TEXAS INSTRUMENTS

AN-2259 LM3556 1.5A Synchronous Boost LED Flash Driver w/ High-Side Current Source Evaluation Board

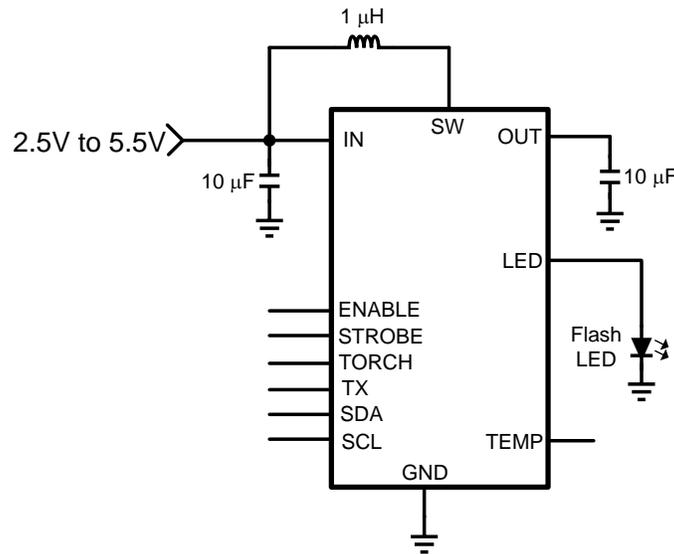## 1   Typical Application Drawing

Table 1. Bill of Materials

Item	Designator	Description	RoHS	Manufacturer	Part Number
1	AA	Printed Circuit Board	Y	TI	551600772-001 REV A
2	CIN, COUT	CAP, CERM, 10µF, 6.3V, +/-20%, X5R, 0603	Y	MuRata	GRM188R60J106ME47D
3	D1	White LED	Y	Philips Lumileds	LXCL-EYW4
4	J1, J5, J10, J14, J16, J17, J18	Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	Y	Samtec, Inc.	TSW-102-07-G-S
5	J2, J4	Header, TH, 100mil, 4x1, Gold plated, 230 mil above insulator	Y	Samtec, Inc.	TSW-104-07-G-S
6	J3, J6, J7, J8, J9	Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	Y	Samtec, Inc.	TSW-103-07-G-S
7	J11	Conn Jack Banana Insulated Nylon Black	Y	Emerson Johnson	108-0903-001
8	J12	Conn Jack Banana Insulated Nylon Red	Y	Emerson Johnson	108-0902-001
9	L1	TOKO Inductor	Y	TOKO	FDSD3012-1R0
10	REN, RSCL, RSDA	RES, 1.00kΩ, 1%, 0.1W, 0603	Y	Vishay-Dale	CRCW06031K00FKEA
11	SW1	Four Terminal SPST Push Button	Y	Panasonic	EVQ-PD05M

Table 1. Bill of Materials (continued)

Item	Designator	Description	RoHS	Manufacturer	Part Number
12	TH1	Thermistor NTC, 100kΩ, 5%, 0402	Y	MuRata	NCP15WL104J03RC
13	U1	1.5A Flash LED Driver	Y	Texas Instruments	LM3556TME
14	USBTOANY	Header, TH, 100mil, 5x2, Gold plated, 230 mil above insulator	Y	Samtec, Inc.	TSW-105-07-G-D

