LP5569 Lighting Pattern Design

ABSTRACT
This application report describes how to design lighting pattern with LP5569 Programmable lighting engine and provides examples of the fashion lighting pattern for the user.

Contents
1 Introduction .................................................................................................................................... 1
2 Device Overview .......................................................................................................................... 2
3 Lighting Pattern Design with LEDs on LP5569EVM ..................................................................... 2
4 Lighting Pattern Design with LEDs on LP5569 Ring Demo ............................................................ 5
5 References ................................................................................................................................... 14

List of Figures
1 LED Board Design ....................................................................................................................... 5
2 Mono-Color Chasing Engine Code for 4 Devices ........................................................................... 7
3 Multi-Color Chasing Code for U1 and U2 ...................................................................................... 8
4 Multi-Color Chasing Code for U3 and U5 ...................................................................................... 9
5 Door Open .................................................................................................................................... 10
6 lasm.exe Path .................................................................................................................................. 11
7 Compile Panel in LP5569EVM GUI .............................................................................................. 12

List of Tables
1 LED and I2C Address Assignment ............................................................................................... 5

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1 Introduction
This application report describes LP5559 lighting pattern design with examples for the device quick start. Most of the programs are presented with command compiler syntax. The Command compiler is described in The Control View - Source Edit Tab of Using the BOOST-LP5569EVM Evaluation Module. This application report also includes LED ring Demo (click here) sample code in both command syntax and C language. Command compiler software is available with the evaluation kit.
2 Device Overview

The LP5569 device is a programmable, easy-to-use 9-channel I2C LED driver designed to produce lighting effects for various applications. The LED driver is equipped with an internal SRAM memory for user programmed sequences and three programmable LED engines, which allow operation without processor control. Autonomous operation reduces system power consumption when the processor is put in sleep mode.

3 Lighting Pattern Design with LEDs on LP5569EVM

The following lighting pattern is realized with white LEDs on LP5569EVM.

3.1 Bouncing Effect

This design is best viewed with 9 white LEDs on the LP5569EVM. This design has 4 white LEDs on at all times. Each LED has different PWM settings to create two tracers bouncing back and forth.

```
; bouncing.src
L10: dw 0000000000000001b
L11: dw 0000000000000010b
L12: dw 0000000000000100b
L13: dw 00000000000001000b
L14: dw 00000000000010000b
L15: dw 00000000000100000b
L16: dw 00000000000001000b
L17: dw 0000000000000010b
L20: dw 0000000100000000b
L21: dw 0000000010000000b
L22: dw 0000000001000000b
L23: dw 0000000000100000b
L24: dw 0000000000010000b
L25: dw 0000000000001000b
L26: dw 0000000000000100b
L27: dw 0000000000000010b

.segment program1
  map_start L10 ; load the start address
  load_end L17 ; load the end address
  loop1:
    trigger s{2}
    set_pwm 0
    map_next
    set_pwm 30
    map_next
    set_pwm 100
    map_prev
    wait 0.1 ; wait time to create effect
    branch 0, loop1
  end

.segment program2
  map_start L20 ; load the start address
  load_end L27 ; load the end address
  loop2:
    trigger w{1}
    set_pwm 0
    map_next
    set_pwm 30
    map_next
    set_pwm 100
    map_prev
    branch 0, loop2
  end

.segment program3
  end
```
3.2 Breath_white Effect

This design is best viewed with 9 white LEDs on the LP5569EVM. This design has 3 group LED breathing.

