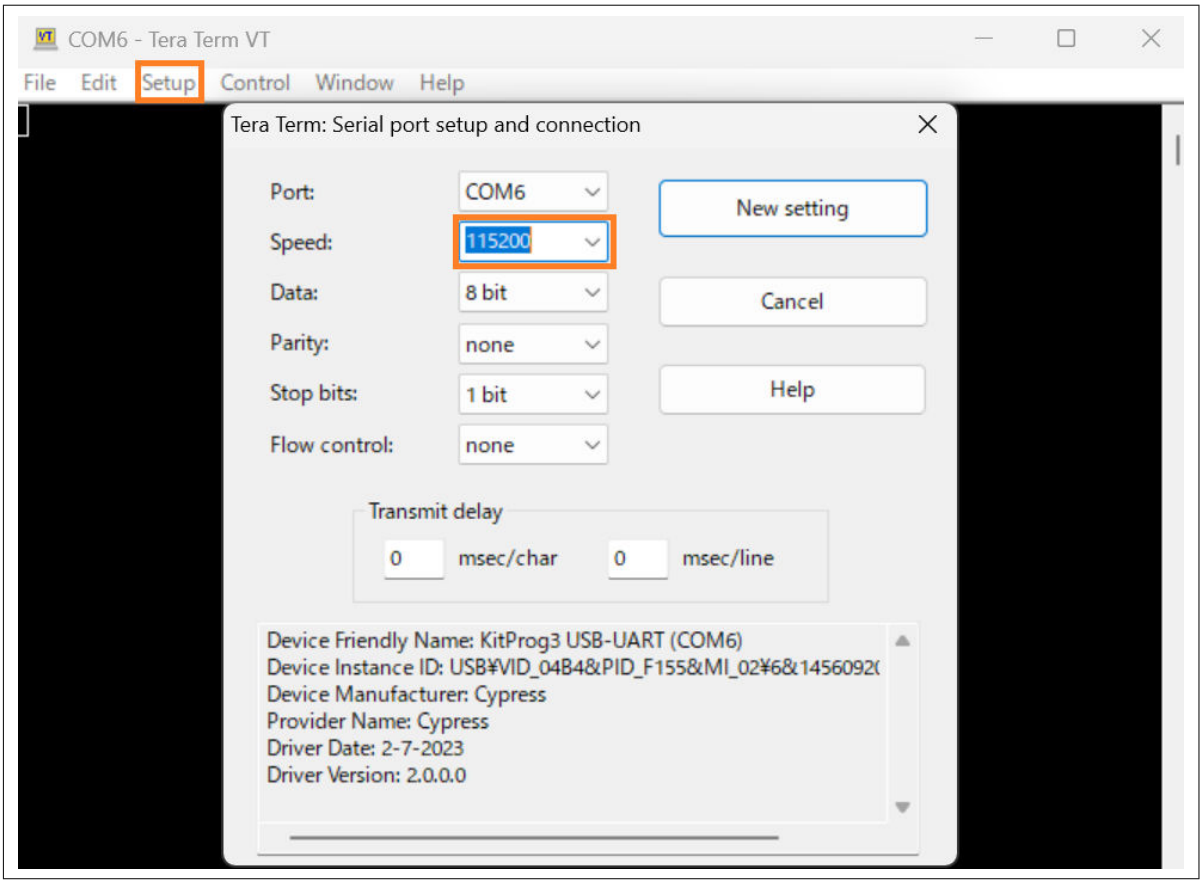


Figure 17 Configuring the baud rate in Tera Term

3. Reset the device

Press the reset switch (SW2) on the kit. A message appears on the terminal as shown in Figure 18. The user LED on the kit starts blinking

