LM3559/LM3560 Evaluation Board

National Semiconductor
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The LM3559/LM3560 Evaluation Board is designed to fully evaluate the LM3559 and LM3560 Synchronous Boost Converter with dual 900mA High Side Flash LED Drivers (LM3559) or dual 1000mA High Side Flash Drivers (LM3560) and I²C-Compatible Interface. Detailed descriptions for either parts can be found in their respective datasheets.

The board comes equipped with two Lumiled Flash LEDs (LXCL-EYW4). An additional LED (LED3) is a red LED which operates as the message indicator. The on-board flash button demonstrates the hardware flash feature of the LM3559/LM3560 and, when pushed, the Flash LEDs turn on at their programmed Flash current. There are two 4.7kΩ pull-up resistors on board for the I²C clock and data lines and a 4.7kΩ pull-up (R_HWEN) that pulls the active high hardware enable pin (HWEN) high. Each Input and/or output from the LM3559 has its own separate header pin to serve as a testpoint.

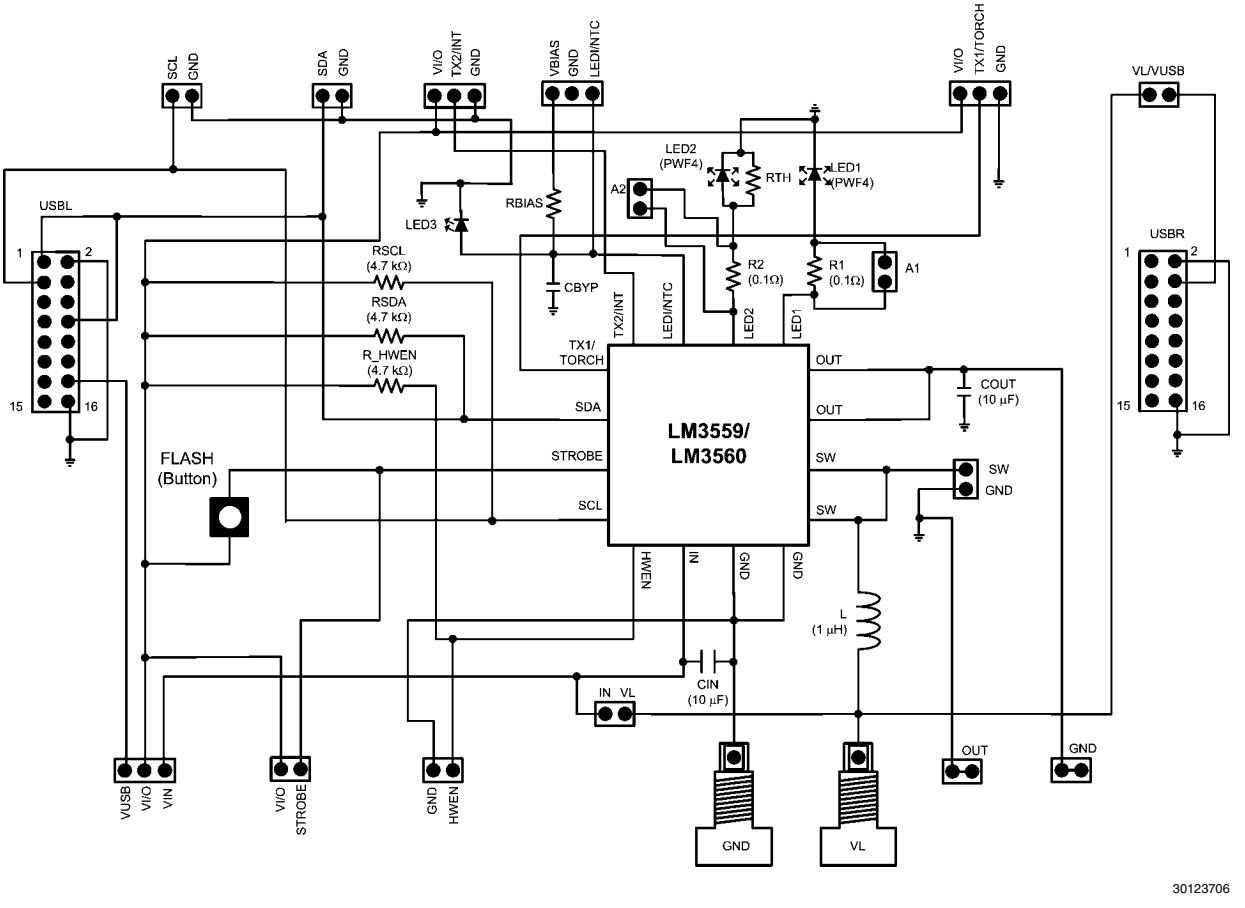

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FIGURE 1. LM3559/LM3560 Evaluation Board Schematic

Evaluation Board Bill of Materials

Component	Manufacturer	Value	Part Number	Size (mm)	Description
L	TOKO	1.0 µH	FDSD0312-1R0M	3x3x1.2	I_{SAT} = 3.4A (43 mΩ)
COUT	Murata	10 µF	GRM188R60J106M	0603 (1.6 x 0.8)	6.3V, X5R
CIN	Murata	10 µF	GRM188R60J106M	0603 (1.6 x 0.8)	6.3V, X5R
LED1, LED2	Lumiled	Flash LED	LXCL-EYW4	(2.04 x 1.64 x 0.7)	145 lm (1A), VF = 3.6V, @1A
LED3	Stanley Electric or equivalent	Red LED	HKR1105W-TR	1206 (3.2 x 1.6)	Red LED (20 mA max)
R1, R2	Panasonic	100 mΩ	ERJ-L06KF10CV	0805 (2 x 1.2)	1/8W, 1% Sense resistors for LED current
RTH (not populated)					
R_PU, RSDA, RSCL	Vishay	4.7 kΩ	CRCW06034700F	0603 (1.6 x 0.8)	
R3 (not populated)					
Flash Button	Panasonic		EVQP1		Momentary push-button
USBL, USBR					USB Interface Board Connector

Operation

To operate the LM3559/LM3560 evaluation board, connect a jumper from the VI/O pin to the IN pin (3-pin header at bottom left of board). This connects the logic level pull-ups to VIN. Next, connect a jumper across the IN VL header. This will short the IN pin and the input terminal of the inductor. This jumper is designed to remove the input bypass capacitor from the input of the inductor to measure the inductor current ripple. With these jumpers in place, connect a 2.5V to 5V supply between the VL banana jack and GND.

Control of the LM3559/LM3560 can be done via two ways. At the top left corner of the board there are two 2-pin headers (SCL/GND and SDA/GND). To control the LM3559/LM3560 using a data generator or an external I²C device connect the I²C lines directly to the SCL and SDA pins of the respective header. Alternatively you can use the National Semiconductor USB board to supply the I²C data (see following section).

OPERATION WITH NATIONAL SEMICONDUCTOR USB INTERFACE

The USBL and USBR connectors (16 pin connectors mounted on the bottom of the board) plug directly into the National Semiconductor USB Interface Board. The connectors are keyed so the boards will fit together only one way. The 3 position header at the bottom of the board (VUSB VI/O VIN) connects the evaluation boards pull-up resistors, tied to VI/O, to either VIN or to the 3.3V regulator (VUSB) from the USB board. Connecting a jumper across VIN/VUSB at the top right of the board allows for power (at the VL pin) to come from the National Semiconductor USB Interface Board. This is useful for demonstrating the device without an external power supply. Keep in mind that the USB board has a 500 mA current limit and is either 3V or 5V depending on the (J1) jumper setting on the National Semiconductor USB Interface Board (see USB Interface Module for Applications document for details). High-current requirements such as high Flash mode and higher Torch mode currents will require an external supply at VL. Also ensure the VIN/VUSB jumper is left open when connecting an external supply to the VL plugs as this will cause a conflict with the power supply from the Interface Board and the external supply connected to VL.

