Using Flash LED Drivers for Infrared (IR) LED Applications

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ABSTRACT

The LM3643/4/8 devices are commonly used for mobile-phone flash LED drivers. This application note discusses the general applications of IR in mobile devices as well as the behavior of TI's LM364x devices for such applications.

These LED flash drivers are small solutions that provide a maximum of 1.5 A to one or two LEDs in either pass mode, where the current sources are connected to the input supply, or boost mode, where the output is powered by the DC-DC boost converter. Features such as hardware flash, hardware torch, and IR strobe are all controlled using an I^{2}C interface. This application note includes the test results for the output LED current rise times while in pass mode and boost mode.

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Trademarks

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1 Activating IR Mode

IR mode is controlled through the Enable Register (0x01). The register settings for turning on IR mode are shown below in Table 1.

Table 1. Enable Register Values for IR Mode

Bit	TX	Strobe Type	Strobe	Torch/NTC	M1	M0	LED2 and LED1(LM3643 and LM3644 only)
Value	X	0	1	X	0	1	1X or X1

The timing for the flash pulse is controlled by the STROBE pin. Ensure level strobe is used (strobe type set to 0), otherwise the LM364X times out and goes into standby mode.

2 LED Current Behavior

The LM3643/4/8 devices can be used for IR strobe applications. Figure 1 and Figure 2 show the typical LED current output in pass and boost mode, respectively. The yellow waveform is the PWM strobe signal, the pink waveform is the output voltage, and the blue waveform is the LED current. To achieve 1.5 A in pass mode, the input voltage must be larger than the LED forward voltage level + the current source headroom voltage + voltage drop across the internal PFET. If the input voltage is lower than this value, the boost of the LM364x is needed. The boost-mode screen capture was taken with an input voltage of 3.3 V.

