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

<table>
<thead>
<tr>
<th>REFERENCE ID</th>
<th>DEVICE</th>
<th>PACKAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>LP5569</td>
<td>WQFN (24)</td>
</tr>
</tbody>
</table>

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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 $V_{\text{IN}}$ is 2.5 V to 5.5 V. The input voltage range for $V_{\text{1P8}}$ is 1.65 V to 1.95 V.

1.1 Input/Output Connector Description

- ADDR_SEL – is provided to configure the $\text{I}^2\text{C}$ 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$^2$C – is provided to monitor the $\text{I}^2\text{C}$ 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 $\text{I}^2\text{C}$ Address Selection

The LP5569 $\text{I}^2\text{C}$ slave address is set according to the jumper installed on ADDR_SEL.

![Figure 1. ADDR_SEL Configuration](image1.png)

The upper 3 bits of slave address is either 3 (LP5569) or 4 (LP5569A).

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](image2.png)
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.
• 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](image)

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.
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 development kit.

1.7 **EVM and MSP-EXP432P401R LaunchPad Development Kit Setup**

The MSP-EXP432P401R LaunchPad jumpers should be set as shown in Figure 6.
Figure 6. MSP432 Jumper Settings

Connect the MSP432 LaunchPad development kit and EVM (BOOSTXL-LP5569) as shown in Figure 7.
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.
7. Make sure the Hardware Connected message appears on the status bar.
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 \( 1 \times \) 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 Development Kit (MSP-EXP432P401R) and LP5569 EVM](image)

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.
Figure 9. Setting Up the LP5569 EVM

Check to accept the agreement and click the Next button to proceed with the installation.
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.
Figure 11. Installation Directory Dialog

Click the Next button to proceed with the installation.
Figure 12. Installation Progress

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

![Desktop Icon](image)

**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.
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.
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.

![MSP432 LED](image)

*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.

![Main Menu Icons](image)

*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, I²C 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.

![Status Bar](image)

*Figure 23. Status Bar (Hardware Connected)*
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 FC RGB LED Driver With Engine Control and Charge Pump.

![Information View](image)

**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.
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)
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.

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

### 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 I²C after changing the value by using the slide bar or text box.
2.10.4 Charge Pump Control

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

![Figure 30. Charge Pump Control Information](image)

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](image)

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](image)

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.
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.

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
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.

#### 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.
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.

<table>
<thead>
<tr>
<th>File Name</th>
<th>Date</th>
<th>Time</th>
<th>Type</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>bouncing.hex</td>
<td>7/6/2017</td>
<td>10:47 AM</td>
<td>HEX File</td>
<td>2 KB</td>
</tr>
<tr>
<td>bouncing.log</td>
<td>7/6/2017</td>
<td>10:47 AM</td>
<td>wrfile</td>
<td>1 KB</td>
</tr>
<tr>
<td>bouncing.lst</td>
<td>7/6/2017</td>
<td>10:47 AM</td>
<td>LST File</td>
<td>4 KB</td>
</tr>
<tr>
<td>bouncing.src</td>
<td>7/6/2017</td>
<td>10:47 AM</td>
<td>SRC File</td>
<td>3 KB</td>
</tr>
</tbody>
</table>

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

![Figure 35. Source Edit Tab](image)

![Figure 36. File List After Compilation](image)
• `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`, `Parameters`, and `Comment` data.

2.14 Control View – Log Tab
The Log tab on the control view provides the history regarding I²C read/write, file access, and so forth.

![Figure 37. Log Tab](image)

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>
<thead>
<tr>
<th>MACRO SYNTAX</th>
<th>FUNCTION</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>REGISTER_NAME()</td>
<td>Register read REGISTER_NAME must be the same as the register map on the GUI (see Figure 26)</td>
<td><code>&gt;CONFIG();</code> read CONFIG(0x00) register</td>
</tr>
<tr>
<td>REGISTER_NAME(hex_data)</td>
<td>Register write REGISTER_NAME must be the same as the register map on the GUI</td>
<td><code>CONFIG(0x40);</code> write CONFIG</td>
</tr>
<tr>
<td>FIELD_NAME()</td>
<td>Field read FIELD_NAME must be same as the register map on the GUI</td>
<td><code>exp_en0();</code> read exp_en0 bit</td>
</tr>
</tbody>
</table>
Table 2. Macro Instructions (continued)

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

Figure 38. Console Window

Figure 39. Macro File
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.