After power is applied to the LM3559/LM3560 Evaluation Board, connect the National Semiconductor USB Interface Board to a PC with the LM3559.exe or LM3560.exe program installed. The LM3559.exe and LM3560.exe programs are simple executables that can be copied to a folder on the PC. (see *Figure 2* and *Figure 3*) .

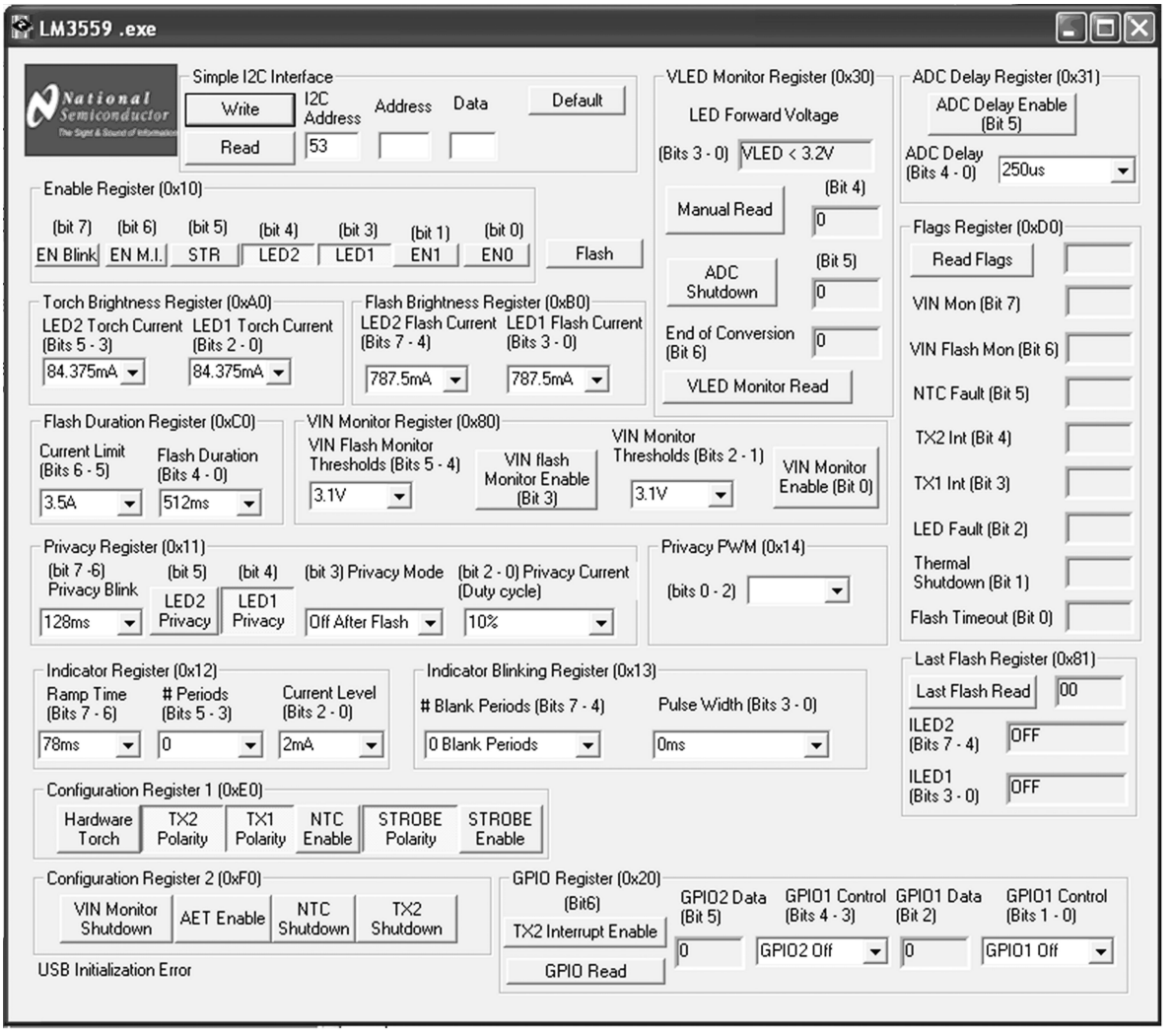

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FIGURE 2. LM3559 Graphical User Interface

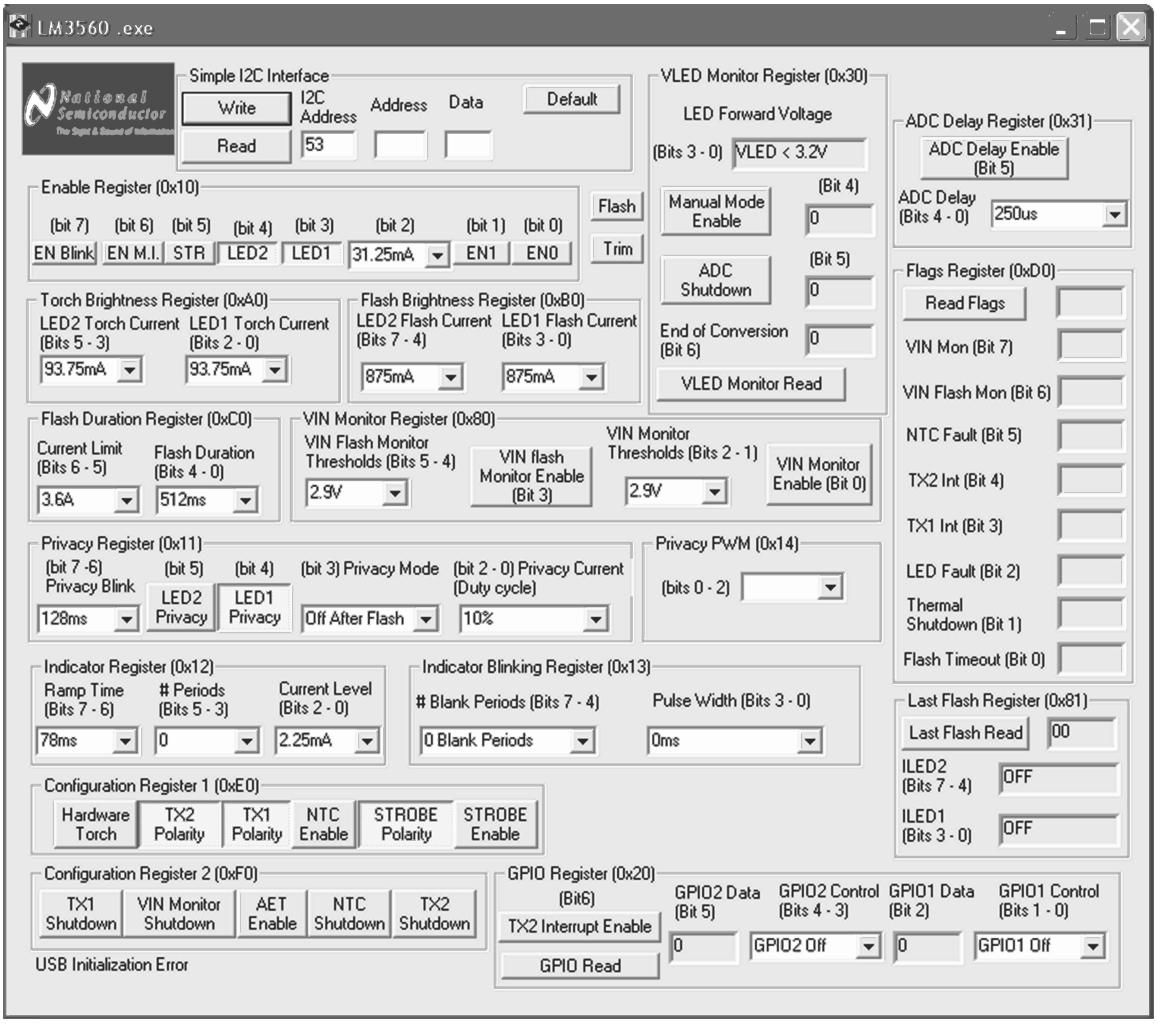

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FIGURE 3. LM3560 Graphical User Interface

