AN-1632 LP5521TMEV Programmable LED Driver

User's Guide

Literature Number: SNVA241E
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EVM Warnings and Restrictions

It is possible to feed VDD voltage from external source to connector J2. It is important to operate this EVM within the V_{DD} voltage range of 2.7 V to 5.5 V. The V_{DD} voltage must never exceed 6 V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to LEDs, linear regulators, switching transistors, Inductors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide.

When placing measurement probes near these devices please be aware that these devices may be very warm to the touch.

The white LEDs which are mounted on the EVM emit light which, at a high enough intensity, have the potential to be harmful to the eyes. To reduce the risk of eye damage TI recommends using engineering controls (for example, light-blocking screens or filters) or personal protection equipment (for example, light-filtering or blocking eyewear). Users should not look directly at any operating LED component regardless of LED color or intensity.

LP5521EV User Guide

1 Read This First

1.1 About this Manual

This user's guide describes the characteristics, operation, and use of the LP5521 evaluation module (EVM). This user's guide includes a schematic diagram and bill of materials (BOM).

1.2 Related Documentation from Texas Instruments

LP5521 data sheet: *LP5521 Programmable Three Channel LED Driver* (SNVS441)

AN-1562 LP5521 Programming Considerations (SNVA205)

1.3 FCC Warning

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user, at his own expense, will be required to take whatever measures may be required to correct this interference.

1.4 If You Need Assistance

Contact your local TI sales representative.

2 Introduction

The Texas Instruments LP5521TMEV evaluation module helps designers evaluate the operation and performance of LP5521 integrated circuit (IC). The LP5521TMEV uses a high-efficiency charge pump, three independent LED channels, and program memory for creating variety of lighting sequences. More information about the LP5521 capabilities can be found in the device datasheet (SNVS441).

The EVM contains power supply connection for the V_{DD} voltage. Test points are provided for key signals. The on-board microcontroller can be used to control the digital input signals of the LP5521 and to control the device with I^2C interface. A graphical user interface (GUI) is provided for fast and easy evaluation of the device.

If an external power supply is used, V_{DD} voltage must be within 2.7 V to 5.5 V. This voltage range is within the absolute maximum input range of the LP5521. Users are cautioned to evaluate their specific operating conditions and choose components with the appropriate voltage ratings before designing this support circuitry into a final product.

3 Description of the LP5521

3.1 General Description

The LP5521 is a three-channel LED driver designed to produce variety of lighting effects for mobile devices. A high-efficiency charge pump enables LED driving over full Li-Ion battery voltage range. The device has a program memory for creating variety of lighting sequences. When program memory has been loaded, LP5521 can operate autonomously without processor control allowing power savings.

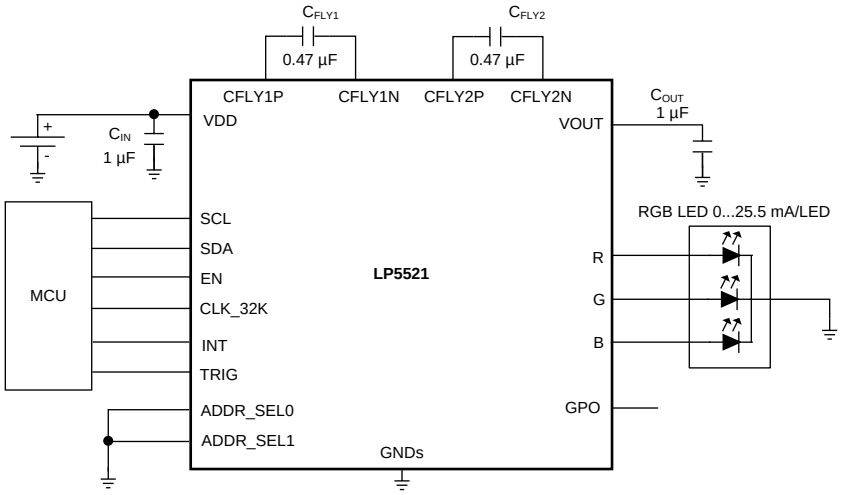
3.2 Features

- Adaptive Charge Pump With 1× and 1.5× Gain Provides Up to 95% LED Drive Efficiency
- Charge Pump with Soft Start and Overcurrent, Short-Circuit Protection
- Low Input Ripple and EMI
- Very Small Solution Size, No Inductor or Resistors Required
- 200-nA Typical Shutdown Current
- Automatic Power Save Mode
- I^2C-Compatible Interface
- Independently Programmable Constant Current Outputs with 8-Bit Current Setting and 8-Bit PWM Control
- Typical LED Output Saturation Voltage 50 mV and Current Matching 1%
- Three Program Execution Engines with Flexible Instruction Set
- Autonomous Operation Without External Control
- Large SRAM Program Memory
- Two General Purpose Digital Outputs
- 36-pin DSBGA package, 2.478 mm × 2.478 mm × 0.6 mm, 0.4 mm pitch

3.3 Applications

- Fun and Indicator Lights
- LCD Sub-Display Backlighting
- Keypad RGB Backlighting and Phone Cosmetics
- Vibra, Speakers, Waveform Generator
- Blood Glucose Meter
- Handheld POS Terminals
- Electronic Access Control
- Where RGB Indication is Needed

3.4 LP5521 Typical Application Drawing



4 LP5521EVM Hardware

Figure 1 shows how to set up shunts on LP5521TMEV. If external V_{DD} supply is used it must be connected to connector J2. Jumper J4 selects supply voltage source. This setup uses on-board microcontroller to control LP5521. LP5521TMEV must be connected to a Windows PC with USB cable. On-board LEDs are used as load.

Jumpers J1, J3, J8, and J9 select if white or RGB LEDs are used.

The LP5521 supports I2C interface. The LP5521 device is connected to the onboard microcontroller through connector J13. If user wants to use own controller to control the LP5521, shunts on connector J13 need to be removed and external controller needs to be connected to the pins on the right side of the J13.

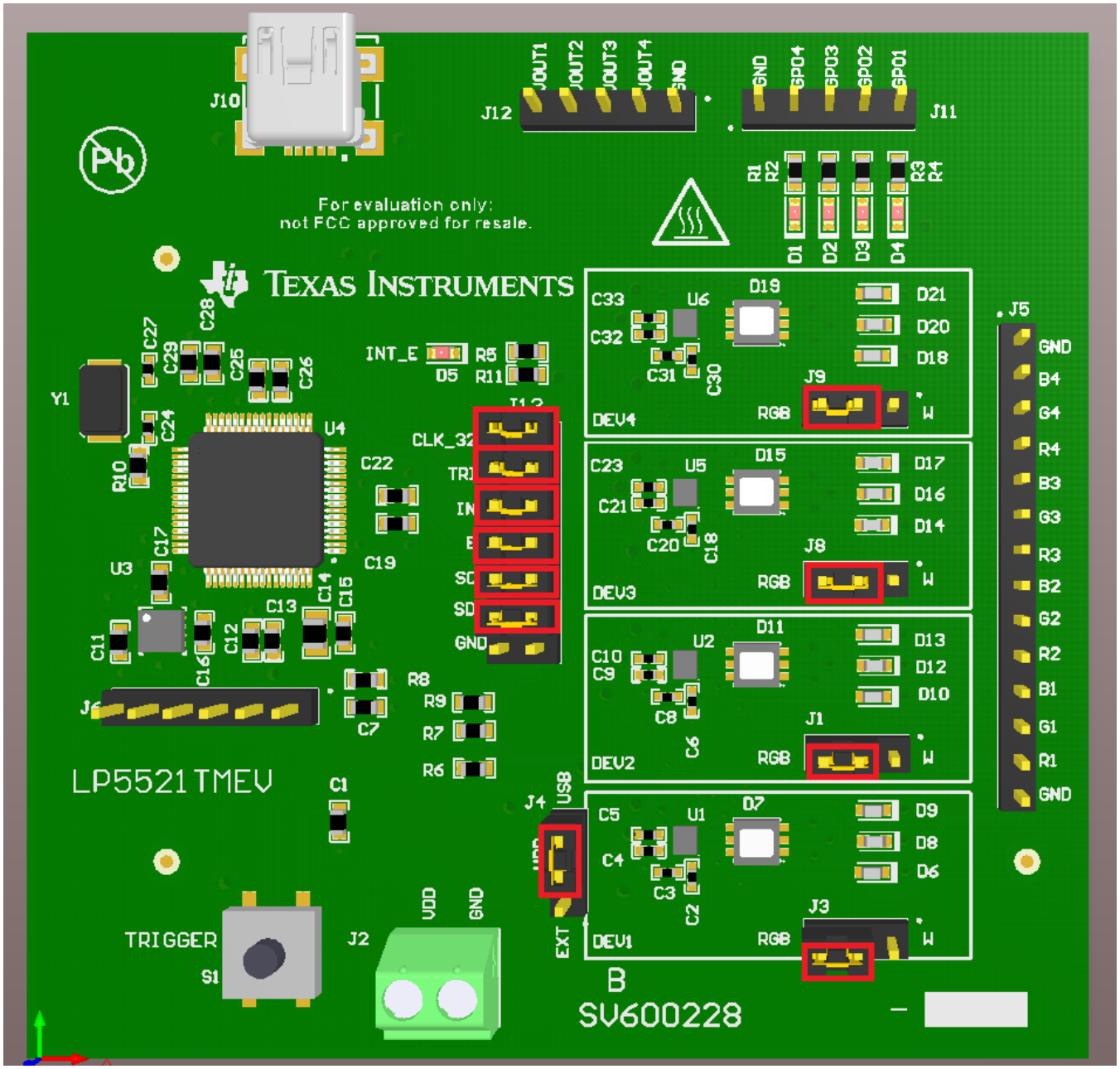


Figure 1. Evaluation Board Connectors and Setup

Figure 2 shows main parts of LP5521 EVM. The board has four LP5521 circuits with the necessary external components placed around them. Test points for the signals are on the board edges. INT and TRIG lines for the four chips are tied together to make it possible to synchronize four LP5521 and make interesting lighting effects. GPO and INT pins have indicator LEDs. Each chip has own I^2C address.

