FAIRCHILD SEMICONDUCTOR®

October 2013

FAN5775
Synchronous Boost and Series / Parallel 10-LED Driver

Features

- Synchronous Current-Mode Boost Converter
- 1120 mW Output Power
- Drives up to 10 LEDs at up to 28 mA Each in a Configuration of 5 Strings of 2 LEDs in Series
- 5 LED Outputs: High-Side Current Sources
- PWM Dimming Control to Support Various Lighting Applications, such as Backlighting LCD Displays and Keypad Illumination
- Selectable LED Current
- High System Efficiency: ≤ 88%
- 2.3 V to 4.8 V Input Voltage Range
- 1.8 MHz Switching Frequency
- Input Under-Voltage Lockout (UVLO)
- Output Over-Voltage Protection (OVP)
- Short-Circuit and Thermal Shutdown (TSD) Protection
- 12-Bump, 0.4 mm Pitch, 1.41 x 1.80 x 0.50 mm WLCSP

Applications

- Mid-and Large-Size LCD Modules
- Cellular Mobile Handsets, Smart Phones
- Smart Books, Netbooks, MIDs
- Pocket PCs
- WLAN DC-DC Converter Modules
- PDA, DSC, PMP, and MP3 Players

Description

The FAN5775 is a synchronous, constant-current LED driver capable of efficiently driving up to ten LEDs in a five-string, two-series-LEDs-per-string configuration. Optimized for small form-factor applications, the 1.8 MHz switching frequency allows the use of tiny chip inductors and capacitors.

For safety, the device features integrated over-voltage, short-circuit, and thermal shutdown protections. In addition, input under-voltage lockout protection is triggered if the battery voltage is too low.

The FAN5775 is comprised of low-dropout, high-side current sources, enabling high-efficiency delivery of power from the battery to the LEDs. The LED current control is established with a series R_{SET} resistor, which is connected between the internal voltage reference on the chip and ground. The series resistor can be changed even during operation. In addition, the maximum current level can be set using an external logic control, allowing more dynamic range for dimming schemes, depending on ambient light conditions.

During operation, the FAN5775 holds the boost regulator's voltage on C_{OUT} during the off cycle of the PWM dimming, which helps minimize audible noise.

The FAN5775 is available in a very low profile, small-form-factor 1.41 x 1.80 x 0.50 mm, 12-bump WLCSP package that is "green" and RoHS compliant.

Ordering Information

Part Number	Temperature Range	Package	Packing
FAN5775UCX	-40°C to 85°C	12-Bump, Wafer-Level Chip-Scale Package (WLCSP), 1.41 x 1.80 x 0.50 mm, 0.40 mm Pitch	Tape and Reel