LM3559 GRAPHICAL USER INTERFACE

The LM3559 graphical user interface features all the register options that are programmable within the LM3559. When the LM3559.exe program is executed and any button is pressed or drop down box is selected, the program will automatically update the LM3559 with the settings of the appropriate register. When starting up the LM3559.exe program the screen displays the default (power on/reset) settings of the device. The Default button in the program will write all the LM3559 registers to their default state and populate the LM3559.exe with the default information.

LM3560 GRAPHICAL USER INTERFACE

The LM3560 graphical user interface operates similar to the LM3559. The differences are: bit 2 in the Enable Register (0x10) in the LM3560.exe has the option for 2 levels of Privacy Mode Current, the Torch and Flash Current nominal settings are different, the LM3560.exe 's Configuration Register 2 (0xF0) reflects the additional option for a TX1 Shutdown, and the VLED Monitor Register nominal thresholds are different between devices.

The Following sections detail each different field within the LM3559.exe/LM3560.exe program.

SIMPLE I²C INTERFACE

The top 3 fields (I²C Address, Address, and Data) provide for a simple way of writing directly to the registers of the LM3559/LM3560. The I²C Address field shows the I²C slave address (0x53). The I2C (hex) address is written into the Address field and the I2C (hex) data is written in the Data field. The Write Button will write the contents to the LM3559/LM3560 and the Read button reads back the (hex) data.

DEFAULT

The Default button will automatically write all the internal registers to their default state and update the program to the default state.

ENABLE REGISTER

The Enable Register section contains buttons for each bit that is programmable within the LM3559/LM3560's enable register.

TABLE 1. Enable Register Description (0x10)

Blink Enable (Bit 7)	Message Indicate Enable (Bit 6)	STROBE Level/Edge (Bit 5)	LED2 Enable (Bit 5)	LED1 Enable (Bit 4)	Privacy Mode Peak Current (LM3560 only) (Bit 2)	EN2 (Bit 1)	EN1 (Bit 0)
0 = Message Indicator Blinking Function is disabled (See Note below). **(default)** 1 = Message Indicator Blinking Function is enabled. The message indicator blinks the pattern programmed in the Indicator Register and Indicator Blinking Register	0 = Message Indicator is disabled **(default)** 1= Message Indicator is enabled.	0 = (Level Sensitive) When STROBE goes high, the Flash current will turn on and remain on for the duration the STROBE pin is held high or when Flash Timeout occurs, whichever comes first **(default)** 1 = (Edge Triggered) When STROBE goes high the Flash current will turn on and remain on for the duration of the Flash Time-out.	0 = LED2 off 1 = LED2 on **(default)**	0 = LED1 off 1 = LED1 on **(default)**	0 = 31.25mA **(default)** 1 = 250mA	**Enable Bits** 00 = Both Current Sources are Shut Down **(default)** 01 = Indicator Mode 10 = Torch Mode 11 = Flash Mode (bits reset at timeout)	

Note: Bit 7 Enables/Disables the Message Indicator Blinking Function. With this bit set to 0 and Bit 6 set to 1, the Message Indicator turns on constantly at the programmed current as set in the Indicator Register, bits [2:0].

FLASH BUTTON

The Flash button automatically writes Register 0x10 (bits 0 and 1 high), enabling flash mode. At the end of the flash event, bit 1 is automatically written with a 0 and bit 0 is either left as a 1 or set to 0 depending on the state of the Privacy Mode bit (bit 3 in register 0x11).

TORCH BRIGHTNESS FIELD

The Torch Brightness field contains the drop down menu for selecting the torch current in either LED1 or LED2. Once the drop down data is selected the register data is automatically written to the LM3559/LM3560.

TABLE 2. Torch Brightness Register Description (Address 0xA0), LM3559

Not Used (Bit 7)	Not Used (Bit 6)	TC2A (Bit 5)	TC2B (Bit 4)	TC2C (Bit 3)	TC1A (Bit 2)	TC1B (Bit 1)	TC1C (Bit 0)
N/A		**LED2 Torch Current Select Bits** 0 = 28.125 mA 1 = 56.25 mA 2 = 84.375 mA **(default)** 3 = 112.5 mA 4 = 140.625 mA 5 = 168.75 mA 6 = 196.875 mA 7 = 225 mA			**LED1 Torch Current Select Bits** 0 = 28.125 mA 1 = 56.25 mA 2 = 84.375 mA **(defaul)** 3 = 112.5 mA 4 = 140.625 mA 5 = 168.75 mA 6 = 196.875 mA 7 = 225 mA		

TABLE 3. Torch Brightness Register Description (Address 0xA0), LM3560

Not Used (Bit 7)	Not Used (Bit 6)	TC2A (Bit 5)	TC2B (Bit 4)	TC2C (Bit 3)	TC1A (Bit 2)	TC1B (Bit 1)	TC1C (Bit 0)
N/A		**LED2 Torch Current Select Bits** 0 = 31.25 mA 1 = 62.5 mA 2 = 93.75 mA **(default)** 3 = 125 mA 4 = 156.25 mA 5 = 187.5 mA 6 = 218.75 mA 7 = 250 mA			**LED1 Torch Current Select Bits** 0 = 31.25 mA 1 = 62.5 mA 2 = 93.75 mA **(defaul)** 3 = 125 mA 4 = 156.25 mA 5 = 187.5 mA 6 = 218.75 mA 7 = 250 mA		

FLASH BRIGHTNESS REGISTER

The Flash Brightness Register field contains drop-down menus for both LED1 and LED2. Once any drop-down menu selection is chosen the data is automatically written to the device.