Jumper J4 on the evaluation board selects supply voltage V_{DD} from either external power or USB power. If external power supply is used, the VDD and ground GND can be connected to the green power connector J2. Possible supply voltage range is from 2.7 V to 5.5 V. When the USB 5-V powering is used, onboard regulator is used to generate a 3.3-V supply voltage.

There are red indicator LEDs connected to the INT and GPO pins to detect the functionality of the pins. With INT LED time it is possible to determine to which external interrupt is sent. Interrupt can be cleared by reading the Status/INT register (offset 0Ch), or by simply pressing the Read Registers button on the evaluation software when the chip which has sent the interrupt is selected. Note that if INT pin is set to work as a CMOS output (EN_GPO_INT bit high) the functionality of the LED is reversed; that is, when GPO_INT is high then the LED is off and when GPO_INT is low, the LED is on. See *Section 9* for reference.

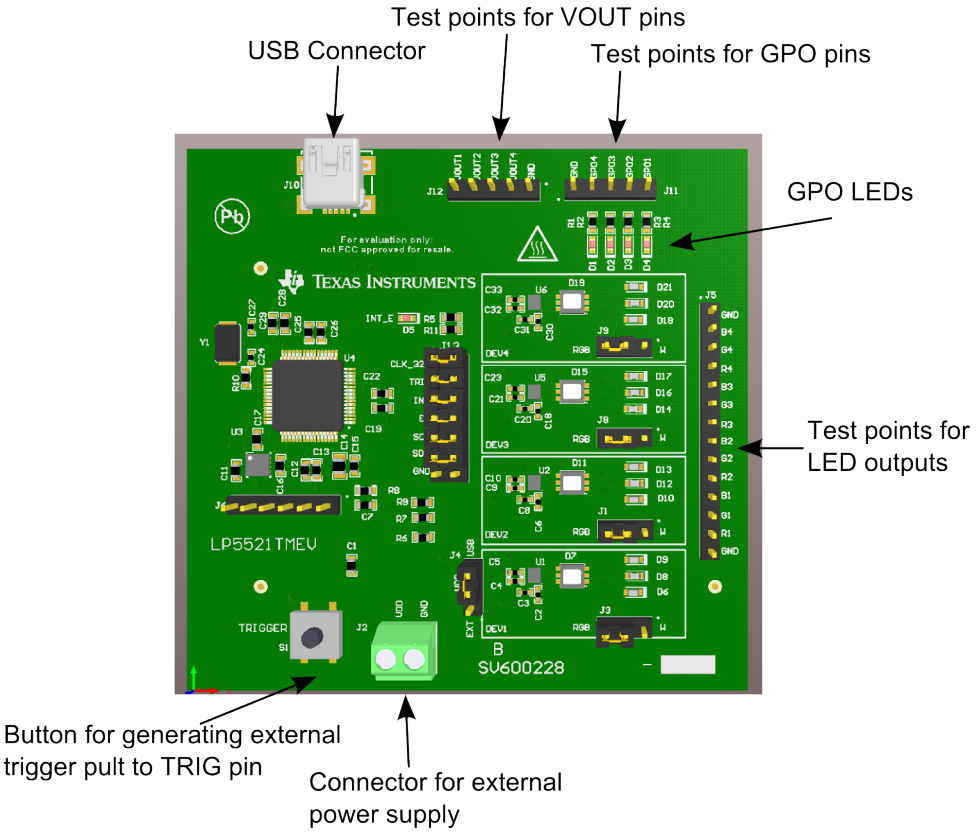


Figure 2. LP5521 Evaluation Board

5 LP5521 Evaluation Software

5.1 General

The LP5521TMEVM is connected to the computer via USB. The EVM is controlled with special evaluation software. The on-board microcontroller is used to provide easy I^2C communication, as well as to control the digital inputs of the LP5521 IC. The microcontroller is powered by default from USB. The LP5521 device can be powered from the USB or from external power supply.

5.2 LP5521 Evaluation Software Installation

Before the LP5521 evaluation software can be used it must be installed. Open the folder containing the installation package and double click the “LP5521TMEV-1.0.0-installer.exe”. If Windows® prompts verification of the installation click “Yes”. The license agreement window opens. Read through the license agreement and click “I agree”. Next the installer prompts for components to install. Select additionally “Desktop Shortcut” if needed and click “Next>”. Then the installer prompts for installation directory. TI recommends installing the program to its default location. Click “Install” button to start installation. Evaluation software is now installed. To read release notes and/or start an application make appropriate selections and click “Finish” to exit.

5.3 Evaluation Software Uninstallation

Uninstallation of the LP5521 evaluation software is done through the Windows Control Panel. Open Control Panel → Programs and Features. Find LP5521 EVM from the list, right click it and select Uninstall.

5.4 Graphical User Interface (GUI)

When LP5521 evaluation software is run it looks like Figure 3. Main parts of the GUI are:

- Menu toolbar
- Quick access toolbar
- Device controls
- Quick start/ Device/ Code/ Log Tabs
- Register access related controls
- Status bar

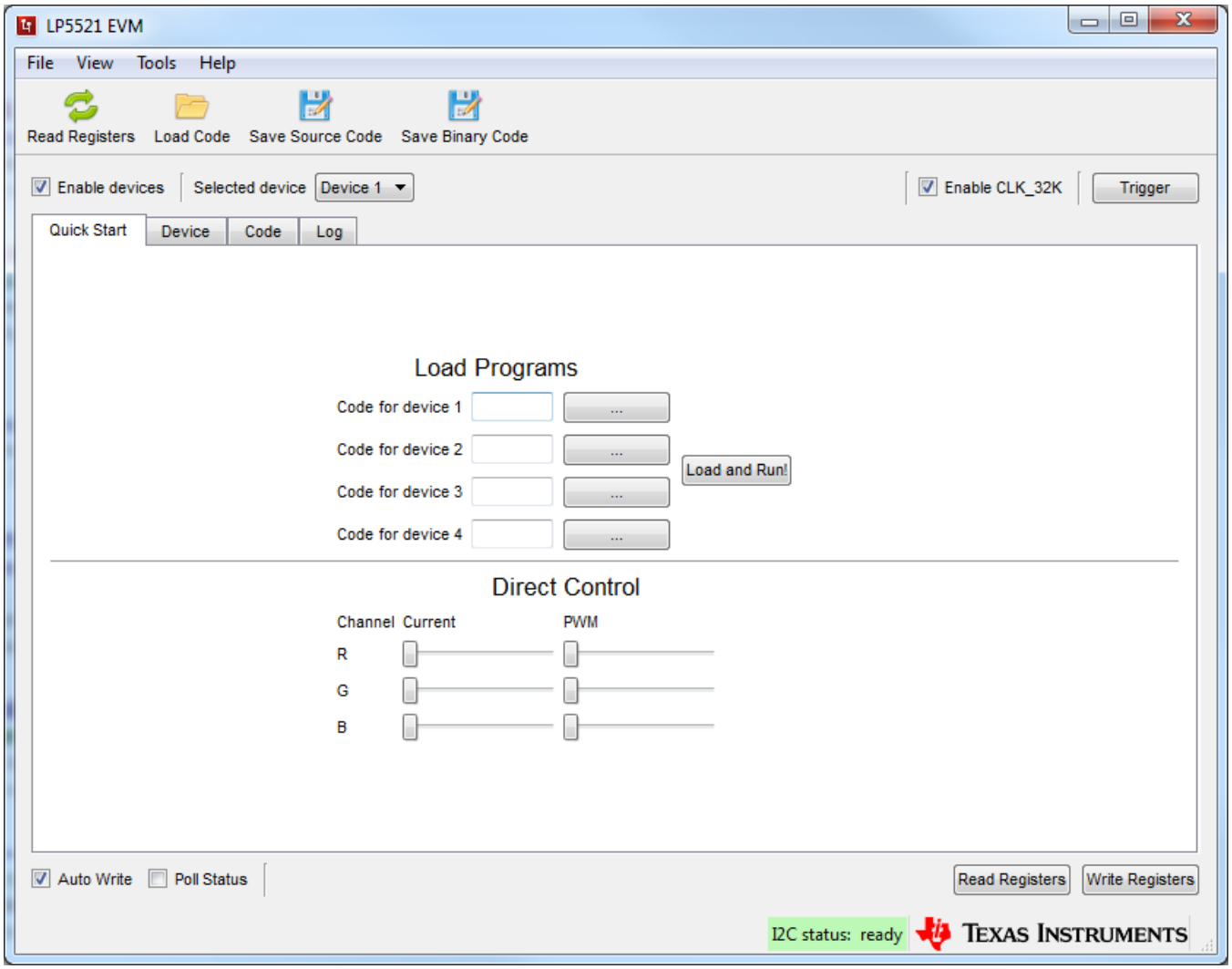
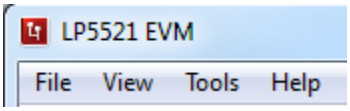


Figure 3. Evaluation Software

5.4.1 Menu Toolbar

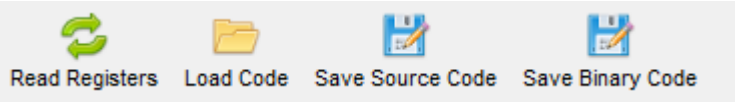
Menu toolbar has four sub menus: File, View, Tools and Help.