![Programming Flow Chart](image-url)
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.
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>
<thead>
<tr>
<th>DIRECTIVE</th>
<th>DESCRIPTION</th>
<th>EXAMPLE SOURCE CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>.segment</td>
<td>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</td>
<td>.segment program1 .segment program2 .segment program3</td>
</tr>
<tr>
<td>ds</td>
<td>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.</td>
<td>ds 3 ds 17</td>
</tr>
<tr>
<td>dw</td>
<td>Define constant Word. Inserts a binary word to the SRAM.</td>
<td>dw 0000000011111111b dw FFABh dw 3</td>
</tr>
</tbody>
</table>

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 a mapping table. Labels must have the colon (:) suffix.

<table>
<thead>
<tr>
<th>INSTRUCTION SYNTAX</th>
<th>FUNCTION</th>
<th>EXAMPLE</th>
<th>16-BIT ASSEMBLED BIT SEQUENCE</th>
<th>ASSEMBLED CODE (HEX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ramp time, PWM</td>
<td>Output PWM with increasing or decreasing duty cycle.</td>
<td>ramp 0.6, 255; Ramp up to full scale over 0.6 s.</td>
<td>0000 1010 1111 1111</td>
<td>0AFF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ramp 1.2, –255; Ramp down to zero over 1.2 s.</td>
<td>0001 0101 1111 1111</td>
<td>15FF</td>
</tr>
<tr>
<td>ramp var1, prescale, var2</td>
<td>Output PWM with increasing or decreasing duty cycle.</td>
<td>ld ra, 31 ld rb, 255 ramp ra, pre=0, +rb; Ramp up to full scale over 3.9 s.</td>
<td>1000 0100 0000 0001</td>
<td>8401</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ld ra, 1; ld rb, 255p; ramp ra, pre=0, -rb; Ramp down to zero over 0.12 s.</td>
<td>1000 0100 0001 0001</td>
<td>8411</td>
</tr>
<tr>
<td>set_pwm PWM</td>
<td>Generate a continuous PWM output.</td>
<td>set_pwm 128; Set PWM duty cycle to 50%.</td>
<td>0100 0000 1000 0000</td>
<td>4080</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000 0100 0110 0010</td>
<td>8462</td>
<td></td>
</tr>
<tr>
<td>set_pwm var1</td>
<td>Generate a continuous PWM output.</td>
<td>ld rc, 128; set_pwm rc; Set PWM duty cycle to 50%.</td>
<td>1000 0100 0110 0010</td>
<td>8411</td>
</tr>
<tr>
<td>wait time</td>
<td>Pause for some time.</td>
<td>wait 0.25; Wait 0.25 seconds.</td>
<td>0110 0000 0000 0000</td>
<td>6000</td>
</tr>
</tbody>
</table>
### 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