TABLE 4. Flash Brightness Register Descriptions (Address 0xB0), LM3559

FC2A (Bit 7)	FC2B (Bit 6)	FC2C (Bit 5)	FC2D (Bit 4)	FC1A (Bit 3)	FC1B (Bit 2)	FC1C (Bit 1)	FC1D (Bit 0)
Flash Current Select Bits 00 = 56.25 mA 01 = 112.5 mA 02 = 168.75 mA 03 = 225 mA 04 = 281.25 mA 05 = 337.5 mA 06 = 393.75 mA 07 = 450 mA 08 = 506.25 mA 09 = 562.5 mA 0A = 618.75 mA 0B = 675 mA 0C = 731.25 mA 0D = 787. 5mA**Default** 0E = 843.75 mA 0F = 900 mA				**Flash Current Select Bits** 00 = 56.25 mA 01 = 112.5 mA 02 = 168.75 mA 03 = 225 mA 04 = 281.25 mA 05 = 337.5 mA 06 = 393.75 mA 07 = 450 mA 08 = 506.25 mA 09 = 562.5 mA 0A = 618.75 mA 0B = 675 mA 0C = 731.25 mA 0D = 787. 5mA**Default** 0E = 843.75 mA 0F = 900 mA			

TABLE 5. Flash Brightness Register Descriptions (Address 0xB0), LM3560

FC2A (Bit 7)	FC2B (Bit 6)	FC2C (Bit 5)	FC2D (Bit 4)	FC1A (Bit 3)	FC1B (Bit 2)	FC1C (Bit 1)	FC1D (Bit 0)
Flash Current Select Bits 00 = 62.5 mA 01 = 125 mA 02 = 187.5 mA 03 = 250 mA 04 = 312.5 mA 05 = 375 mA 06 = 437.5 mA 07 = 500 mA 08 = 562.5 mA 09 = 625 mA 0A = 687.5 mA 0B = 750 mA 0C = 812.5 mA 0D = 875 mA**Default** 0E = 937.5 mA 0F = 1000 mA				**Flash Current Select Bits** 00 = 62.5 mA 01 = 125 mA 02 = 187.5 mA 03 = 250 mA 04 = 312.5 mA 05 = 375 mA 06 = 437.5 mA 07 = 500 mA 08 = 562.5 mA 09 = 625 mA 0A = 687.5 mA 0B = 750 mA 0C = 812.5 mA 0D = 875 mA**Default** 0E = 937.5 mA 0F = 1000 mA			

FLASH DURATION REGISTER

This field contains two drop-down menus to program the Flash Duration Register (address 0xC0) with the Flash Time-Out data and Current Limit Data. Once any of these values are set the Flash Duration Register is automatically updated with the new data. *Table 6* shows the bit settings for the Flash Duration Register.

TABLE 6. Flash Duration Register Descriptions (Address 0xC0)

Not used (Bit 7)	CL1 (Bit 6)	CL0 (Bit 5)	T4 (Bit 4)	T3 (Bit 3)	T2 (Bit 2)	T1 (Bit 1)	T0 (Bit 0)
N/A	**Current Limit Select Bits (LM3559)** 00 = 1.4A Peak Current Limit 01 = 2.1A Peak Current Limit 10 = 2.8A Peak Current Limit 11 = 3.5A Peak Current Limit **(default)** ---------- **Current Limit Select Bits (LM3560)** 00 = 1.6A Peak Current Limit 01 = 2.3A Peak Current Limit 10 = 3.0A Peak Current Limit 11 = 3.6A Peak Current Limit **(default)**		**Flash Time-out Select Bits** 00 = 32 ms time-out 01 = 64 ms time-out 02 = 96 ms time-out 03 = 128 ms time-out 04 = 160 ms time-out 05 = 192 ms time-out 06 = 224 ms time-out 07 = 256 ms time-out 08 = 288 ms time-out 09 = 320 ms time-out 0A = 352 ms time-out 0B = 384 ms time-out 0C = 416 ms time-out 0D = 448 ms time-out 0E = 480 ms time-out 0F = 512 ms time-out **(default)** 10 = 544 ms time-out 11 = 576 ms time-out 12 = 608 ms time-out 13 = 640 ms time-out 14 = 672 ms time-out 15 = 704 ms time-out 16 = 736 ms time-out 17 = 768 ms time-out 18 = 800 ms time-out 19 = 832 ms time-out 1A = 864 ms time-out 1B = 896 ms time-out 1C = 928 ms time-out 1D = 960 ms time-out 1E = 992 ms time-out 1F = 1024 ms time-out				

VIN MONITOR REGISTER

The VIN Monitor Register field contains 2 buttons and 2 drop-down menus to program the VIN Flash Monitor and the VIN Monitor. The VIN Flash Monitor Enable button and the VIN Monitor Button control the VIN Flash Monitor Enable and VIN Monitor Enable bits respectively. The 2 drop-down menus program the comparator thresholds for the respective monitor. Once any button is pushed or drop-down menu is selected the register data is automatically written.

TABLE 7. VIN Monitor Register (Address 0x80), LM3559

Bit 7 Not Used	Bit 6 Not Used	Bit 5 (VIN Flash Monitor Threshold)	Bit 4 (VIN Flash Monitor Threshold)	Bit 3 (VIN Flash Monitor Enable)	Bit 2 (VIN Monitor Threshold)	Bit 1 (VIN Monitor Threshold)	Bit 0 (VIN Monitor Enable)
N/A	N/A	00 = 3.1V **(default)** 10 = 3.2V 10 = 3.3V 11 = 3.4V		0 = VIN Flash Monitor is Disabled **(default)** 1 = VIN Flash Monitor is Enabled	00 = 3.1V **(default)** 10 = 3.2V 10 = 3.3V 11 = 3.4V		0 = VIN Monitor Disabled **(default)** 1 = VIN Monitor Enabled

TABLE 8. VIN Monitor Register (Address 0x80), LM3560

Bit 7 Not Used	Bit 6 Not Used	Bit 5 (VIN Flash Monitor Threshold)	Bit 4 (VIN Flash Monitor Threshold)	Bit 3 (VIN Flash Monitor Enable)	Bit 2 (VIN Monitor Threshold)	Bit 1 (VIN Monitor Threshold)	Bit 0 (VIN Monitor Enable)
N/A	N/A	00 = 2.9V **(default)** 10 = 3.0V 10 = 3.1V 11 = 3.2V		0 = VIN Flash Monitor is Disabled **(default)** 1 = VIN Flash Monitor is Enabled	00 = 2.9V **(default)** 10 = 3.0V 10 = 3.1V 11 = 3.2V		0 = VIN Monitor Disabled **(default)** 1 = VIN Monitor Enabled

PRIVACY REGISTER

The Privacy Register contains the drop-down menus and push buttons to select the duty cycle of the Privacy PWM Period. The Privacy Current (Duty Cycle), selects the percentage of the Privacy PWM period that the LED current is on. The LED current in Privacy mode is equal to the minimum Torch current (LM3559) or selectable between the minimum Torch current or maximum Torch current (LM3560). The Privacy Mode selects whether Privacy mode remains on or turns off after a flash current pulse. The two buttons (LED1 Privacy and LED2 Privacy) enable LED1 or LED2 during Privacy mode. Privacy Blink selects the blinking period for the Privacy Mode. *Figure 4* displays the Privacy Indicator timing.

TABLE 9. Privacy Register (Address 0X11)