GRP1:  dw  0000000001001001b
GRP2:  dw  0000000010010010b
GRP3:  dw  0000000100100100b

.segment program1 ;Begin of a segment
 map_addr GRP1
 set_pwm 00
 loop1:
   ramp 1, 100
   ramp 1, -100
   wait 0.3
   branch 0, loop1
 end

.segment program2 ;Begin of a segment
 map_addr GRP2
 set_pwm 00
 loop2:
   ramp 1, 100
   ramp 1, -100
   wait 0.3
   branch 0, loop2
 end

.segment program3 ;Begin of a segment
 map_addr GRP3
 set_pwm 00
 loop3:
   ramp 1, 100
   ramp 1, -100
   wait 0.3
   branch 0, loop3
 end
3.3 **Chaser Effect**

This design is best viewed with 9 white LEDs on the LP5569EVM. This design has 3 white LEDs on at all times. Each LED has different PWM settings to create a chaser (or tracer) effect.

```assembly
; chaser.src

L00: dw 0000000000000001b
L01: dw 0000000000000010b
L02: dw 0000000000000100b
L03: dw 00000000000001000b
L04: dw 0000000000100000b
L05: dw 00000000001000000b
L06: dw 000000000010000000b
L07: dw 0000000000100000000b
L08: dw 00000000001000000000b
L09: dw 000000000001000000000b
L10: dw 0000000000001000000000b
L11: dw 00000000000001000000000b
L12: dw 00000000000000100000000b
L13: dw 000000000000000100000000b
L14: dw 0000000000000000100000000b
L15: dw 000000000000000001000000000b
ALL: dw 0000000111111111b

.segment program1
map_addr ALL
ramp 0.5, 150
ramp 0.5, -150
wait 0.2
map_start L00 ;load the start address
load_end L15 ;load the end address
loop1:
set_pwm 0
map_next
set_pwm 5
map_next
set_pwm 50
map_next
set_pwm 150
map_prev
map_prev
wait 0.07 ;wait time to create effect
branch 0, loop1
end
.end

.segment program2
end
```
4 Lighting Pattern Design with LEDs on LP5569 Ring Demo

The LED ring is the latest HMI in the smart personal electronic device space and improves the user experience. More and more appliance vendors are adopting this concept in next generation products. For the appliance customer, the existing model with the existing MCU already meets system specification, but the fancy lighting pattern will exhaust the system resources and potentially cause the MCU to crash. It is requires a triple design circle to design complex lighting patterns without an engine control LED driver.

According to Figure 1 for LED board design, U1,U2,U3, and U5 drive 12 pcs RGB LED modules. The LED mapping and I2C address assignments are shown as the Table 1.

![Figure 1. LED Board Design](image)

Table 1. LED and I2C Address Assignment

<table>
<thead>
<tr>
<th>Device</th>
<th>I2C Address</th>
<th>Broadcasting I2C Address</th>
<th>Channel Number of The LED Driver</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>0x32H</td>
<td>0x40H</td>
<td>LED0, LED3, LED6</td>
<td>D1-B, D1-G,D1-R</td>
</tr>
<tr>
<td>U1</td>
<td>0x32H</td>
<td>0x40H</td>
<td>LED1, LED4, LED7</td>
<td>D2-B, D2-G,D2-R</td>
</tr>
<tr>
<td>U1</td>
<td>0x32H</td>
<td>0x40H</td>
<td>LED2,LED5, LED8</td>
<td>D3-B, D3-G,D3-R</td>
</tr>
<tr>
<td>U2</td>
<td>0x33H</td>
<td>0x40H</td>
<td>LED0, LED3, LED6</td>
<td>D4-B, D4-G,D4-R</td>
</tr>
<tr>
<td>U2</td>
<td>0x33H</td>
<td>0x40H</td>
<td>LED1, LED4, LED7</td>
<td>D5-B, D5-G,D5-R</td>
</tr>
<tr>
<td>U2</td>
<td>0x33H</td>
<td>0x40H</td>
<td>LED2,LED5, LED8</td>
<td>D6-B, D6-G,D6-R</td>
</tr>
<tr>
<td>U3</td>
<td>0x34H</td>
<td>0x40H</td>
<td>LED0, LED3, LED6</td>
<td>D7-B, D7-G,D7-R</td>
</tr>
<tr>
<td>U3</td>
<td>0x34H</td>
<td>0x40H</td>
<td>LED1, LED4, LED7</td>
<td>D8-B, D8-G,D8-R</td>
</tr>
<tr>
<td>U3</td>
<td>0x34H</td>
<td>0x40H</td>
<td>LED2,LED5, LED8</td>
<td>D9-B, D9-G,D9-R</td>
</tr>
<tr>
<td>U5</td>
<td>0x35H</td>
<td>0x40H</td>
<td>LED0, LED3, LED6</td>
<td>D10-B, D10-G,D10-R</td>
</tr>
<tr>
<td>U5</td>
<td>0x35H</td>
<td>0x40H</td>
<td>LED1, LED4, LED7</td>
<td>D11-B, D11-G,D11-R</td>
</tr>
<tr>
<td>U5</td>
<td>0x35H</td>
<td>0x40H</td>
<td>LED2,LED5, LED8</td>
<td>D12-B, D12-G,D12-R</td>
</tr>
</tbody>
</table>
Firstly, define the LED Mapping in the beginning of the engine coding as shown below.

```assembly
row1:    dw 0000000001001001b ;Map B LED = D1, D4, D7 on the eval. board.
dw 0000000010010010b ;Map G LED = D2, D5, D8 on the eval. board.
dw 0000000000100100b ;Map R LED = D3, D6, D9 on the eval. board.
dw 0000000110110111b ;Map BG LED on the eval. board.
dw 0000000110110110b ;Map GR LED on the eval. board.
dw 0000000101101101b ;Map RB LED on the eval. board.
row7:    dw 0000000111111111b ;Map all LEDs on the eval. board.
row8:    dw 0000000001001001b ;Map B LED = D1,D4,D7 on the eval. board.
row9:    dw 0000000010010010b ;Map G LED = D2,D5,D8 on the eval. board.
```