Block Diagram

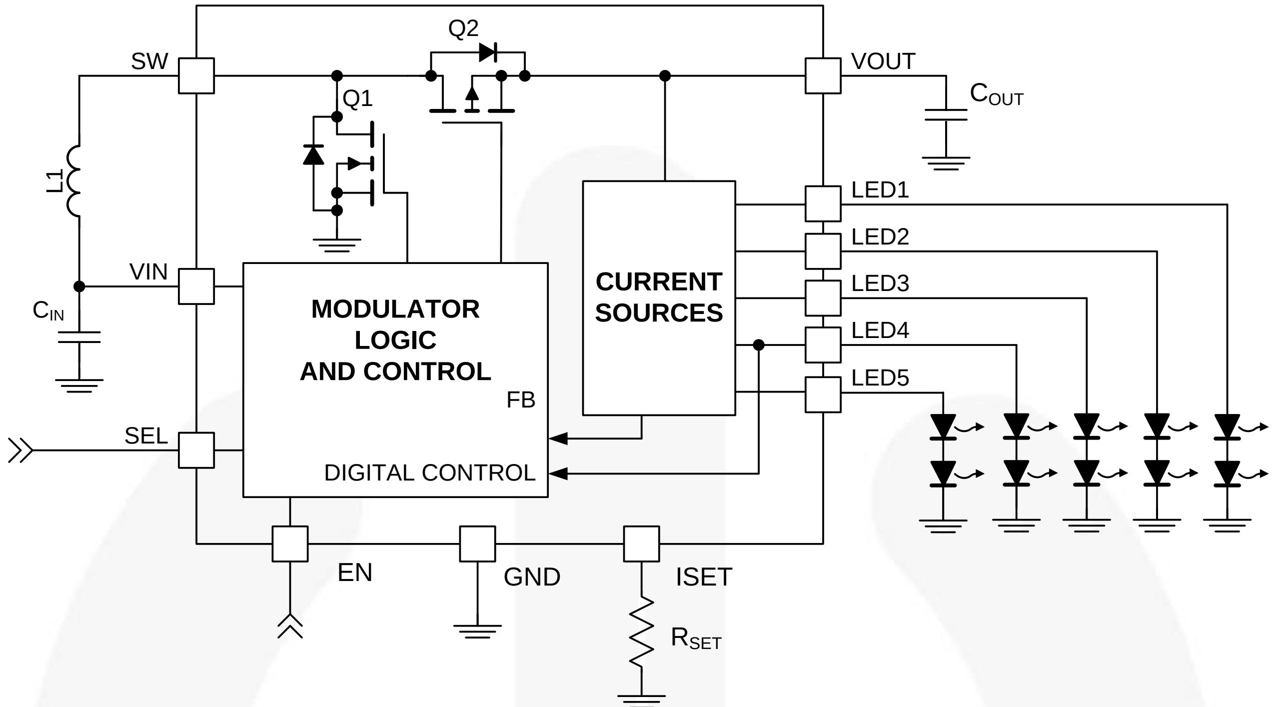


Figure 1. Typical Application Block Diagram

Table 1. Recommended External Components

Component	Description	Vendor	Parameter	Min.	Typ.	Max.	Units
L_1	I_{L1} = 1000 mA	Various	L	1.50	4.70		µH
			R		130	155	mΩ
R_{SET}	1% or Better	Various	R	18		200	kΩ
C_{OUT}	10 µF, 25 V, X5R, 2012	Murata GRM219R61A116UE82	C	4.2	10.0	20.0	µF
C_{IN}	2.2 µF, 10 V, X5R, 1005	Murata GRM155R61A225KE95	C		2.2		µF

Pin Configuration

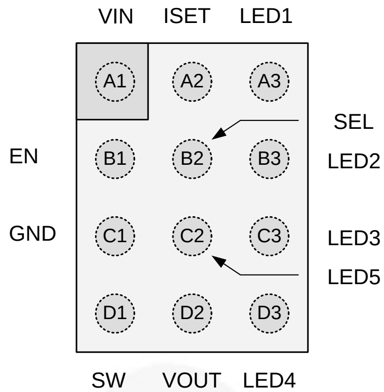


Figure 2. Top View (Bump Face Down)

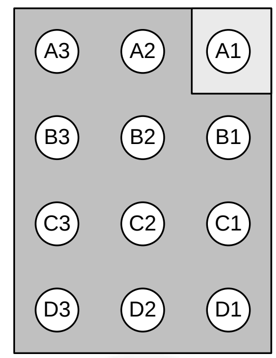


Figure 3. Bottom View (Bump Face Up)

Pin Definitions

Pin #	Name	Description
A1	VIN	**Input voltage**.
A2	ISET	A resistor from the internal reference to GND is measured to determine the LED current setting. This resistor value sets current for the LED strings in RSET Mode. If the device is used in FULL Mode only, ISET must be connected with a resistor of valid range or to GND.
A3	LED1	**LED string #1 output**.
B1	EN	**Enable/PWM pin for LED1 - LED5**. A logic LOW on this pin turns off the LED drivers. The IC goes to shutdown 30 ms after the enable pin is set LOW. It is connected to an internal pull-down resistor of 280 kΩ.
B2	SEL	**RSET/FULL mode selection**. 1-wire interface to program the current. RSET Mode (SEL = LOW), internal current multiplier is 400, and FULL Mode (SEL = HIGH); programmed output current = 28 mA (default) per string. It is connected to an internal pull-down resistor of 280 kΩ.
B3	LED2	**LED string #2 output**.
C1	GND	**Ground**. All power and analog signals are referenced to this pin.
C2	LED5	**LED string #5 output**.
C3	LED3	**LED string #3 output**.
D1	SW	**Switching node**. Tie inductor L1 from VIN to this pin.
D2	VOUT	**Boost output voltage** used to supply the LED current sources. This voltage is regulated to the minimum value required to ensure adequate voltage across all active LED current sources.
D3	LED4	**LED string #4 output**.