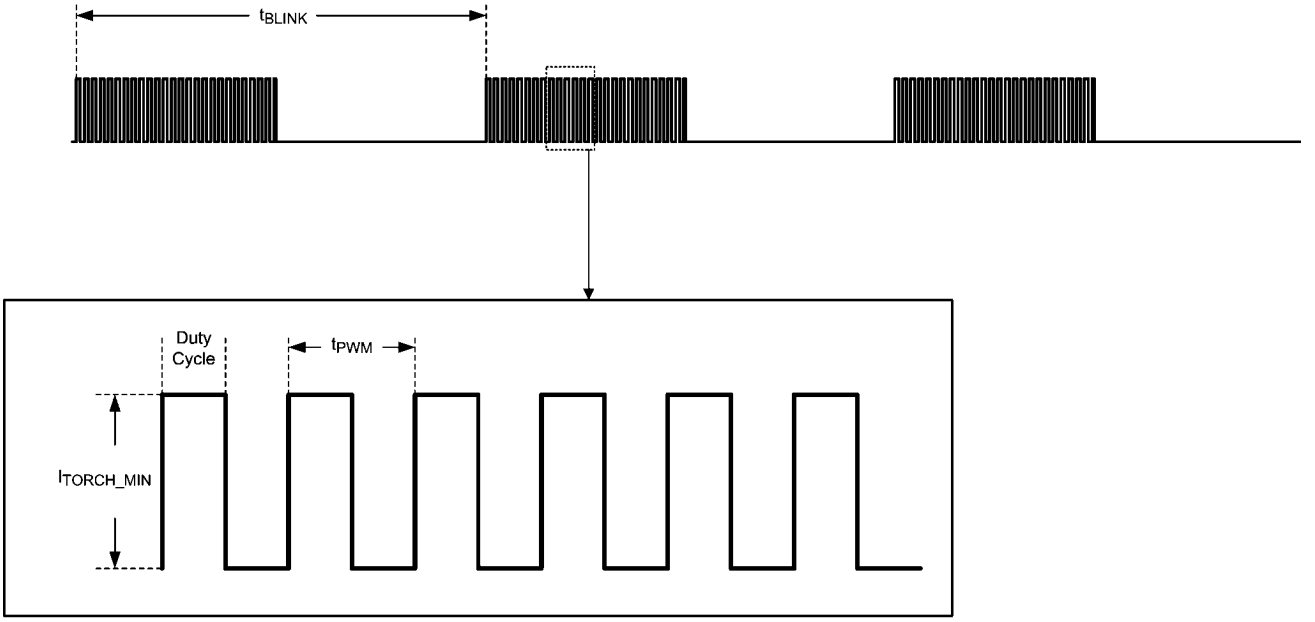
Privacy PWM Period (Bits 7 - 6)	LED2 On During Privacy Mode (Bit 5)	LED1 On During Privacy Mode (Bit 4)	Privacy Mode (Bit 3)	Privacy Current Duty Cycle (Bits 2 - 0)
00 = Always On 01 = 128 ms **(Default)** 10 = 256 ms 11 = 512ms	0 = LED2 current source is off during privacy mode **(Default)** 1 = LED2 current source is on during privacy mode	0 = LED1 current source is off during privacy mode 1 = LED1 current source is on during privacy mode **(Default)**	0 = Privacy mode turns off after the flash pulse 1 = Privacy mode remains on after the flash pulse **(Default)**	Privacy Mode Current Duty Cycle (% of min Torch Current) 000 = 10% **(Default)** 001 = 20% 010 = 30% 011 = 40% 100 = 50% 101 = 60% 110 = 70% 111 = 80%

PRIVACY PWM REGISTER

The Privacy PWM register field contains a drop-down menu which selects the Privacy PWM period setting. Once a menu item is selected the Privacy PWM Register is automatically written with the selected data. The Privacy PWM Period is the pulse period of the LED current when the device is in privacy mode. Figure 3 displays the Privacy Indicator timing. *Table 10* shows the bit settings for this register.

TABLE 10. Privacy PWM Period Register (Address 0x14)

Bits 7 - 3 (Not used)	Bit 2	Bit 1	Bit 0
N/A	000 = 5.12ms **(Default)** 001 = 2.56 ms 010 = 1.28 ms 011 = 640 µs 1XX = 320 µs		



- t_{BLINK} set via bits [7:6] of Privacy Register (0x11)
- Duty cycle set via bits [2:0] of Privacy Register (0x11)
- t_{PWM} set via bits[2:0] of the Privacy PWM Register (0x14)
- I_{TORCH_MIN} = 28.125 mA

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FIGURE 4. Privacy Indicator Timing

INDICATOR REGISTER

The Indicator Register field contains 3 drop-down menus that control the Indicator Current Level, number of Indicator Periods, and the ramp time of the indicator current (from 0 to the programmed current level). See *Figure 5* for Message Indicator Timing. Once a drop-down menu is selected the Indicator Register is automatically updated with the new register data.

TABLE 11. Indicator Register (Address 0x12)

Bits 7 - 6 (Ramp Time ($t_R = t_F$))	Bits 5 - 3 (# Pulses)	Bits 2 - 0 (Current Level (I_{IND}))
00 = 78 ms **(Default)**	000 = 0 **(Default)**	000 = 2.3 mA **(Default)**
01 = 156 ms	001 = 1	001 = 4.6 mA
10 = 312 ms	010 = 2	010 = 6.9 mA
11 = 624 ms	011 = 3	011 = 9.2 mA
	100 = 4	100 11.5 mA
	101 = 5	101 = 13.8 mA
	110 = 6	110 = 16.1 mA
	111 = 7	111 = 18.4 mA

INDICATOR BLINKING REGISTER

The Indicator Blinking Register field contains the features available in the Indicator Blinking Register. The Pulse Width drop-down menu programs the pulse width time (t_{PULSE}), and the # Blank Period drop-down menu programs the number of blank periods. These relate to the Indicator Timing Diagram by the following 3 identities:

1. Number of periods ($t_{PERIOD} = t_{RAMP} \times 2 + t_{PULSE} \times 2$)
2. Active Time ($t_{ACTIVE} = t_{PERIOD} \times$ PERIOD#)
3. Blank Time ($t_{BLANK} = t_{ACTIVE} \times$ BLANK#)
   (see)

TABLE 12. Indicator Blinking Register (Address 0x13)

Bits 7 - 4 (# Blank Periods)	Bits 3 - 0 (Pulse Width (t_{WIDTH}))
0000 = 0 **(Default)**	000 = 0 **(Default)**
0001 = 1	0001 = 32 ms
0010 = 2	0010 = 64 ms
0011 = 3	0011 = 96 ms
0100 = 4	0100 = 128 ms
0101 = 5	0101 = 160 ms
0110 = 6	0110 = 160 ms
0111 = 7	0111 = 224 ms
1000 = 8	1000 = 256 ms
1001 = 9	1001 = 288 ms
1010 = 10	1010 = 320 ms
1011 = 11	1011 = 352 ms
1100 = 12	1100 = 384 ms
1101 = 13	1101 = 416 ms
1110 = 14	1110 = 448 ms
1111 = 15	1111 = 480 ms

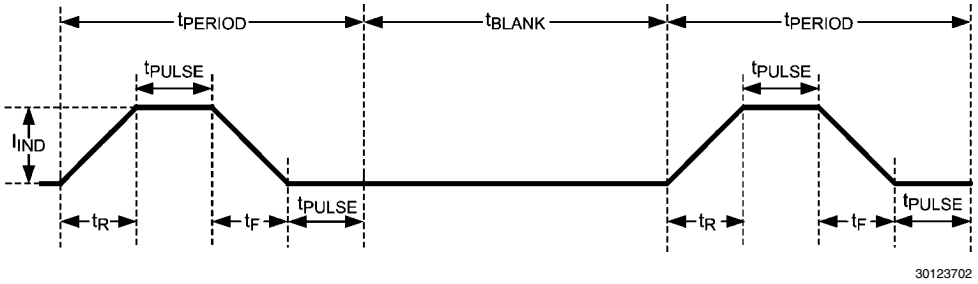

FIGURE 5. Indicator Timing

CONFIGURATION REGISTER 1

The Configuration Register 1 field contains the buttons for setting each bit within Configuration Register 1. Each time a bit is set the Register is updated with the new register data.