4.1 Breathing

During the breathing pattern, all LEDs fade in and out as the same color at the same rate, therefore all devices should run the same engine code below.

```assembly
.segment program1 ;Program for engine 1.
loop1_0:
    map_start  row1 ;Map the first LED.
    load_end   row7 ;End address of the mapping data table.
loop1:
    ramp   2, 200 ;Increase PWM 0->78% in 2 second.
    ramp   2, -255 ;Decrease PWM ->0% in 2 seconds.
    wait   0.4 ;Wait for 0.4 seconds.
    ramp   2, 200 ;Increase PWM 0->78% in 2 second.
    ramp   2, -255 ;Decrease PWM ->0% in 2 seconds.
    wait   0.4 ;Wait for 0.4 seconds.
    map_next ;Set the next row active in the mapping table.
    branch 6,loop1 ;Loop 6 time
    map_addr row8
    ramp   1.5, 200 ;Increase PWM 0->78% in 1.5 second.
    wait   0.4 ;Wait for 0.4 seconds.
    wait   0.4 ;Wait for0.4 seconds.
    map_addr row9
    ramp   3, 200 ;Increase PWM 0->78% in 3 second.
    ramp   3, -255 ;Decrease PWM ->0% in 3 seconds.
    ramp   3, 200 ;Increase PWM 0->78% in 3 second.
    ramp   3, -255 ;Decrease PWM ->0% in 3 seconds.
    map_addr row8
    ramp   1.5, -255 ;Decrease PWM ->0% in 1.5 seconds.
```
### 4.2 Mono-Color Chasing

The mono-color chasing pattern needs the devices to start execution with a specific sequence delay. Each device has different code, as shown in Figure 2.

