Using the BOOST-LP5569EVM Evaluation Module

The Texas Instruments LP5569 evaluation module (EVM) helps designers evaluate the operation and performance of the LP5569 nine-LED driver. The LP5569 device is an RGB LED driver that can individually control up to 9 LEDs. The driver has 12-bit PWM and 8-bit current control of each low-side LED current sink. The current sinks can be individually controlled through the I^2C interface.

The EVM contains one LP5569 device (see Table 1).

Table 1. Device and Package Configurations

REFERENCE ID	DEVICE	PACKAGE
U1	LP5569	WQFN (24)

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1 Setup

This section describes the jumpers and connectors on the EVM as well and how to properly connect, set up, and use the LP5569EVM. The input voltage range for V_{IN} is 2.5 V to 5.5 V. The input voltage range for V_{1P8} is 1.65 V to 1.95 V.

1.1 Input/Output Connector Description

- ADDR_SEL – is provided to configure the I^2C slave address.
- DISVIO – is provided to disable the onboard 1.8-V LDO when supplying an external 1.8-V supply.
- I18 – is provided to measure the V1P8 supply current through a 1-Ω sense resistor.
- I^2C – is provided to monitor the I^2C SDA and SCL signals.
- IIN – is provided to measure the VIN supply current through a 1-Ω sense resistor.
- IOUT – is provided to measure the VOUT supply current. The jumper must be installed for normal operation.
- J1 and J2 are the TI LaunchPad connector interface.
- JLED – is provided to connect an external LED to the LP5569EVM evaluation module.
- JIS – is provided to measure the LED current through a 1-Ω sense resistor.
- JL1 – is provided to select either a white or RGB LED on LED0, LED1, and LED2 and on the LED supply.
- JL2 – is provided to select either a white or RGB LED on LED3, LED4, and LED5 and on the LED supply.
- JL3 – is provided to select either a white or RGB LED on LED6, LED7, and LED8 and on the LED supply.
- VINSEL – is provided to select 3.3 V either from the MSP432 LaunchPad™ development kit or from an external supply connected to JLED.

1.2 I^2C Address Selection

The LP5569 I^2C slave address is set according to the jumper installed on ADDR_SEL.

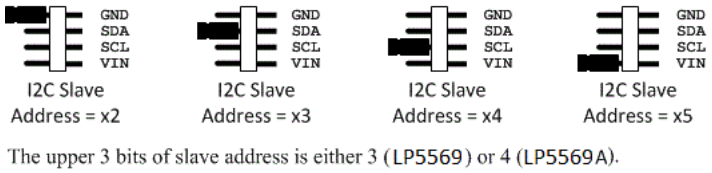


Figure 1. ADDR_SEL Configuration

1.3 LED Type and Supply Selection

The connectors JL1, JL2, and JL3 are used to select the LED type and supply rail.

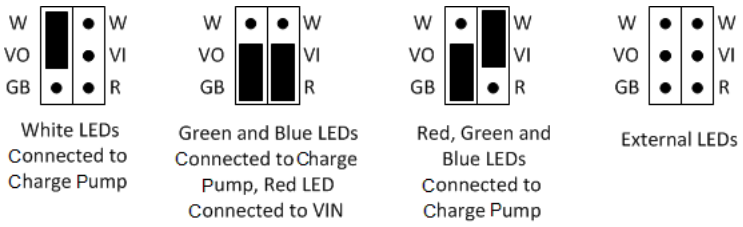


Figure 2. JL1, JL2, JL3 Configuration

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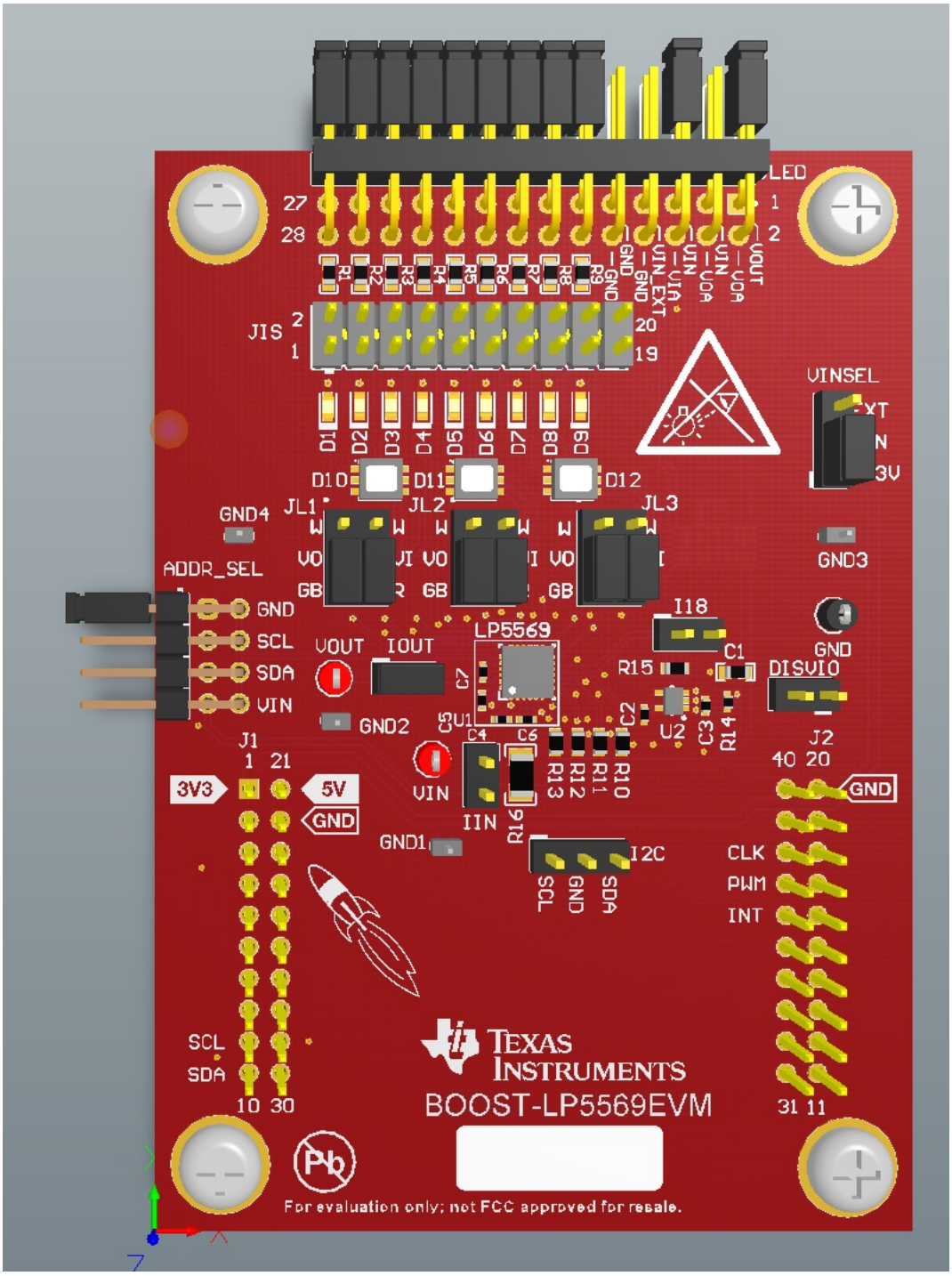


Figure 3. LP5569EVM

1.4 RGB LED Operation

For proper operation of the LP5569 device, ADDR_SEL, IOUT, JL1, JL2, JL3, JLED, and VINSEL must be properly configured. The recommended settings, using shunts, are as follows:

- ADDR_SEL: Shunt installed between pins 1 and 2 only.
- IOUT: Shunt installed.

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- JL1: Shunts installed between pins 3 and 5 and pins 4 and 6 (RGB LED selected).
- JL2: Shunts installed between pins 3 and 5 and pins 4 and 6 (RGB LED selected).
- JL3: Shunts installed between pins 3 and 5 and pins 4 and 6 (RGB LED selected).
- JLED: Shunts installed between pins 1 and 2, 5 and 6, 11 and 12, 13 and 14, 15 and 16, 17 and 18, 19 and 20, 21 and 22, 23 and 24, 25 and 26, 27 and 28.

In this configuration, the green and blue LEDs are connected to the charge pump output with the red LEDs connected to VIN.

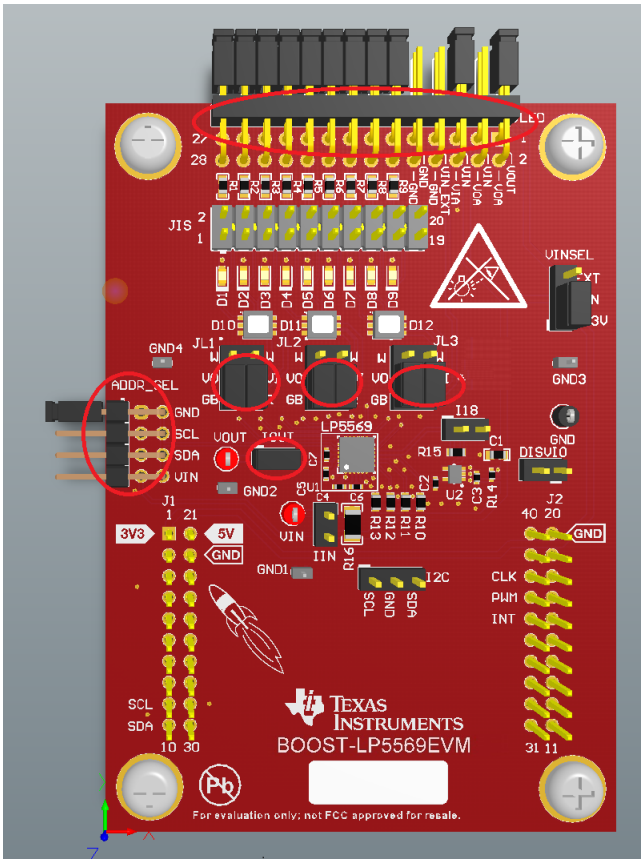


Figure 4. RGB Configuration Jumper Settings

1.5 White LED Operation

For proper operation of the LP5569 device, ADDR_SEL, IOUT, JL1, JL2, JL3, JLED, and VINSEL must be properly configured. The recommended settings, using shunts, are as follows:

- ADDR_SEL: Shunt installed between pins 1 and 2 only.
- IOUT: Shunt installed.
- JL1: Shunt installed between pins 1 and 3 (white LED selected).
- JL2: Shunt installed between pins 1 and 3 (white LED selected).
- JL3: Shunt installed between pins 1 and 3 (white LED selected).
- JLED: Shunts installed between pins 1 and 2, 5 and 6, 11 and 12, 13 and 14, 15 and 16, 17 and 18, 19 and 20, 21 and 22, 23 and 24, 25 and 26, 27 and 28.

In this configuration, the white LEDs are connected to the charge pump output.

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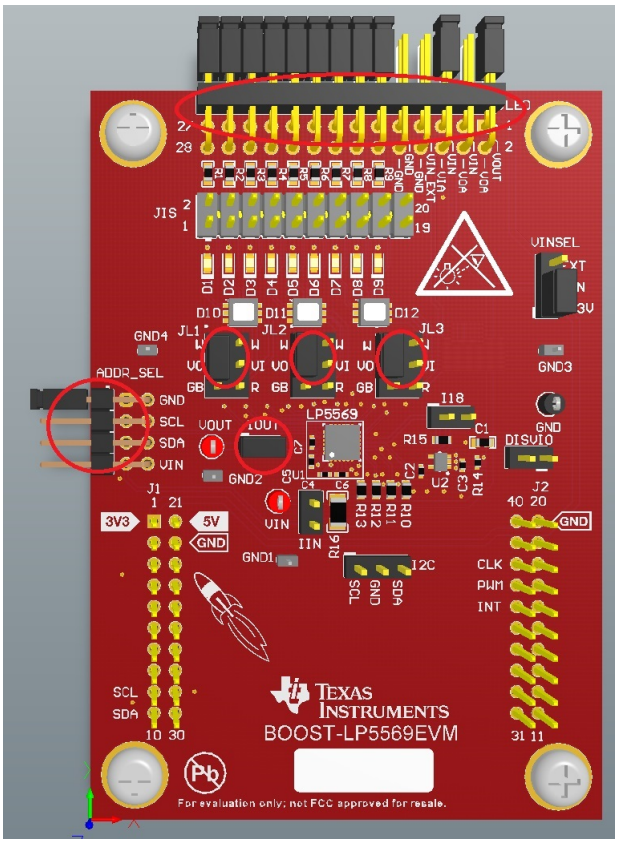


Figure 5. White LED Jumper Settings

1.6 External LED Operation

For proper operation of the LP5569 device, ADDR_SEL, IOUT, JL1, JL2, JL3, JLED, and VINSEL must be properly configured. The recommended settings, using shunts, are as follows:

- ADDR_SEL: Shunt installed between pins 1 and 2 only.
- IOUT: Shunt installed.
- JL1: No shunt installed.
- JL2: No shunt installed.
- JL3: No shunt installed.
- JLED: No shunt installed, external LED cathodes connected to JLED pins 11, 13, 15, 17, 19, 21, 23, 25, and 27 with LED anodes connected to either JLED pin 1 (VOUT) or pin 3 (VIN).

In this configuration, the LEDs are located on a separate board connected to JLED. Multiple LP5569-EVMs can be stacked vertically to control up to 72 LEDs (8 LP5569EVMs) using a single MSP432 LaunchPad developmant kit.

1.7 EVM and MSP-EXP432P401R LaunchPad Development Kit Setup

The MSP-EXP432P401R LaunchPad jumpers should be set as shown in Figure 6.