- File->Load Code: loads source of binary to code editor.
- File->Save Source Code: Saves source code from code editor to a file.
- File->Save Binary File: Saves code from code editor to a file in binary format.
- File->Exit: Exits the application.
- View->Console: Opens console in the right side of the window. See *Section 5.4.8* for more information.
- Tools->Direct Register Access: Opens direct register access dialog. See *Section 5.4.7*
- Tools->Update Firmware: Can be used to update the firmware of the microcontroller on EVM.

5.4.2 Quick Access Toolbar

Quick Access toolbar contains shortcuts to features placed under File menu.



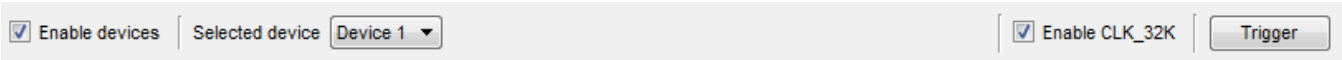
5.4.3 Device Controls

Checkbox “Enable Devices” controls the state of EN signal.

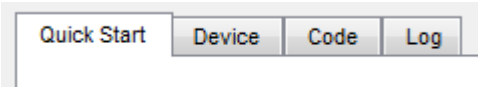
Dropdown menu is used to select to which device I^2C commands are sent.

Checkbox “Enable CLK_32K” enables onboard clock signal generator .

Push button “Trigger” send short pulse to TRIGGER input.



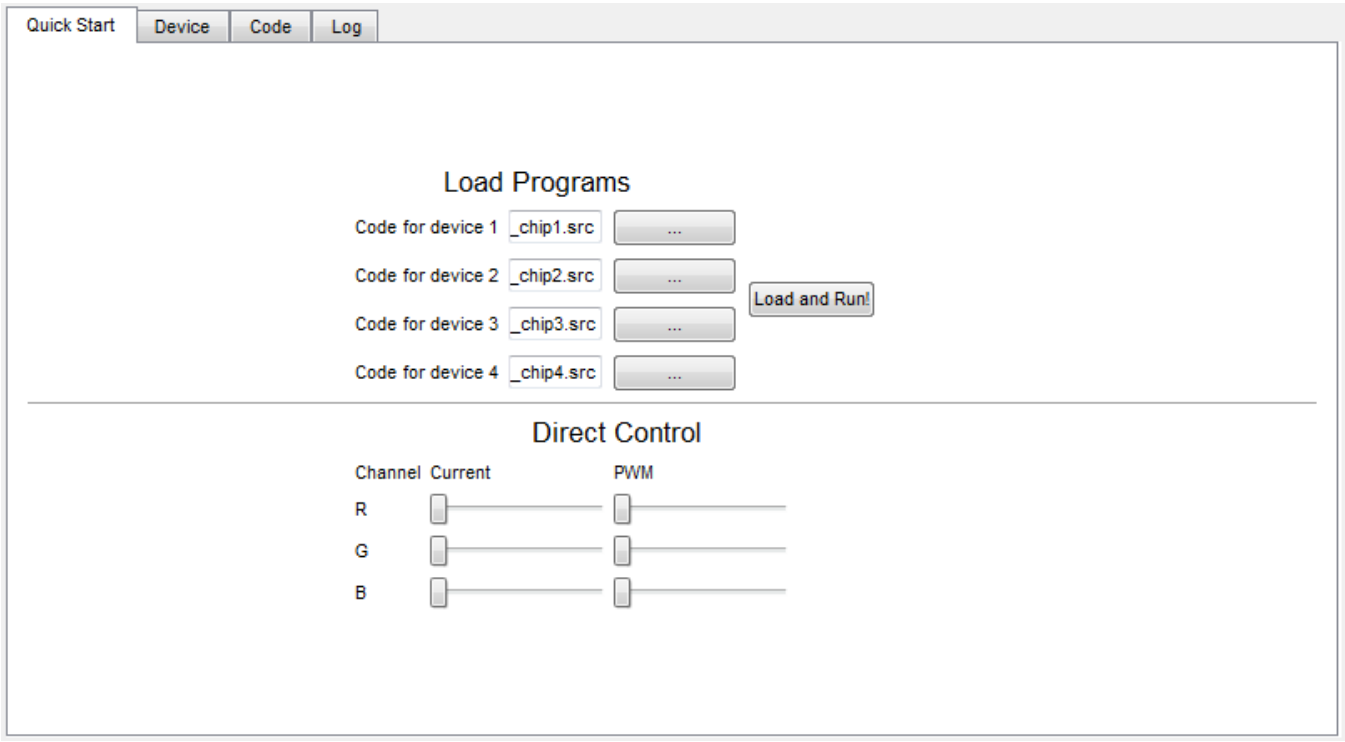
5.4.4 Tabs



There are four separate tabs. See Section 5.4.4.1 to Section 5.4.4.4 for more detailed description.

5.4.4.1 Quick Start Tab

Quick Start tab can be used to quickly load example code files to the program memory or to control directly current and PWM of the LEDS.

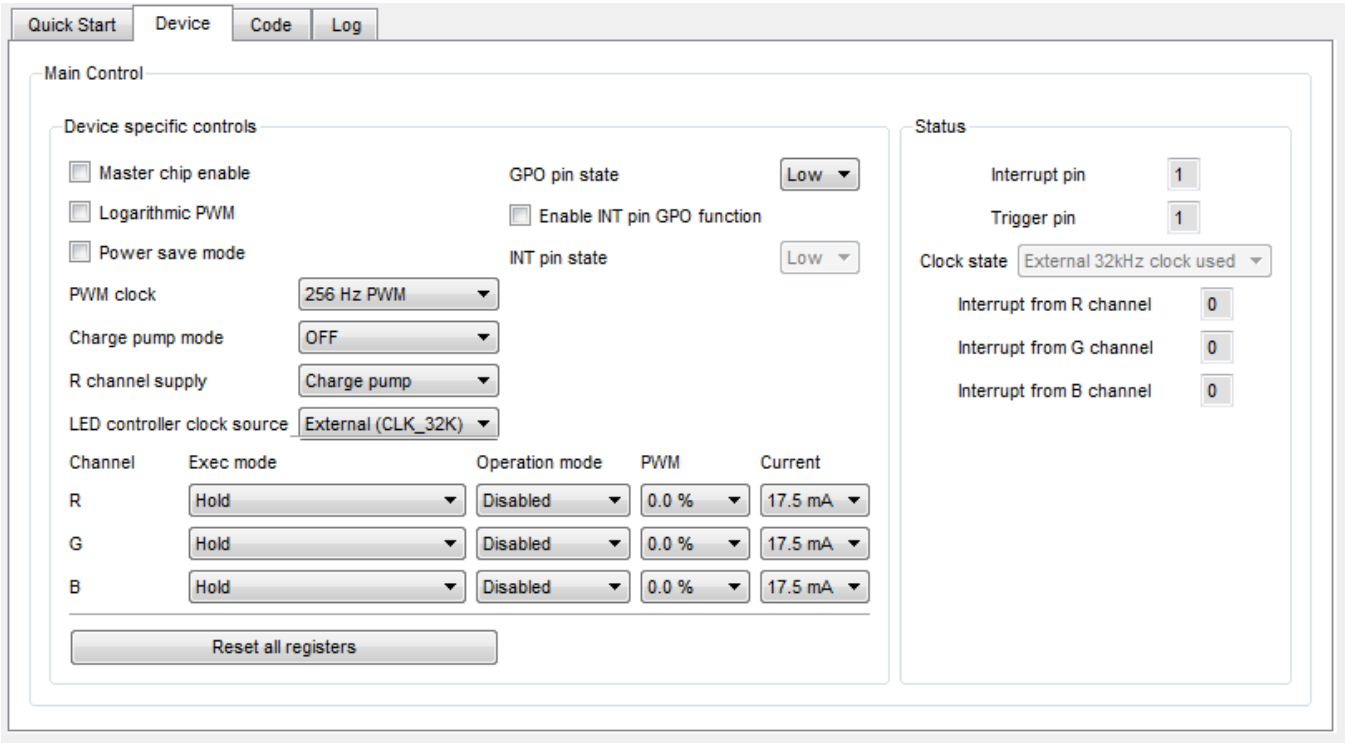


Click "…" button to select code file to be loaded for each device and click "Load and Run!" button. The evaluation software is provided with several example programs. They can be found in "program_examples" directory. Some of the examples wait for TRIGGER signal before they start. TRIGGER signal can be toggled by clicking "Trigger" button or pressing button S1 on EVM.

Alternatively LEDs can be controlled directly by using sliders on the lower part of the tab. Each LED has separate slider for current and PWM value. Device to be controlled is selected by dropdown menu labeled "Selected device". Notice that LED currents can be adjusted while programs are running, but adjusting PWM stops the execution of the current programs.

5.4.4.2 Device Tab

Device Tab contains most of the register controls. Change to any control is written immediately to the selected device unless "Auto Write" checkbox is unchecked. Refer to LP5521 datasheet for more detailed information.



On the left side there are controls covering most of the device functions.

Master Chip Enable— Enables device internal start-up sequence.

GPO Pin State— Controls the state of the GPO pin.

Logarithmic PWM— Checking this sets INT pin to fucntion as GPO pin.

Enable INT pin GPO function— Selected register is read from the selected device.

NT Pin State— Controls the state of the INT pin. (it must be in GPO mode).

Power-Save Mode— Enabled power-save mode.