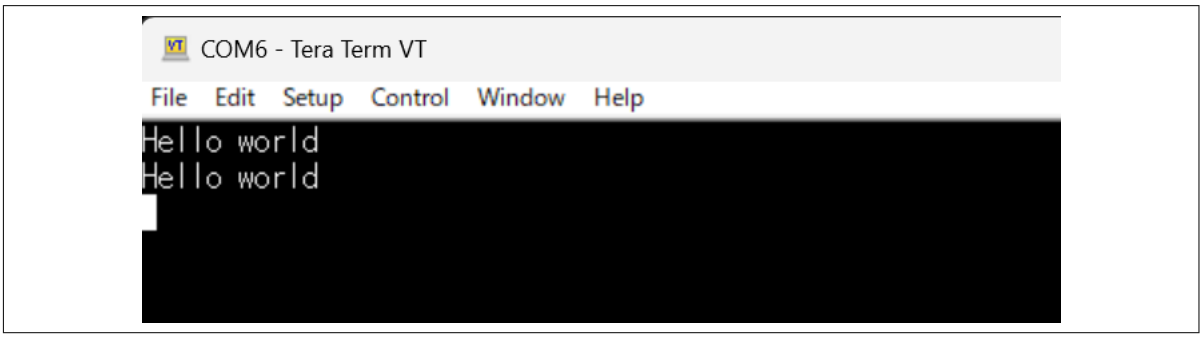


Figure 18 Printed UART message

5 Summary

This application note explores the PSOC™ 4 HVMS MCU device architecture and the associated development tools. The PSOC™ 4 HVMS MCU is a truly programmable embedded system-on-chip with configurable analog and digital peripheral functions, memory, and a triple-CPU system on a single chip. The integrated features and low-power modes make PSOC™ 4 HVMS MCU an ideal choice for BCM, gateway, and other automotive body control applications.

References

PSOC™ 4 HV webpage

[1] Infineon Technologies AG: *32-bit PSOC™ 4 HV Arm® Cortex®-M0+*; Available online

Application notes

[2] Infineon Technologies AG: *AN234115 – Getting started with PSOC™ HVMS/HVPA family*; Available online
[3] Infineon Technologies AG: *AN234116 – Hardware design guide for PSOC™ HVMS family*; Available online
[4] Infineon Technologies AG: *AN230625 – Hardware design guide for PSOC™ HVPA family*; Available online

Device datasheets

[5] Infineon Technologies AG: *CY8C41x5/CY8C41x6, PSOC™ 4 High Voltage Mixed Signal (HVMS) Automotive MCU Based on 32-bit Arm® Cortex®-M0+*; Available online
[6] Infineon Technologies AG: *CY8C412x, CY8C414xLCE PSOC™ 4 High Voltage Precision Analog (HVPA) Automotive MCU Based on 32-bit Arm® Cortex®-M0+*; Available online

PSOC™ 4 HVMS reference manuals

[7] Infineon Technologies AG: *PSOC™ 4 HVMS MCU architecture reference manual*; Available online
[8] Infineon Technologies AG: *PSOC™ 4 HVMS 64K MCU registers reference manual*; Available online
[9] Infineon Technologies AG: *PSOC™ 4 HVMS 128K MCU registers reference manual*; Available online

PSOC™ 4 HVPA reference manuals

[10] Infineon Technologies AG: *PSOC™ 4 HVPA MCU architecture reference manual*; Available online
[11] Infineon Technologies AG: *PSOC™ 4 HVPA MCU registers reference manual*

***Note**: For more PSOC™ 4 HV documents, see PSOC™ 4 HV Arm® Cortex®-M0+.*

Glossary

This section lists the most commonly used terms that you might encounter while working with PSOC™ 4 HVMS family of devices.

- Board support package (BSP): A BSP is the layer of firmware containing board-specific drivers and other functions. The board support package is a set of libraries that provide firmware APIs to initialize the board and provide access to board level peripherals
- Hardware Abstraction Layer (HAL): The HAL wraps the lower-level drivers and provides a high-level interface to the MCU. The interface is abstracted to work on any MCU
- **KitProg:** Onboard programmer/debugger with USB-I^{2}C and USB-UART bridge functionality. KitProg is integrated onto most PSOC™ 4 HVMS development kits
- MiniProg3/MiniProg4: Programming hardware for development that is used to program PSOC™ 4 HVMS devices on your custom board or PSOC™ 4 HVMS development kits that do not support a built-in programmer
- **Personality:** Expresses the configurability of a resource for a functionality. For example, the SCB resource can be configured to be an UART, SPI, or I2C personalities
- Middleware: Middleware is a set of firmware modules that provide specific capabilities to an application. Some middleware may provide network protocols (e.g., MQTT), and some may provide high-level software interfaces to device features (e.g., USB, audio)
- Peripheral Driver Library (PDL): Simplifies software development for the PSOC™ 4 HVMS MCU architecture. The PDL reduces the need to understand register usage and bit structures, therefore, easing software development for the extensive set of peripherals available

Revision history

Document revision	Date	Description of changes
V 1.0	2025-01-21	Initial release
V 1.1	2025-06-19	Template update; no content update
V 1.2	2025-08-29	Added PSOC™ 4 HVPA series Updated supported version of the ModusToolbox™
V 1.3	2026-03-05	Added PSOC™ HVPA-SPM series Updated supported version of the ModusToolbox™

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