2 Schematic

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3   LM3556 Evaluation Board Layout
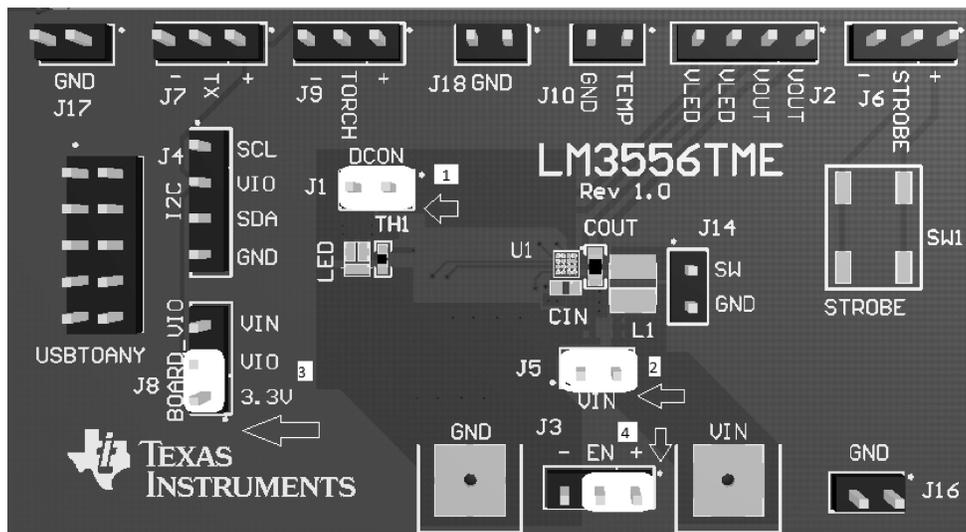
Figure 1. LM3556 Evaluation Board

To operate the LM3556 1.5A Single Flash LED Driver System with I2C Compatible Interface, the following jumpers will have to be connected.

Jumper 1: This in shown in Figure 1 as 1. This connects the LED to the part. If this jumper is not present, the part will run into an OVP fault.

Jumper 2: This is shown in Figure 1 as 2. This connects the inductor to the supply voltage to make sure the part is able to switch during the boost phase. This also hooks in the bypass capacitor at the input to the supply voltage. The part should never be allowed to turn on without this jumper.

Jumper 3: This is shown in Figure 1 as 3. This pulls up the SDA and SCL voltages to either be 3.3V or the supply voltage (Vin).