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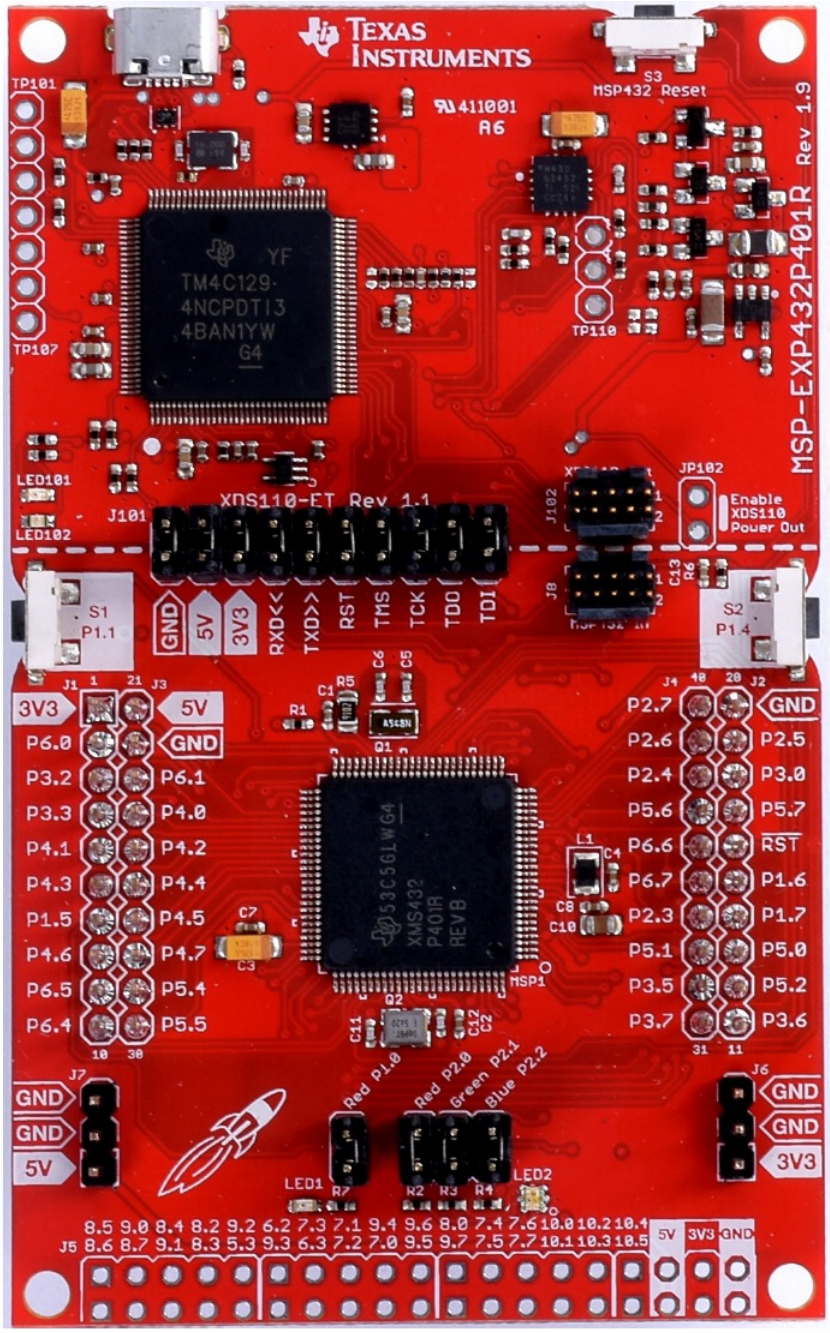


Figure 6. MSP432 Jumper Settings

Connect the MSP432 LaunchPad development kit and EVM (BOOSTXL-LP5569) as shown in Figure 7.

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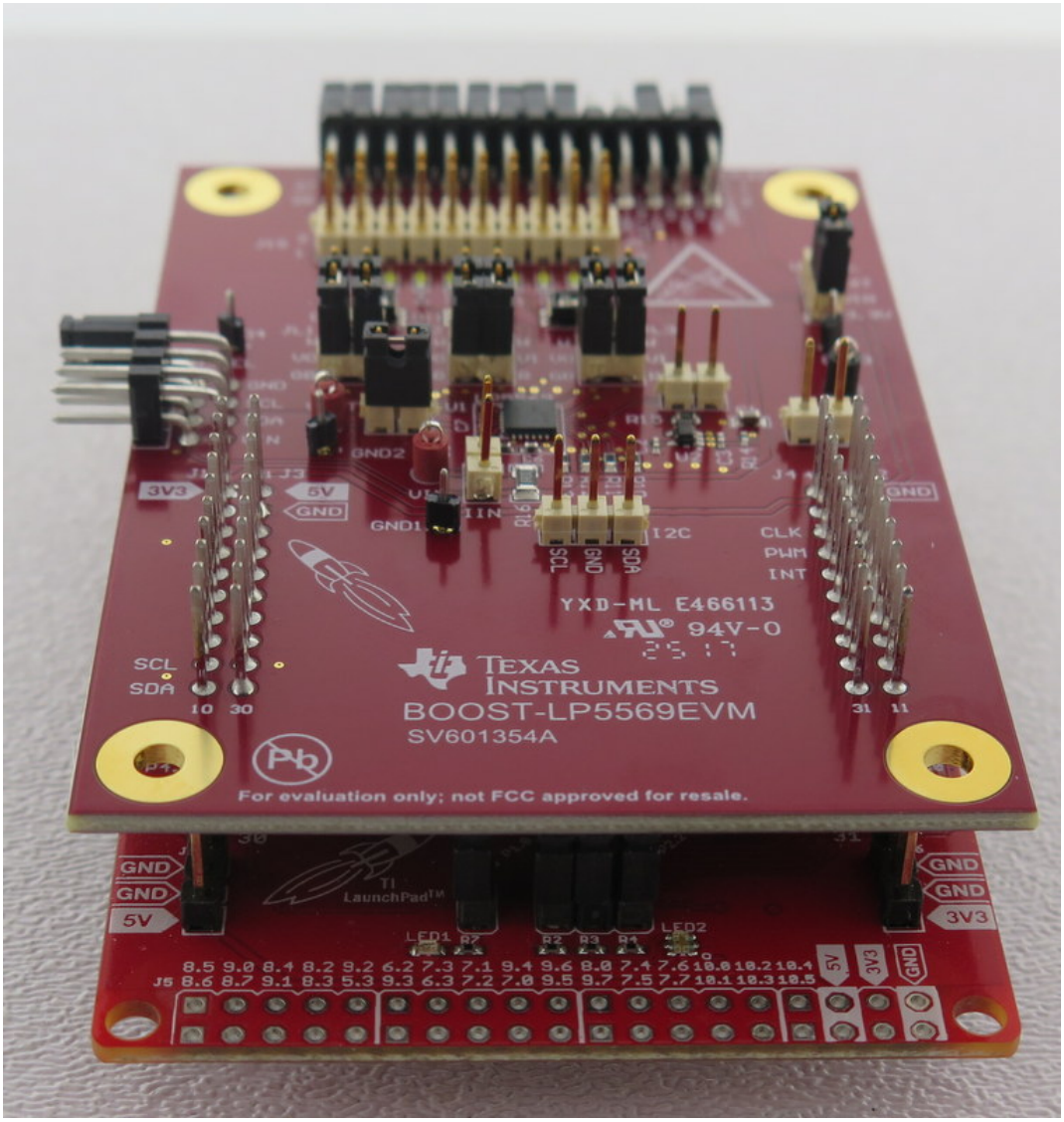


Figure 7. Connect Evaluation Board and LaunchPad Development Kit

1.8 Minimum Procedure for Turning on the LEDs

The minimum procedure for turning on the LEDs is as follows:

1. Verify jumper pin settings on the MSP-EXP432P401R LaunchPad development kit and the LP5569EVM board.
2. Connect the MSP-EXP432P401R LaunchPad to the LP5569EVM board.
3. If it is the first time to use the MSP432, install an XDS110 driver. See the MSP432P401R *SimpleLink™ Microcontroller LaunchPad™ Development Kit (MSP-EXP432P401R) User's Guide* for more-detailed information regarding the XDS110 driver.
4. Verify the *XDS110 Class Application/User UART* and *XDS110 Class Auxiliary Data Port* on the Microsoft® Windows® Device Manager.
5. Install and run the EVM software.
6. If the LaunchPad development kit is a new one or was used another purpose, the EVM software asks to update the firmware. Update the firmware through the top menu, File → Update Firmware. The EVM software restarts after updating the firmware.

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7. Make sure the *Hardware Connected* message appears on the status bar.
8. Select the *Control* Page Menu and *Manual* tab.
9. Set the appropriate I^2C slave address.
10. Click the EN button to high. (Red color means high.)
11. Set the chip_en bit and click *Yes* to read all registers.
12. Set cp_mode to *1× mode*.
13. Change the pwm[0….8] register values and click the *Update* button.

2 EVM Software

EVM software is available for download from the Product Folder. The LP5569EVM is connected via USB to the computer and controlled with special EVM software (Windows 7 and 10 compatible). A *SimpleLink™ MSP432P401R LaunchPad™ Development Kit* is used with the EVM to provide I^2C communication and external PWM, EN, and INT pin control with the LP5569 device via USB.

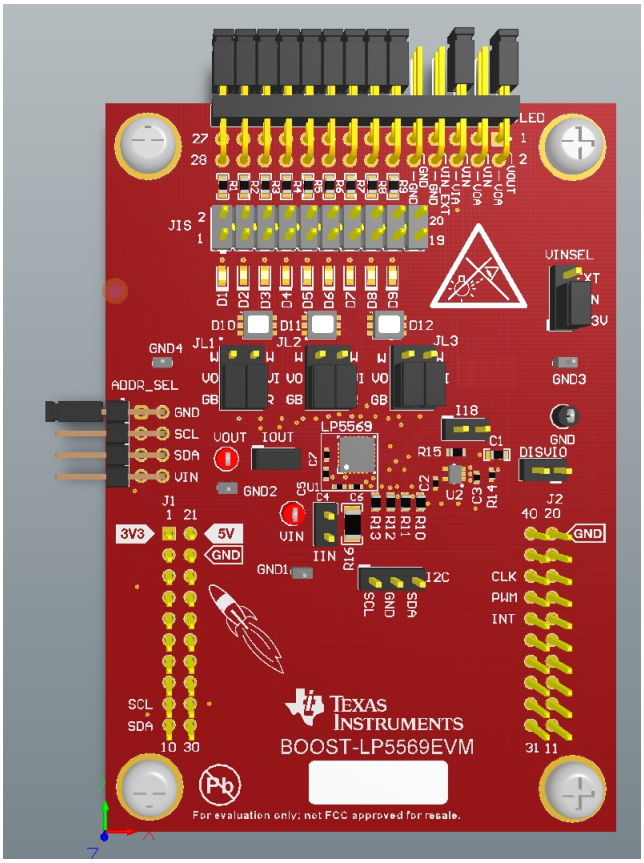


Figure 8. MSP432 LaunchPad Developmant Kit (MSP-EXP432P401R) and LP5569 EVM

2.1 EVM Software Installation

Execute the setup_LP5569_EVM.msi file. If it is compressed in zip file format, unzip first in any location, and then click the *Run* button even though the Windows security warning message appears. Click the *Next* button.

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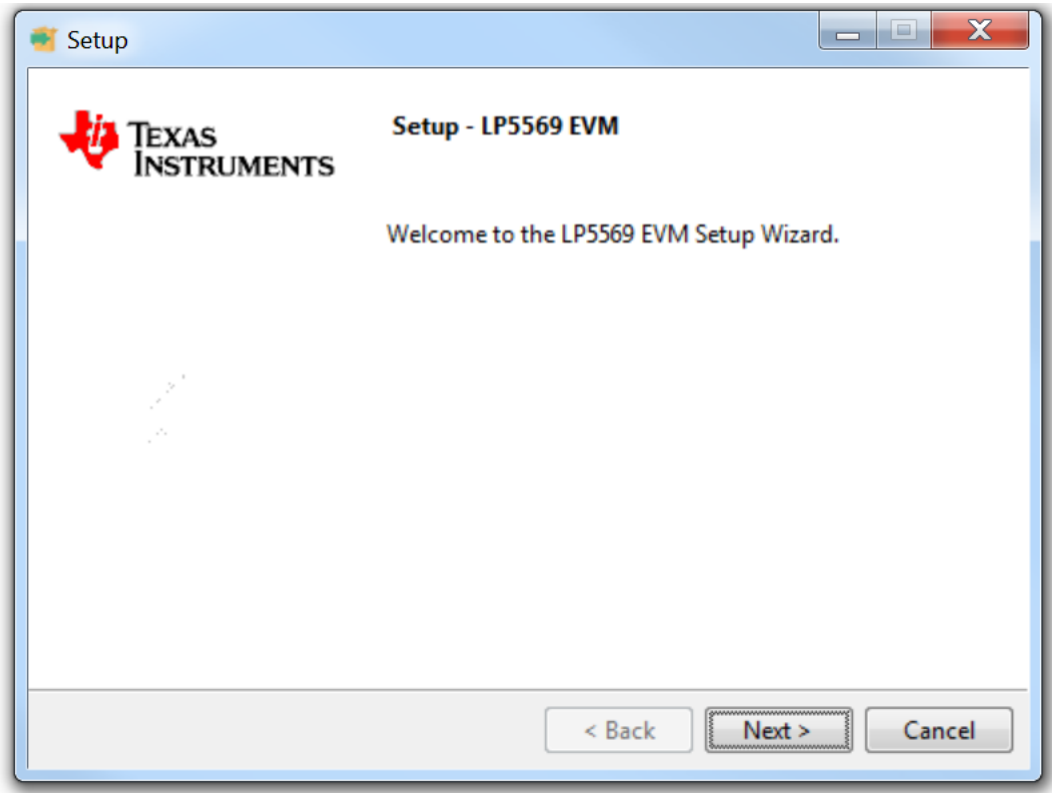


Figure 9. Setting Up the LP5569 EVM

Check to accept the agreement and click the *Next* button to proceed with the installation.

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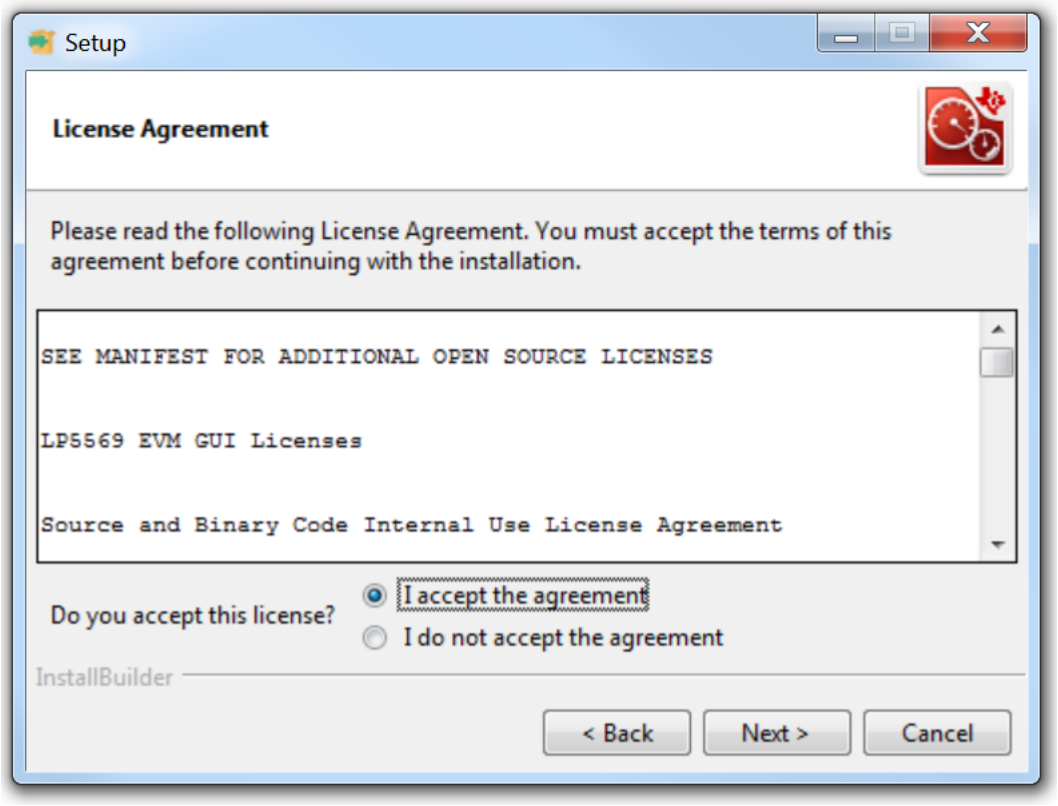


Figure 10. License Agreement

Click *Next* button. By default, the program is installed in the C:\Program Files (x86)\Texas Instruments\LP5569 folder and Texas Instruments\LP5569EVM in the start menu.