PWM Clock— Selects between 256 Hz (source external 32-kHz clock) and 558-Hz clock (source internal oscillator).

Charge Pump Mode— Sets mode of the charge pump to OFF, forced bypass mode, forced 1.5× mode or automatic mode.

R Channel Supply— Selects between charge pump and battery.

LED-Controller Clock Source— Options: external 32-kHz or internal clock or automatic selection.

Exec Mode— Selects the execution mode of each engine. Options: Hold, Step, Run and Step, but not increment PC.

Operation Mode— Selects the operation mode of each engine. Options: Disabled, Load program, Run program and Direct control.

PWM— Sets the PWM value for each output.

Current— Sets the LED current for each output.

On the right side are status indicators for interrupt and trigger pin and various status bits.

INTERRUPT Pin— Shows the state of the INTERRUPT pin.

TRIGGER Pin— Shows the state of the TRIGGER pin.

Clock State— Shows currently selected clock source.

Interrupt from X Channel— Shows which channel(s) triggered interrupt.

NT Pin State— Controls the state of the INT pin. (it must be in GPO mode).

Power-Save Mode— Enabled power-save mode.

Current— Sets the LED current for each output.

5.4.4.3 Code Tab

The Code tab is divided to source code editor (left side) and binary view (right side). Code file (source or binary) can be loaded by clicking “Load Code” button in Quick Access toolbar or in the File menu. File format is automatically detected. “Assemble>>" button is used for compiling code in the source code editor. Results are shown in binary view. It is possible to disassemble contents of binary view by clicking "<<Disassemble” button. Source or binary code can be saved to a file by clicking corresponding button in Quick Access toolbar.

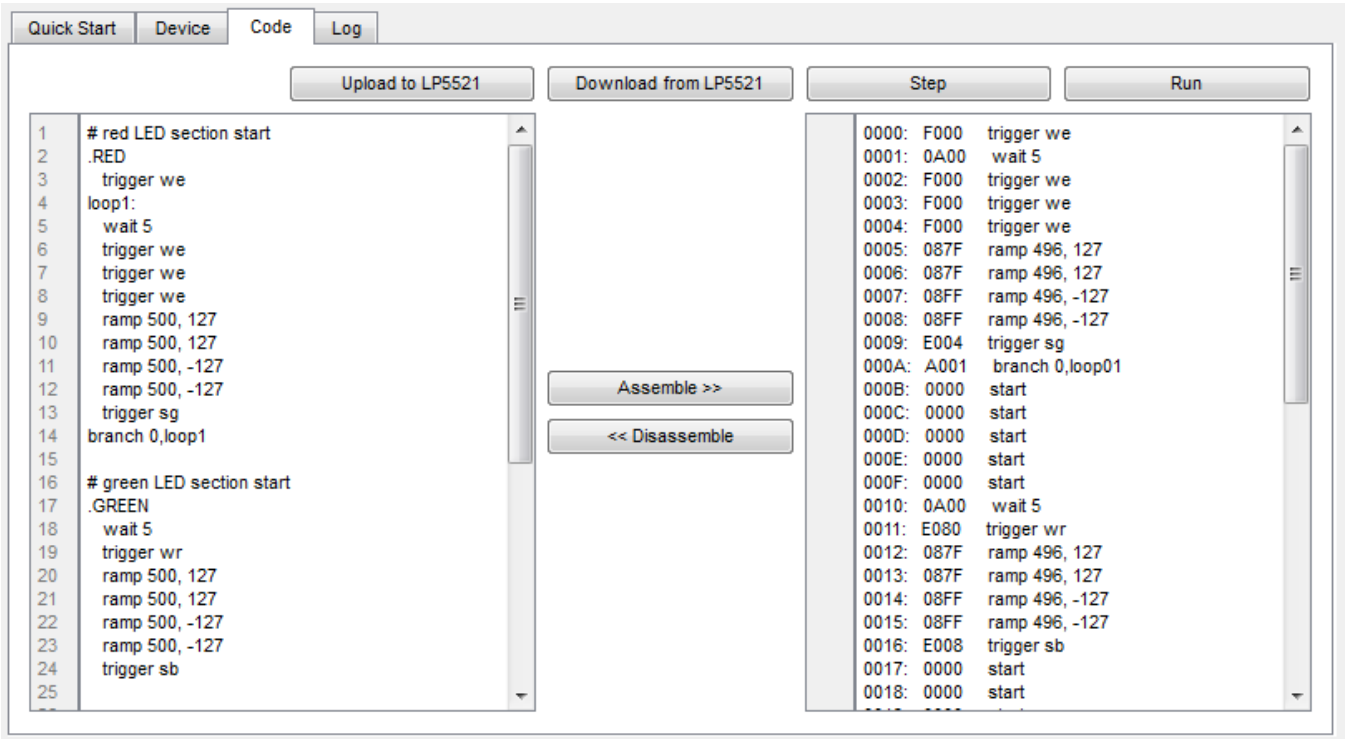
“Upload to LP5521” button sends compiled program code to selected device.

“Download from LP5521” button reads program code from selected device and show results in binary view.

“Step” button executes loaded code one instruction at time. When code is stepped, instruction pointers of each engine are shown in the left side of the binary view.

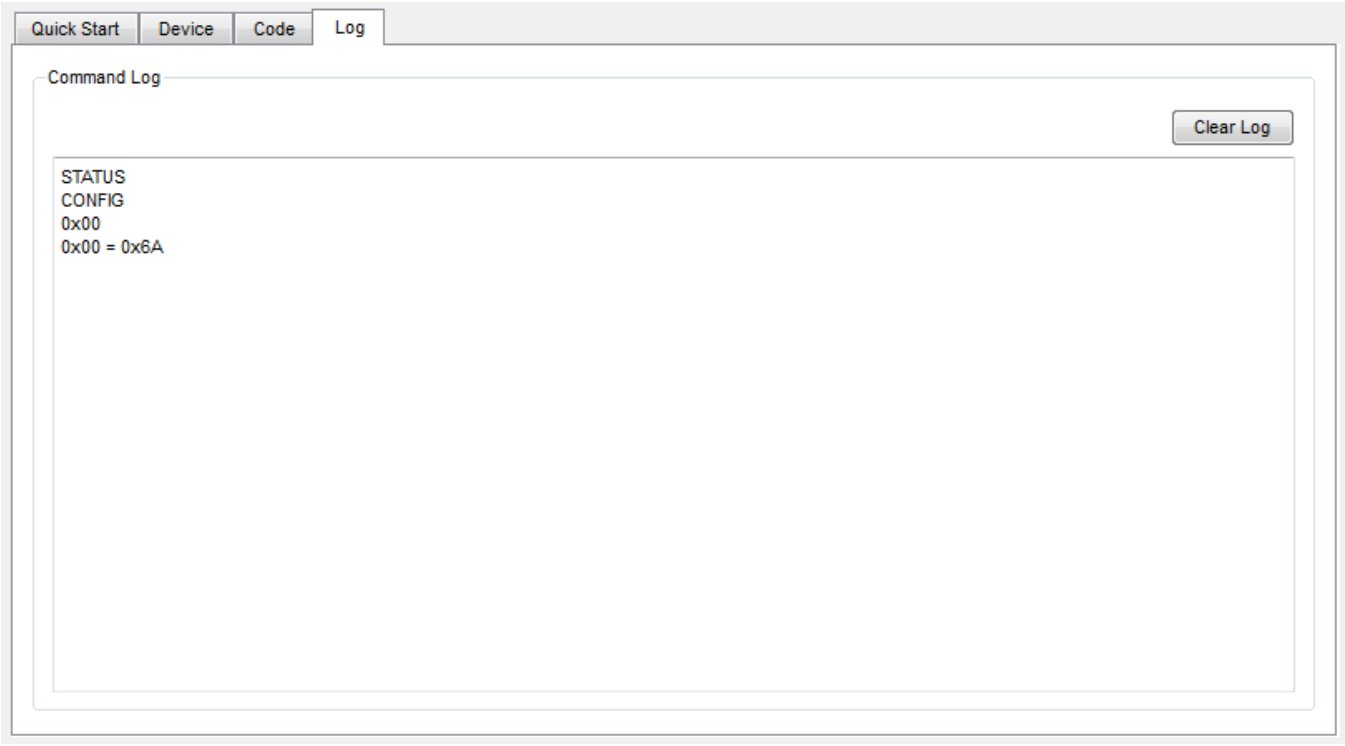
“Run” button starts the execution of loaded code. When code is running, it can be stopped by clicking “Stop” button.

For more information about LP5521 assembly language, see *Section 8.1*.



5.4.4.4 Log Tab

The Log tab shows the commands that have been sent to the LP5521. Log can be cleared by clicking the clear Log button.



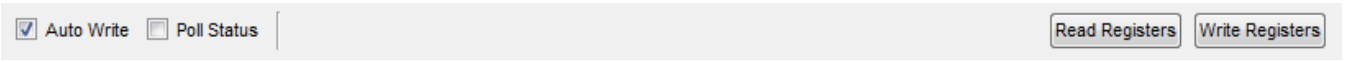
5.4.5 Register Access Related Controls

"Auto Write" checkbox controls if changes are written immediately to the device or not.

"Poll Status" checkbox controls if status registers are polled repeatedly.

"Read Registers" push button reads all registers of the device.

"Write Registers" push button writes values from the GUI to the device. This is useful only if "Auto Write" checkbox is unchecked.



5.4.6 Status Bar

Status bar shows the connection status of the EVM and the status of the last I^2C operation.

5.4.7 Direct Register Access Dialog

Register map can be opened from Tools menu -> Direct Register Access. This gives an easy way to show content of all the registers. Direct register access can also be used to change the content of any of the registers. Register contents of the selected device are read when Direct Register Access Dialog is opened.