Jumper 4: This is shown in Figure 1 as 4. This pulls the Enable pin in the part to the supply voltage.
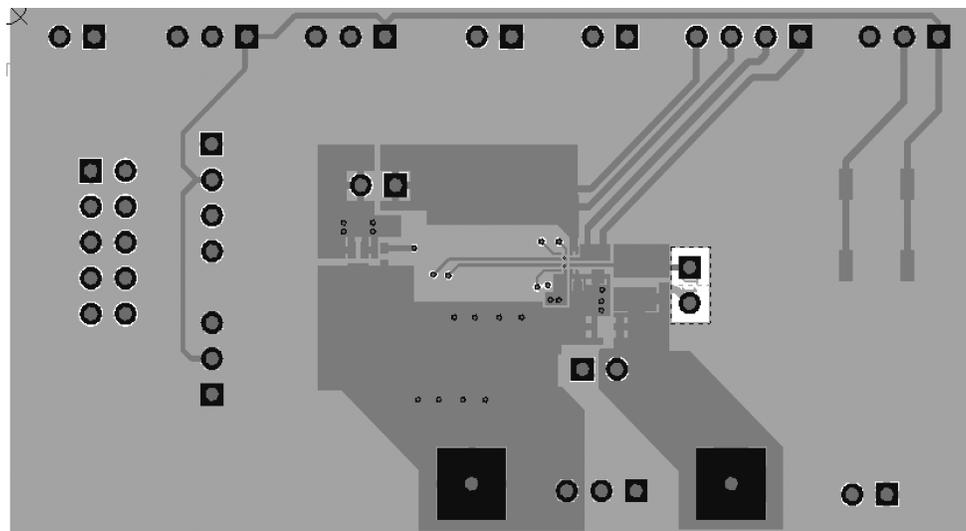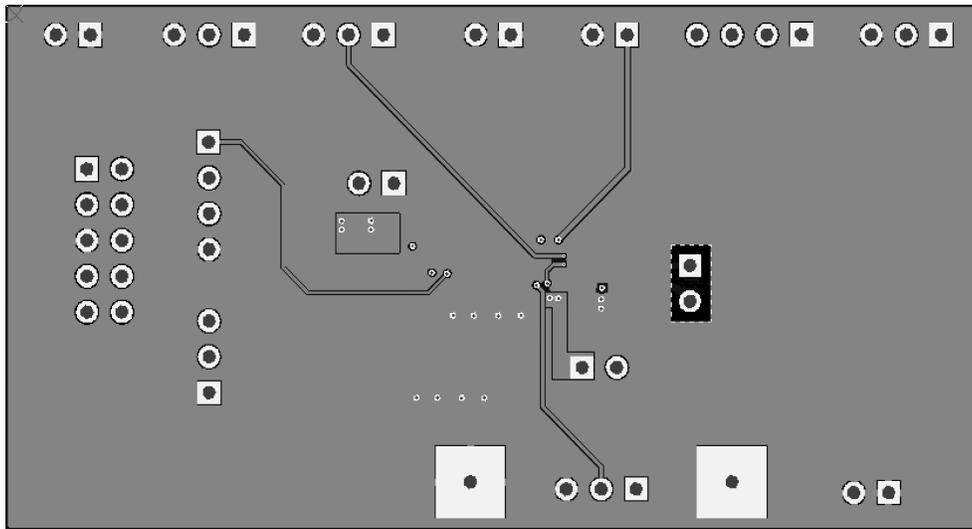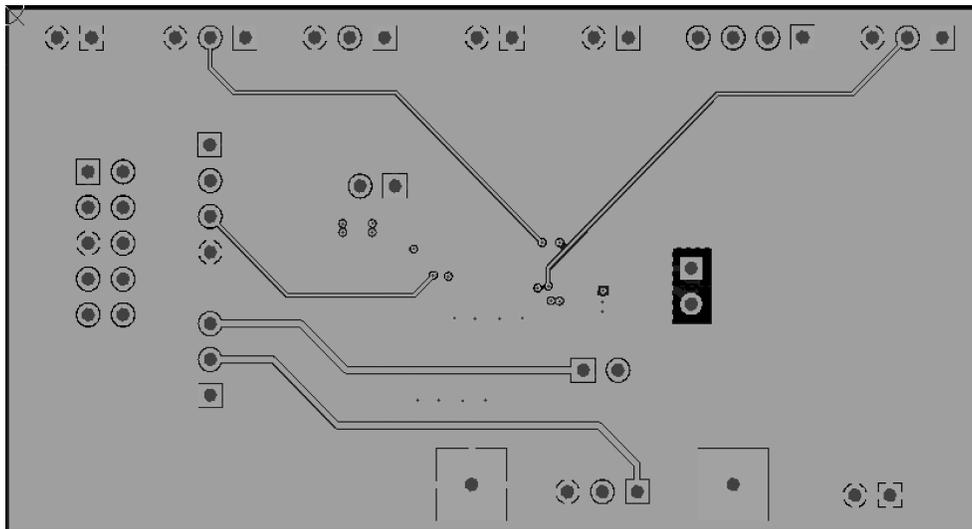