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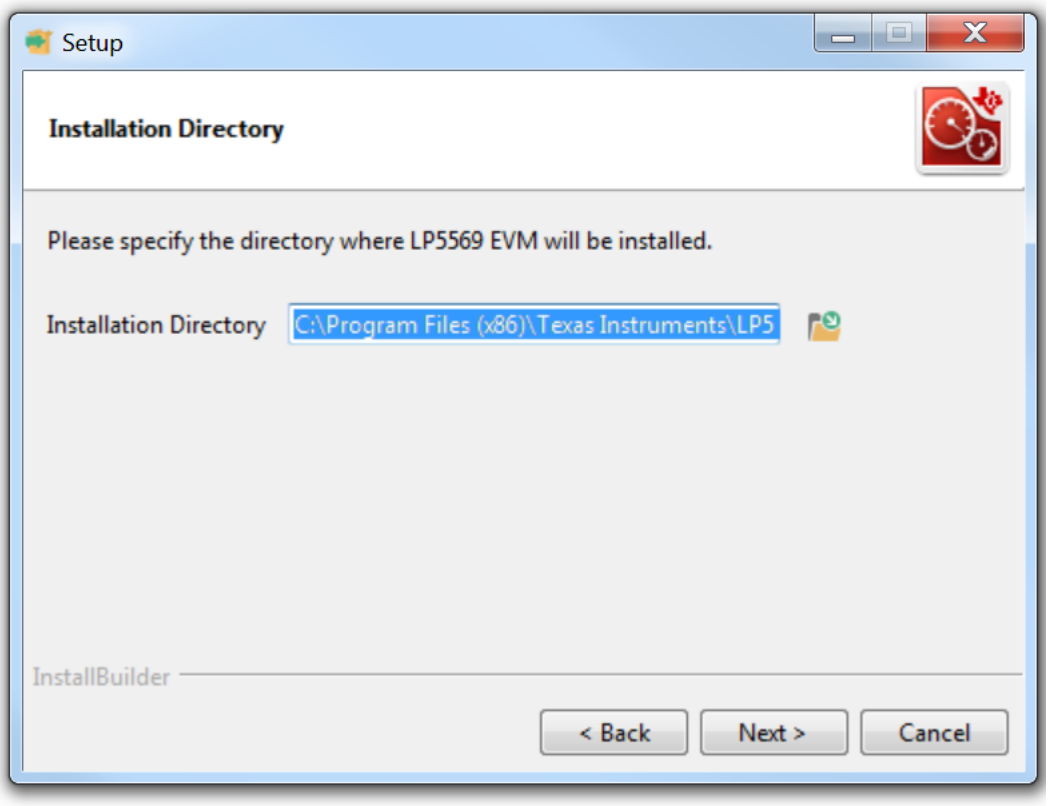


Figure 11. Installation Directory Dialog

Click the *Next* button to proceed with the installation.

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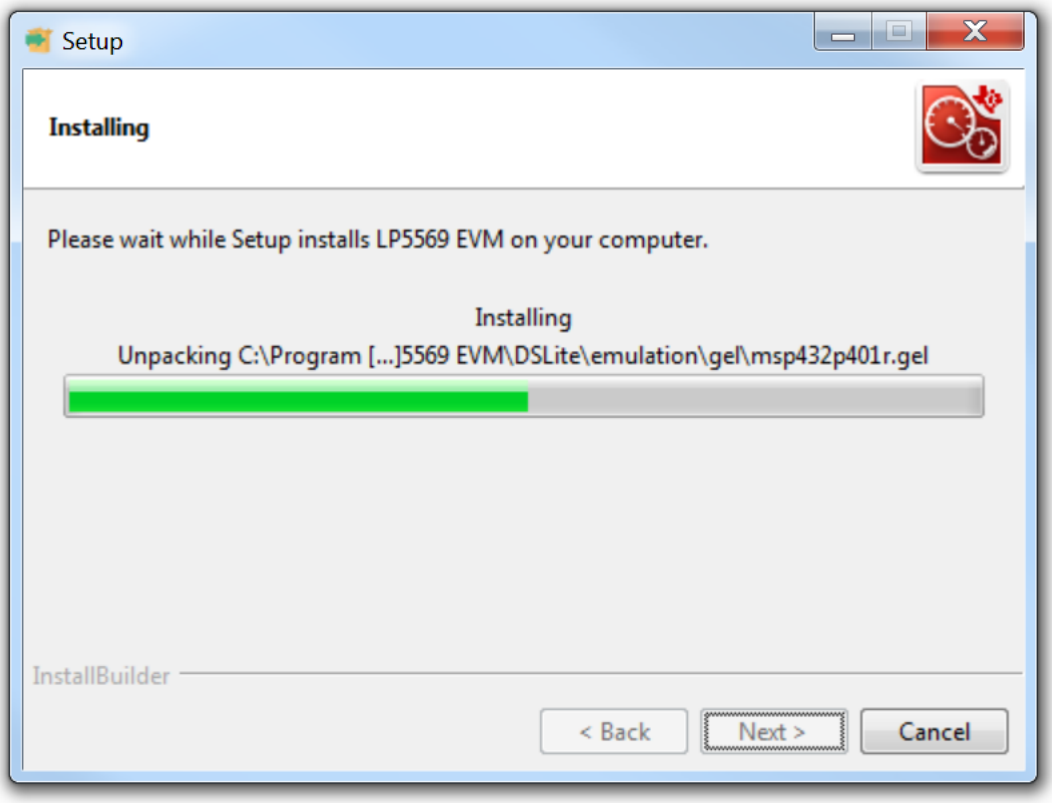


Figure 12. Installation Progress

Check to create a desktop icon for the program and check to launch the EVM software after installation.

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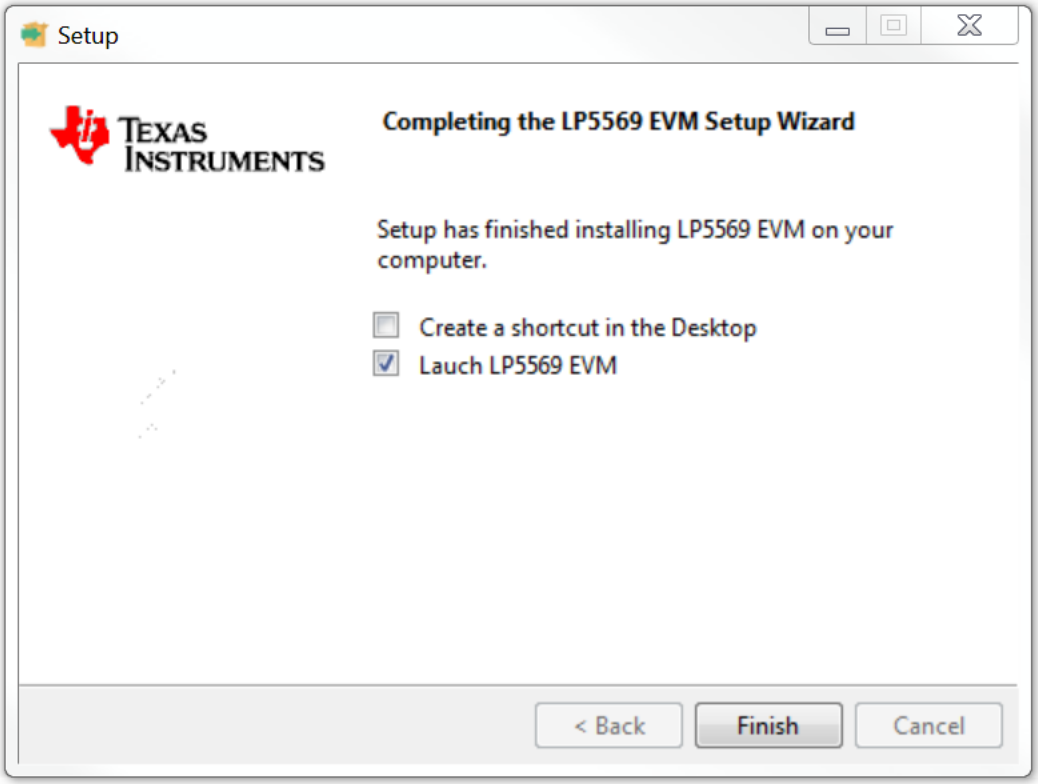


Figure 13. LP5569 Setup Wizard

2.2 XDS110 Driver Installation

The EVM software uses XDS110, a *back-channel* UART-over-USB connection, so it should be installed properly.

Connect the PC and MSP-EXP432P401R LaunchPad development kit using a USB cable and open the Device Manager of Windows (Control Panel→Device Manager). Verify that *XDS110 Class Application/User UART* and *XDS110 Class Auxiliary Data Port* appear.

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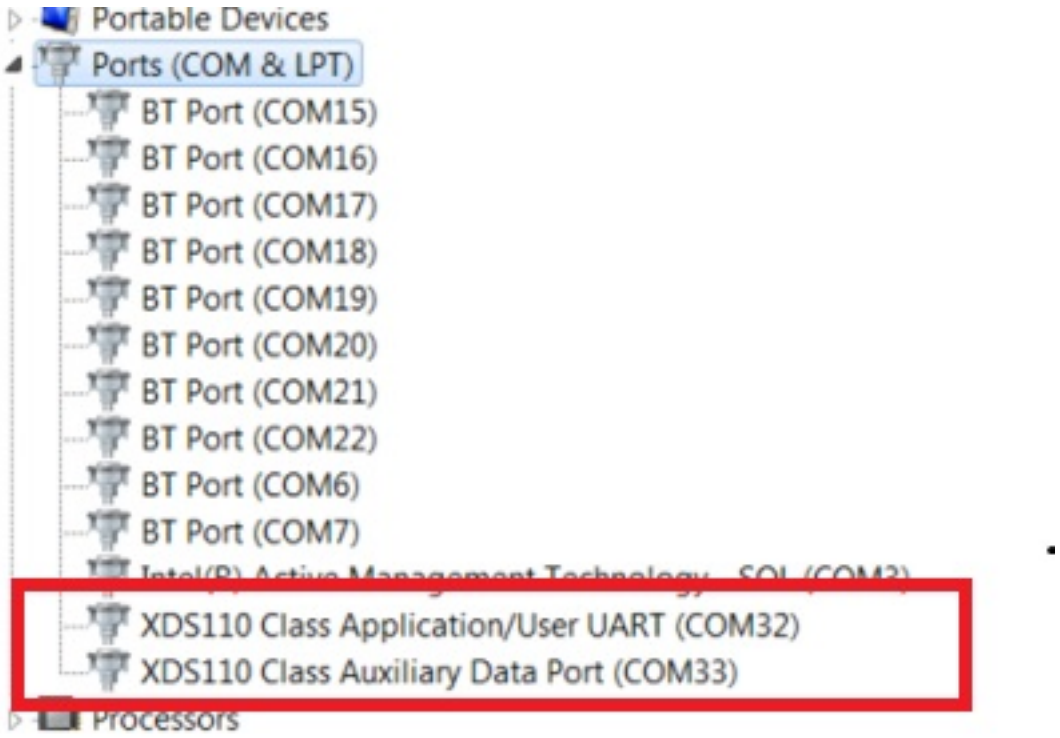


Figure 14. Verify XDS110 Driver

If they are shown as *USB Serial Device (COMx)*, the driver must be updated.

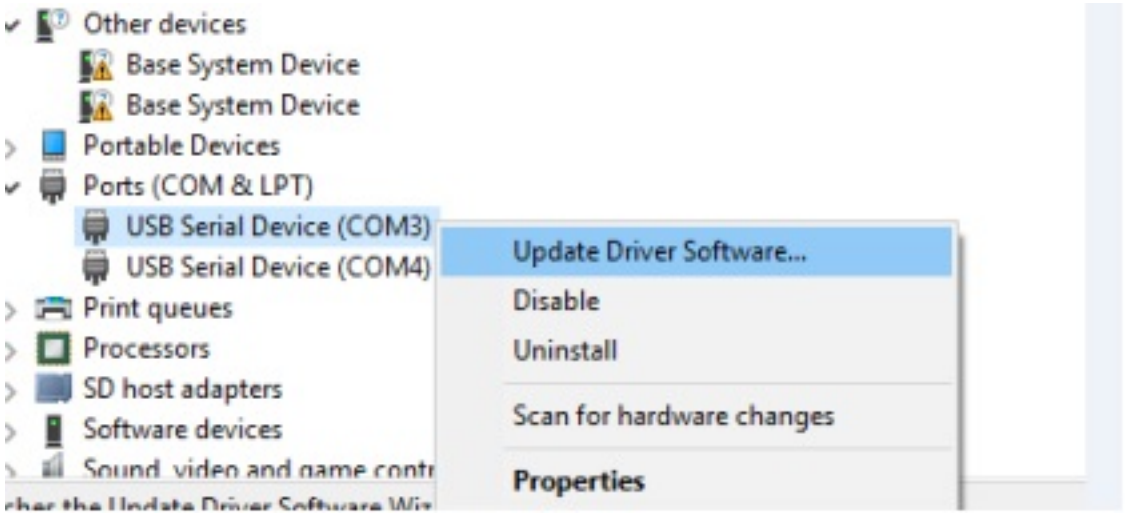


Figure 15. Driver Update

The XDS100 driver can be downloaded from *XDS Emulation Software Package*. If the EVM software is already installed in your computer, the driver software can be saved in the folder where the EVM software is already installed. The default EVM software installation folder is *C:\Program Files (x86)\Texas Instruments\LP5569 EVM*.