<table>
<thead>
<tr>
<th>Device</th>
<th>Code</th>
</tr>
</thead>
</table>
| U1     | ```
wait 0.4 
ld ra, 75 
loop1_2: map_sel 7 
set_pwm ra 
map_sel 4 
sub ra, 20 
set_pwm ra 
map_sel 1 
sub ra, 20 
set_pwm ra 
add ra, 20 
wait 0.03 
branch 63, loop1_2 
branch 10, loop1_2 
wait 0.1 
map_addr row7 
set_pwm 0
``` |
| U2     | ```
wait 0.4 
ld ra, 135 
loop1_2: map_sel 7 
set_pwm ra 
map_sel 4 
sub ra, 20 
set_pwm ra 
map_sel 1 
sub ra, 20 
set_pwm ra 
add ra, 20 
wait 0.03 
branch 63, loop1_2 
branch 3, loop1_2 
wait 0.1 
map_addr row7 
set_pwm 0
``` |
| U3     | ```
wait 0.4 
ld ra, 255 
loop1_2: map_sel 7 
set_pwm ra 
map_sel 4 
sub ra, 20 
set_pwm ra 
map_sel 1 
sub ra, 20 
set_pwm ra 
add ra, 20 
wait 0.03 
branch 63, loop1_2 
branch 3, loop1_2 
wait 0.1 
map_addr row7 
set_pwm 0
``` |
| U4     | ```
wait 0.4 
ld ra, 195 
loop1_2: map_sel 7 
set_pwm ra 
map_sel 4 
sub ra, 20 
set_pwm ra 
map_sel 1 
sub ra, 20 
set_pwm ra 
add ra, 20 
wait 0.03 
branch 63, loop1_2 
branch 3, loop1_2 
wait 0.1 
map_addr row7 
set_pwm 0
``` |

Figure 2. Mono-Color Chasing Engine Code for 4 Devices
### 4.3 Multi-Color Chasing

The multi-color chasing pattern requires the devices to start execution with a specific sequence delay. Each device has different code, as shown in Figure 3 and Figure 4.

**Figure 3. Multi-Color Chasing Code for U1 and U2**
Figure 4. Multi-Color Chasing Code for U3 and U5
4.4  Door Open

The door open pattern needs the devices to start execution with a specific sequence delay. Each device has different code as shown in Figure 5.

Figure 5. Door Open
4.5 **Coding Tips**

- Use the branch instruction to synchronize multiple devices, as it guarantees all devices will be at the same time scale and step.
- Remember to clear the LED mapping with map_clr when using the same LED in the difference engine.
- Use the appropriate variable (ra, rb, rc, rd) for the progressive increase or decrease operation.

4.6 **Uploading The Program to SRAM**

The compile tool (Lasm.exe) can be downloaded from the GUI package on ti.com. The command window or GUI can be used to compile the .scr file.

![Figure 6. lasm.exe Path](image-url)
After the compiling, a .hex file will appear in the same folder as the .scr file.