Figure 2. Top Layer

Figure 3. Mid-Layer 1

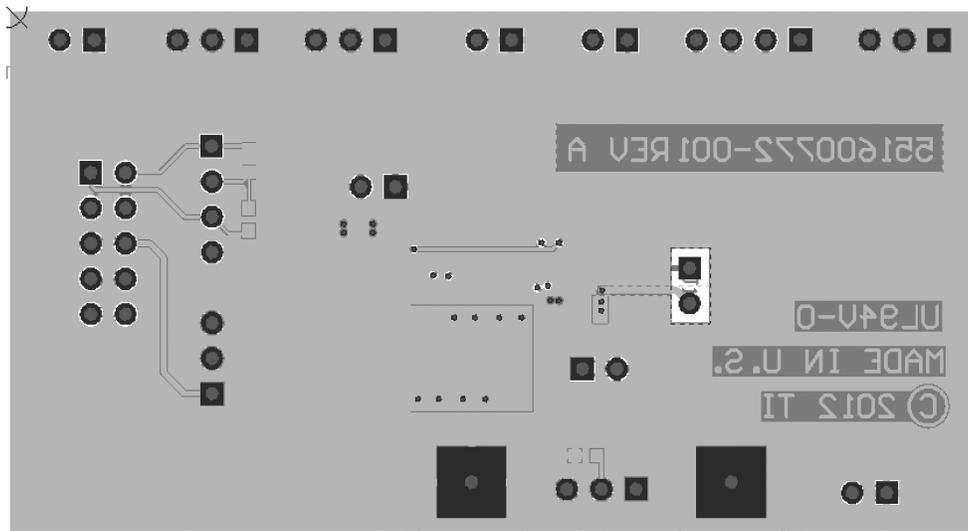

Figure 4. Mid-Layer 2

Figure 5. Bottom Layer (unmirrored)

4   Board Operation

4.1   *GUI*

Following is a screenshot image of the GUI that could be used to operate the LM3556 IC. The register description follows the GUI.

Figure 6. GUI Startup

5   Register Descriptions

Register Name	Internal Hex Address	Power On/RESET Value [1]
Silicon Revision and Filter Time Register	0x00	0x04
IVFM Mode Register	0x01	0x80
NTC Settings Register	0x02	0x12
Indicator Ramp Time Register	0x03	0x00
Indicator Blinking Register	0x04	0x00
Indicator Period Count Register	0x05	0x00
Torch Ramp Time Register	0x06	0x00
Configuration Register	0x07	0x78
Flash Features Register	0x08	0xD2
Current Control Register	0x09	0x0F
Enable Register	0x0A	0x00
Flags Register	0x0B	0x00

[1]   All unused bits are internally pulled HIGH.

5.1 Silicon Revision and Filter Time Register (0x00)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	RFU	RFU	**IVFM Filter Times** '00' = 1/2 of the Current Step Time '01' = 256 µs '10' =512 µs '11' = 1024 µs		Bits available for Silicon Revision Current Value = '100'		

5.2 Input Voltage Flash Monitor (IVFM) Mode Register (0x01)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1 = UVLO EN (default)	**Hysteresis Level** 00 = 50 mV (default) 01 = 100 mV 10 = 150 mV 11 = Hysteresis Disabled		**IVM-D (Down) Threshold** 000 = 2.9V (default) 001 = 3.0V 010 = 3.1V 011 = 3.2V 100 = 3.3V 101 = 3.4V 110 = 3.5V 111 = 3.6V			**IVFM Adjust Mode** 00 = Report Mode (default) 01 = Stop and Hold Mode 10 = Down Mode 11 = Up and Down Mode	

00 = Report Mode— Sets IVFM Flag in Flags Register upon crossing IVM-D Line Only. Does not adjust current.

01 = Stop and Hold Mode— Stops Current Ramp and Holds the level for the remaining flash if V_{IN} crosses IVM-D Line. Sets IVFM Flag in Flags Register upon crossing IVM-D Line.

10 = Down Mode— Adjusts current down if V_{IN} crosses IVM-D Line and will stop decreasing once V_{IN} rises above the IVM-D line + the IVFM hysteresis setting. The LM3556 will decrease the current throughout the flash pulse anytime the input voltage falls below the IVM-D line, and not just once. The flash current will not increase again until the next flash. Sets IVFM Flag in Flags Register upon crossing IVM-D Line.

11 = Up and Down Mode— Adjusts current down if V_{IN} crosses IVM-D Line and adjusts current up if V_{IN} rises above the IVM-D line + the IVFM hysteresis setting. In this mode, the current will continually adjust with the rising and falling of the input voltage throughout the entire flash pulse. Sets IVFM Flag in Flags Register upon crossing IVM-D Line.