<table>
<thead>
<tr>
<th>INSTRUCTION SYNTAX</th>
<th>FUNCTION</th>
<th>EXAMPLE</th>
<th>16-BIT ASSEMBLED BIT SEQUENCE</th>
<th>ASSEMBLED CODE (HEX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>load_start address</td>
<td>Defines the start address of the mapping-data table. The mapping-data-table start address is restricted to the lower half of memory.</td>
<td>load_start row1 : The first row can be found at the address marked with row1.</td>
<td>1001 1110 0000 0000</td>
<td>9E00</td>
</tr>
<tr>
<td>map_start address</td>
<td>Defines the start address of the mapping-data table and sets the row active.</td>
<td>map_start row1 ; The first row can be found at the address marked with row1.</td>
<td>1001 1100 0000 0000</td>
<td>9C00</td>
</tr>
<tr>
<td>load_end address</td>
<td>Defines the last address of the mapping-data table. The mapping-data-table end address is restricted to the lower half of memory.</td>
<td>load_end row9 ; The last row can be found at the address marked with row9.</td>
<td>1001 1100 1000 1000</td>
<td>9C88</td>
</tr>
<tr>
<td>map_sel output</td>
<td>Connects one and only one LED output to an engine.</td>
<td>map_sel 1 ; D1 output is connected to the engine.</td>
<td>1001 1101 0000 0001</td>
<td>9D01</td>
</tr>
<tr>
<td>map_clr</td>
<td>Clears engine-to-driver mapping.</td>
<td>map_clr</td>
<td>1001 1101 0000 0000</td>
<td>9D00</td>
</tr>
<tr>
<td>map_next</td>
<td>Sets the next row active in the mapping table.</td>
<td>map_next</td>
<td>1001 1101 1000 0000</td>
<td>9D80</td>
</tr>
<tr>
<td>map_prev</td>
<td>Sets the previous row active in the mapping table.</td>
<td>map_prev</td>
<td>1001 1101 1100 0000</td>
<td>9DC0</td>
</tr>
<tr>
<td>load_next</td>
<td>The index pointer is set to point to the next row in the mapping-data table.</td>
<td>load_next</td>
<td>1001 1101 1000 0000</td>
<td>9D81</td>
</tr>
<tr>
<td>load_prev</td>
<td>The index pointer is set to point to the previous row in the mapping-data table.</td>
<td>load_prev</td>
<td>1001 1101 1100 0000</td>
<td>9DC1</td>
</tr>
<tr>
<td>load_addr address</td>
<td>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.</td>
<td>load_addr row2</td>
<td>1001 1111 0000 0001</td>
<td>9F01</td>
</tr>
<tr>
<td>map_addr address</td>
<td>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.</td>
<td>map_addr row2</td>
<td>1001 1111 1000 0001</td>
<td>9F81</td>
</tr>
</tbody>
</table>
Table 6. Branch Instructions

<table>
<thead>
<tr>
<th>INSTRUCTION SYNTAX</th>
<th>FUNCTION</th>
<th>EXAMPLE</th>
<th>16-BIT ASSEMBLED BIT SEQUENCE</th>
<th>ASSEMBLED CODE (HEX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>rst</td>
<td>Resets program counter and starts the program again.</td>
<td>rst</td>
<td>0000 0000 0000 0000</td>
<td>0000</td>
</tr>
<tr>
<td>branch loopcount, address</td>
<td>Repeat a section of code. A branch to the outside of a segment is not allowed.</td>
<td>branch 20, loop1; Define loop for 20 times.</td>
<td>1010 1010 0000 0000</td>
<td>AA00</td>
</tr>
<tr>
<td>int</td>
<td>Causes an interrupt.</td>
<td>int</td>
<td>1100 0100 0000 0000</td>
<td>C400</td>
</tr>
<tr>
<td>end interrupt, reset</td>
<td>End program execution.</td>
<td>end i; End program execution and send an interrupt.</td>
<td>1101 0000 0000 0000</td>
<td>D000</td>
</tr>
<tr>
<td>trigger w[source1</td>
<td>source2...]</td>
<td>Wait for a trigger.</td>
<td>trigger w(1); Wait for a trigger from engine 1.</td>
<td>1110 0000 1000 0000</td>
</tr>
<tr>
<td>trigger s[target1</td>
<td>target2...]</td>
<td>Send a trigger.</td>
<td>trigger s(1); Send a trigger to engine 1</td>
<td>1110 0000 0000 0010</td>
</tr>
<tr>
<td>trig_clear</td>
<td>Clear pending triggers.</td>
<td>trig_clear</td>
<td>1110 0000 0000 0000</td>
<td>E000</td>
</tr>
<tr>
<td>jne var1, var2, address</td>
<td>Jump if not equal. It jumps forward to the address relative to the present location.</td>
<td>jne ra, rb, flash; jump to flash if A!=B.</td>
<td>1000 1000 0010 0001</td>
<td>8B21</td>
</tr>
<tr>
<td>jl var1, var2, address</td>
<td>Jump if less. It jumps forward to the address relative to the present location.</td>
<td>jl ra, rb, flash; jump to flash if A&lt;B</td>
<td>1000 1010 0001 0001</td>
<td>8A11</td>
</tr>
<tr>
<td>jge var1, var2, address</td>
<td>Jump if greater or equal. It jumps forward to the address relative to the present location.</td>
<td>jge ra, rb flash; jump to flash if A&gt;=B</td>
<td>1000 1100 0001 0001</td>
<td>8C11</td>
</tr>
<tr>
<td>je var1, var2, address</td>
<td>Jump if equal. It jumps forward to the address relative to the present location.</td>
<td>je ra, rb, flash; jump to flash if A==B</td>
<td>1000 1110 0001 0001</td>
<td>8E11</td>
</tr>
</tbody>
</table>
### Table 7. Data Transfer and Arithmetic Instructions