00 49 00 92 01 24 00 DB 01 B6 01 6D 01 FF 00 49
00 92 9C 00 9C 86 28 C8 21 FF 74 00 28 C8 21 FF
74 00 9D 80 A3 02 9F 87 1E C8 74 00 74 00 9F 88
3E C8 31 FF 3E C8 31 FF 9F 87 19 FF 74 00 90 FF
9D 07 84 60 9D 04 92 14 84 60 9D 01 92 14 84 60
91 14 44 00 BF 97 A1 97 4C 00 9F 86 40 00 74 00
90 FF 9F 87 14 C8 74 00 9D 08 84 60 9D 05 92 14
84 60 9D 02 92 14 84 60 91 14 44 00 BF AB A1 AB
4C 00 9F 86 40 00 9F 87 14 C8 46 00 A4 BC 9D 02
40 C8 46 00 9D 05 40 C8 46 00 9D 08 40 C8 46 00
9D 02 40 00 46 00 9D 05 40 00 46 00 9D 08 40 00
46 00 A3 4F A8 3E 9F 86 40 00 74 00 9D 07 40 C8
46 00 9D 04 40 C8 46 00 9D 01 40 C8 46 00 A3 5D
74 00 9D 01 40 00 46 00 9D 04 40 00 46 00 9D 07
40 00 46 00 A2 54 9D 00 E0 04 E2 00 00 00 E0 80
9F 87 14 C8 4A 00 A1 83 9D 03 40 C8 4A 00 9D 06
40 C8 4A 00 9D 09 40 C8 4A 00 9D 03 40 00 4A 00
9D 06 40 00 4A 00 9D 09 40 00 4A 00 9D 02 40 C8
4A 00 9D 05 40 C8 4A 00 9D 08 40 C8 4A 00 9D 02
40 00 4A 00 9D 05 40 00 4A 00 9D 08 40 00 4A 00
A5 05 9F 86 40 00 9D 00 E0 08 00 00 E1 00 46 00
A4 01 9D 03 40 D7 46 00 9D 06 40 EB 46 00 9D 09
40 FF 46 00 9D 09 40 00 46 00 9D 06 40 00 46 00
9D 03 40 00 46 00 A4 94 A2 01 9D 00 E0 02 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
@ 09 program1
@ 77 program2
@ A6 program3
Then, copy the hex file to the array table and upload the data to the SRAM by the below coding.

```c
void load_SRAM()
{
    int i, j;
    MAP_I2C_setSlaveAddress(EUSCI_B1_BASE,0x40); //Device global setting
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE,0x2F); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x48); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x02); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x54); //send register data

    MAP_I2C_setSlaveAddress(EUSCI_B1_BASE, 0x32); //load hex to SRAM in U1
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4b); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x09); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4c); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0xa8); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4d); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0xae); //send register data
    for(j=0; j<16; j++)
    {
        MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4F); //send register address
        MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,j); //send register data
        MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE,0x50); //send register address
        for(i=0; i<32; i++)
            MAP_I2C_masterSendMultiByteNext(EUSCI_B1_BASE,table_32[i+j*32]); //send register data
    }

    MAP_I2C_setSlaveAddress(EUSCI_B1_BASE, 0x33); //load hex to SRAM in U2
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4b); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x09); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4c); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0xb8); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4d); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x70); //send register data
    for(j=0; j<16; j++)
    {
        MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4F); //send register address
        MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,j); //send register data
        MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE,0x50); //send register address
        for(i=0; i<32; i++)
            MAP_I2C_masterSendMultiByteNext(EUSCI_B1_BASE,table_33[i+j*32]); //send register data
    }

    MAP_I2C_setSlaveAddress(EUSCI_B1_BASE, 0x34); //load hex to SRAM in U3
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4b); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x09); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4c); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0xb7); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4d); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x7b); //send register data
    for(j=0; j<16; j++)
    {
        MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4F); //send register address
        MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,j); //send register data
        MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE,0x50); //send register address
        for(i=0; i<32; i++)
            MAP_I2C_masterSendMultiByteNext(EUSCI_B1_BASE,table_34[i+j*32]); //send register data
    }

    MAP_I2C_setSlaveAddress(EUSCI_B1_BASE, 0x35); //load hex to SRAM in U5
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4b); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x09); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4c); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0xb6); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4d); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x6b); //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4e); //send register data
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE,0x66); //send register data
}
```
for(j=0; j<16; j++)
{
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x4F); //send register address
    MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE, j);    //send register data
    MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x50); //send register address
    for(i=0; i<32; i++)
        MAP_I2C_masterSendMultiByteNext(EUSCI_B1_BASE, table_35[i+j*32]);//send register data;
}

MAP_I2C_setSlaveAddress(EUSCI_B1_BASE, 0x32); //SET U1 as the clk out
MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x2F); //send register address
MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE, 0x49); //send register data
MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x3d); //send register address
MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE, 0x08); //send register data

MAP_I2C_setSlaveAddress(EUSCI_B1_BASE, 0x40); //Run all the engine
MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x02); //send register address
MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE, 0x00); //send register data
MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x02); //send register address
MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE, 0xa8); //send register data
MAP_I2C_masterSendMultiByteStart(EUSCI_B1_BASE, 0x01); //send register address
MAP_I2C_masterSendMultiByteFinish(EUSCI_B1_BASE, 0xa8); //send register data
}

5 References
Using the BOOST-LP5569EVM Evaluation Module
LP5569 Nine-Channel I2C RGB LED Driver With Engine Control and Charge Pump
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