UVLO EN— If enabled and VIN drops below 2.8V, the LM3556 will enter standby and set the UVLO flag in the Flags Register. Enabled = '1', Disabled = '0'
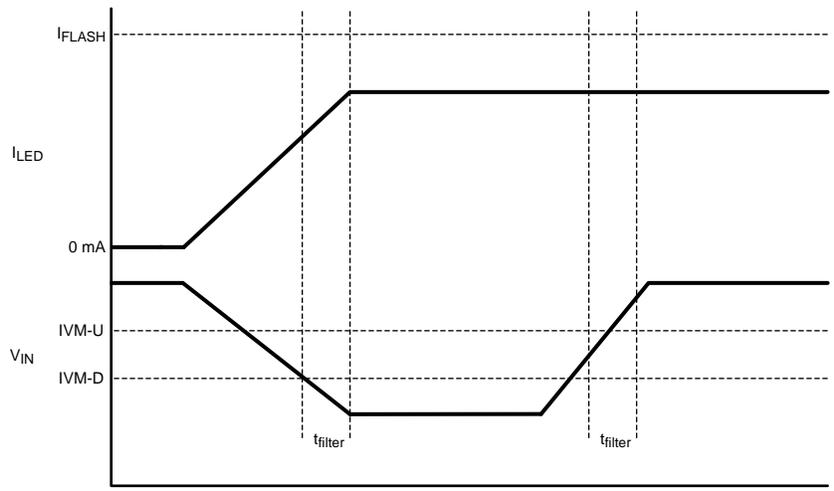IVM-U = IVM-D + IVFM Hysteresis
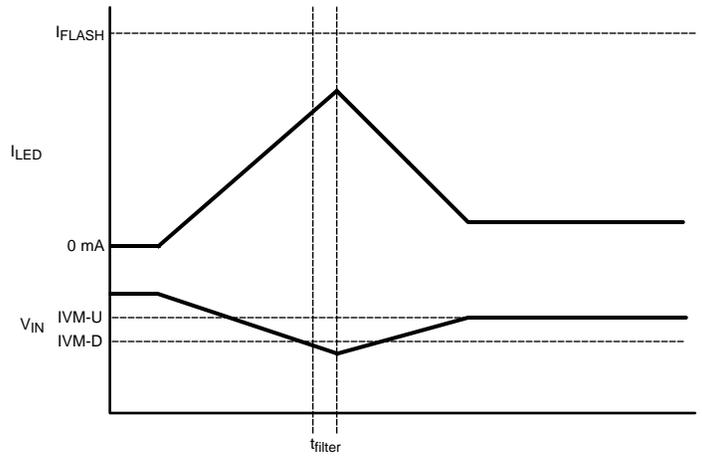
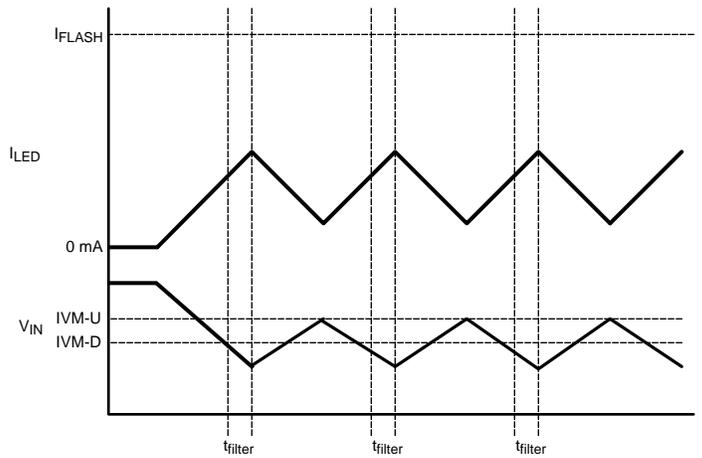**Figure 7. Stop and Hold Mode**