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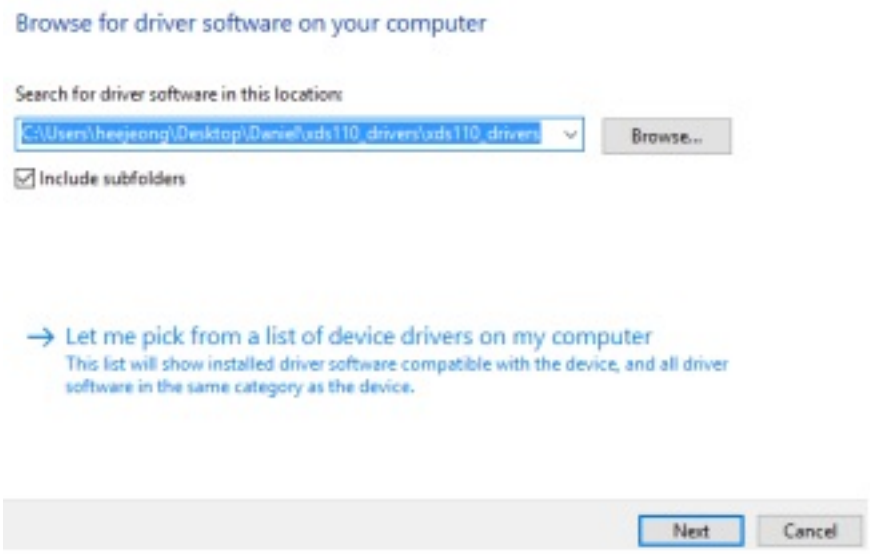


Figure 16. Driver Installation

2.3 EVM Software Launch

Run *C:\Program Files (x86)\Texas Instruments\ LP5569 EVM\LP5569_EVM.exe* if the default installation folder was not modified in the *EVM software installation* step or click the desktop icon, *LP5569_EVM*.

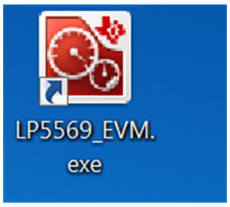


Figure 17. Desktop Icon

2.4 Update Firmware for MSP-EXP432P401R LaunchPad Development Kit

The MSP-EXP432P401R LaunchPad development kit can be used for many purposes. Therefore, if the LaunchPad development kit is a new one or was used for another purpose, the EVM software asks to update the firmware through a popup window.

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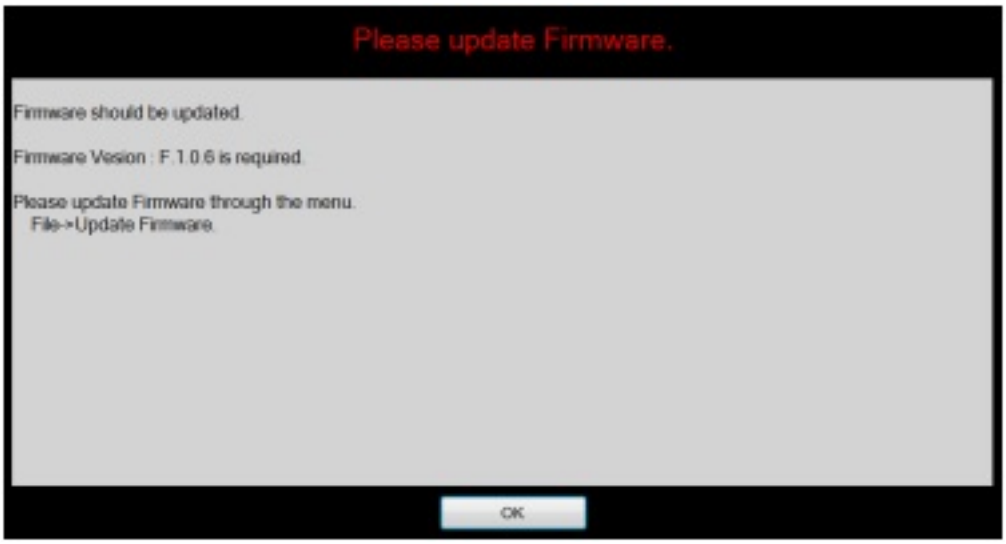


Figure 18. MSP432 Update Firmware

Firmware can be updated through the top menu, *FILE → FW Update*.



Figure 19. Firmware Update Menu

A firmware-download-status popup is displayed after finishing the firmware update.

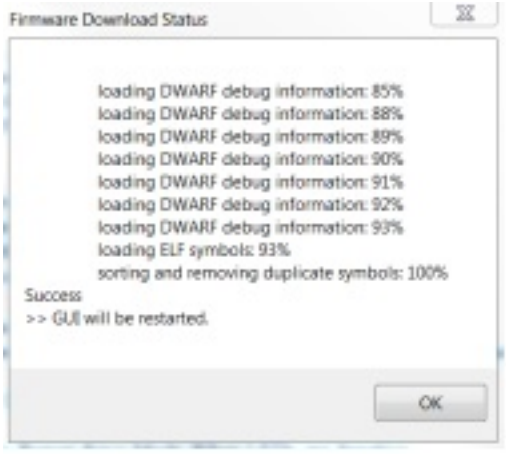


Figure 20. Firmware Download Status

The EVM software is restarted after updating the firmware.

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2.5 MSP432 Firmware Running

There are three LEDs on the MSP-EXP432P401R LaunchPad development kit, and if the firmware is working properly, the LED color is usually blue when there is no transaction between the firmware and the EVM software.



Figure 21. MSP432 LED

2.6 Main Menu

There are three available views on the main menu: *Info*, *Register*, and *Control*. The components in each view are synchronized so any changes performed in one view of the menu are automatically updated in the others.



Figure 22. Main Menu Icons

2.7 Status Bar

The status bar at the bottom of the EVM software screen provides information regarding hardware connection status, I^2C communication status, and software versions. Once the EVM software is connected to the hardware and starts to communicate with the firmware of the MSP432 LaunchPad development kit, the light blue sign *Hardware Connected* is displayed.



Figure 23. Status Bar (Hardware Connected)

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2.8 Information View

The information view is shown when the EVM software is started or the *Info* icon is clicked, and it provides brief information about the LP5569 device. For more-detailed information, see *LP5569 Nine-Channel I²C RGB LED Driver With Engine Control and Charge Pump*.

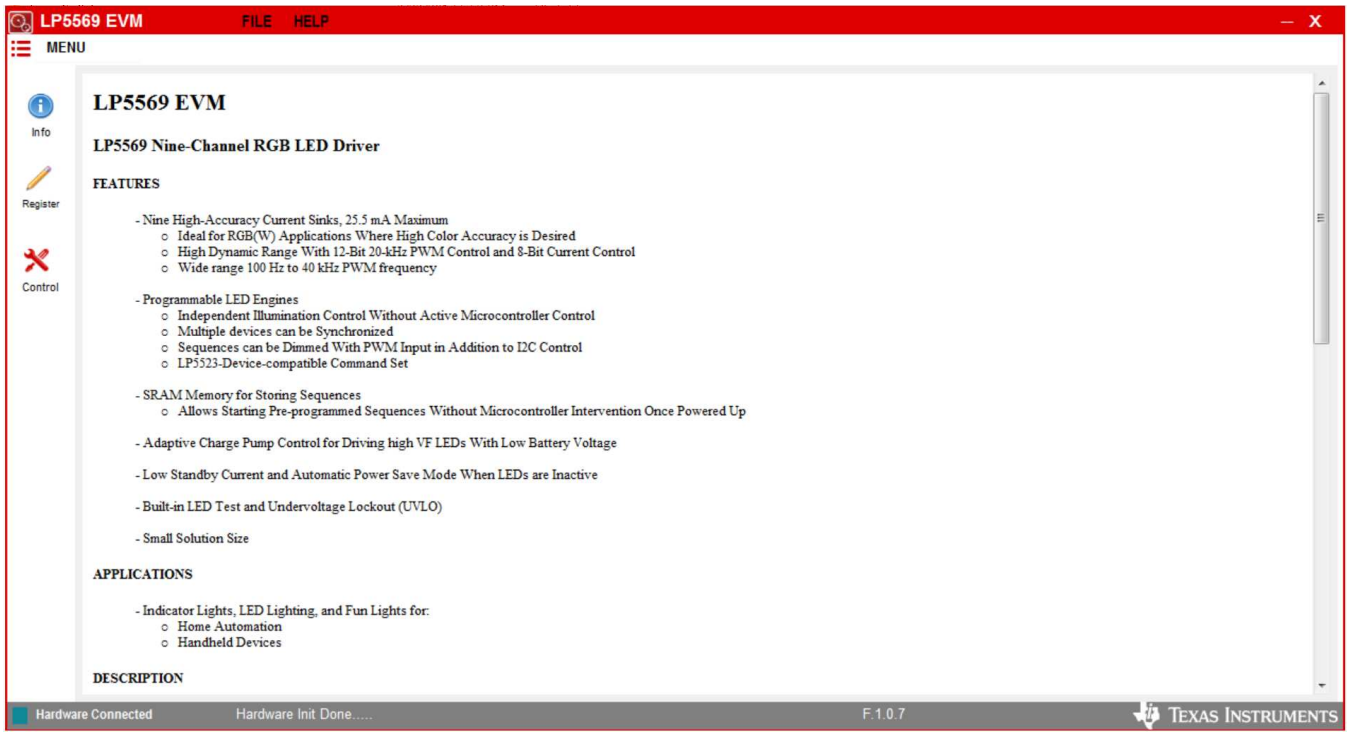


Figure 24. Information View

2.9 Register View

The register view is shown when the *Register* icon is clicked, and it provides the register values, field values, and descriptions.

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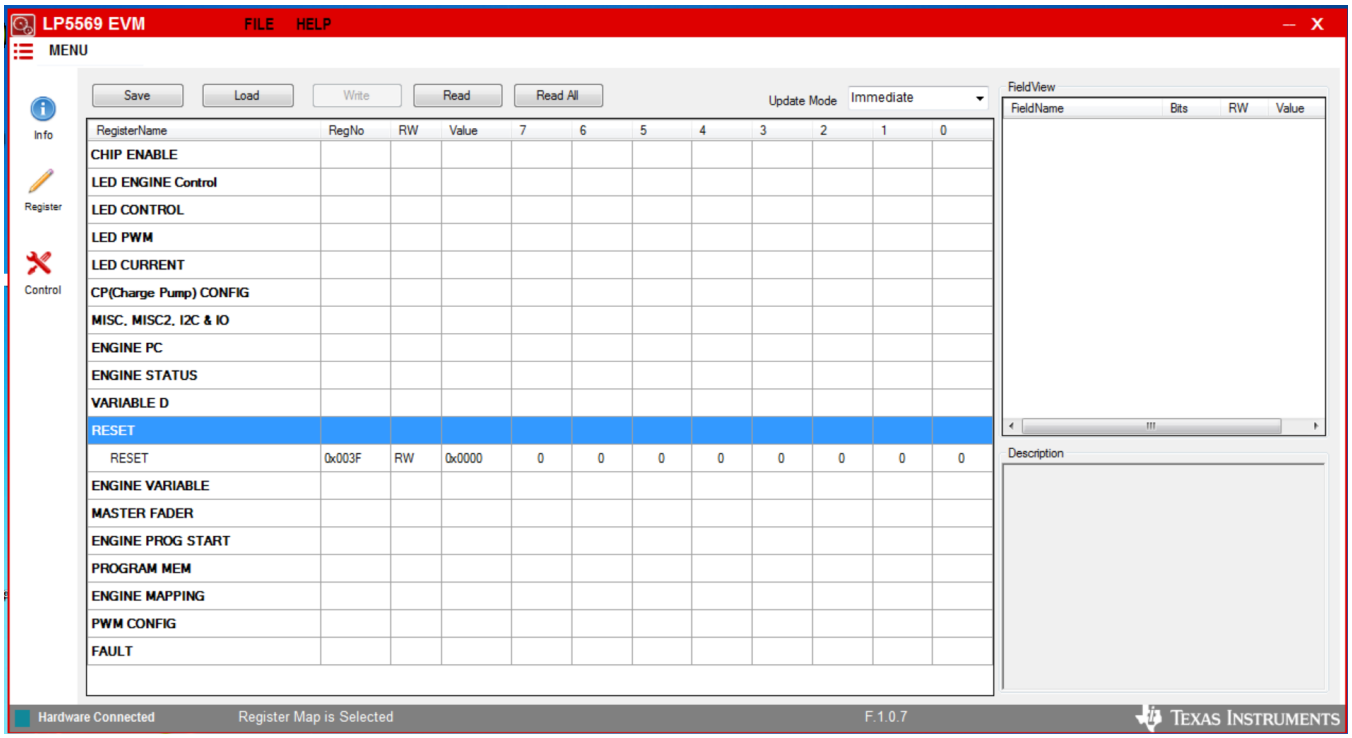


Figure 25. Register View (Collapsed)

Clicking on a bold text entry in the RegisterName column expands the register group to reveal all registers contained within the RegisterName group. Any RegisterName that is expanded can be collapsed by clicking on the RegisterName a second time.

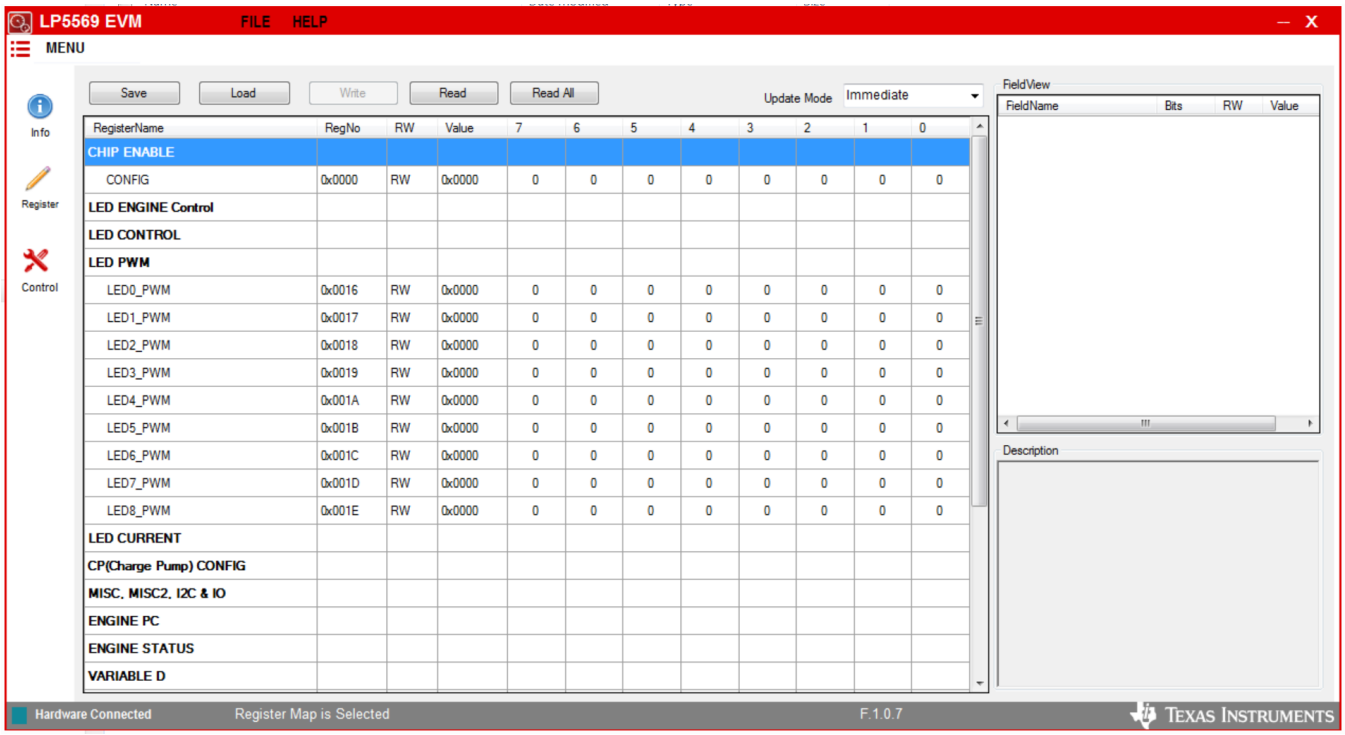


Figure 26. Register View (Expanded)

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Enter the desired hex value in the registers (*Current Value* column), perform a bit-wise configuration of any register fields by double-clicking on the corresponding register bit, or configure a register field by entering the desired hex value in the *Value* column located under *FieldView*. *FieldView* displays the description of all fields of the selected register. Each register can be read independently or all registers can be read at once by using the *Read* or *Read All* button, respectively. The data is written to the register(s) in one of two ways, depending on the *Update Mode* field selection: In *Immediate* mode, the register data is written immediately following a *Current Value* , an individual bit, or a *Value* change. In *Deferred* mode, the displayed data is written to all registers on depression of the *Write* button.