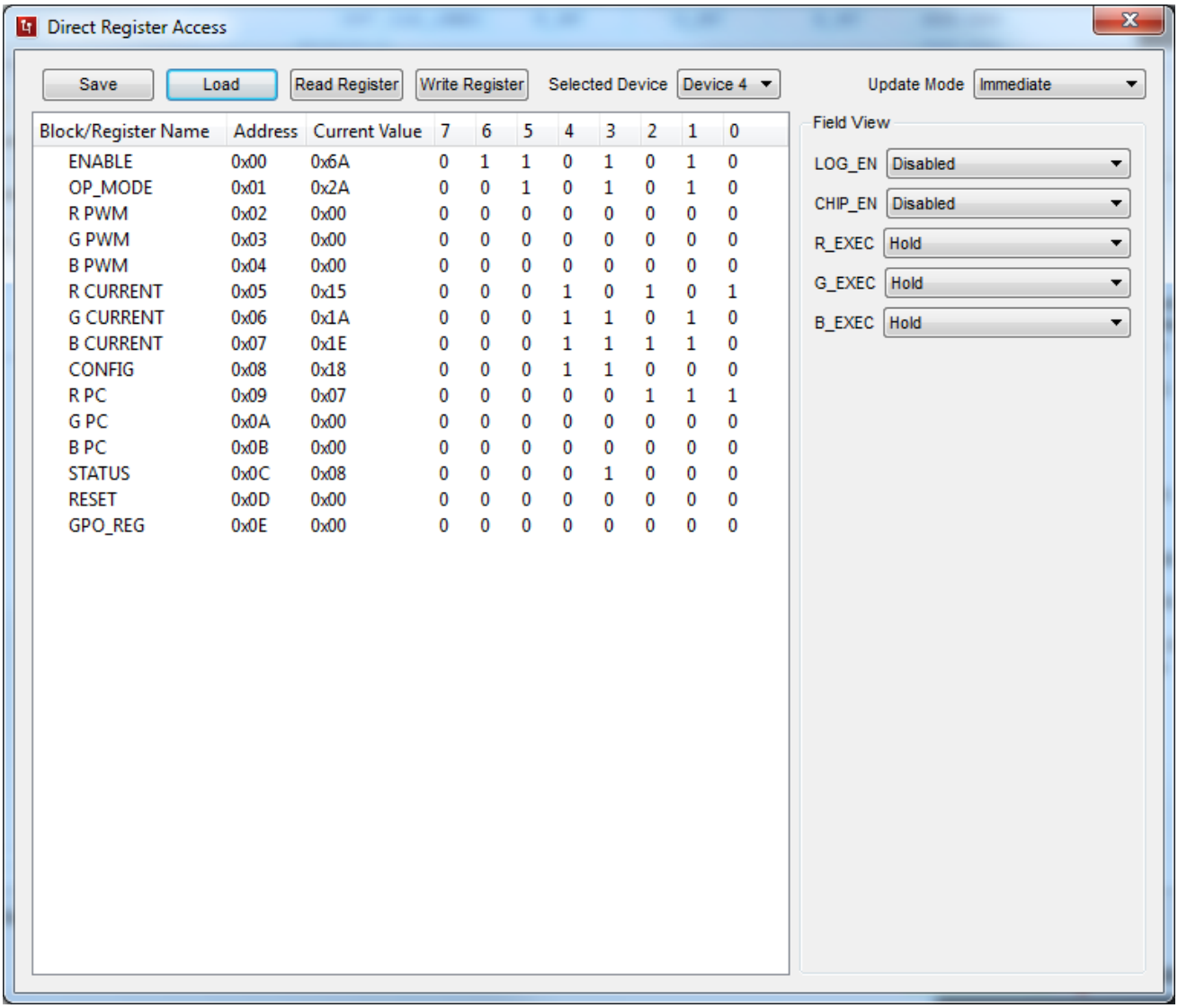


Figure 4. Direct Register Access Dialog

In the top part of the dialog there are the following controls:

Save— All registers are saved to a file.

Load— Register contents are restored from a file.

Read Register— Selected register is read from the selected device.

Write Register— Selected register is read from the selected device.

Selected Register— Selects the device to be controlled.

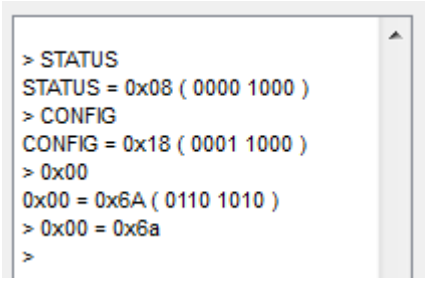
Update Mode— Immediate = changes are written to the selected device immediately.
Manual = "Write Register" button has to be used to write change to the device.

5.4.8 Console

The console window can be used to read and write any of the registers. A register can be read by giving register address, for example 0x00. Register value can be changed by giving register address followed by data, for example 0x00 = 0x05.

Console can also be used to run predefined script files. Script file needs to be located in the same folder as the LP5521 evaluation software. Script files are described with more details in the Script files chapter

Console can be enabled by clicking View → Console



6 Examples

This section describes how to do some basic operations with LP5521EV software.

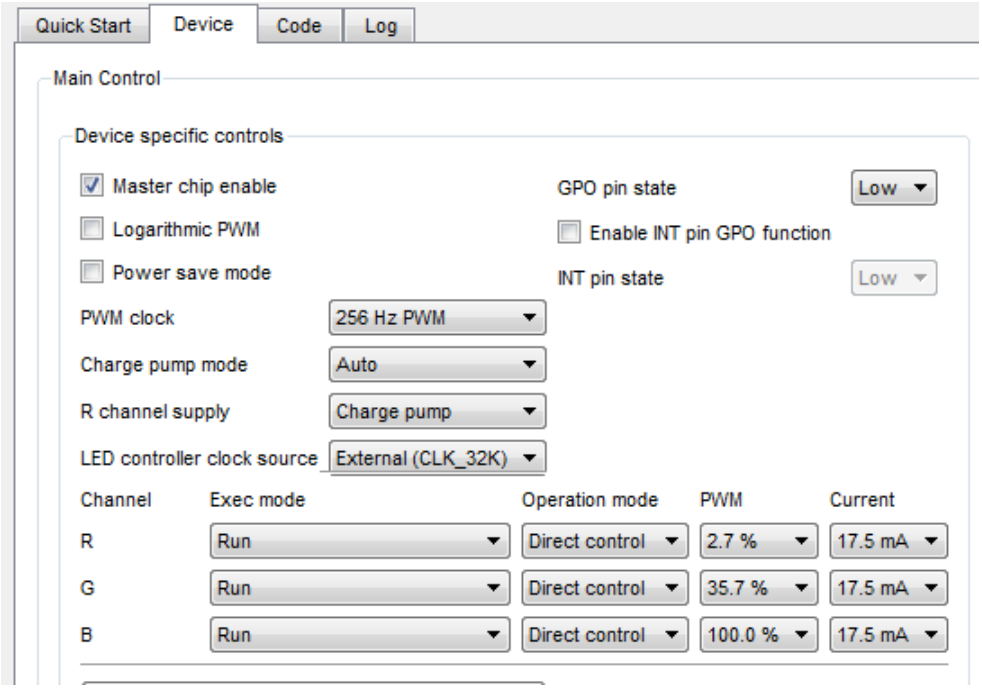
6.1 Starting up the LP5521

To start up the LP5521 and to be able to communicate with the device follow these steps:

- Connect and set up the EVM hardware as described in chapter LP5521TMEV Hardware and turn on the power supply if external supply is used.
- Set EN pin high by checking “Enable devices”. LP5521 is now in normal mode and all the registers can be read and written.
- Use “Selected Device” dropdown menu to select right device.

6.2 Set R, G, and B LEDs ON

- Start up the device as described in chapter Section 6.1.
- In Device tab, check checkbox “Master chip enable”.
- Set operation mode for each channel to “Direct control”.
- Set charge pump mode to “auto”.
- Increase PWM values of each LED.



7 Using Scripts

Script file is a text file that contains number of different register write/read operations. Script files also support simple looping, wait command and can take parameters as inputs. Script file can be used to set up LP5521. They can also be used to generate brightness ramps etc.

Script file can be run by typing the name of the script file to the console window. To be able to run the script file it needs to be stored into the LP5521 evaluation software installation folder. If LP5521 evaluation software was installed to default location it can be found in “C:\Program Files\Texas Instruments\LP5521 EVM”.

7.1 Register Access

Registers can be accessed by register name or by direct address. It is also possible to limit access to specific bit field to keep other bits in same register address unaltered.

7.1.1 Example: Read contents of ENABLE register in address 0h.

By direct address:

```
> 0x0
0x0 = 0x6A ( 0110 1010 )
```

By register name:

```
> ENABLE
ENABLE = 0x6A ( 0110 1010 )
```

7.1.2 Example: Write value AAh to R_PWM register in address 02h.

By direct address:

```
> 0x02=0xaa
```

By register name:

```
> R_PWM = 0xaa
```

7.1.3 Example: Read bit field R_EXEC (bits [5:4]) from ENABLE register in address 0h.

By direct address:

```
> 0x0[5:4]
0x0[5:4] = 0x02 ( 0000 0010 )
```

By bit name:

```
> R_EXEC
R_EXEC = 0x02 ( 0000 0010 )
```

7.1.4 Example: Write 02h to bit field R_EXEC (bits [5:4]) in ENABLE register, address 0h.

By direct address:

```
> 0x0[5:4] = 0x02
```

By bit name:

```
> R_EXEC
R_EXEC = 0x02 ( 0000 0010 )
```

When writing to registers or bit fields, values can be given in several formats. The following example shows commands which do effectively same thing.

```
> 0x02=0xaa
> 0x02=aah
> 0x02=170
> 0x02=10101010b
```

7.2 Parameters

It is possible to execute a script with parameters. Scripts can also call other scripts and give them parameters.