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

<table>
<tr><th>Symbol</th><th colspan="2">Parameter</th><th>Min.</th><th>Max.</th><th>Units</th></tr>
<tr><td>V_{IN}</td><td colspan="2">Supply Voltage</td><td>-0.3</td><td>6.0</td><td>V</td></tr>
<tr><td>V_{ISET}</td><td colspan="2">ISET Voltage</td><td>-0.3</td><td>V_{IN} + 0.3</td><td>V</td></tr>
<tr><td>V_{EN}</td><td colspan="2">EN and SEL Pin Maximum Voltage</td><td>-0.3</td><td>6.0</td><td>V</td></tr>
<tr><td>V_{OVP}</td><td colspan="2">VOUT, SW, and LEDx Drive Pins’ Maximum Voltage</td><td>-0.3</td><td>10.0</td><td>V</td></tr>
<tr><td rowspan="2">ESD</td><td rowspan="2">Electrostatic Discharge Protection Level</td><td>Human Body Model per JESD22-A114</td><td colspan="2">2.0</td><td rowspan="2">kV</td></tr>
<tr><td>Charged Device Model per JESD22-C101</td><td colspan="2">1.0</td></tr>
<tr><td>T_A</td><td colspan="2">Operating Ambient Temperature</td><td>–40</td><td>+85</td><td>°C</td></tr>
<tr><td>T_J</td><td colspan="2">Junction Temperature</td><td>–40</td><td>+150</td><td>°C</td></tr>
<tr><td>T_{STG}</td><td colspan="2">Storage Temperature</td><td>–65</td><td>+150</td><td>°C</td></tr>
<tr><td>T_L</td><td colspan="2">Lead Soldering Temperature, 10 Seconds</td><td></td><td>+260</td><td>°C</td></tr>
</table>

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Min.	Typ.	Max.	Units
V_{IN}	V_{IN} Supply Voltage	2.3	3.7	4.8	V
V_{OUT}	V_{OUT} Voltage[(1)]	3.5		8.5	V
$I_{LED(FS)}$	Full-Scale LED Current per Channel	2.5		28.0	mA
T_A	Ambient Temperature	–40		+85	°C
T_J	Junction Temperature	–40		+125	°C

Note:

1. The minimum V_{OUT} must be 3.5 V to guarantee a maximum LED current of 28mA for each LED pin. Internally, the device sets a minimum $V_{OUT} = V_{IN}$+0.2 V and the LED driver dropout is increased accordingly. If V_F < 3.3 V and V_{IN} < 3.3 V, V_{OUT} voltage has to be forced above 3.5 V by connecting for example series resistor for one of the LED-strings.

Thermal Properties

Junction-to-ambient thermal resistance is a function of application and board layout. This data is measured with four-layer 2s2p boards in accordance to JEDEC standard JESD51. Special attention must be paid not to exceed junction temperature $T_{J(max)}$ at a given ambient temperate T_A.

Symbol	Parameter	Min.	Typ.	Max.	Units
θ_{JA}	Junction-to-Ambient Thermal Resistance		90		°C/W

Electrical Specifications

Unless otherwise specified: V_{IN} = 2.3 V to 4.8 V, T_A = -40°C to +85°C, and EN = V_{IN}, SEL = 0 V. Typical values are V_{IN} = 3.7 V, T_A = +25°C, V_{OUT} = 6.7 V, I_{LED1-5} = 28 mA. Circuit and components are according to Figure 1.