Press the *Read All* button to read back all the registers and update the values in this table. If any register value must be changed, simply double-click on the individual bit values to change the value in this table in immediate updated mode or press the *Write Register* button to write all the registers at a time if *Deferred* is selected instead of *Immediate* from the drop-down box.

Register settings can be saved in text-file format by selecting *Save Registers* from file menu.

A register settings file in text-file format can be loaded and programmed automatically by selecting *Load Register* from the file menu.

2.10 Control Menu

The *Control* view is shown when the *Control* icon is clicked, and provides easy ways to control registers and pin values.

There are five tabs available under the *Control* view: *Manual*, *Program*, *Code Memory*, *Source Edit*, and *Log*. The LP5569 registers are grouped by function with the description of each function being displayed in the lower right quadrant. When hovering the cursor over a check box, a drop-down dialog pops up a field describing the settings available. The *Control* view provides immediate mode only, unlike the *Registers* view which also provides deferred mode.

2.10.1 Control View – Common Controls

The GUI provides control of I²C slave-address selection, direct register access, EN/PWM pin control, and the external clock that is common to all five control screen tabs.



Figure 27. Common Controls

- I²C Slave Address Selection
  - The I²C slave addresses 0x32, 0x33, 0x34, 0x35, 0x40, 0x42, 0x43, 0x44, and 0x45 are available. The user must ensure that the slave address selected matches the jumper setting on the EVM ADDR_SEL header (see Figure 1).
- Direct Register Access
  - Register data can be accessed through the direct access group. The EN pin should be in the high state before reading or writing data though I²C.
- EN/PWM Pin Control
  - EN pin control. Red color means high, gray means low.
  - The EN pin can be used as PWM, and EVM software supports 500 Hz, 600 Hz, 700 Hz, 800 Hz, 900 Hz, and from 1 kHz to 20 kHz with 1-kHz steps.
  - When PWM is unchecked, the frequency, duty cycle, and update controls are gray (inactive). The PWM checkbox must be checked to activate the PWM signal from the MSP432 LaunchPad development kit and enable frequency and duty-cycle updates. The *Update* button must be clicked after any change to frequency or duty cycle.
- External Clock Control
  - External clock pin control. Red color means that a 32.7-kHz external clock is operating.

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Figure 28 illustrates the GUI *Read all registers* prompt which appears after setting the chip_en bit in the CHIP_EN register.

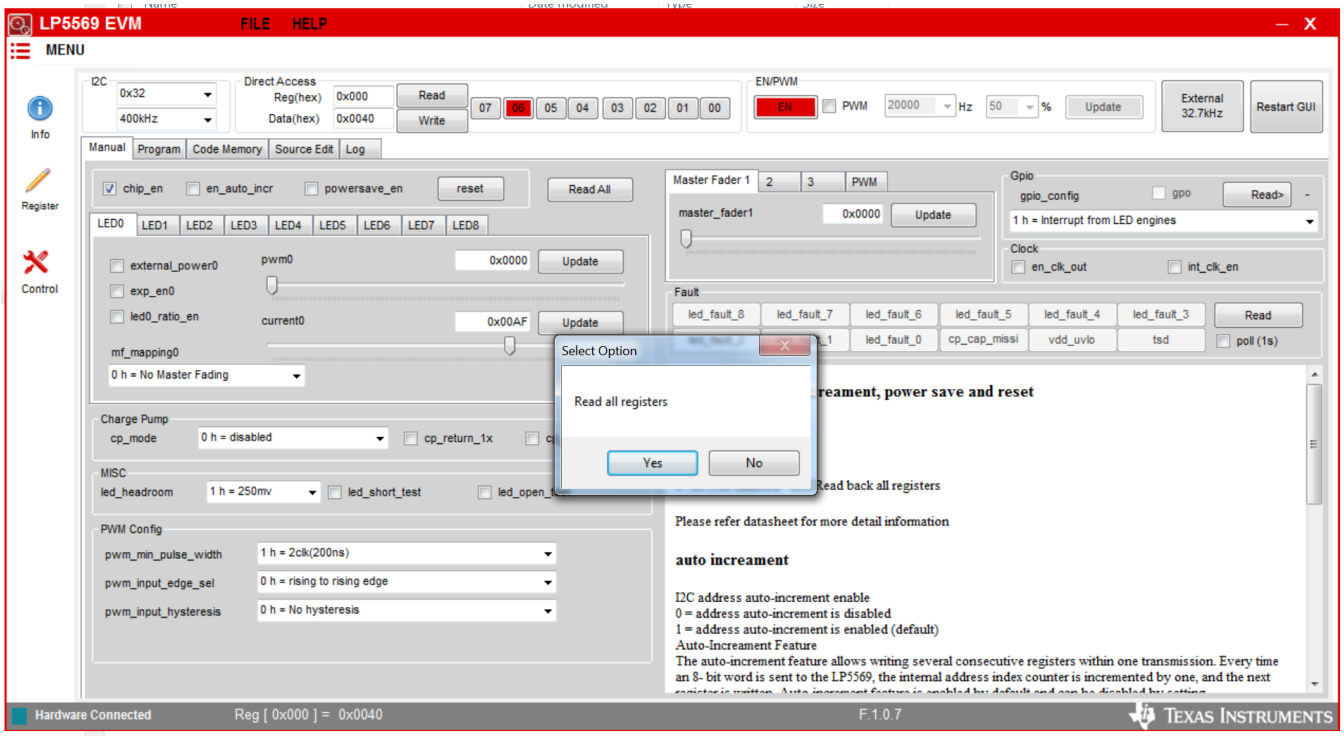


Figure 28. Control View (Manual Tab)

2.10.2 Chip Enable and MISC Setting

The chip_en bit of the CONFIG register can be written by clicking the chip_en check box, and a popup window is shown to read all registers after writing the chip_en bit. Note that the EN pin should be high before accessing registers. The en_auto_incr bit and powersave_en bit of the MISC register can be controlled also.

2.10.3 Direct LED Current and PWM Control

There are nine tabs to control each LED from LED0 to LED8. The external_power(x), exp_en(x), led(x)_ratio_en and mf_mapping(x) bits of the LED(X)_CONTROL register can be controlled. The pwm(x) bit of the LED(X)_PWM register and the current(x) bit of the LED(X)_CURRENT register can also be adjusted. Regarding pwm(x) and current(x), an *Update* button click is required to write data through I^2C after changing the value by using the slide bar or text box.

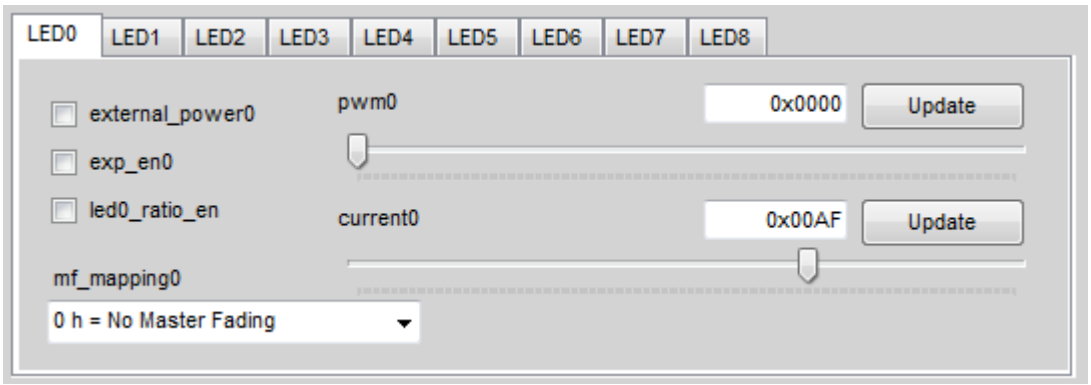


Figure 29. LED ON-OFF Control

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2.10.4 Charge Pump Control

The charge pump mode, cp_return_1x and cp_dis_dischg settings in registers MISC and MISC2 are configured within this group.

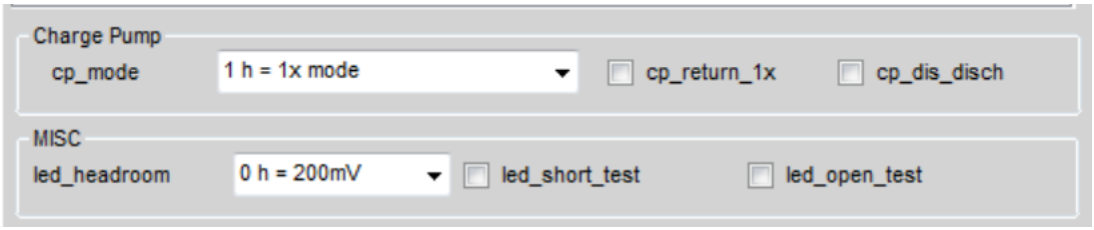


Figure 30. Charge Pump Control Information

2.10.5 PWM Control

The PWM group box provides information and control of the CONFIG_PWM register (0x00) and external PWM signal generation.

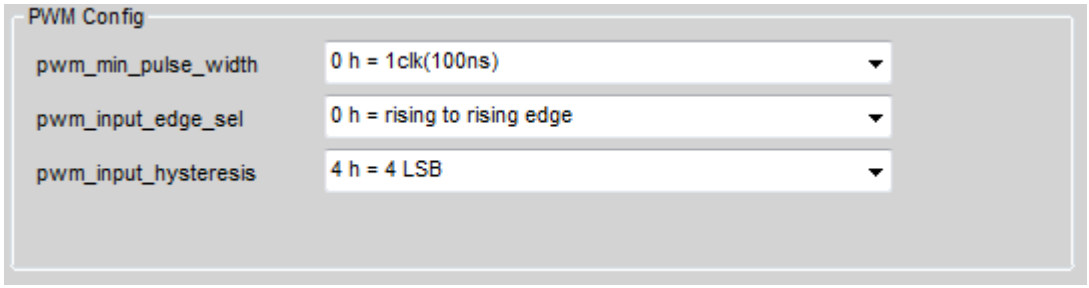


Figure 31. PWM Register Information

2.10.6 GPIO Control

The gpo and gpio_config bits of the IO_CONTROL register can be controlled. The check box for gpo is enabled only when the gpio_config bits are set to 2h or 3h, whereas the *Read*> button to read the current status of pin is available only when the gpio_config bits are set to 0h or 1h.

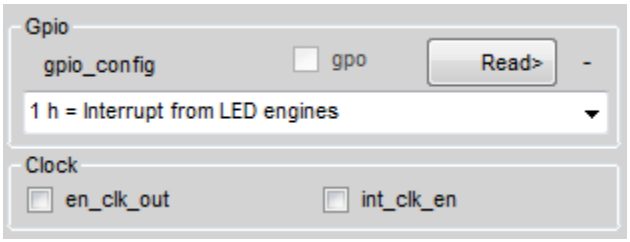


Figure 32. Interrupt Status/Mask/Clear

2.10.7 Fault Status

The LED_FAULT1, LED_FAULT2, and GENERAL_FAULT registers can be read by clicking the read button or selecting the poll check box. The polling time to read the fault registers is 1s.

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2.11 Control View – Program Tab

The Program tab on the control view provides the interfaces to load the compiled file, upload or download a program to or from the device, and control each engine. The Program tab is divided into two parts: the right part contains the compiled version of the code; the left part contains program execution-engine controls.

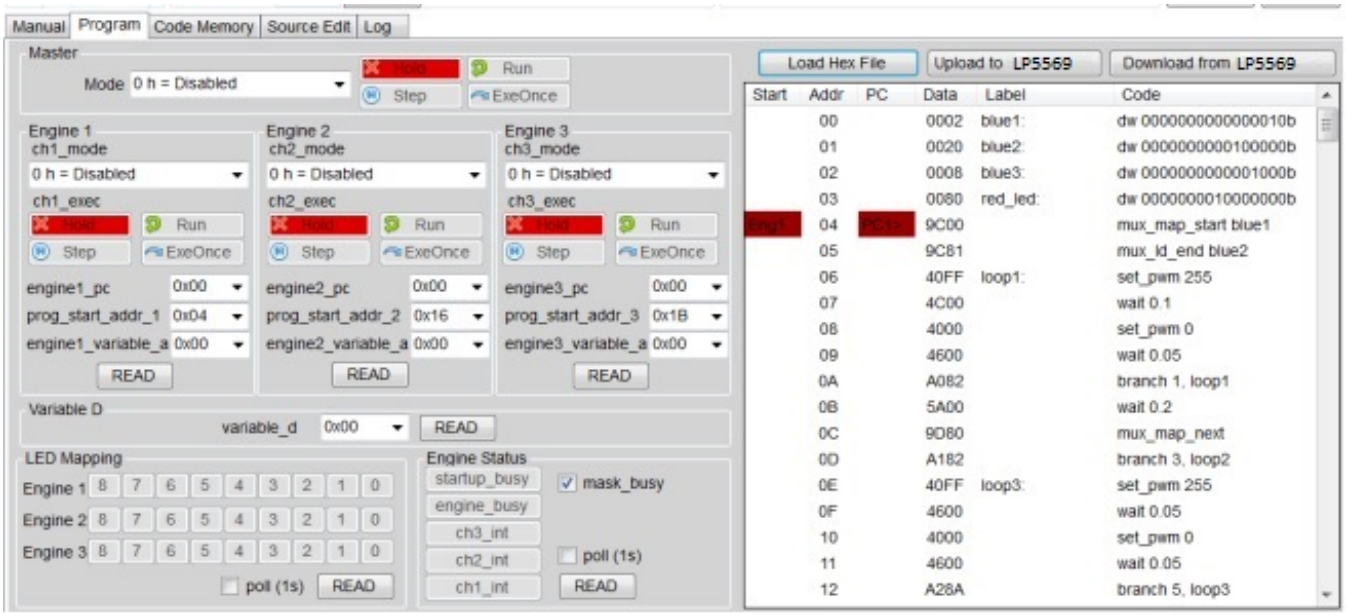


Figure 33. Program Tab

2.11.1 Load Hex File

The generated *.hex file can be loaded by clicking the *Load Hex File* button, browsing the file and clicking *Open*. The hex data is shown in the Data column and the *Code Memory* tab. If there are *.src file and *.lst files in same file path with the *.hex file, more data is displayed in the *Label* and *Code* columns and *Source Edit* Tab.