Figure 8. Adjust Down Only Mode

Figure 9. Adjust Up and Down Mode

5.3 NTC Settings Register (0x02)

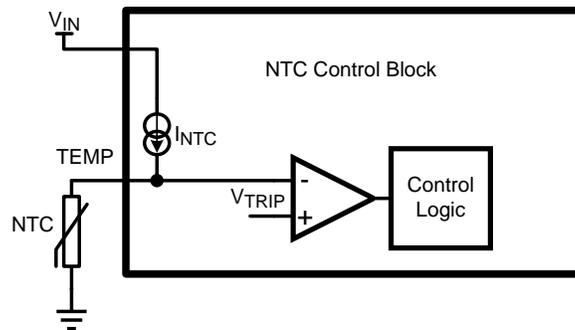| Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	RFU	NTC Event Level 0 = Go to Standby (default) 1 = Reduce to Min Torch Current	NTC Trip Thresholds 000 = 200 mV 001 = 300 mV 010 = 400 mV 011 = 50 mV 100 = 600 mV (default) 101 = 700 mV 110 = 800 mV 111 = 900 mV			NTC Bias Current Level 00 = 25 µA 01 = 50 µA 10 = 75 µA (default) 11 = 100 µA	

Figure 10. NTC Control Block

The TEMP node is connected to an NTC resistor as shown in above. A constant current source from the input is connected to this node. Any change in the voltage because of a change in the resistance of the NTC resistor is compared to a set V_{TRIP}. The trip thresholds are selected by Bits[4:2] of the NTC Register. The output of the Control Logic upon an NTC trip is selected through Bit[5].

5.4 Indicator Ramp Time Register (0x03)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	RFU	Indicator Ramp-Up Time (t_R) 000 = 16 ms (default) 001 = 32 ms 010 = 64 ms 011 = 128 ms 100 = 256 ms 101 = 512 ms 110 = 1.024s 111 = 2.048s			Indicator Ramp-Down Time (t_F) 000 = 16 ms (default) 001 = 32 ms 010 = 64 ms 011 = 128 ms 100 = 256 ms 101 = 512 ms 110 = 1.024s 111 = 2.048s		

5.5 Indicator Blinking Register (0x04)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
N$_{BLANK}$ 0000 = 0 (default) 0001 = 1 0010 = 2 0011 = 3 0100 = 4 0101 = 5 0110 = 6 0111 = 7 1000 = 8 1001 = 9 1010 = 10 1011 = 11 1100 = 12 1101 = 13 1110 = 14 1111 = 15				Pulse Time (t$_{PULSE}$) 0000 = 0 (default) 0001 = 32 ms 0010 = 64 ms 0011 = 92 ms 0100 = 128 ms 0101 = 160 ms 0110 = 196 ms 0111 = 224 ms 1000 = 256 ms 1001 = 288 ms 1010 = 320 ms 1011 = 352 ms 1100 = 384 ms 1101 = 416 ms 1110 = 448 ms 1111 = 480 ms			

5.6 Indicator Period Count Register (0x05)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	RFU	RFU	RFU	RFU	N$_{PERIOD}$ 000 = 0 (default) 001 = 1 010 = 2 011 = 3 100 = 4 101 = 5 110 = 6 111 = 7		
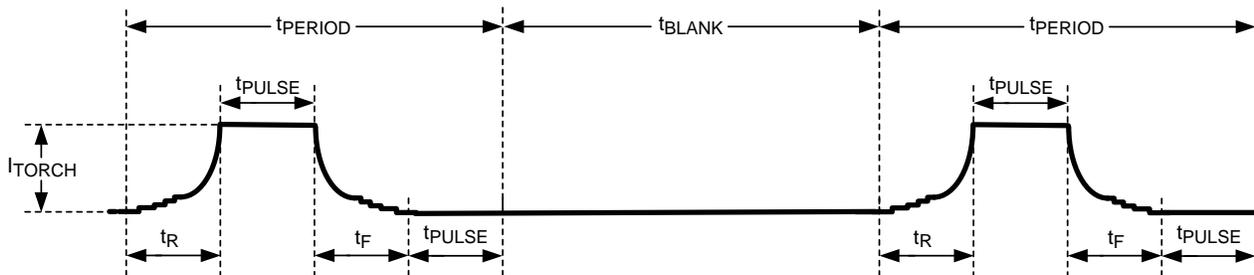
Figure 11. Indicator Usage