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

### 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

<table>
<thead>
<tr>
<th>Label/Seg</th>
<th>INSTRUCTION</th>
<th>PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG1:</td>
<td>dw</td>
<td>0000 0001 0001 0001b</td>
</tr>
<tr>
<td>ENG2:</td>
<td>dw</td>
<td>0000 0000 1000 1100b</td>
</tr>
<tr>
<td>ENG3:</td>
<td>dw</td>
<td>0000 0000 0110 0010b</td>
</tr>
<tr>
<td>ALL:</td>
<td>dw</td>
<td>0000 0001 1111 1111b</td>
</tr>
<tr>
<td>.segment program1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>map_addr</td>
<td>ALL</td>
</tr>
<tr>
<td></td>
<td>set_pwm</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>map_addr</td>
<td>ENG1</td>
</tr>
<tr>
<td></td>
<td>trigger</td>
<td>s(2</td>
</tr>
<tr>
<td>loop1:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ramp</td>
<td>2, 255</td>
</tr>
<tr>
<td></td>
<td>ramp</td>
<td>2, -255</td>
</tr>
<tr>
<td></td>
<td>branch</td>
<td>0, loop1</td>
</tr>
<tr>
<td></td>
<td>rst</td>
<td></td>
</tr>
<tr>
<td>.segment program2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>trigger</td>
<td>w(1)</td>
</tr>
<tr>
<td></td>
<td>map_addr</td>
<td>ENG2</td>
</tr>
</tbody>
</table>
Table 8. Example .src file (continued)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>loop2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ramp</td>
<td>2, 255</td>
<td></td>
</tr>
<tr>
<td>ramp</td>
<td>2, 255</td>
<td></td>
</tr>
<tr>
<td>branch</td>
<td>0, loop2</td>
<td></td>
</tr>
<tr>
<td>rst</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.segment</td>
<td>program3</td>
<td></td>
</tr>
<tr>
<td>trigger</td>
<td>w[1]</td>
<td></td>
</tr>
<tr>
<td>map_addr</td>
<td>ENG3</td>
<td></td>
</tr>
<tr>
<td>loop3:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ramp</td>
<td>2, 255</td>
<td></td>
</tr>
<tr>
<td>ramp</td>
<td>2, 255</td>
<td></td>
</tr>
<tr>
<td>branch</td>
<td>0, loop3</td>
<td></td>
</tr>
<tr>
<td>rst</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using the BOOST-LP5569EVM Evaluation Module

.LST: 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.