7.2.1 Example: Call “example2.txt” script with three parameters.

Example: Call “example2.txt” script with three parameters:

```
// variables example
// execute this script by giving it
parameter:
// example2.txt <time> <addr in hex>
<data>

// input parameters
// $0 wait time
// $1 address
// $2 data to write

wait($0)

$1 = $2
```

It is possible to call script with up to 7 parameters.

7.3 Loops

It is possible to create simple for-loops in script files. Example below shows how to use for-loops.

```
// for-loop example


// incrementing variable

for i=0:10:100
      wait($i)
end


// decrementing
for i=100:-10:0
      wait($i)
end

// nested loop

for i=0:1:5
      for j=0:10:100
            wait($j)
      end
end
```

7.4 Command Reference

wait()	Programmable delay

wait(N)

Creates N milliseconds long delay. N can be between 1 and 10000.

example: wait(1000)

8 Command Compiler

Command compiler is used to write LED sequences for the LP5521. It is simple to use tool integrated to GUI application. User can write own memory files by using source editor in Code tab. Compiling can be done by clicking “Assemble>>” button.

8.1 Instruction Reference

8.1.1 ramp

Ramp command generates a PWM ramp from current value. Ramp command has two parameters – first is time in milliseconds (maximum time = 1000 ms x number of steps) and second is number of steps (positive or negative integer, 2-128) separated by comma.

Example: ramp 100,50

8.1.2 wait

With wait command, program execution stops for time defined. Command has one parameter, time in milliseconds. (1-999)

Example: wait 500

8.1.3 branch

Branch command can be used to loop certain sequences in program. Command loads step number to program counter. It has two parameters, loop count (0-63, 0 means infinite loop) and label separated with comma, Label must be defined before using in a branch command. The following example loops 5 times between label1 and branch command.

Example: label1: …

…

…

branch 5, label1

8.1.4 set_pwm

set_pwm command sets PWM output value. Command has one parameter, PWM value (0-255).

Example: set_pwm 23

8.1.5 start

start command resets program counter and continues executing from the beginning of the section.

Example: start

8.1.6 trigger

trigger command waits or sends trigger. Command has two parameters, wait channel and send channel. Channels are defined as: r = red, g = green, b = blue and e = external.

Examples: trigger sr => Send trigger to red channel

trigger sg => Send trigger to green channel

trigger sb => Send trigger to blue channel

trigger se => Send trigger to external channel

trigger sgb => Send trigger to green and blue channel

trigger wr => Wait for trigger from red channel

trigger sr,wb => Send trigger to red channel and wait for trigger from blue channel.

8.1.7 end

end command ends program execution. Optionally interrupt signal can be sent or program counter can be reset. Command can have up to two parameters. I = send interrupt to INT pin, R = reset program counter.

Examples:

end I

end R

end R,I

end I,R

end

8.1.8 Comment

Comment lines must start with “#” or “/” character.

Example: # red LED section start

8.1.9 Sections

Red, green and blue LED engine sections start with .RED, .GREEN or .BLUE.

Example: .RED

8.1.10 Labels

Any words with colon (:) as last character.

Example: label1:

8.2 Example Code

```
# red LED section
start
.RED
ramp 20.5,6
ramp 10,-15
wait 10
# green LED section
start
.GREEN
ramp 10,-15
start
# blue LED section
start
.BLUE
ramp 10,15
end R
```