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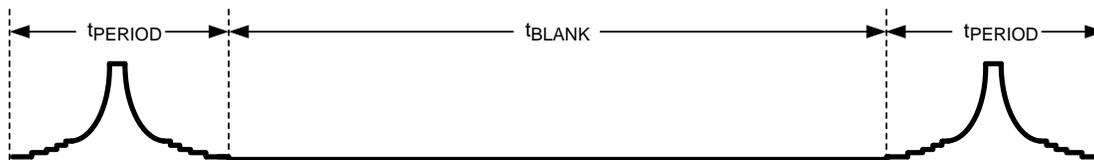3. Blank Time ($t_{BLANK} = t_{ACTIVE} \times N_{BLANK}$)
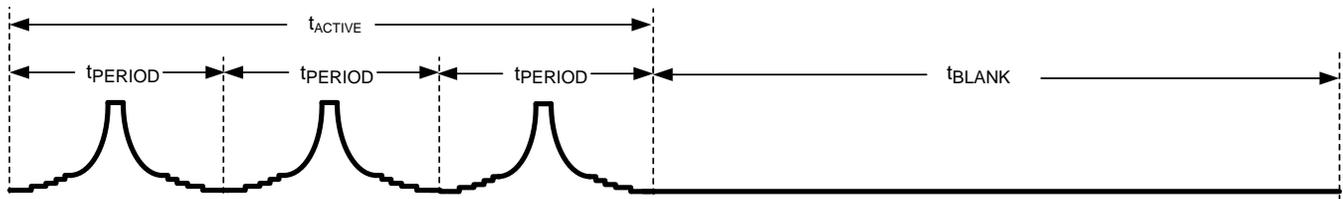

Figure 12. Single Pulse with Dead Time

Figure 13. Multiple Pulse with Dead Time

5.7 Torch Ramp Time Register (0x06)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	RFU	Torch Ramp-Up Time 000 = 16 ms (default) 001 = 32 ms 010 = 64 ms 011 = 128 ms 100 = 256 ms 101 = 512 ms 110 = 1.024s 111 = 2.048s			Torch Ramp-Down Time 000 = 16 ms (default) 001 = 32 ms 010 = 64 ms 011 = 128 ms 100 = 256 ms 101 = 512 ms 110 = 1.024s 111 = 2.048s		

5.8 Configuration Register (0x07)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Strobe Usage 0 = Edge (default) 1 = Level	Strobe Pin Polarity 0 = Active Low 1 = Active High (default)	Torch Pin Polarity 0 = Active Low 1 = Active High (default)	TX Pin Polarity 0 = Active Low 1 = Active High (default)	TX Event Level 0 = Off 1 = Torch Current (default)	IVFM Enable 0 = Disabled (default) 1 = Enabled	NTC Mode 0 = Normal (default) 1 = Monitor	Indicator Mode 0 = Internal (default) 1 = External

Strobe Usage—Level or Edge. Flash will follow Strobe timing if Level and internal timing if Edge.

Strobe Polarity—Active High or Active Low Select.

Torch Polarity—Active High or Active Low Select.

TX Polarity—Active High or Active Low Select.

TX Event Level—Transition to Torch Current Level or Off if TX event occurs.

> **NOTE:** The TX Event Level "Off" setting is designed to only force a shutdown during a flash event. When Torch or Indicator Mode is enabled, and a TX event occurs with the TX Event Level set to "Off", the LM3556 does not shut down. The TX flag bit (bit7 in the Section 5.12) will be set, and the mode bits (bit0 and bit1 in Section 5.11) get locked out until the fault register is cleared via an I²C read. Because a TX event is periodic and frequently occurring, clearing the fault register becomes more difficult. Depending on the I²C read/write speed and TX event frequency, it may be necessary to set the TX enable bit (bit6 in the Section 5.11) to a '0' before clearing the fault register to prevent future flag sets.

IVFM Enable—Enables Input Voltage Flash Monitoring.

NTC Mode—Monitor Mode (Report Only) or Normal Mode (Reduce Current or Shutdown).

Indicator Mode—Externally generated via TORCH Pin or internally generated PWM.