2.11.2 Upload to LP5569

The loaded hex data can be uploaded to the chip by clicking the *Upload to LP5569* button.

2.11.3 Download From LP5569

The data on the chip can be downloaded to EVM software by clicking the *Download from LP5569* button.

2.11.4 Master Operating Mode

The operation mode is set by selecting the desired value on the drop-down box. Operation modes include:

- Disable—Engine operation is disabled and the engines cannot be run.
- Load Program to SRAM—In this mode, writing to program memory is allowed. While one or more engines are in the load-program mode. all the three engines are placed in Hold until the loading is complete.. PWM values are also frozen. Program execution continues when all the engines are out of the load-program mode. The load-program mode resets the program counter of the respective engine. The load-program mode can be entered from the disabled mode only. Entering the load-program mode from the run-program mode is not allowed. Note that the load-program mode does not automatically load the program opened with the *Load Hex File* button. When using this operation mode, one must write the program through the *Code Memory* tab.
- Run Program—This mode executes the instructions stored in the program memory. Execution register (ENG1_EXEC, and so forth) bits define how the program is executed (hold, step, free run, or execute

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once). The program start address can be programmed into the Program Counter (PC) register. The program counter is reset to zero when the upper limit value of the PC is reached.

- Halt—In this mode, instruction execution aborts immediately and engine operation halts. Execution can be continued if the operation mode is set to Run again.

2.11.5 Run Mode for Engines 1, 2, and 3

Each LED engine has four execution modes. The execution mode is selected by clicking one of the four push-buttons. Functions of the buttons from left to right are:

- Hold—Engine execution is stopped. The current instruction is executed and then execution stops.
- Step—Execute the instruction at the location pointed to by the program counter, increment the program counter by 1 and then reset ENG1_EXEC bits to 00 (enter the hold mode).
- Free Run—Start program execution from the instruction pointed to by the program counter.
- Execute Once—Execute the instruction pointed to by the current program counter value and reset.

ENG1_EXEC to 00 (for example, enter Hold mode). The difference between Step and Execute Once is that Execute Once does not increment the program counter.

2.12 Control View – Code Memory Tab

The *Code Memory* tab on the control view provides the interfaces to read or write data from or to SRAM pages.

Manual | Program | Code Memory | Source Edit | Log

Read Page | Write Page | Read All Pages | Write All Pages

	Page00	Page01	Page02	Page03	Page04	Page05	Page06	Page07	Page08	Page09	Page10	Page11	Page12	Page13	Page14	Page15
cmd00	0002	4000	40FF	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd01	0020	4600	4600	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd02	0008	A28A	4000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd03	0080	9D80	7A00	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd04	9C00	A18A	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd05	9C81	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd06	40FF	9F83	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd07	4C00	7A00	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd08	4000	08FF	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd09	4600	11FF	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd10	A082	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd11	5A00	9C02	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd12	9D80	40FF	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd13	A182	4600	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd14	40FF	4000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
cmd15	4600	5A00	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000

Figure 34. Code Memory Tab

The code memory tab supports read/write to a single page or read/write of all pages. These operations are described in the following list:

- Read Page—A single page can be read from the device. Select the row of the desired page and click the *Read Page* button.
- Write Page—A single page can be written to the device. Select the row of the desired page and click the *Write Page* button.
- Read All Pages—All pages from 0 to 15 can be read by clicking the *Read All Pages* button.
- Write All Pages — All pages from 0 to 15 can be written by clicking the *Write All Pages* button.

2.13 Control View – Source Edit Tab

The *Source Edit* tab on the control view provides the interfaces to create or edit a source file and compile.

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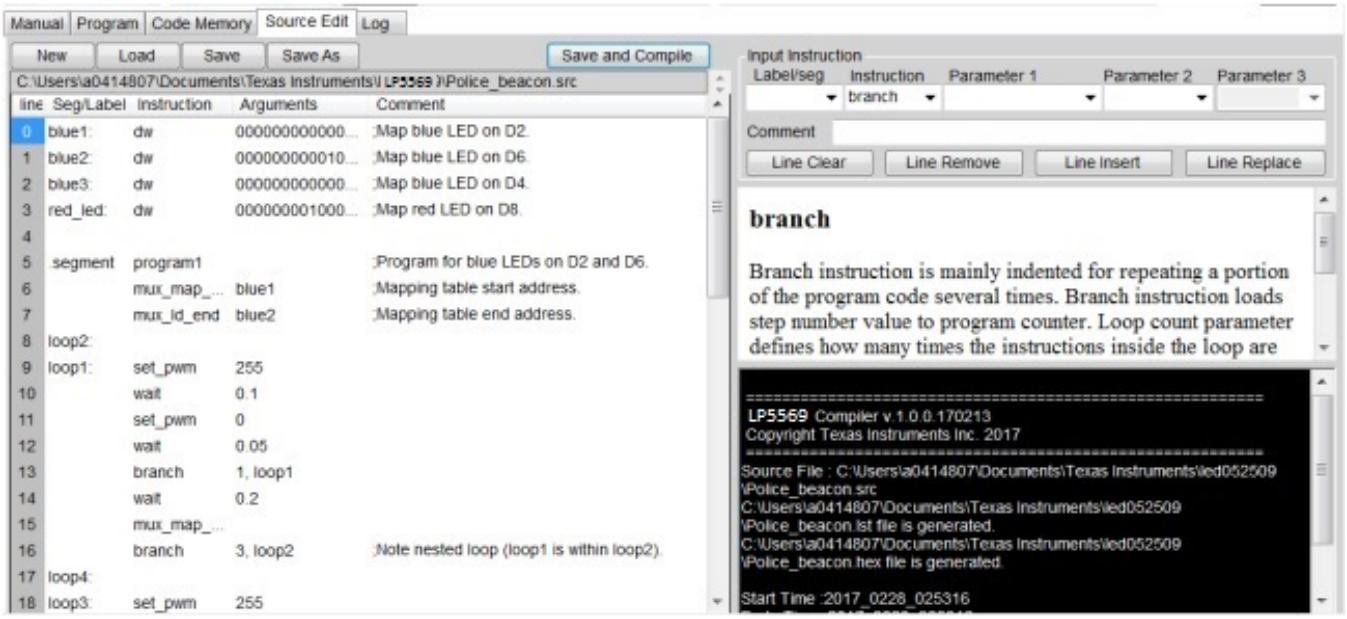


Figure 35. Source Edit Tab

2.13.1 New Source File

A new source file can be created by clicking the *New* button, browsing to a folder, selecting the file name and clicking *Save*. The default target folder is C:\Users\[User Name]\Documents\Texas Instruments\lp5569.

2.13.2 Load Source File

An existing source file can be loaded by clicking the *Load* button, browsing to the folder, selecting the file name and clicking *Open*. The default target folder is C:\Users\[User Name]\Documents\Texas Instruments\lp5569.

2.13.3 Save (As) Source File

An edited source file can be saved by clicking the *Save* button. The *Save As* button saves the file under a new name.

2.13.4 Compile Source File

An edited or loaded source file can be compiled by clicking the *Save and Compile* button. The result of compilation from the assembler (lasm.exe) is displayed on the Compile Log area.



Figure 36. File List After Compilation

2.13.5 Input Instruction

A source file can be edited using the interfaces on the *Input Instruction* group.

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- *Seg/Label* supports predefined label names and .segment directives. If a .segment directive is selected, the Instruction supports only three options (program1, program2, program3).
- Instruction provides all available instructions. If an instruction is selected, parameter1, parameter2, and parameter3 are enabled according to the type of instruction and the available parameters should be provided. The detailed instruction format and examples are displayed.

2.13.6 Line Clear

The selected line is cleared but not removed.

2.13.7 Line Remove

The selected line is cleared and removed.

2.13.8 Line Insert

Seg/Label, Instruction, *Parameters*, and *Comment* data are inserted into the selected line.

2.13.9 Line Replace

The selected line is replaced by the *Seg/Label*, *Instruction*, *Parameter*s, and *Comment* data.

2.14 Control View – Log Tab

The *Log* tab on the control view provides the history regarding I^2C read/write, file access, and so forth.

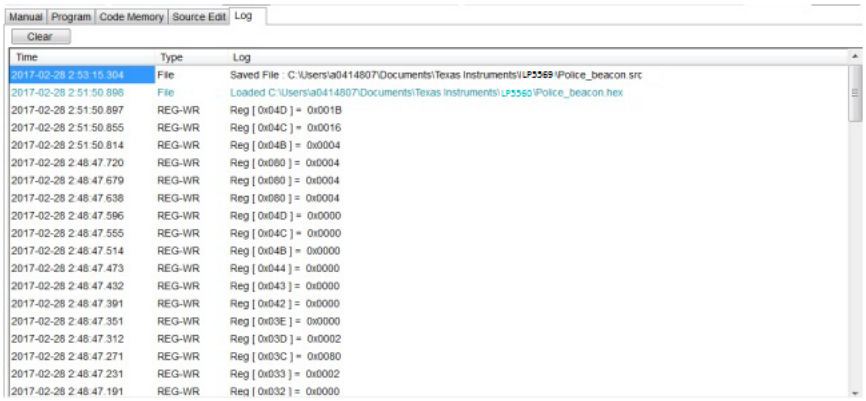


Figure 37. Log Tab

2.15 Console

A predefined macro file can be executed using the *Console* window (see Figure 38). The *Console* window can be opened by selecting Help→Console. The predefined macro file should be saved in .txt file format, and it can be loaded and executed by clicking the *Load File* button. The default folder path is *C:\Users\[ID]\Documents\Texas Instruments\ lp5569*.

Table 2. Macro Instructions

MACRO SYNTAX	FUNCTION	EXAMPLE
REGISTER_NAME()	Register read REGISTER_NAME must be the same as the register map on the GUI (see Figure 26)	>CONFIG(); read CONFIG(0x00) register
REGISTER_NAME(hex_data)	Register write REGISTER_NAME must be the same as the register map on the GUI	CONFIG(0x40); write CONFIG
FIELD_NAME()	Field read FIELD_NAME must be same as the register map on the GUI	exp_en0(); read exp_en0 bit

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Table 2. Macro Instructions (continued)

MACRO SYNTAX	FUNCTION	EXAMPLE
FIELD_NAME(hex_data)	Field write FIELD_NAME must be same as the register map on the GUI	exp_en0(0x1); write exp_en0 bit
read_all()	Read all registers	read_all(); real all registers from chip
i2c_addr(hex_addr)	Set slave address	i2c_addr(0x32); use 0x32 slave address
en_pin(high/low	Enable pin control to low or high	en_pin(high); set en pin to high en_pin(low); set en pin to low
ext_clk(on/off)	External clock control to on or off	ext_clk(on); set ext_clk on ext_clk(off); set ext_clk off
wait(time_ms)	Wait time in ms	wait(1000); wait 1s
repeat(number_of_loop) { …… }	Loop for repeated macro execution	repeat(10); repeat 10 times {en_pin(high); en pin set to high chip_en(0x01); set chip_en bit to 1 read_all(); read all regsiters wait(1000); en_pin(low); en pin set to low}



Figure 38. Console Window

```
1
2  i2c_addr(0x32)        ; set i2c address
3
4  repeat(10)            ; test it 10 times
5  {
6    en_pin(high)        ; enable pin set to high
7
8    CONFIG()            ; read CONFIG register
9    exp_en0()           ; read exp_en0 bit
10   read_all()          ; read all resgiters
11
12   ext_clk(on)         ; external clcok on
13
14   exp_en0(0x1)          ; write exp_en0 bit to 0x1
15   CONFIG(0xff)        ; write CONFIG register 0xff
16
17   en_pin(low)         ; enable pin low
18   ext_clk(off)        ; external clock off(input no-pull)
19
20   wait(500)           ; wait 500ms
21
22   clear()             ; log clear
23 }
```

Figure 39. Macro File

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3 LP5569 Programming

3.1 Programming Flow Chart

Figure 40 shows the typical programming flow of the LP5569 device. The program is first typed in with the *Source Edit* tab of the EVM software or with the PSPad (or equivalent) text editor (See *AN-2227 LP5523 Evaluation Kit* regarding PSPad usage.) Then the program is compiled into hex and binary files. Finally, the hex file is loaded into the LP5569 memory and tested.