9 Evaluation Board Schematics

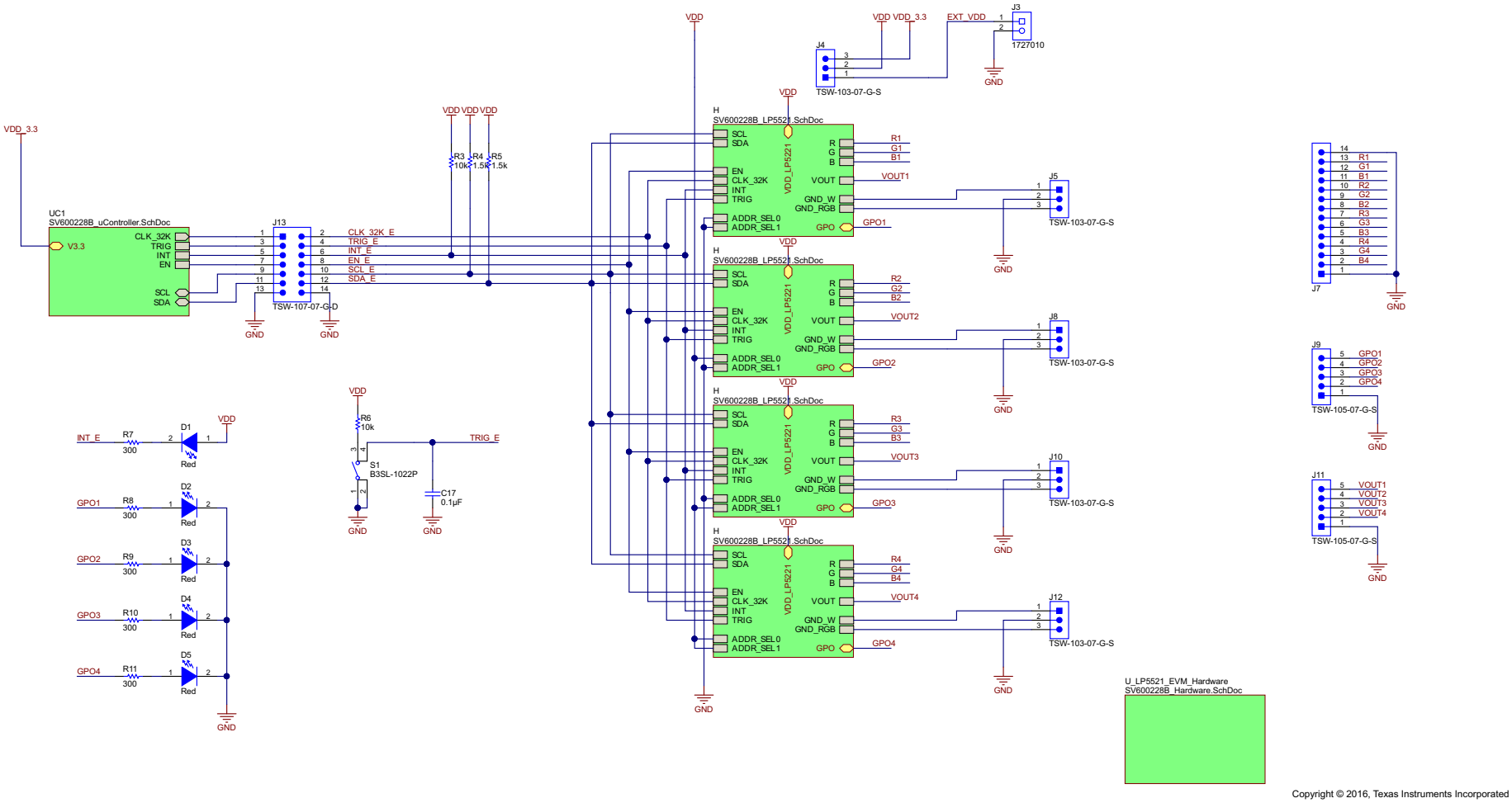


Figure 5. Top Level

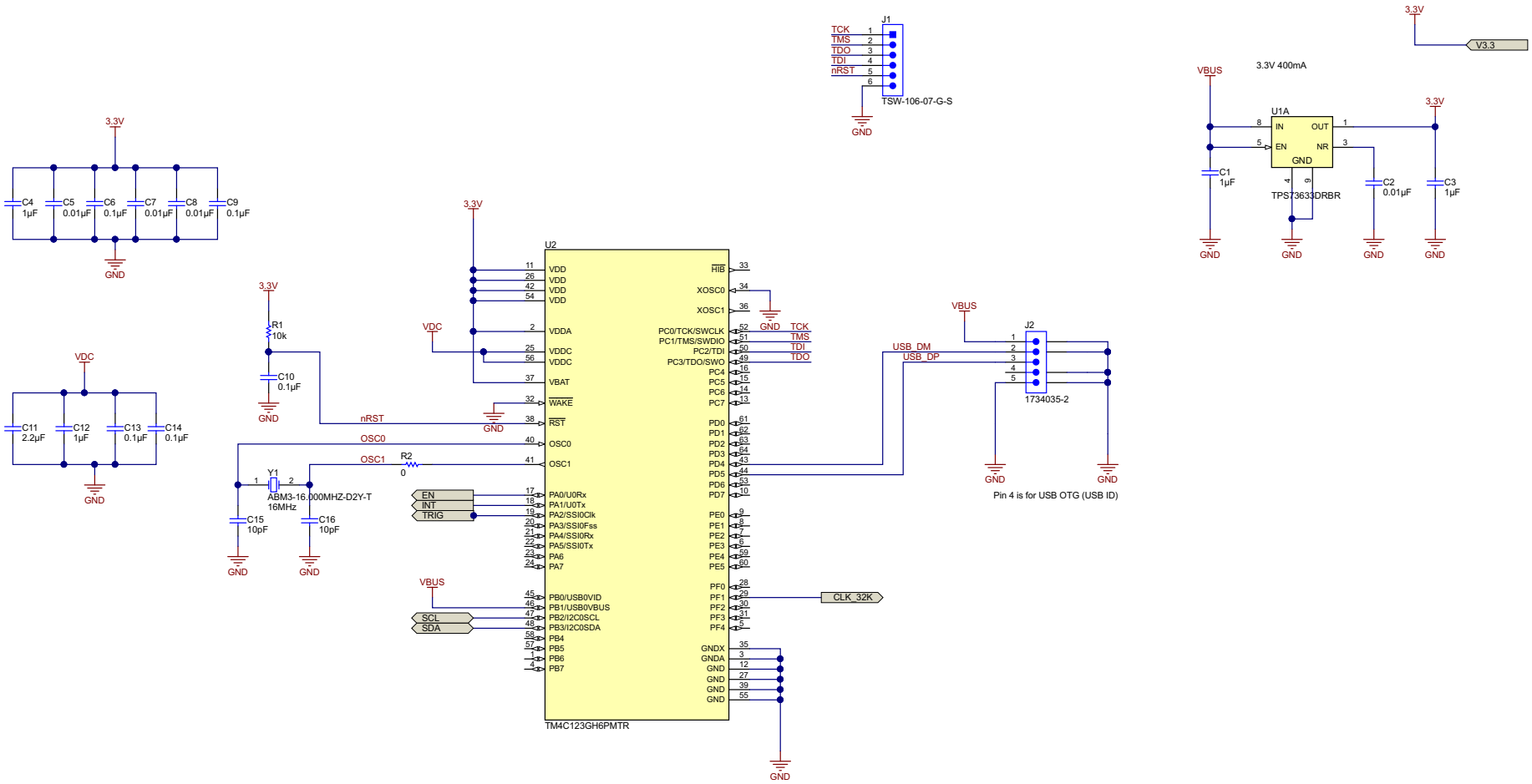


Figure 6. Microcontroller

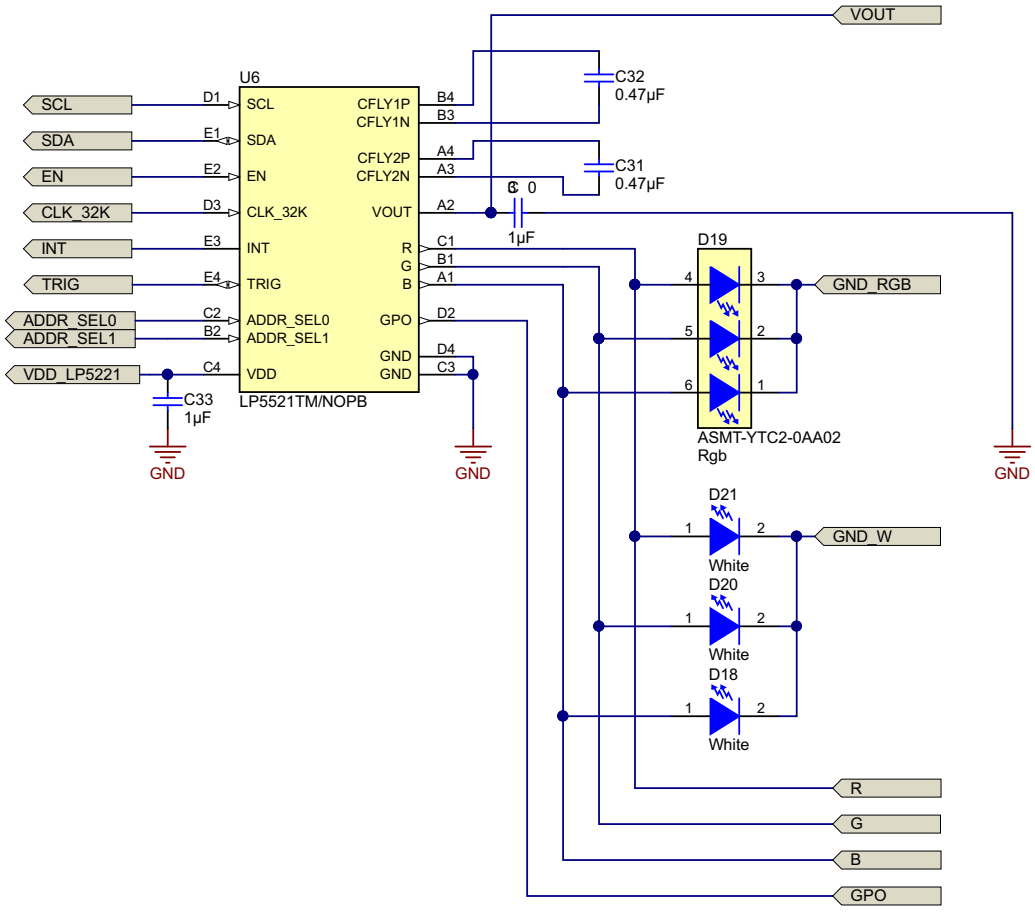


Figure 7. LP5521 (Device 1)

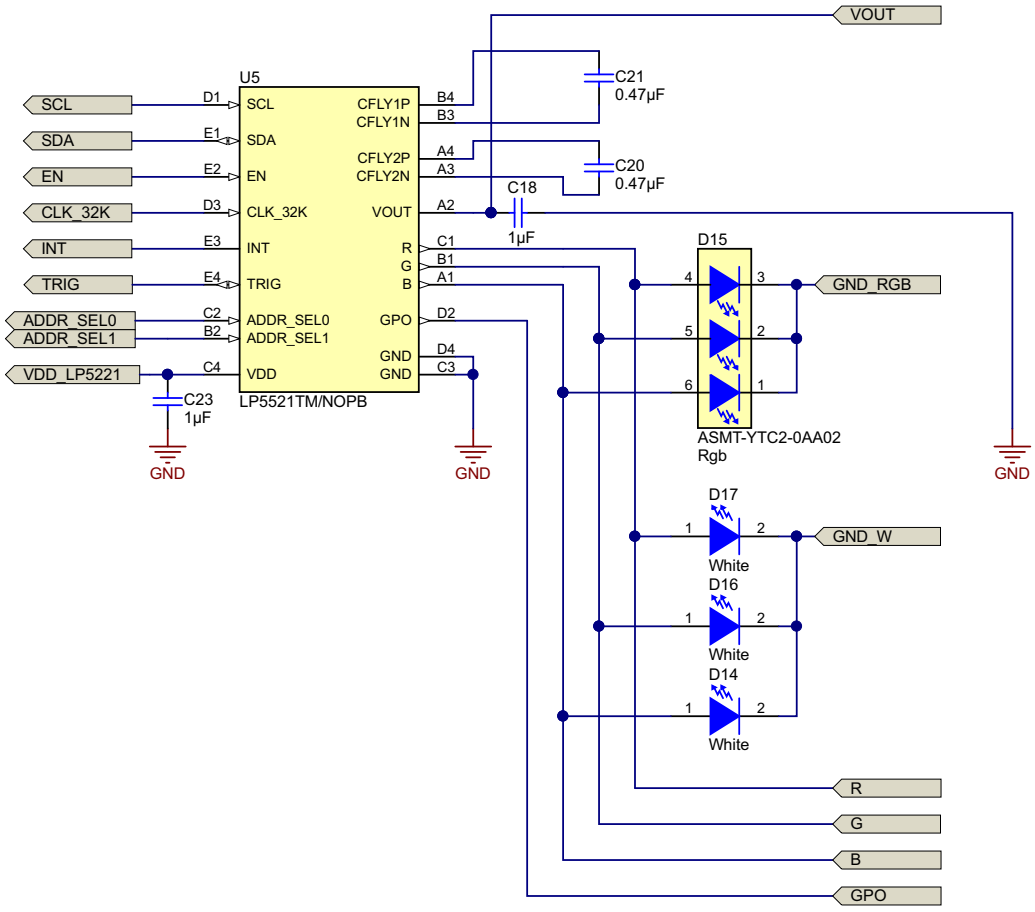


Figure 8. LP5521 (Device 2)