5.9 Flash Features Register (0x08)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Inductor Current Limit 00 =1.7A 01 = 1.9A 10 = 2.5A 11 = 3.1A (default)		**Flash Ramp Time** 000 = 256 µs 001 = 512 µs 010 = 1.024 ms (default) 011 = 2.048 ms 100 = 4.096 ms 101 = 8.192 ms 110 = 16.384 ms 111 = 32.768 ms			**Flash Time-Out Time** 000 = 100 ms 001 = 200 ms 010 = 300 ms (default) 011 = 400 ms 100 = 500 ms 101 = 600 ms 110 = 700 ms 111 = 800 ms		

5.10 Current Control Register (0x09)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
RFU	**Torch Current** 000 = 46.88 mA (default) 001 =93.75 mA 010 =140.63 mA 011 = 187.5 mA 100 =234.38 mA 101 = 281.25 mA 110 = 328.13 mA 111 =375 mA			**Flash Current** 0000 = 93.75 mA 0001 = 187.5 mA 0010 = 281.25 mA 0011 = 375 mA 0100 = 468.75 mA 0101 = 562.5mA 0110 = 656.25 mA 0111 = 750 mA 1000 = 843.75 mA 1001 = 937.5 mA 1010 = 1031.25 mA 1011 = 1125 mA 1100 = 1218.75 mA 1101 = 1312.5 mA 1110 = 1406.25 mA 1111 = 1500 mA (default)			

5.11 Enable Register (0x0A)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
NTC Enable 0 = Disabled (default) 1 = Enabled	**TX Pin Enable** 0 = Disabled (default) 1 = Enabled	**STROBE Pin Enable** 0 = Disabled (default) 1 = Enabled	**TORCH Pin Enable** 0 = Disabled (default) 1 = Enabled	**PreCharge Mode Enable** 0 = Normal (default) 1 = PreCharge	**Pass-Mode Only Enable** 0 = Normal (default) 1 = Pass Only	Mode Bits: M1, M0 00 = Standby (default) 01 = Indicator 10 = Torch 11 = Flash	

5.11.1 Enable Register (8 Bits)

NTC EN—Enables NTC Block.

TX EN—Allows TX events to change the current.

Strobe EN—Enables Strobe Pin to start a Flash Event.

Torch EN—Enables Torch Pin to start a Torch Event.

PreCharge Mode EN—Enables Pass Mode to pre-charge the output cap.

Pass-Only Mode EN—Only allows Pass Mode and disallows Boost Mode.

> **NOTE:** If Pass-Only Mode is enabled during any LED mode (Indicator, Torch or Flash), it will remain enabled until the LM3556 enters the standby state regardless of whether the Pass-Only Mode bit is reset or not during the following command.

5.11.2   Two-Mode Bits

00–Standby— Off

01–Indicator— Sets Indicator Mode. Default Indicator Mode uses external pattern on TORCH Pin.

10–Torch— Sets Torch Mode with ramping. If Torch EN = 0, Torch will start after I^{2}C-compatible command.

11–Flash— Sets Flash Mode with ramping. If Strobe EN = 0, Flash will start after I^{2}C-compatible command.

5.12   Flags Register (0x0B)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
TX Event 0 = Default	NTC Trip 0 = Default	IVFM 0 = Default	UVLO 0 = Default	OVP 0 = Default	LED or VOUT Short Fault 0 = Default	Thermal Shutdown 0 = Default	Flash Time-out 0 = Default

TX Event Flag—TX Event occurred.

NTC Trip Flag—NTC Threshold crossed.

IVFM Flag—IVFM block reported and/or adjusted LED current.

UVLO Fault—UVLO Threshold crossed.

OVP Flag—Over-voltage Protection tripped. Open Output cap or open LED.

LED Short Fault—LED Short detected.

Thermal Shutdown Fault—The LM3556 die temperature reached thermal shutdown value.

Time-Out Flag—Flash Timer tripped

> **NOTE:**   Faults require a read-back of the "Flags Register" to resume operation. Flags report an event occurred, but do not inhibit future functionality. A read-back of the Flags Register will only be updated again if the fault or flags is still present upon a restart.

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