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

Table 9. Example .lst File

Figure 41. Example .hex File
Table 9. Example .lst File (continued)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>008</td>
<td>03 01FF ALL:</td>
<td>dw</td>
</tr>
<tr>
<td>009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>010</td>
<td>.segment</td>
<td>program1</td>
</tr>
<tr>
<td>011</td>
<td>04 9F83 map_addr</td>
<td>ALL</td>
</tr>
<tr>
<td>012</td>
<td>05 4000 set_pwm</td>
<td>0</td>
</tr>
<tr>
<td>013</td>
<td>06 9F80 map_addr</td>
<td>ENG1</td>
</tr>
<tr>
<td>014</td>
<td>07 E00C trigger</td>
<td>s(2)(3)</td>
</tr>
<tr>
<td>015</td>
<td>loop1:</td>
<td></td>
</tr>
<tr>
<td>016</td>
<td>08 20FF ramp</td>
<td>2, 255</td>
</tr>
<tr>
<td>017</td>
<td>09 21FF ramp</td>
<td>2, –255</td>
</tr>
<tr>
<td>018</td>
<td>0A 21FF ramp</td>
<td>2, –255</td>
</tr>
<tr>
<td>019</td>
<td>0B A004 branch</td>
<td>0, loop1</td>
</tr>
<tr>
<td>020</td>
<td>0C 0000 rst</td>
<td></td>
</tr>
<tr>
<td>021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>023</td>
<td>0D E080 trigger</td>
<td>w(1)</td>
</tr>
<tr>
<td>024</td>
<td>0E 9F81 map_addr</td>
<td>ENG2</td>
</tr>
<tr>
<td>025</td>
<td>loop2:</td>
<td></td>
</tr>
<tr>
<td>026</td>
<td>0F 21FF ramp</td>
<td>2, –255</td>
</tr>
<tr>
<td>027</td>
<td>10 20FF ramp</td>
<td>2, 255</td>
</tr>
<tr>
<td>028</td>
<td>11 21FF ramp</td>
<td>2, –255</td>
</tr>
<tr>
<td>029</td>
<td>12 A002 branch</td>
<td>0, loop2</td>
</tr>
<tr>
<td>030</td>
<td>13 0000 rst</td>
<td></td>
</tr>
<tr>
<td>031</td>
<td></td>
<td></td>
</tr>
<tr>
<td>032</td>
<td>.segment</td>
<td>program3</td>
</tr>
<tr>
<td>033</td>
<td>14 E080 trigger</td>
<td>w(1)</td>
</tr>
<tr>
<td>034</td>
<td>15 9F82 map_addr</td>
<td>ENG3</td>
</tr>
<tr>
<td>035</td>
<td>loop3:</td>
<td></td>
</tr>
<tr>
<td>036</td>
<td>16 21FF ramp</td>
<td>2, –255</td>
</tr>
<tr>
<td>037</td>
<td>17 21FF ramp</td>
<td>2, –255</td>
</tr>
<tr>
<td>038</td>
<td>18 20FF ramp</td>
<td>2, 255</td>
</tr>
<tr>
<td>039</td>
<td>19 A002 branch</td>
<td>0, loop3</td>
</tr>
<tr>
<td>040</td>
<td>1A 0000 rst</td>
<td></td>
</tr>
</tbody>
</table>

========================
========

Labels:
ENG1 = 00
ENG2 = 01
ENG3 = 02
ALL = 03
loop1 = 08
loop2 = 0F
loop3 = 16

========================
========

Segments:
program1 = 04
program2 = 0D
Table 9. Example .lst File (continued)

<table>
<thead>
<tr>
<th>program3 = 14</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>==============</td>
<td>==============</td>
</tr>
<tr>
<td>Free memory: 228</td>
<td></td>
</tr>
<tr>
<td>Errors: 0</td>
<td></td>
</tr>
</tbody>
</table>