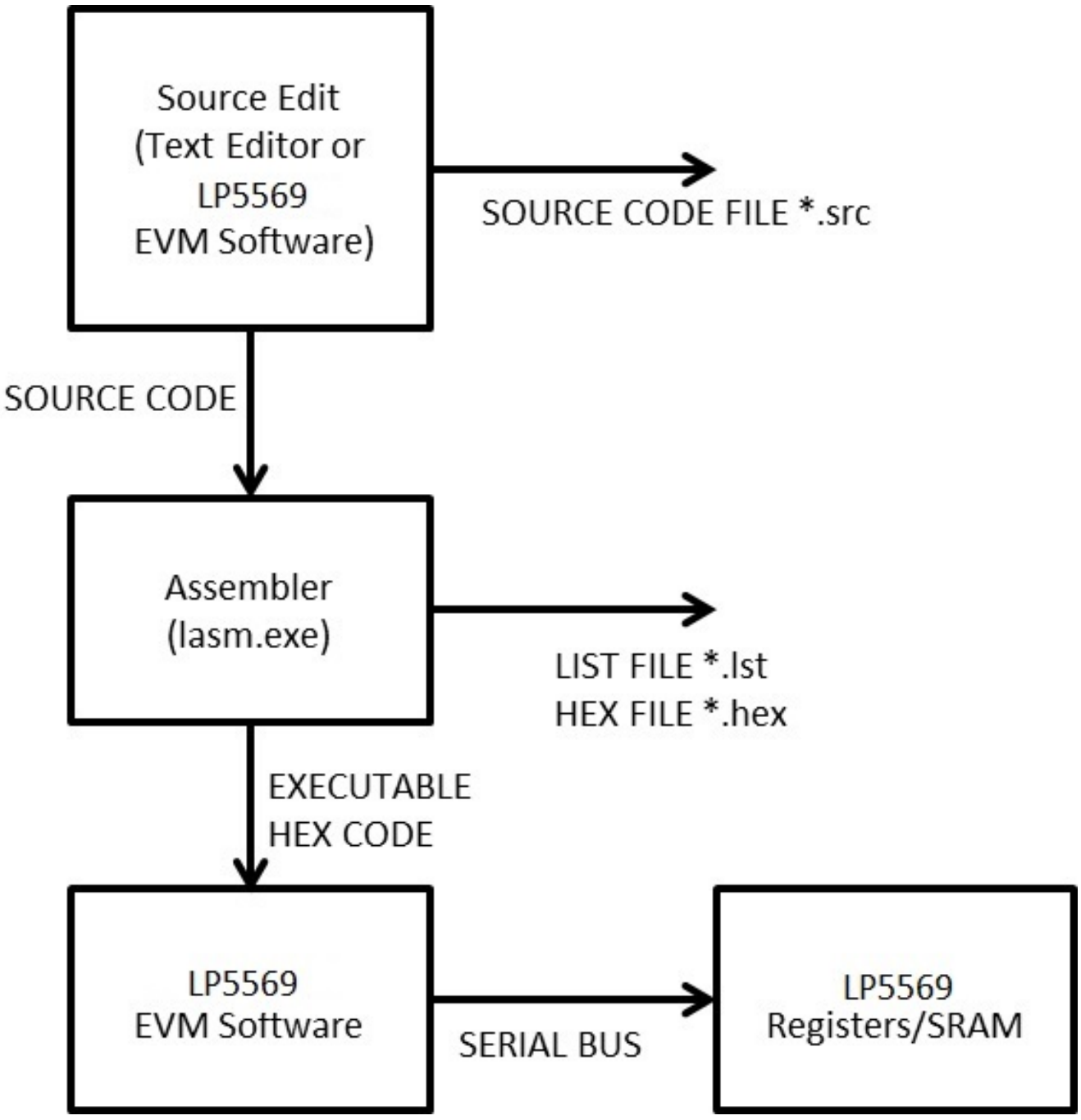


Figure 40. Programming Flow Chart

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3.2 Reserved Keywords

The names of registers and instructions are assembler-reserved keywords. For the LP5523 device, the following words are reserved and may not be used as statement labels:

Register names :

- ra
- rb
- rc
- rd

Instructions:

- add
- branch
- end
- int
- je
- jge
- jl
- jne
- ld
- load_addr
- load_end
- load_next
- load_prev
- load_start
- map_addr
- map_clr
- map_next
- map_prev
- map_sel
- map_start
- ramp
- rst
- set_pwm
- sub
- trig_clear
- trigger
- wait

Directives:

- ds
- dw
- .segment

3.3 Commenting

Commenting starts with a semicolon (;). The assembler ignores all characters after a semicolon.

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3.4 Directives

The directives are not translated directly in the LP5569 device. Instead, directives are instructions for the LASM.exe assembler. Directives are used to adjust the location of the engine 1, 2, and 3 programs in memory and reserve memory resources in the LP5569 SRAM. For example, .segment program1 is a directive which tells the assembler that whatever follows is the program for the program execution engine 1. An overview of the directives is given in the following table.

Table 3. Directives

DIRECTIVE	DESCRIPTION	EXAMPLE SOURCE CODE
.segment	Adjust the location of the programs in SRAM. Note the leading dot segment name of engine1 is program1 segment name of engine2 is program2 segment name of engine3 is program3	.segment program1 .segment program2 .segment program3
ds	Define Storage. The directive reserves memory resources in the SRAM. The ds directive takes one parameter, which is the number of words to reserve. The number of bits in a word (word length) is 16. The allocated words are initialized with zeros.	ds 3 ds 17
dw	Define constant Word. Inserts a binary word to the SRAM.	dw 0000000011111111b dw FFABh dw 3

3.5 Labels

A label is a symbolic address. Labels are used to mark program line(s), like in a branch instruction or when labeling rows in amapping table. Labels must have the colon (:) suffix.

Table 4. LED Driver Instructions

INSTRUCTION SYNTAX	FUNCTION	EXAMPLE	16-BIT ASSEMBLED BIT SEQUENCE	ASSEMBLED CODE (HEX)
ramp time, PWM Time is a positive constant (0.000484 × PWM); PWM is a positive or negative constant (–255 to 255). Note: time is rounded by the assembler if needed.	Output PWM with increasing or decreasing duty cycle.	ramp 0.6, 255; Ramp up to full scale over 0.6 s.	0000 1010 1111 1111	0AFF
		ramp 1.2, –255; Ramp down to zero over 1.2 s.	0001 0101 1111 1111	15FF
ramp var1, prescale, var2 Var1 is a variable (ra, rb, rc, rd); Prescale is a boolean constant (pre=0 or pre=1); Var2 is a variable (ra, rb, rc, rd).	Output PWM with increasing or decreasing duty cycle.	ld ra, 31 ld rb, 255 ramp ra, pre=0, +rb; Ramp up to full scale over 3.9 s.	1000 0100 0000 0001	8401

		ld ra, 1; ld rb, 255p;
		ramp ra, pre=0, -rb;
		Ramp down to zero over 0.12 s.
			1000 0100 0001 0001	8411

set_pwm PWM PWM is a constant (0–255 or 0–FFh).	Generate a continuous PWM output.	set_pwm 128; Set PWM duty cycle to 50%.	0100 0000 1000 0000	4080
set_pwm var1 Var1 is a variable (ra, rb, rc, rd).	Generate a continuous PWM output.	ld rc, 128; set_pwm rc; Set PWM duty cycle to 50%.	1000 0100 0110 0010	8462
wait time Time is a positive constant (0 to 0.484). Note: time is rounded by assembler if needed.	Pause for some time.	wait 0.25; Wait 0.25 seconds.	0110 0000 0000 0000	6000

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3.6 Instruction Set Details

Instructions are executable statements. The LASM assembler translates text-based language source instructions into hex-based executable codes. This section provides the syntax with detailed examples for all the LP5569 instructions supported by the LASM assembler.

Table 5. LED Mapping Instructions

INSTRUCTION SYNTAX	FUNCTION	EXAMPLE	16-BIT ASSEMBLED BIT SEQUENCE	ASSEMBLED CODE (HEX)
load_start address Address is a label which specifies where to find the first row.	Defines the start address of the mapping-data table. The mapping-data-table start address is restricted to the lower half of memory.	load_start row1 ; The first row can be found at the address marked with row1.	1001 1110 0000 0000 Assumed that row1 points to addr 00h.	9E00
map_start address Address is a label which specifies where to find the first row.	Defines the start address of the mapping-data table and sets the row active.	map_start row1 ; The first row can be found at the address marked with row1.	1001 1100 0000 0000	9C00
load_end address Address is a label which specifies where to find the first row.	Defines the last address of the mapping-data table. The mapping-data-table end address is restricted to the lower half of memory.	load_end row9 ; The last row can be found at the address marked with row9.	1001 1100 1000 1000	9C88
map_sel output Output is a constant (0 to 9); 10 through 127 = no drivers selected.	Connects one and only one LED output to an engine.	map_sel 1 ; D1 output is connected to the engine.	1001 1101 0000 0001	9D01
map_clr	Clears engine-to-driver mapping.	map_clr	1001 1101 0000 0000	9D00
map_next	Sets the next row active in the mapping table.	map_next	1001 1101 1000 0000	9D80
map_prev	Sets the previous row active in the mapping table.	map_prev	1001 1101 1100 0000	9DC0
load_next	The index pointer is set to point to the next row in the mapping-data table.	load_next	1001 1101 1000 0000	9D81
load_prev	The index pointer is set to point to the previous row in the mapping-data table.	load_prev	1001 1101 1100 0000	9DC1
load_addr address Address is a label which specifies the row to which the pointer is to be moved.	Sets the index pointer to point to the mapping-data-table row defined by address. An SRAM address containing mapping data is restricted to lower half of memory.	load_addr row2	1001 1111 0000 0001	9F01
map_addr address Address is a label which specifies the row to which the pointer is to be moved.	Sets the index pointer to point to the mapping-data-table row defined by address and sets the row active. An SRAM address containing mapping data is restricted to lower half of memory.	map_addr row2	1001 1111 1000 0001	9F81

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Table 6. Branch Instructions

INSTRUCTION SYNTAX	FUNCTION	EXAMPLE	16-BIT ASSEMBLED BIT SEQUENCE	ASSEMBLED CODE (HEX)
rst	Resets program counter and starts the program again.	rst	0000 0000 0000 0000	0000
branch loopcount, address Loopcount is a constant (0 to 63); address is a label which specifies the offset.	Repeat a section of code. A branch to the outside of a segment is not allowed.	branch 20, loop1; Define loop for 20 times.	1010 1010 0000 0000	AA00
int	Causes an interrupt.	int	1100 0100 0000 0000	C400
end interrupt, reset Interrupt (i) is an optional flag. Reset (r) is an optional flag.	End program execution.	end i; End program execution and send an interrupt.	1101 0000 0000 0000	D000
trigger w{source1|source2...} Source is the source of the trigger (1, 2, 3, external).	Wait for a trigger.	trigger w{1}; Wait for a trigger from engine 1.	1110 0000 1000 0000	E080
trigger s{target1|target2...} Source is the source of the trigger (1, 2, 3, extenal).	Send a trigger.	trigger s{1}; Send a trigger to engine 1	1110 0000 0000 0010	E002
trig_clear	Clear pending triggers.	trig_clear	1110 0000 0000 0000	E000
jne var1, var2, address var1 is a variable (ra, rb, rc, rd); var2 is a variable (ra, rb, rc, rd); address is a label which specifies the offset.	Jump if not equal. It jumps forward to the address relative to the present location.	jne ra, rb, flash; jump to flash if A!=B.	1000 1000 0010 0001 Assumes that offset = 2.	8821
jl var1, var2, address var1 is a variable (ra, rb, rc, rd); var2 is a variable (ra, rb, rc, rd); address is a label which specifies the offset.	Jump if less. It jumps forward to the address relative to the present location.	jl ra, rb, flash; jump to flash if A<B	1000 1010 0001 0001 Assumes that offset = 1.	8A11
jge var1, var2, address var1 is a variable (ra, rb, rc, rd); var2 is a variable (ra, rb, rc, rd); address is a label which specifies the offset	Jump if greater or equal. It jumps forward to the address relative to the present location.	jge ra, rb flash; jump to flash if A>=B.	1000 1100 0001 0001 Assumes that offset = 1.	8C11
je var1, var2, address var1 is a variable (ra, rb, rc, rd); var2 is a variable (ra, rb, rc, rd); address is a label which specifies the offset.	Jump if equal. It jumps forward to the address relative to the present location.	je ra, rb, flash; jump to flash if A==B	1000 1110 0001 0001 Assumes that offset = 1.	8E11

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Table 7. Data Transfer and Arithmetic Instructions

INSTRUCTION SYNTAX	FUNCTION	EXAMPLE	16-BIT ASSEMBLED BIT SEQUENCE	ASSEMBLED CODE (HEX)
ld var, value var is a variable (ra, rb, rc); value is a constant (0 to 255 or 0 to FFh)	Assigns a value to a variable	ld ra, 10; Variable A = 10.	1001 0000 0000 1010	900A
add var, value var is a variable (ra, rb, rc); value is a constant (0 to 255 or 0 to FFh)	Add the 8-bit value to the variable value.	add ra, 30; A = A + 30.	1001 0001 0001 1110	911E
add var1, var2, var3 var1 is a variable (ra, rb, rc); var2 is a variable (ra, rb, rc, rd); var3 is a variable (ra, rb, rc, rd).	Add the value of var3 to the value of var2 and store the result in var1.	add ra, rc, rd; A = C + D.	1001 0011 0000 1010	930B
sub var, value var is a variable (ra, rb, rc); value is a constant (0 to 255 or 0 to FFh)	Subtract the 8-bit value from the variable value.	sub ra, 30; A = A – 30	1001 0010 0001 1110	921E
sub var1, var2, var3 var1 is a variable (ra, rb, rc); var2 is a variable (ra, rb, rc, rd); var3 is a variable (ra, rb, rc, rd).	Subtract the value of var3 from the value of var2 and store the result in var1.	sub ra, rc, rd; A = C – D	1001 0011 0001 1011	931B

3.7 Programming Examples

This is a demonstration example to display a slow ramp of all three colors for each tri-color LED.

Table 8. Example .src file

Label/Seg	INSTRUCTION	PARAMETERS
ENG1:	dw	0000 0001 0001 0001b
ENG2:	dw	0000 0000 1000 1100b
ENG3:	dw	0000 0000 0110 0010b
ALL:	dw	0000 0001 1111 1111b
.segment	program1	
	map_addr	ALL
	set_pwm	0
	map_addr	ENG1
	trigger	s{2|3}
loop1:		
	ramp	2, 255
	ramp	2, –255
	ramp	2, -255
	branch	0, loop1
	rst	
.segment	program2	
	trigger	w{1}
	map_addr	ENG2

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Table 8. Example .src file (continued)

loop2:		
	ramp	2, –255
	ramp	2, 255
	ramp	2, –255
	branch	0, loop2
	rst	
.segment	program3	
	trigger	w{1}
	map_addr	ENG3
loop3:		
	ramp	2, –255
	ramp	2, –255
	ramp	2, 255
	branch	0, loop3
	rst	

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.hex file: The .src file is translated to the following .hex file by the assembler (lasm.exe).

```
01 11 00 8C 00 62 01 FF 9F 83 40 00 9F 80 E0 0C
20 FF 21 FF 21 FF A0 04 00 00 E0 80 9F 81 21 FF
20 FF 21 FF A0 02 00 00 E0 80 9F 82 21 FF 21 FF
20 FF A0 02 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
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00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
@ 04 program1
@ 0D program2
@ 14 program3
```

Figure 41. Example .hex File

.lst file: The .lst file is generated by the assembler (lasm.exe). The listing file contains the source code along with the compiled machine code and is helpful for debugging and seeing how source code is translated into machine code. The first column is the row number, the second column indicates the SRAM memory address, the third column shows the machine code data and the fourth column includes the source code.