Symbol	Parameters	Conditions		Min.	Typ.	Max.	Units
Power Supplies							
I_{SD}	Shutdown Current	Device Disabled (EN = 0 V), V_{IN} = 2.3 V to 4.8 V			0.5	2.0	µA
V_{UVLO}	Under-Voltage Lockout Threshold	Rising V_{IN}			2.1	2.2	V
		Falling V_{IN}		1.8	1.9		V
V_{UVHYST}	Under-Voltage Lockout Hysteresis				200		mV
Oscillator							
f_{SW}	Switching Frequency	PWM Mode CCM			1.8		MHz
Boost Regulator							
$V_{OUT-RIPPLE}$	Output Voltage Ripple	BW = 20 MHz				100	mV
I_{LIM-PK}	Peak Switch Current Limit(2)	Open Loop, V_{IN} = 2.3 V to 4.8 V			1000	1300	mA
$I_{SOFT-PK}$	Soft-Start Peak Switch Current	Open Loop			350		mA
I_{LOAD}	Maximum Continuous Output Current(3)	V_{IN} > 2.5 V, V_{OUT} = 7.5 V		140			mA
η_{SYSTEM}	System Efficiency as a Function of LED Current PWM Duty Cycle(3)	V_{IN} = 3.7 V, V_{LED} = 6.5 V, PWM = 100%	Total I_{LED} = 25 mA		83		%
			Total I_{LED} = 80 mA		86		
			Total I_{LED} = 115 mA	87	88		
			Total I_{LED} = 140 mA	85			
		V_{IN} = 3.7 V, V_{LED} = 6.5 V, PWM = 1%, 1600 Hz	Total I_{LED} = 80 mA	75			
			Total I_{LED} = 115 mA	75			
LED Current Driver Characteristics							
$\Delta I_{LED}/I_{LED}$	Line Transient Response to V_{IN} Variations(3)	Relative Response to 350 mV Pulses				10	%
		Response to 350 mV Pulses Integrated Over 20 ms period				1	
V_{LED_DO}	LED Driver Drop-Out Voltage(5)				260		mV
f_{PWM}	LED PWM Frequency(3)			100		1600	Hz
I_{LED_ACC}	LED Current Accuracy (R_{SET} Connected to ISET Pin)	Variation within each I_{LEDx} Output. Pin Voltage Difference < 250 mV(4), SEL = 0, 2.70 V ≤ V_{IN} ≤ 4.35 V	2.5 mA ≤ I_{LED} < 8 mA			9.0	%
			8 mA ≤ I_{LED} ≤ 20 mA			7.5	
			20 mA ≤ I_{LED} ≤ 28 mA			7.0	
I_{LED_ACC}	LED Current Accuracy(6) (Internal Accuracy)	Variation within each I_{LEDx} output. Pin Voltage Difference < 250 mV(4), SEL = 1 Pulsed for Different I_{LEDx}: 25 mA, 26 mA, 27 mA, 28 mA				7.0	%
I_{LED_MATCH}	LED Current Matching	Variation between Different I_{LED1} – I_{LED5} Currents. Matching LED Pin Voltage Difference < 250 mV(4), 2.70 V ≤ V_{IN} ≤ 4.35 V	2.5 mA ≤ I_{LED} < 15 mA			6.5	%
			15 mA ≤ I_{LED} ≤ 23 mA			6.0	
			23 mA ≤ I_{LED} ≤ 25 mA			5.0	
			25 mA ≤ I_{LED} ≤ 28mA			4.5	
$I_{LINEARITY}$	LED Current Linearity(3)	2/255 ≤ PWM ≤ 24/255, 1600 Hz				10	%
		PWM ≥ 25/255, 1600 Hz				2	

Continued on the following page…

Electrical Specifications

Unless otherwise specified: V_{IN} = 2.3 V to 4.8 V, T_A = -40°C to +85°C, and EN = V_{IN}, SEL = 0 V. Typical values are V_{IN} = 3.7 V, T_A = +25°C, V_{OUT} = 6.7 V, I_{LED1-5} = 28 mA. Circuit and components are according to Figure 1.

Symbol	Parameters	Conditions	Min.	Typ.	Max.	Units
I_{LED_RIPPLE}	Peak-to-Peak LED Current Ripple(3)	V_{LED_DO} ≤ 0.6 V, f_{PWM} = 300 Hz, Measurement, BW = 500k Hz		0.4	1.2	mA_{P-P}
$I_{LEAKAGE}$	LED Driver Leakage	In OFF State			0.5	µA
V_{ISET}	ISET Voltage			1.25		V
I_{SET}	ISET Ratio	Current Mirror Ratio; SEL = 0, Normal Mode		400		
I_{LED_MAX}	LED Driver Maximum Current(6)	R_{SET} = 18 kΩ, ±1%, SEL = 0			30	mA
		SEL = 1, Default Setting or 4 Pulses			30	
I_{LED_OCP}	LED Over Current Protection		32	35	39	mA
Logic Control						
V_{IL}	Logic LOW Threshold				0.68	V
V_{IH}	Logic HIGH Threshold		1.07			V
$R_{EN, SEL}$	EN, SEL Pull-Down Resistor			280		kΩ
t_{INIT}	Initialization Time to Engage SEL Pin(3)		120			µs
t_{LOW}	Time Period when Pulse is LOW on SEL Pin(3)		2	10	25	µs
t_{HIGH}	Time Period when Pulse is HIGH on SEL Pin(3)		2	10	25	µs
t_{WINDOW}	Time Window to Count Rising Edges on SEL Pin(3)			500		µs
Protection						
T_{TSD}	Over-Temperature Shutdown			150		°C
T_{HYS}	Over-Temperature Hysteresis			25		°C
$t_{SHUTDOWN}$	Shutdown Time		30	33	36	ms
$t_{STARTUP}$	Startup Time			1.2		ms
$V_{OV-RISE}$	V_{OUT} Over-Voltage Rising Threshold			9.0		V
$V_{OV-FALL}$	V_{OUT} Over-Voltage Falling Threshold			8.5		V
V_{OV-HYS}	V_{OUT} Over-Voltage Hysteresis			500		mV
$V_{LED(OCD)}$	LED Open-Circuit Detection Threshold	2.70 V ≤ V_{IN} ≤ 4.35 V	8.0	8.3	8.5	V
$V_{LED(SCP)}$	LED Short-Circuit Protection Threshold		0.70	1.00	1.25	V
$I_{LED-SHORT}$	Shorted LED Current	LED Short-Circuit Protection Threshold Tripped			1	µA