4 Board Layout

Figure 42. Top Assembly Layer
Figure 43. Top Layer Routing

Figure 44. Middle Layer 1 Routing
Figure 45. Middle Layer 2 Routing

Figure 46. Bottom Layer Routing (Mirrored)
5 Schematic

Figure 47. LP5569EVM Schematic
### Table 10. LP556EVM BOM

<table>
<thead>
<tr>
<th>DESIGNATOR</th>
<th>QTY.</th>
<th>VALUE</th>
<th>DESCRIPTION</th>
<th>PACKAGE REFERENCE</th>
<th>PART NUMBER</th>
<th>MANUFACTURER</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1</td>
<td>10 µF</td>
<td>Capacitor, ceramic, 10 µF, 6.3 V, ±10%, JB, 0603</td>
<td>0603</td>
<td>C160JBJ0106K080AB</td>
<td>TDK</td>
</tr>
<tr>
<td>C2, C3, C4, C5, C6, C7</td>
<td>6</td>
<td>1 µF</td>
<td>Capacitor, ceramic, 1 µF, 6.3 V, ±10%, X5R, 0402</td>
<td>0402</td>
<td>GRM155R60J105KE19D</td>
<td>Murata</td>
</tr>
<tr>
<td>D1, D2, D3, D4, D5, D6, D7, D8, D9</td>
<td>9</td>
<td>Cool white</td>
<td>LED, cool white, SMD</td>
<td>0603 LED</td>
<td>LJN037X8ARA</td>
<td>Panasonic</td>
</tr>
<tr>
<td>D10, D11, D12</td>
<td>3</td>
<td>RGB</td>
<td>LED, RGB, SMD</td>
<td>LED, 3- × 2- × 3.6-mm</td>
<td>ASMT-YTC2-0AA02</td>
<td>Avago</td>
</tr>
<tr>
<td>H1, H2, H3, H4</td>
<td>4</td>
<td></td>
<td>Machine screw, round, #4-40 × 1/4, nylon, philips panhead</td>
<td>Screw</td>
<td>NY PMS 440 0025 PH</td>
<td>B&amp;F Fastener Supply</td>
</tr>
<tr>
<td>H5, H6, H7, H8</td>
<td>4</td>
<td></td>
<td>Standoff, hex, 0.5&quot;L #4-40 nylon</td>
<td>Standoff</td>
<td>1902C</td>
<td>Keystone</td>
</tr>
<tr>
<td>J1</td>
<td>1</td>
<td></td>
<td>Receptacle, 2.54 mm, 10 × 2, tin, TH</td>
<td>10 × 2 receptacle</td>
<td>SSQ-110-03-T-D</td>
<td>Samtec</td>
</tr>
<tr>
<td>J2</td>
<td>1</td>
<td></td>
<td>Receptacle, 2.54 mm, 10 × 2, tin, TH</td>
<td>10 × 2 receptacle</td>
<td>SSQ-110-03-T-D</td>
<td>Samtec</td>
</tr>
<tr>
<td>J3, J4</td>
<td>2</td>
<td></td>
<td>Header, 100-mil, 3 × 1, gold, TH</td>
<td>3 × 1 header</td>
<td>TSW-103-07-G-S</td>
<td>Samtec</td>
</tr>
<tr>
<td>J5</td>
<td>1</td>
<td></td>
<td>Header, 2.54 mm, 4 × 2, gold, R/A, TH</td>
<td>Header, 2.54-mm, 4 × 2, R/A, TH</td>
<td>61300821021</td>
<td>Wurth Elektronik</td>
</tr>
<tr>
<td>J6, J7, J8, J9</td>
<td>4</td>
<td></td>
<td>Header, 100-mil, 2 × 1, gold, TH</td>
<td>2 × 1 header</td>
<td>TSW-102-07-G-S</td>
<td>Samtec</td>
</tr>
<tr>
<td>J10</td>
<td>1</td>
<td></td>
<td>Header, 10 × 2, 2.54 mm, tin, TH</td>
<td>Header, 10 × 2, 2.54 mm, tin, TH</td>
<td>TSW-110-07-T-D</td>
<td>Samtec</td>
</tr>
<tr>
<td>J11, J12, J13</td>
<td>3</td>
<td></td>
<td>Header, 100-mil, 3 × 2, gold, TH</td>
<td>3 × 2 header</td>
<td>TSW-103-07-G-D</td>
<td>Samtec</td>
</tr>
<tr>
<td>J14</td>
<td>1</td>
<td></td>
<td>Header, 100-mil, 14 × 2, gold, R/A, TH</td>
<td>14 × 2 R/A header</td>
<td>TSW-114-08-G-D-R-A</td>
<td>Samtec</td>
</tr>
<tr>
<td>R1, R2, R3, R4, R5, R6, R7, R8, R9</td>
<td>9</td>
<td>1.00</td>
<td>Resistor, 1.00 Ω, 1%, 0.1 W, 0603</td>
<td>0603</td>
<td>CRCW0603R00FKEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R10, R11, R12, R13</td>
<td>4</td>
<td>6.04 kΩ</td>
<td>Resistor, 6.04 kΩ, 1%, 0.1 W, 0603</td>
<td>0603</td>
<td>CRCW0603K04FKEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R14</td>
<td>1</td>
<td>1.0 kΩ</td>
<td>Resistor, 1.0 kΩ, 5%, 0.063 W, 0402</td>
<td>0402</td>
<td>CRCW04021K00JNED</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R15</td>
<td>1</td>
<td>1.00 Ω</td>
<td>Resistor, 1.00 Ω, 1%, 0.1 W, 0603</td>
<td>0603</td>
<td>CRCW06031R00FKEA</td>
<td>Vishay-Dale</td>
</tr>
<tr>
<td>R16</td>
<td>1</td>
<td>1.00 Ω</td>
<td>Resistor, 1.00 Ω, 1%, 0.5 W, 1206</td>
<td>1206</td>
<td>CSR1206FK1R00</td>
<td>Stackpole Electronics Inc</td>
</tr>
<tr>
<td>SH1, SH2, SH3, SH4, SH5, SH6, SH7, SH8, SH9, SH10, SH11, SH12, SH13, SH14, SH15, SH16, SH17, SH18, SH19, SH20</td>
<td>20</td>
<td>1 × 2</td>
<td>Shunt, 100 mil, flash gold, black</td>
<td>Closed-top 100-mil shunt</td>
<td>SPC02SYAN</td>
<td>Sullins Connector Solutions</td>
</tr>
<tr>
<td>TP1, TP2</td>
<td>2</td>
<td></td>
<td>Test point, miniature, red, TH</td>
<td>Red miniature test point</td>
<td>5000</td>
<td>Keystone</td>
</tr>
<tr>
<td>TP3, TP4, TP5, TP6</td>
<td>4</td>
<td></td>
<td>Header, 1 × 1, tin, TH</td>
<td>Header, 1 × 1, 50-mil, TH</td>
<td>TMS-101-02-T-S</td>
<td>Samtec</td>
</tr>
<tr>
<td>TP7</td>
<td>1</td>
<td></td>
<td>Test point, miniature, black, TH</td>
<td>Black miniature test point</td>
<td>5001</td>
<td>Keystone</td>
</tr>
<tr>
<td>U1</td>
<td>1</td>
<td></td>
<td>Easy-to-use nine-channel RGB LED driver, RTW0024B (WQFN-24)</td>
<td>RTW0024B</td>
<td>LP5569RTW</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>U2</td>
<td>1</td>
<td></td>
<td>Micropower, 150-mA low-dropout CMOS voltage regulator, 5-pin SC-70, Pb-free</td>
<td></td>
<td>MAA05A</td>
<td>LP5951MG-1.8/NOPB</td>
</tr>
</tbody>
</table>
STANDARD TERMS FOR EVALUATION MODULES