TABLE 13. Configuration Register 1 (Address 0xE0)

Bit 7 (Hardware Torch Mode Enable)	Bit 6 (TX2 Polarity)	Bit 5 (TX1 Polarity)	Bit 4 (NTC Mode Enable)	Bit 3 (STROBE Polarity)	Bit 2 (STROBE Input Enable)	Bit 1 (Not Used)	Bit 0 (Not Used)
0 = TX1/TORCH pin is a TX input **(default)**	0 = TX2 is configured for active low polarity	0 = TX1 is configured for active low polarity	0 = LEDI/NTC pin is configured as an indicator output **(default)**	0 = STROBE Input is active low. Pulling STROBE low will turn on Flash current	0 = STROBE Input Disabled **(default)**	N/A	N/A
1 = TX1/TORCH pin is a hardware TORCH enable	1 = TX2 is configured for active high polarity **(default)**	1 = TX1 is configured for active high polarity **(default)**	1 = LEDI/NTC is configured as a comparator input for an NTC thermistor.	1 = STROBE Input is active high. Pulling STROBE high will turn on Flash current **(default)**	1 = STROBE Input Enabled		

CONFIGURATION REGISTER 2

The Configuration Register 2 field contains buttons for setting each bit within the Configuration Register 2. Once the buttons are set the LM3559/LM3560 is written with the new register data. *Table 14* shows the bits settings for Configuration Register 2.

TABLE 14. Configuration Register 2 (Address 0xF0)

Bit [7:5] (Not Used)	Bit 4 (TX1 Shutdown, LM3560 Only)	Bit 3 (VIN Monitor Shutdown)	Bit 2 (Alternate External Torch Mode)	Bit 1 (NTC Shutdown)	Bit 0 (TX2 Shutdown)
N/A	0 = TX1 interrupt will force the LED current to the programmed torch current level **(default)**	0 = Input voltage falling below the programmed VIN Monitor threshold will force the LED current into the programmed torch current. **(default)**	0 = AET Mode Disabled **(default)**	0 = Voltage at LEDI/NTC falling below VTRIP will force the LED current into the programmed torch current. **(default)**	0 = TX2 interrupt will force the LED current into the programmed torch current **(default)**
	1 = TX1 interrupt will force the LED current into shutdown.	1 = Input voltage falling below the programmed VIN Monitor threshold will force the LED current into shutdown.	1 = AET Mode Enabled	1 = Voltage at LEDI/NTC falling below VTRIP will force the LED current into shutdown.	1 = TX2 interrupt will force the LED current into shutdown.

GPIO REGISTER

The GPIO Register field contains the buttons and drop-down menus to configure the GPIO Register. The GPIO1 Control and GPIO2 Control provide the drop-down menus for setting the particular pin as either an input or an output. The GPIO1 Data and GPIO2 Data display the data (GPIO Output) or will read back the data (GPIO Input) that is entered in the respective field. When configuring the GPIO's as outputs, a double write is required to the GPIO register. For example, if both GPIO's are inputs, in order to make both GPIO outputs, two writes of b00X11X11 to the GPIO register are required. (X represents the output data). The drop-down menus which contain the GPIO write commands take this into account, so when the LM3559 or LM3560's Graphical User Interface program is used, the double write process is not required.

When configured as inputs, in order to read back a change of data on the GPIO input, the particular GPIO pin must be reconfigured as an input (Write) and then the data on the pin can be read back (Read). For example, if both GPIO pins are inputs and the previous data on the pin was a logic '1', but then changed to a logic '0', in order to read the logic '0' into the GPIO register the read sequence would first be a Write of (b00X01X01) to register 0x20, then a Read of register 0x20 would be done to read in the new data. The GPIO Read button is available to read back the contents of the GPIO Data fields (GPIO Inputs Only). This button takes into account the Write /Read (2 instruction process) so only a push of the Read button is required to read in the contents of the GPIO lines.

The Interrupt Enable button controls the interrupt option available for GPIO2.

TABLE 15. GPIO Register (Address 0x20)

Bit 7 (Not Used)	Bit 6 (TX2/INT/ GPIO2 Interrupt Enable)	Bit 5 (TX2/INT/ GPIO2 data)	Bit 4 (TX2/INT/ GPIO2 data direction)	Bit 3 (TX2/INT/ GPIO2 Control)	Bit 2 (TX1/TORCH/ GPIO1 data)	Bit 1 (TX1/TORCH/ GPIO1 data direction)	Bit 0 (TX1/TORCH/ GPIO1 Control)
N/A	0 = TX2/INT/ GPIO2 is configured according to bit 3 of this register **(default)**	This bit is the read or write data for GPIO2 in GPIO mode **(default)**	0 = TX2/INT/ GPIO2 is a GPIO Input **(default)**	0 = TX2/INT/ GPIO is configured according to the Configuration Register bit 5 **(default)**	This bit is the read or write data for GPIO1 in GPIO mode **(default)**	0 = TX1/ TORCH/GPIO1 is a GPIO input **(default)**	0 = TX1/ TORCH/GPIO1 pin is configured as a active high hardware enable **(defalt)**
	1 = with bits [4:3] = 11, TX2/ INT/ GPIO2 is an interrupt output. See Interrupt section.		1 = TX2/INT/ GPIO2 is a GPIO Output	1 = TX2/INT/ GPIO2 is configured as a GPIO		1 = TX1/ TORCH/GPIO1 is an output	1 = TX1/ TORCH/GPIO1 pin is configured as a GPIO

VLED MONITOR REGISTER

The VLED Monitor section provides the fields for configuring and reading from the VLED Monitor Register. The VLED Monitor Read button reads back the contents of the VLED Monitor Register and populates the fields in the VLED Monitor section with the register contents. The LED Forward Voltage section displays the nominal forward voltage reading from bits [3:0]. The thresholds are different between the LM3559 and LM3560 (see). The LED forward voltage field displays the midpoint of the voltage range. The Manual Read button performs a manual conversion and updates the LED Forward Voltage section. The ADC Shutdown button disables/enables the ADC.

TABLE 16. VLED Monitor Register (Address 0x30)

Bit 7 (Not Used)	Bit 6 (End of Conversion, Read Only)	Bit 5 (Shutdown)	Bit 4 (Manual Conversion)	Bit 3 (ADC3)	Bit 2 (ADC2)	Bit 1 (ADC1)	Bit 0 (ADC0)
N/A	0 = Conversion in progress **(default)**	0 = ADC is enabled. A conversion is initiated automatically at the start of a flash pulse **(default)**	0 = ADC is set up according to bit 5 **(default)**	see ()			
	1 = Conversion done.	1 = ADC is shutdown.	1 = Manual Conversion is initiated provided that bit 5 = 0. Bit 4 is reset to 0 when a manual conversion is complete.				

VLED MONITOR THRESHOLDS (LM3559 and LM3560)

LM3559	LM3560
0000 (VLED < 3.2V)	0000 = (VLED < 2.8V)
0001 (3.2V ≤ VLED ≤ 3.3V)	0001 = (2.8V ≤ VLED < 2.9V)
0010 (3.2V ≤ VLED ≤ 3.3V)	0010 = (2.9V ≤ VLED < 3.0V)
0011 (3.3V ≤ VLED ≤ 3.4V)	0011 = (3.0V ≤ VLED < 3.1V)
0100 (3.4V ≤ VLED ≤ 3.5V)	0100 = (3.1V ≤ VLED < 3.2V)
0101 (3.5V ≤ VLED ≤ 3.6V)	0101 = (3.2V ≤ VLED < 3.3V)
0110 (3.6V ≤ VLED ≤ 3.7V)	0110 = (3.3V ≤ VLED < 3.4V)
0111 (3.7V ≤ VLED ≤ 3.8V)	0111 = (3.4V ≤ VLED < 3.5V)
1000 (3.8V ≤ VLED ≤ 3.9V)	1000 = (3.5V ≤ VLED < 3.6V)
1001 (3.9V ≤ VLED ≤ 4.0V)	1001 = (3.6V ≤ VLED < 3.7V)
1010 (4.0V ≤ VLED ≤ 4.1V)	1010 = (3.7V ≤ VLED < 3.8V)
1011 (4.1V ≤ VLED ≤ 4.2V)	1011 = (3.8V ≤ VLED < 3.9V)
1100 (4.2V ≤ VLED ≤ 4.3V)	1100 = (3.9V ≤ VLED < 4.0V)
1101 (4.3V ≤ VLED ≤ 4.4V)	1101 = (4.0V ≤ VLED < 4.1V)
1110 (4.4V ≤ VLED ≤ 4.5V)	1110 = (4.1V ≤ VLED < 4.2V)
1111 (4.5V ≤ VLED ≤ 4.6V)	1111 = (4.2V ≤ VLED)

ADC DELAY REGISTER

The ADC Delay Register sets the delay from when the Flash LED current hits its target value to when a conversion is performed, or the delay from when bit 4 goes high to when a manual conversion is performed. The ADC Delay Enable button sets whether the delay is effectively 0 or is set via the ADC Delay drop-down menu.