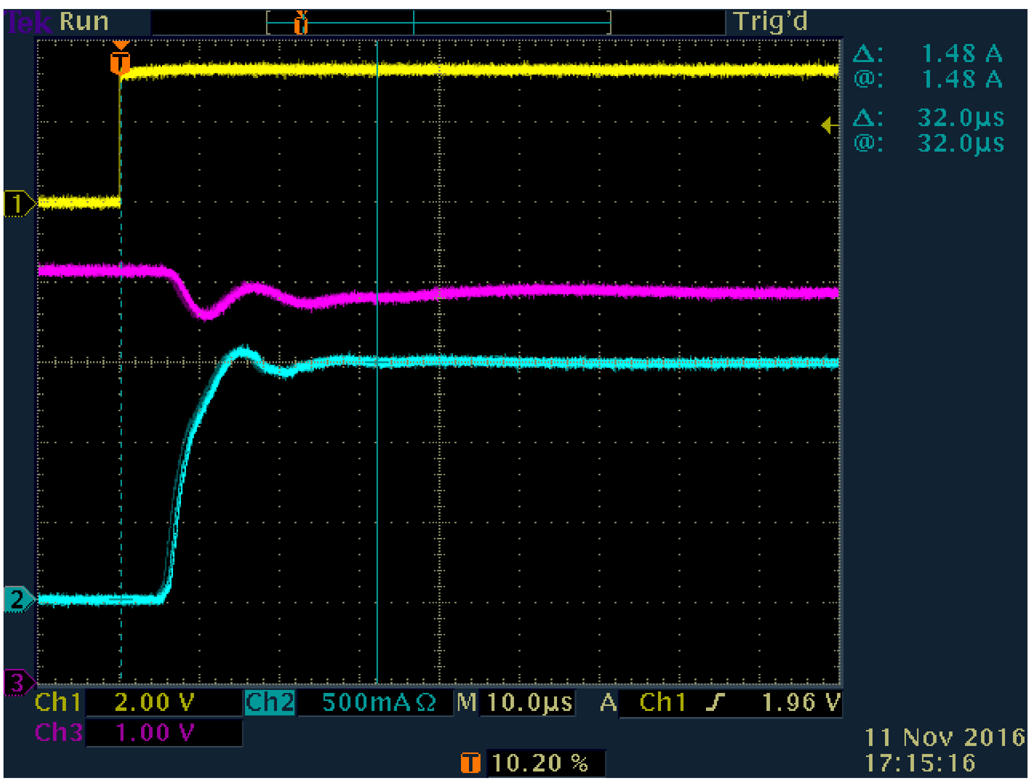

Figure 1. Pass-Mode Behavior

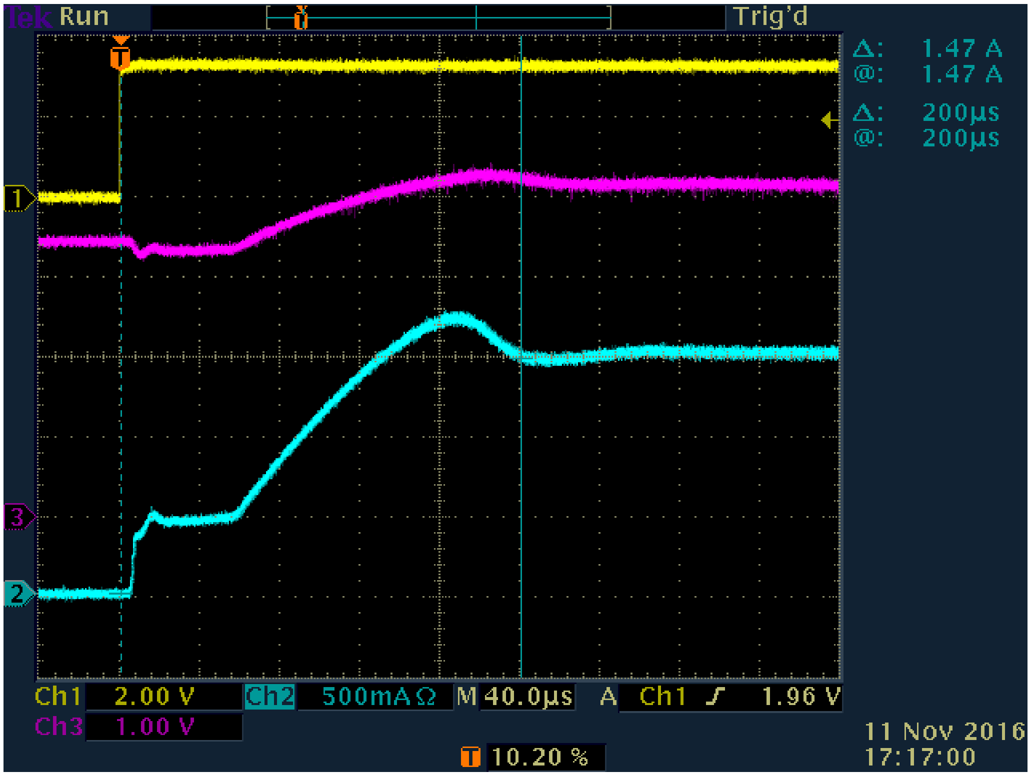

Figure 2. Boost-Mode Behavior

In pass mode, the slew rate of the output current is fast, as it depends on the fast response time of the current source. In boost mode, the transient response of the boost loop dominates the slew rate of the output current.

3 Timing

3.1 Current vs. Timing

The settling times at different output currents in pass mode and boost mode can vary significantly due to the time associated with the boost turning on. The 100% time is defined as the time where the output current reaches the programmed value for the first time. The settling time includes the current overshoot time shown in Figure 3. In Figure 3, the blue waveform is STROBE, the pink is V_{OUT} and the cyan waveform is I_{LED}.

NOTE: These tests were done using two series stacked IR LEDs, which required a larger voltage potential to turn on.