1. Delivery: TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software.

1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 Limited Warranty and Related Remedies/Disclaimers:

2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

2.2 TI warrants that the TI EVM will conform to TI’s published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User’s claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

2.3 TI’s sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User’s account for such EVM. TI’s liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

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. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

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.
FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• 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.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

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.

3.3 Japan

3.3.1 Notice for EVMs delivered in Japan: Please see http://www.tij.co.jp/lds/ti JA/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lds/ti JA/general/eStore/notice_01.page

3.3.2 Notice for Users of EVMs Considered “Radio Frequency Products” in Japan: EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry’s Rule for Enforcement of Radio Law of Japan.

2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or EVMs.

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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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

日本テキサス・エンスツルメンツ株式会社
東京都新宿区西新宿6丁目24番1号
西新宿三井ビル

3.3.3 Notice for EVMs for Power Line Communication: Please see http://www.tij.co.jp/lsvds/ti_ja/general/eStore/notice_02.page

3.4 European Union
3.4.1 For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):
This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 EVM Use Restrictions and Warnings:
4.1 EVMs ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.
4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.
4.3 Safety-Related Warnings and Restrictions:
4.3.1 User shall operate the EVM within TI’s recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.
4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.
4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User’s handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. Accuracy of Information: To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
6. **Disclaimers:**

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. **User's Indemnity Obligations and Representations.** User will defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any handling or use of the EVM that is not in accordance with these terms. This obligation shall apply whether Claims arise under statute, regulation, or the law of tort, contract or any other legal theory, and even if the EVM fails to perform as described or expected.

8. **Limitations on Damages and Liability:**

8.1 **General Limitations.** In no event shall TI be liable for any special, collateral, indirect, punitive, incidental, consequential, or exemplary damages in connection with or arising out of these terms or the use of the EVMS, regardless of whether TI has been advised of the possibility of such damages. Excluded damages include, but are not limited to, cost of removal or reinstallation, ancillary costs to the procurement of substitute goods or services, retesting, outside computer time, labor costs, loss of goodwill, loss of profits, loss of savings, loss of use, loss of data, or business interruption. No claim, suit or action shall be brought against TI more than twelve (12) months after the event that gave rise to the cause of action has occurred.

8.2 **Specific Limitations.** In no event shall TI's aggregate liability from any use of an EVM provided hereunder, including from any warranty, indemnity or other obligation arising out of or in connection with these terms, exceed the total amount paid to TI by User for the particular EVM(s) at issue during the prior twelve (12) months with respect to which losses or damages are claimed. The existence of more than one claim shall not enlarge or extend this limit.

9. **Return Policy.** Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. **Governing Law:** These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.
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