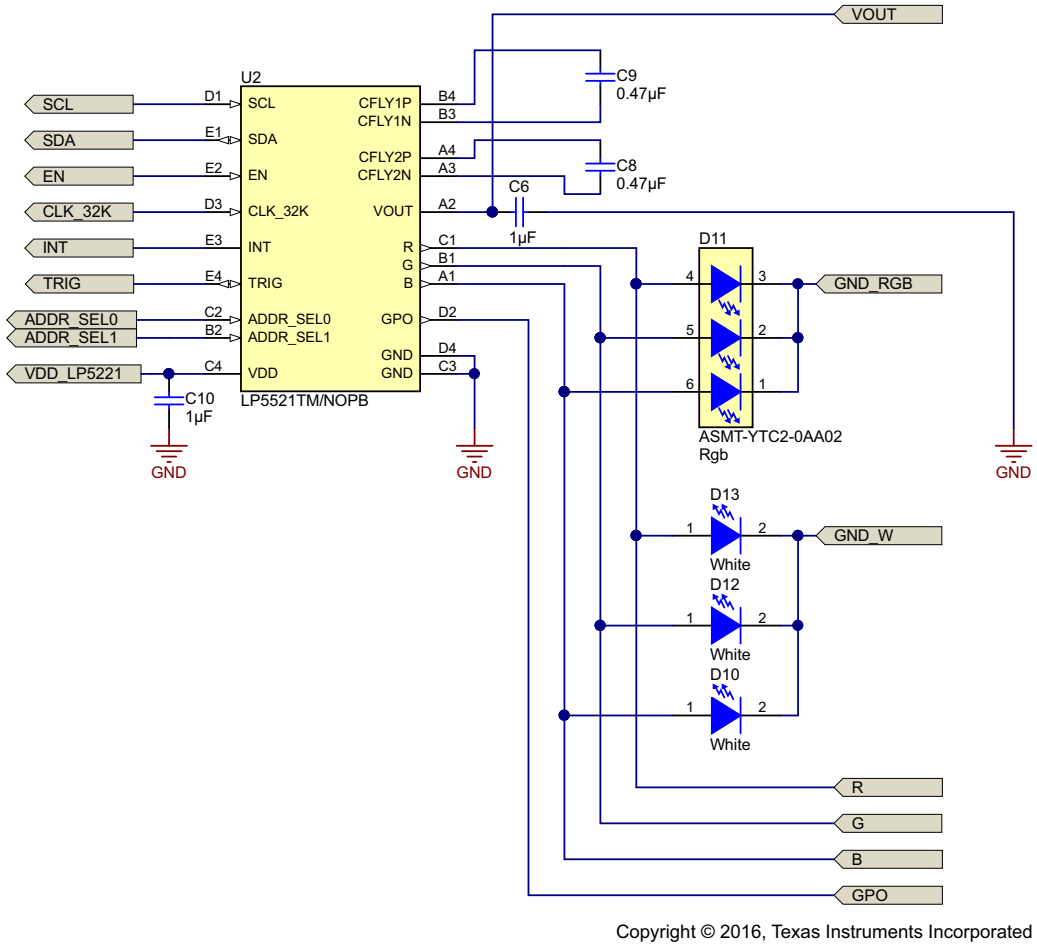


Figure 9. LP5521 (Device 3)

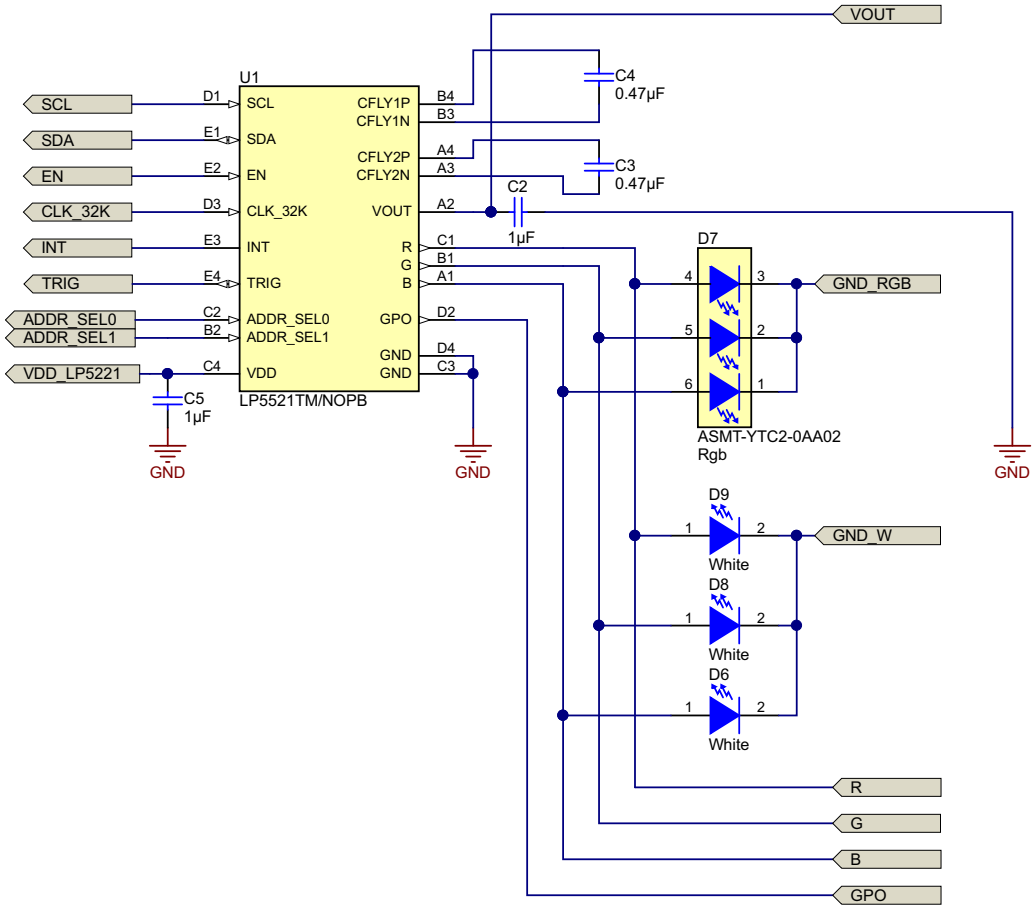


Figure 10. LP5521 (Device 4)

10 PCB Layout

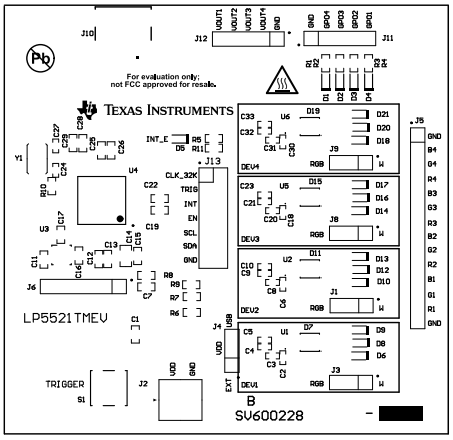


Figure 11. Top Overlay

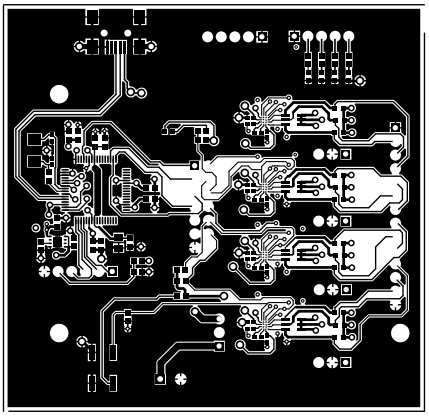


Figure 12. Layer 1 (Top, Signal)

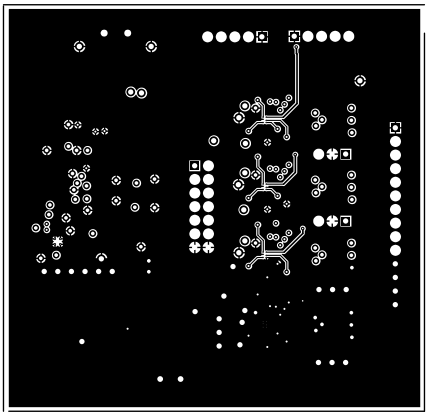


Figure 13. Layer 2 (GND)

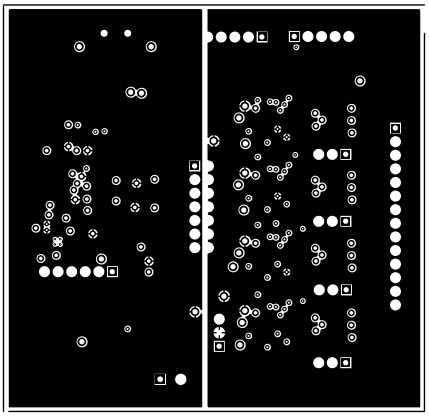


Figure 14. Layer 4 (Power)

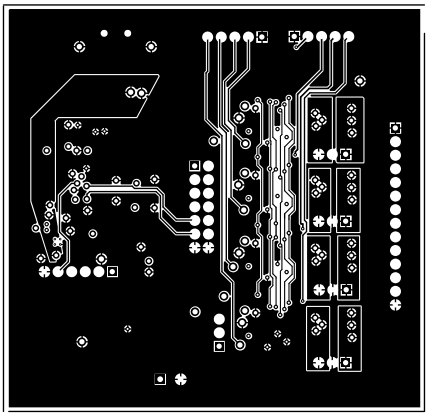


Figure 15. Layer 4 (Bottom, Signal)

11 Bill of Materials

The following is the bill of materials for the LP5521TMEV:

DESIGNATOR	QUANTITY	VALUE	PART NUMBER
C1, C7, C15, C22, C25, C29	6	0.1uF	GRM188R71C104KA01D
C2, C5, C6, C10, C18, C23, C30, C33	8	1uF	C1005X5R1A105K050BB
C3, C4, C8, C9, C20, C21, C31, C32	8	0.47uF	C1005X5R1A474K050BB
C11, C13, C19, C28	4	0.01uF	C0603H103J3GACTU
C12, C16, C17, C26	4	1uF	GRM188R61A105KA61D
C14	1	2.2uF	EMK212B7225KG-T
C24, C27	2	10pF	GRM1555C1H100FA01D
D1, D2, D3, D4, D5	5	Red	HSMC-C190
D6, D8, D9, D10, D12, D13, D14, D16, D17, D18, D20, D21	12	White	SML312WBCW1
D7, D11, D15, D19	4	Rgb	ASMT-YTC2-0AA02
R1, R2, R3, R4, R5	5	300	RC0603JR-07300RL
R6, R11	2	10k	RC0603JR-0710KL
R7, R9	2	1.5k	RC0603JR-071K5L
R8	1	10k	CRCW060310K0JNEA
R10	1	0	CRCW06030000Z0EA
S1	1		B3SL-1022P
U1, U2, U5, U6	4		LP5521TM/NOPB
U3	1		TPS73633DRBR
U4	1		TM4C123GH6PMTR
Y1	1		ABM3-16.000MHZ-D2Y-T

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
September 2016	E	Complete re-write of user guide.

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2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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:*

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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/lsds/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/lsds/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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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
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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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.

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Last updated 10/2025