TABLE 17. ADC Delay (Address 0x31)

Bits [7:6] (Not Used)	Bit 5 (ADC Delay Disable)	Bits [4:0] (ADC Delay)
N/A	0 = ADC Conversion delay set via bits [4:0] **(default)** 1 = No delay from when the LED current hits the target current level or from when the Manual conversion bit is set to '1', to when a conversion is performed.	Bits [4:0] set the delay from when the flash LED current hits its nominal value to when a conversion is performed. This is also the delay from when the Manual conversion bit is set to '1' to when a conversion is performed. Settings are in increments of 250 µs. 00000 = 250 µs 00001 = 500 µs : : : 11111 = 8ms

FLAGS REGISTER

The Flags Register is a read only register. The Flags Register field contains 8 fields that display each flag in the register. Pushing the Read Flags button will read the contents of the Flags Register and populate the Flags Register fields with the appropriate data.

TABLE 18. Flags Register Settings (0xD0)

Bit 7 (VIN Monitor)	Bit 6 (VIN Flash Monitor)	Bit 5 (NTC Fault)	Bit 4 (TX2 Interrupt)	Bit 3 (TX1 Interrupt)	Bit 2 (Led Fault)	Bit 1 (Thermal Shutdown)	Bit 0 (Flash Timeout)
0 = VIN is above the VIN Monitor Threshold or VIN Monitor Threshold is Disabled	0 = VIN did not fall below the VIN Flash Monitor threshold during the flash pulse turn-on or VIN Flash Monitor is disabled	0=LEDI/NTC pin is above 1V	0=TX2 has not changed state	0=TX1 has not changed state	0 = Proper LED Operation	0 = Die Temperature below Thermal Shutdown Limit	0 = Flash Time-Out did not expire
1 = VIN Monitor is Enabled and VIN has Fallen below the programmed threshold.	1 = VIN Flash Monitor is enabled and VIN fell below the programmed VIN Flash Monitor threshold during the flash pulse turn-on	1=LEDI/NTC has fallen below 1V (NTC mode only)	1=TX2 has changed state	1=TX1 has changed state	1 = LED Failed (Open or Short	1 = Die Temperature has crossed the Thermal Shutdown Threshold	1 = Flash Time-Out expired

LAST FLASH REGISTER

The Last Flash Register is a read only register that is updated with the Flash Brightness data for both LED1 and LED2 when the Input Flash Monitor is enabled and the input voltage falls below the programmed VIN Flash Monitor Threshold (see VIN Monitor Register). When the Last Flash Read button is pushed the data field is populated with the contents of the Last Flash Register (displayed as nominal current set points).

TABLE 19. Last Flash Register (Address 0x81)

Bit 7 (LF2A)	Bit 6 (LF2B)	Bit 5 (LF2C)	Bit 4 (LF2D)	Bit 3 (LF1A)	Bit 2 (LF1B)	Bit 1 (LF1C)	Bit 0 (LF1D)
These bits are read only and represent the Flash Current Code for LED2 that the LM3559/LM3560 was at during the last flash during an interrupt. see *Table 4* and *Table 5*				These bits are read only and represent the Flash Current Code for LED1 that the LM3559 was at during the last flash during an interrupt. see *Table 4* and *Table 5*			

Board Layout

The LM3559/LM3560 board layout is shown in (*Figure 6*, *Figure 7*, *Figure 8*, and *Figure 9*)

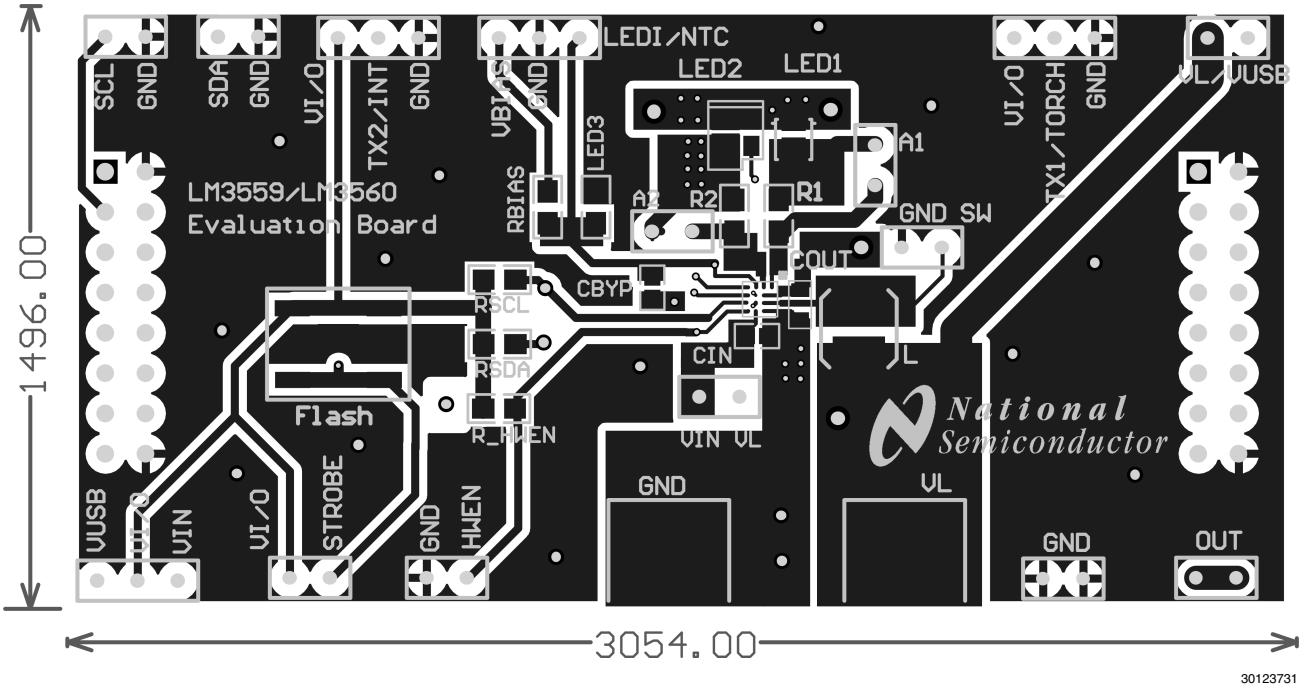

FIGURE 6. Board Layout (Top Layer)