Table 9. Example .lst File

001	; This is a demonstration to display a slow		
002	; ramp of all 3 colors for each tri-color LED		
003			
004	00 0111 ENG1:	dw	0000 0001 0001 0001b
005	01 008C ENG2:	dw	0000 0000 1000 1100b
006	02 0062 ENG3:	dw	0000 0000 0110 0010b
007			

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Table 9. Example .lst File (continued)

008	03 01FF ALL:	dw	0000 0001 1111 1111b
009			
010	.segment	program1	
011	04 9F83 map_addr	ALL	
012	05 4000 set_pwm	0	
013	06 9F80 map_addr	ENG1	
014	07 E00C trigger	s{2|3}	
015	loop1:		
016	08 20FF ramp	2, 255	
017	09 21FF ramp	2, –255	
018	0A 21FF ramp	2, –255	
019	0B A004 branch	0, loop1	
020	0C 0000 rst		
021			
022		program2	
023	0D E080 trigger	w{1}	
024	0E 9F81 map_addr	ENG2	
025	loop2:		
026	0F 21FF ramp	2, –255	
027	10 20FF ramp	2, 255	
028	11 21FF ramp	2, –255	
029	12 A002 branch	0, loop2	
030	13 0000 rst		
031			
032	.segment	program3	
033	14 E080 trigger	w{1}	
034	15 9F82 map_addr	ENG3	
035	loop3:		
0326	16 21FF ramp	2, –255	
037	17 21FF ramp	2, –255	
038	18 20FF ramp	2, 255	
039	19 A002 branch	0, loop3	
040	1A 0000 rst		
==========			
Labels:			
ENG1 = 00			
ENG2 = 01			
ENG3 = 02			
ALL = 03			
loop1 = 08			
loop2 = 0F			
loop3 = 16			
==========			
Segments:			
program1 = 04			
program2 = 0D			

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Table 9. Example .lst File (continued)

program3 = 14			
========== ========			
Free memory: 228			
Errors: 0			

4 Board Layout

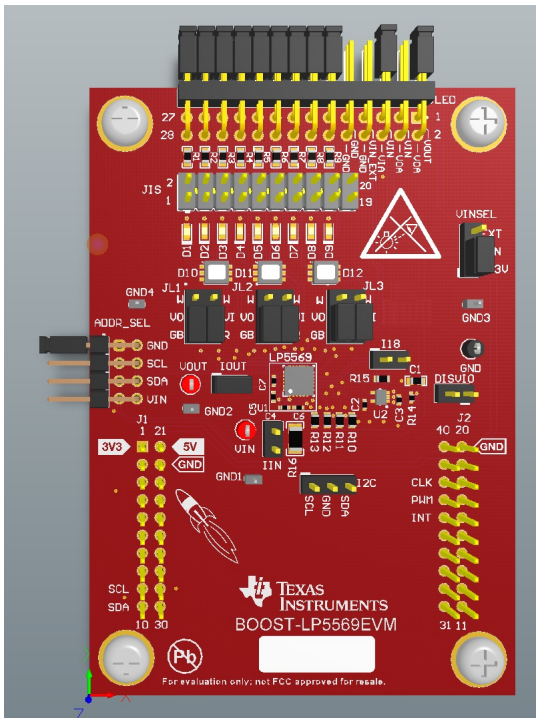


Figure 42. Top Assembly Layer

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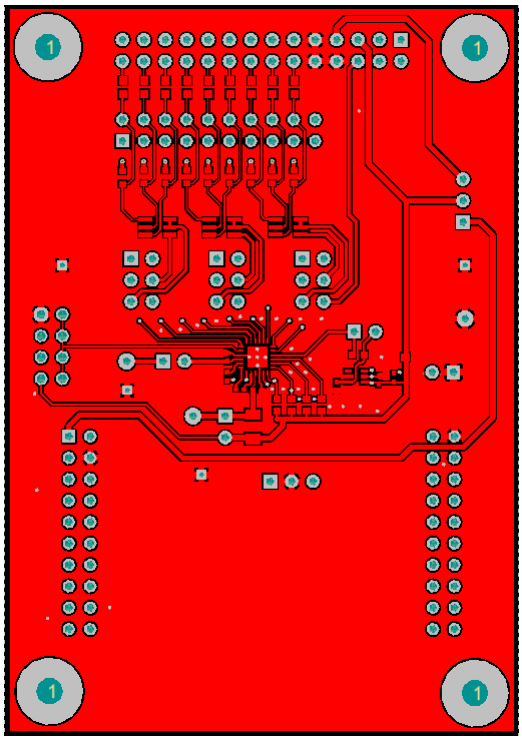


Figure 43. Top Layer Routing

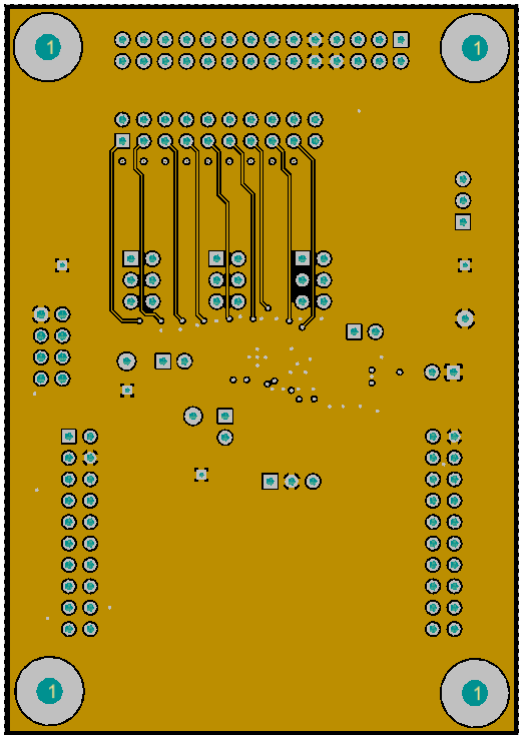


Figure 44. Middle Layer 1 Routing

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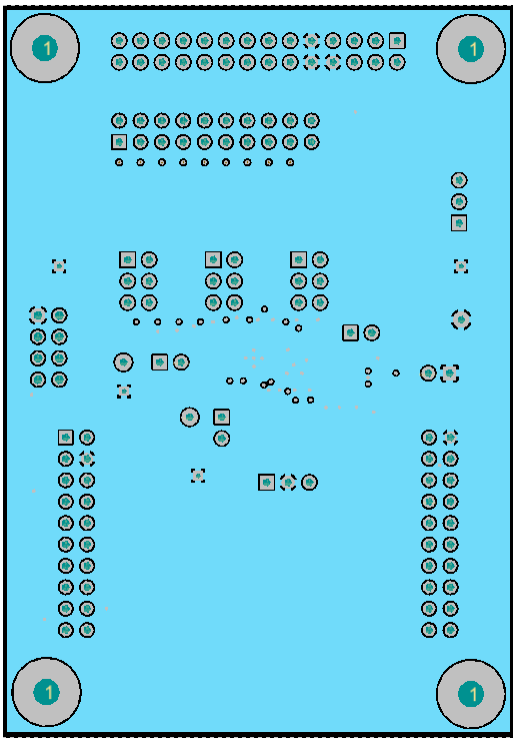


Figure 45. Middle Layer 2 Routing

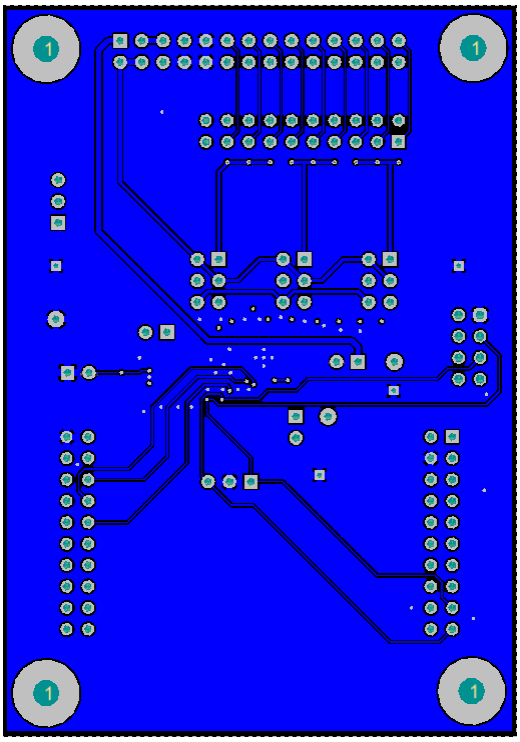


Figure 46. Bottom Layer Routing (Mirrored)

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5 Schematic

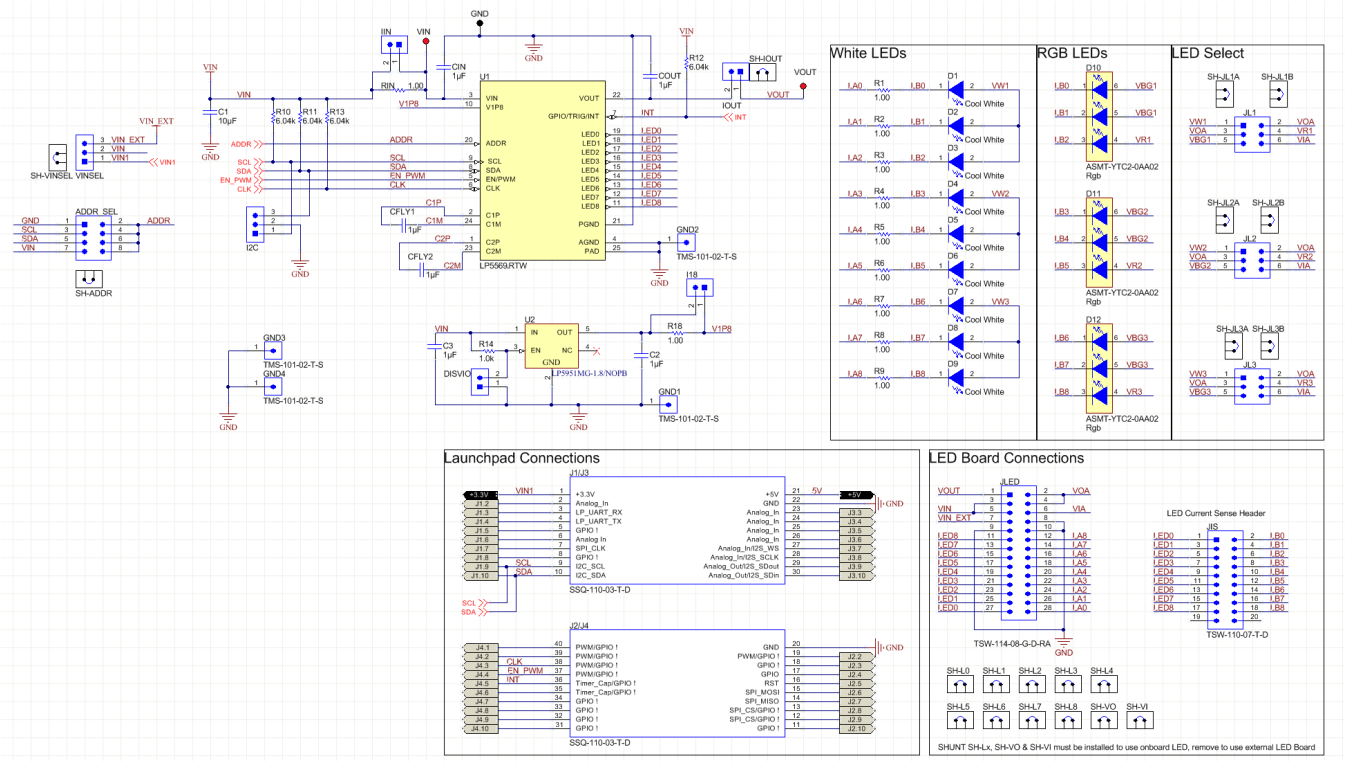


Figure 47. LP5569EVM Schematic

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6 Bill of Materials (BOM)

Table 10. LP556EVM BOM

DESIGNATOR	QTY.	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C1	1	10 µF	Capacitor, ceramic, 10 µF, 6.3 V, ±10%, JB, 0603	0603	C1608JB0J106K080AB	TDK
C2, C3, C4, C5, C6, C7	6	1 µF	Capacitor, ceramic, 1 µF, 6.3 V, ±10%, X5R, 0402	0402	GRM155R60J105KE19D	MuRata
D1, D2, D3, D4, D5, D6, D7, D8, D9	9	Cool white	LED, cool white, SMD	0603 LED	LNJ037X8ARA	Panasonic
D10, D11, D12	3	RGB	LED, RGB, SMD	LED, 3- × 2- × 3.6-mm	ASMT-YTC2-0AA02	Avago
H1, H2, H3, H4	4		Machine screw, round, #4-40 × 1/4, nylon, philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, hex, 0.5"L #4-40 nylon	Standoff	1902C	Keystone
J1	1		Receptacle, 2,54 mm, 10 × 2, tin, TH	10 × 2 receptacle	SSQ-110-03-T-D	Samtec
J2	1		Receptacle, 2,54 mm, 10 × 2, tin, TH	10 × 2 receptacle	SSQ-110-03-T-D	Samtec
J3, J4	2		Header, 100-mil, 3 × 1, gold, TH	3 × 1 header	TSW-103-07-G-S	Samtec
J5	1		Header, 2.54 mm, 4 × 2, gold, R/A, TH	Header, 2,54-mm, 4 × 2, R/A, TH	61300821021	Wurth Elektronik
J6, J7, J8, J9	4		Header, 100-mil, 2 × 1, gold, TH	2 × 1 header	TSW-102-07-G-S	Samtec
J10	1		Header, 10 × 2, 2,54 mm, tin, TH	Header, 10 × 2, 2,54 mm, tin, TH	TSW-110-07-T-D	Samtec
J11, J12, J13	3		Header, 100-mil, 3 × 2, gold, TH	3 × 2 header	TSW-103-07-G-D	Samtec
J14	1		Header, 100-mil, 14 × 2, gold, R/A, TH	14 × 2 R/A header	TSW-114-08-G-D-RA	Samtec
R1, R2, R3, R4, R5, R6, R7, R8, R9	9	1.00	Resistor, 1.00 Ω, 1%, 0.1 W, 0603	0603	CRCW06031R00FKEA	Vishay-Dale
R10, R11, R12, R13	4	6.04 kΩ	Resistor, 6.04 kΩ, 1%, 0.1 W, 0603	0603	CRCW06036K04FKEA	Vishay-Dale
R14	1	1.0 kΩ	Resistor, 1.0 kΩ, 5%, 0.063 W, 0402	0402	CRCW04021K00JNED	Vishay-Dale
R15	1	1.00 Ω	Resistor, 1.00 Ω, 1%, 0.1 W, 0603	0603	CRCW06031R00FKEA	Vishay-Dale
R16	1	1.00 Ω	Resistor, 1.00 Ω, 1%, 0.5 W, 1206	1206	CSR1206FK1R00	Stackpole Electronics Inc
SH1, SH2, SH3, SH4, SH4, SH6, SH7, SH8, SH9, SH10, SH11, SH12, SH13, SH14, SH15, SH16, SH17, SH18, SH19, SH20	20	1 × 2	Shunt, 100 mil, flash gold, black	Closed-top 100-mil shunt	SPC02SYAN	Sullins Connector Solutions
TP1, TP2	2		Test point, miniature, red, TH	Red miniature test point	5000	Keystone
TP3, TP4, TP5, TP6	4		Header, 1 × 1, tin, TH	Header, 1 × 1, 50-mil, TH	TMS-101-02-T-S	Samtec
TP7	1		Test point, miniature, black, TH	Black miniature test point	5001	Keystone
U1	1		Easy-to-use nine-channel RGB LED driver, RTW0024B (WQFN-24)	RTW0024B	LP5569RTW	Texas Instruments
U2	1		Micropower, 150-mA low-dropout CMOS voltage regulator, 5-pin SC-70, Pb-free	MAA05A	LP5951MG-1.8/NOPB	Texas Instruments

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      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

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Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

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3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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