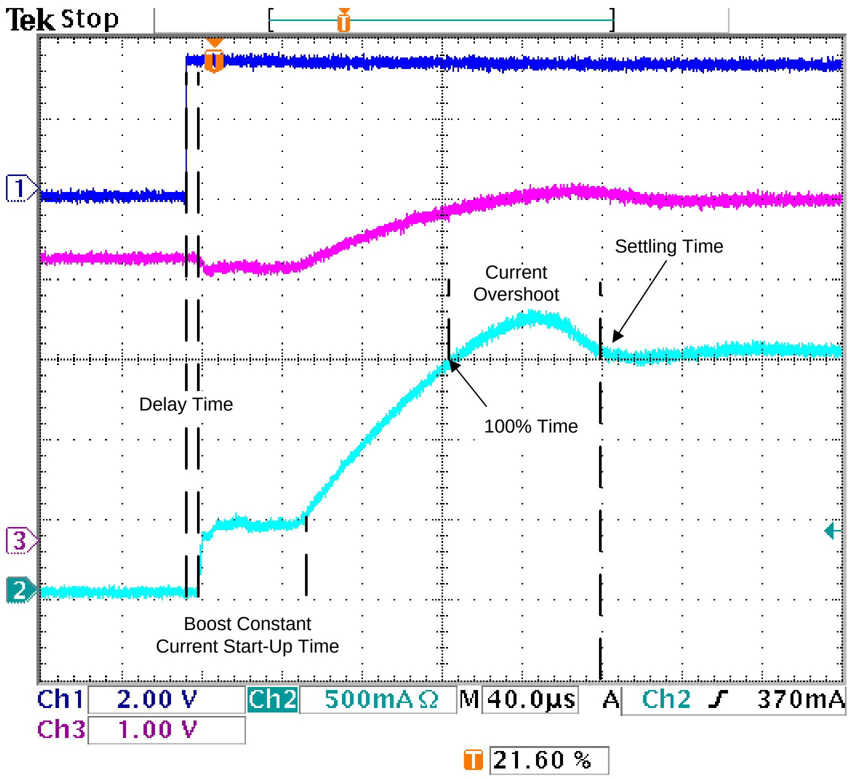

Figure 3. Boost Mode 100% vs Settling Time

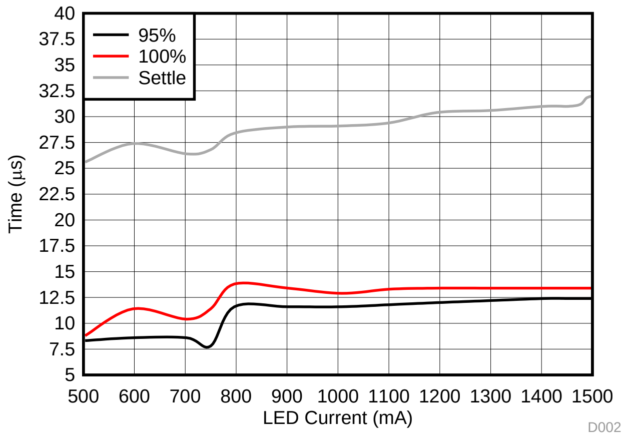

Figure 4. Pass-Mode Rise and Settling Times

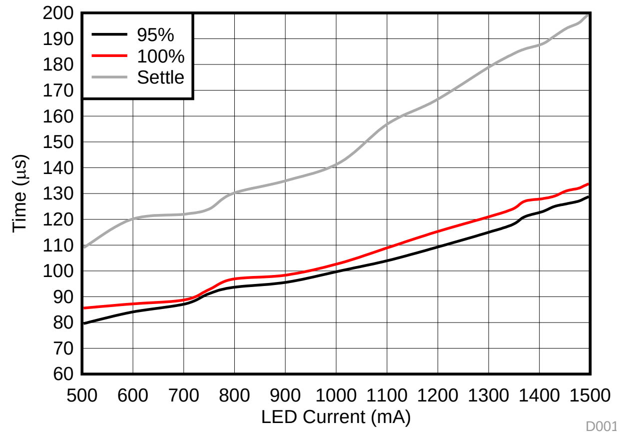

Figure 5. Boost-Mode Rise and Settling Times

3.2 Strobe-to-Current Rise Latency

There are short delays between the rising and falling edges of the STROBE signal and the response of the output current. These are labeled in Figure 6 and are discussed in the following sections.