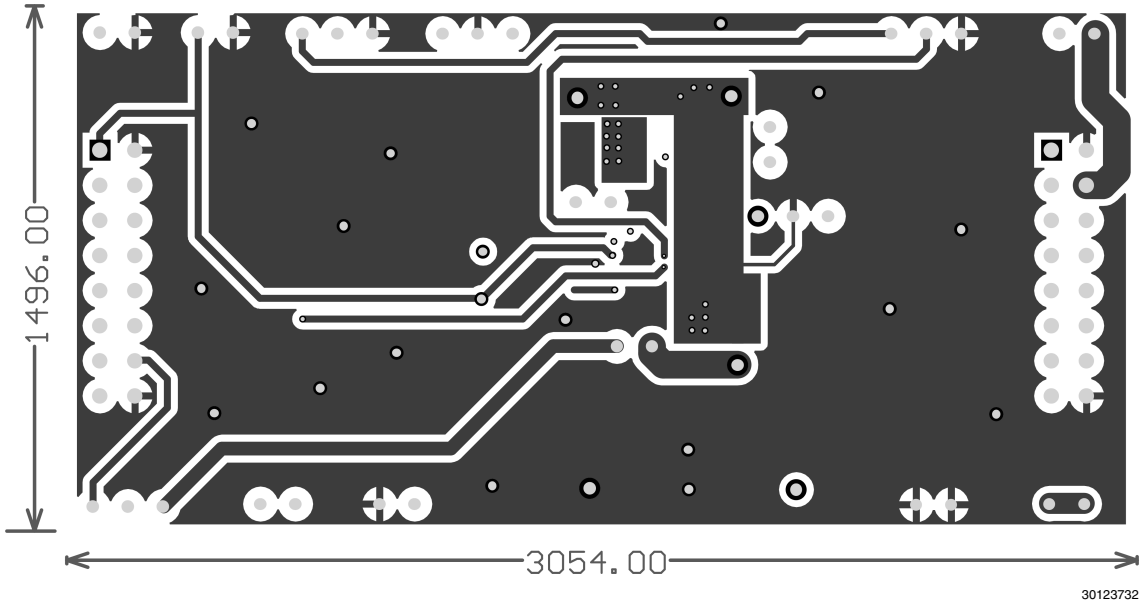

FIGURE 7. Board Layout (Mid Layer 1)

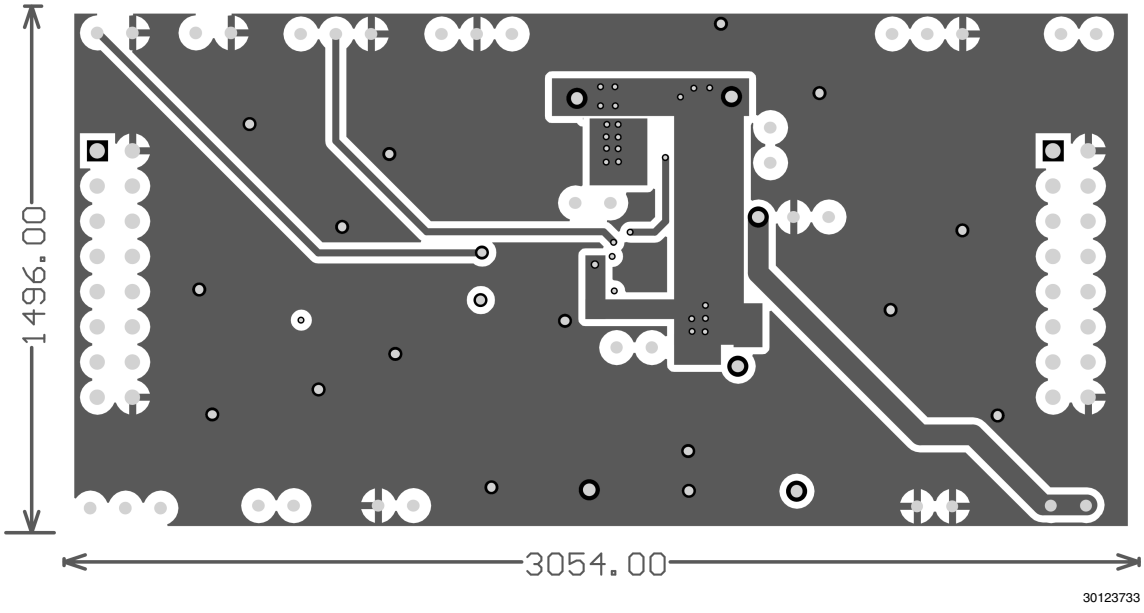

FIGURE 8. Board Layout (Mid Layer 2)

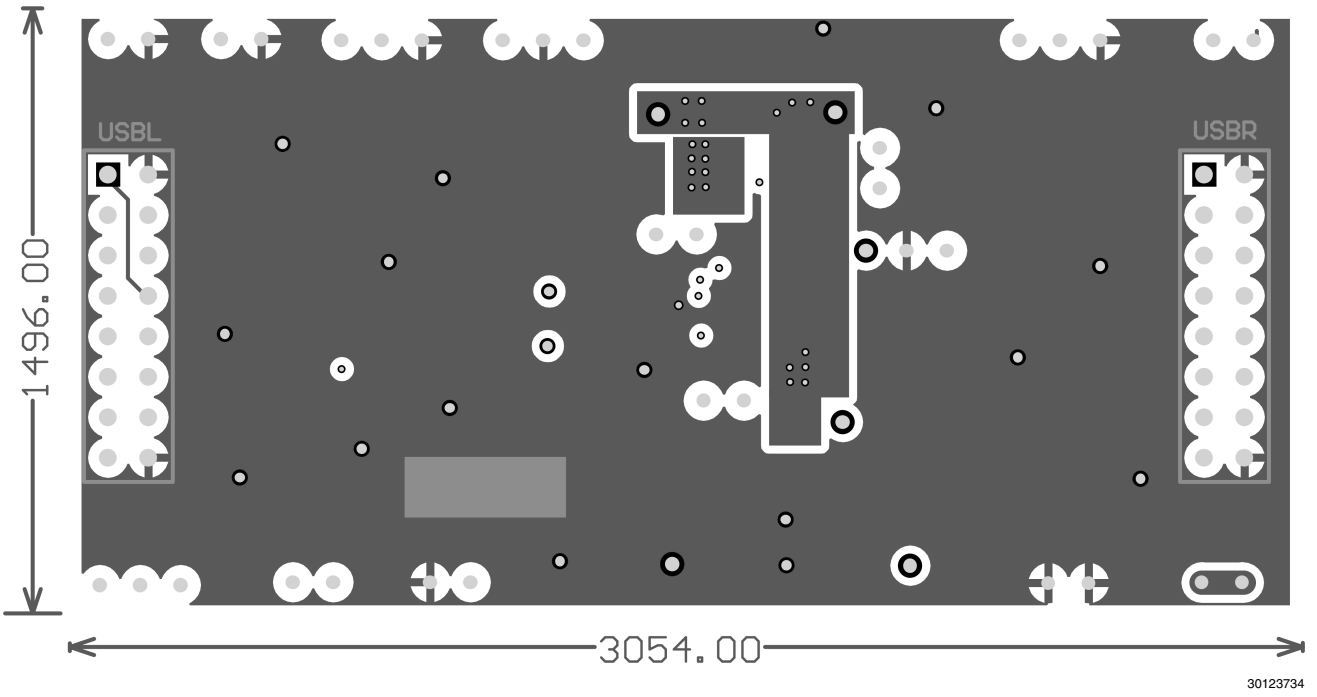

FIGURE 9. Board Layout (Bottom Layer)

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