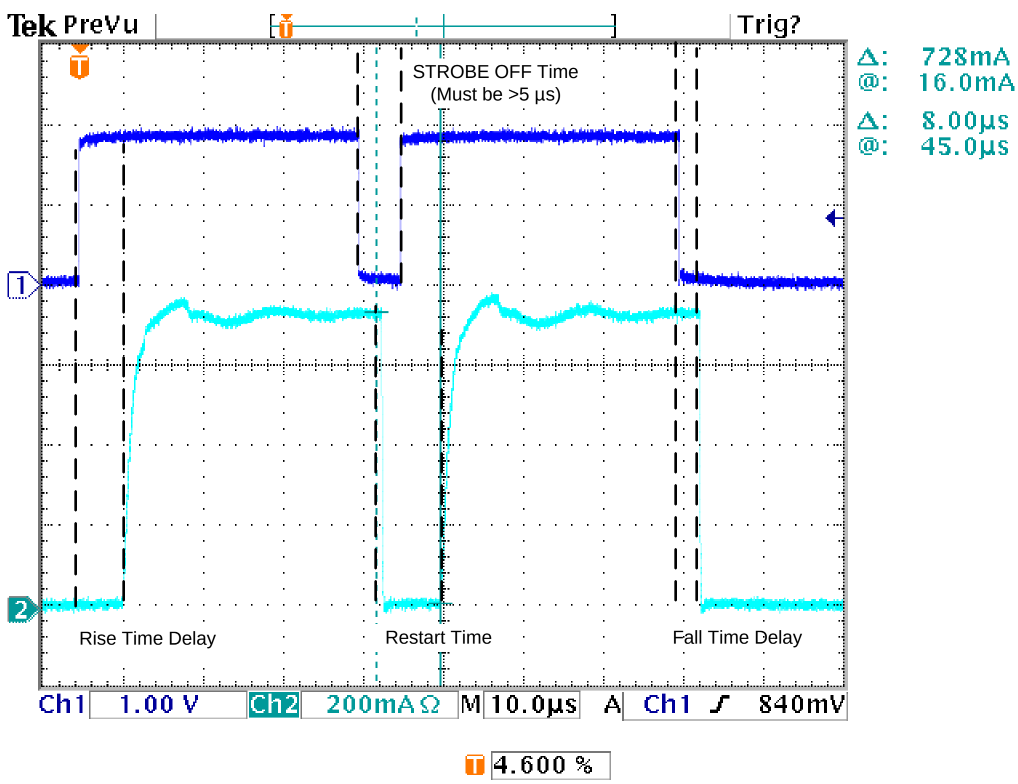

Figure 6. Pass-Mode Timing Identification

Table 2. Typical Values

NAME	TIME (µs)
Rise time delay	5
Fall time delay	3

3.3 Minimum STROBE OFF Time

The minimum STROBE OFF time between two PWM pulses is 5 µs. If smaller, the device shuts down and resets into standby mode.

4 Maximum Thermal Capabilities

The junction-to-thermal resistance ($R_{\theta JA}$) of the LM364x devices is 90.2°C/W. The maximum current capability of the device is determined by the power dissipated ($P_{D\text{-}MAX}$) in the device and the maximum ambient temperature ($T_{A\text{-}MAX}$). The maximum recommended junction temperature ($T_{J\text{-}MAX\text{-}OP}$) is 125°C; Figure 7 and Figure 8 show the maximum current and duty cycle capabilities in relation to this maximum junction temperature. Figure 7 considers a 5-V input voltage with a 3.3-V forward voltage across the stacked IR LED resulting in 1.7 V × I_{LED} being dissipated on the LM364x. Figure 8 considers a 3.3-V input voltage with a 2-V forward voltage single IR LED resulting in 1.3 V × I_{LED} being dissipated. These were calculated using Equation 1:

$$T_{A\text{-}MAX} = T_{J\text{-}MAX\text{-}OP} - (R_{\theta JA} \times P_{D\text{-}MAX}) \quad (1)$$

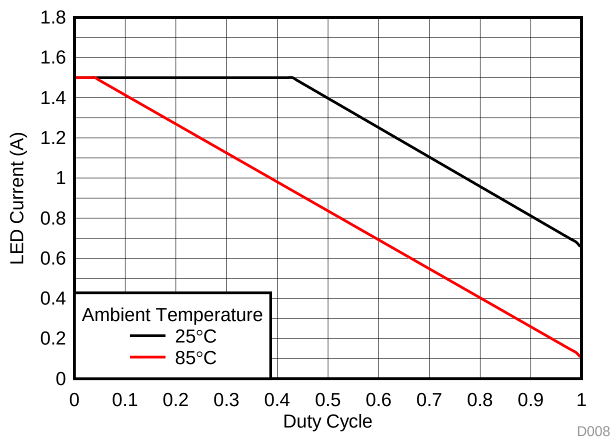

Figure 7. 3.3-V Forward Voltage LED With 5-V Maximum Input-Current Capability

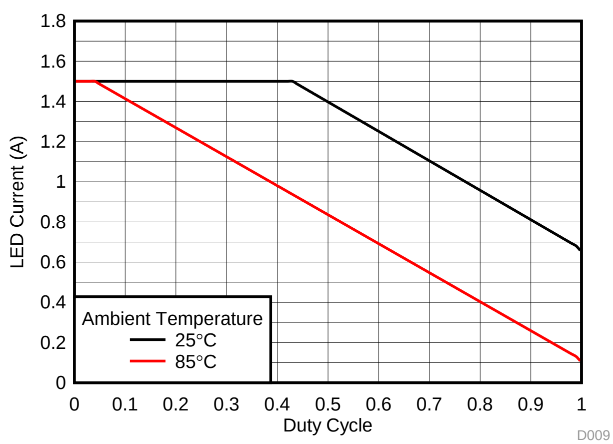

Figure 8. 2-V Forward Voltage LED With 3.3-V Maximum Input-Current Capability