Notes:

2. In closed-loop operation, the inductor current (I_L) is 100 mA greater than I_{LIM-PK}.
3. Guaranteed by characterization and design.
4. For the LED outputs, the following are determined: the maximum LED current in the group (MAX), the minimum LED current in the group (MIN), and the average LED current of the group (AVG). Two matching numbers are calculated: (MAX-AVG)/AVG and (AVG-MIN)/AVG. The larger number of the two (worst case) is considered the matching value for the group. The matching value for a given part is considered to be the highest matching value of the two groups. The typical specification provided is the most likely norm of the matching value for all parts.
5. LED driver drop-out voltage is the smallest voltage across all the LED channels.
6. Average LED current across all five (5) outputs.

Typical Characteristics

V_{IN} = 3.7 V, T_A = +25°C, I_{LED} = 5 x 28 mA, V_{OUT} = 6.7 V, L1 = 4.7 µH, and C_{OUT} = 10 µF (unless otherwise specified).

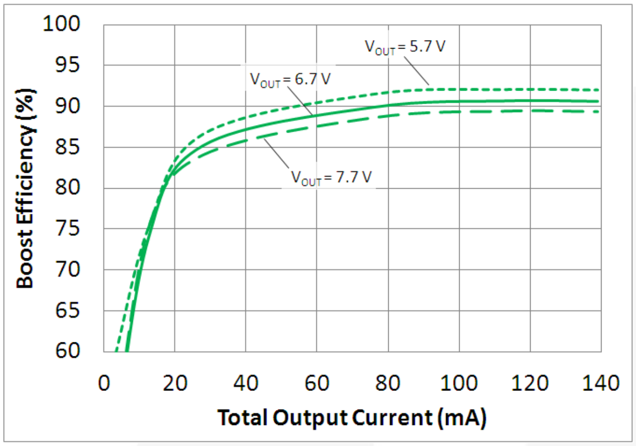


Figure 4. Boost Efficiency vs. Output Current vs. Output Voltage

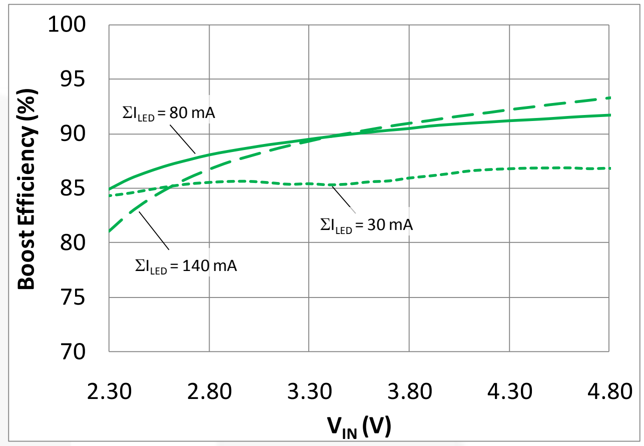


Figure 5. Boost Efficiency vs. Input Voltage vs. Total LED Current

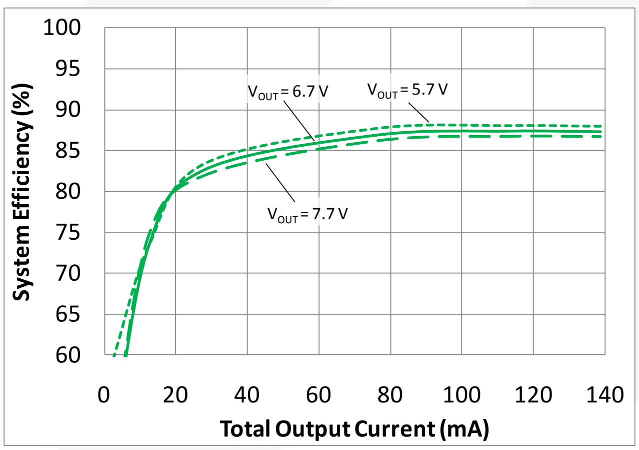


Figure 6. System Efficiency vs. Output Current vs. Output Voltage

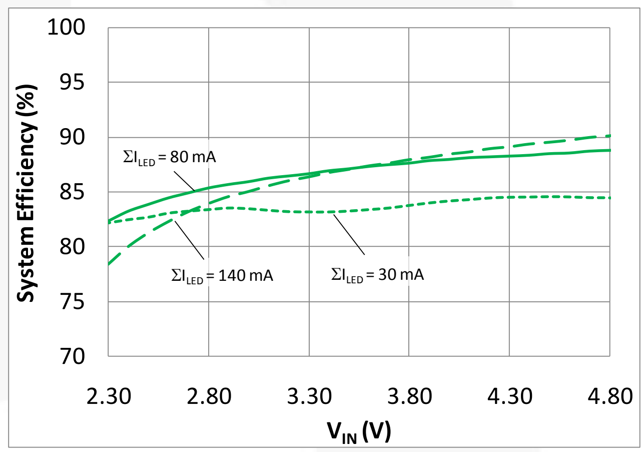


Figure 7. System Efficiency vs. Input Voltage vs. Total LED Current

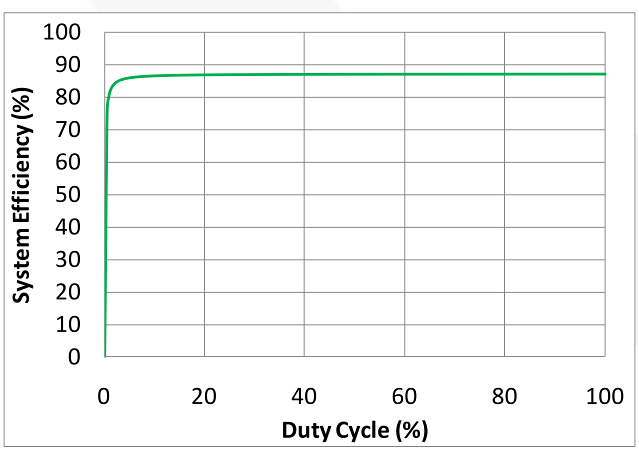


Figure 8. System Efficiency vs. PWM Duty Cycle, f_{PWM} = 1 kHz

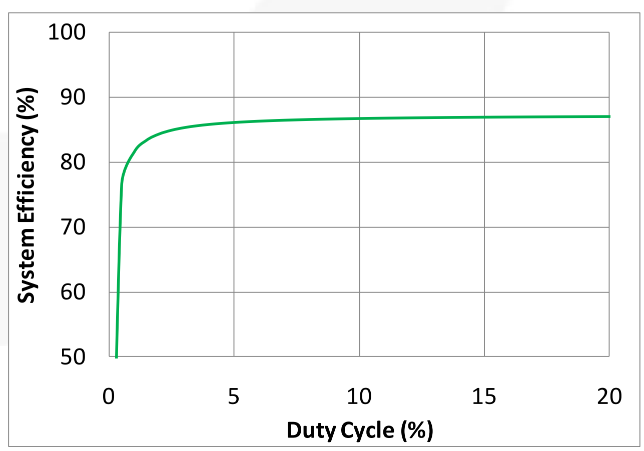


Figure 9. System Efficiency vs. PWM Duty Cycle, f_{PWM} = 1 kHz

Typical Characteristics

V_{IN} = 3.7 V, T_A = +25°C, I_{LED} = 5 x 28 mA, V_{OUT} = 6.7 V, L1 = 4.7 µH, and C_{OUT} = 10 µF (unless otherwise specified).

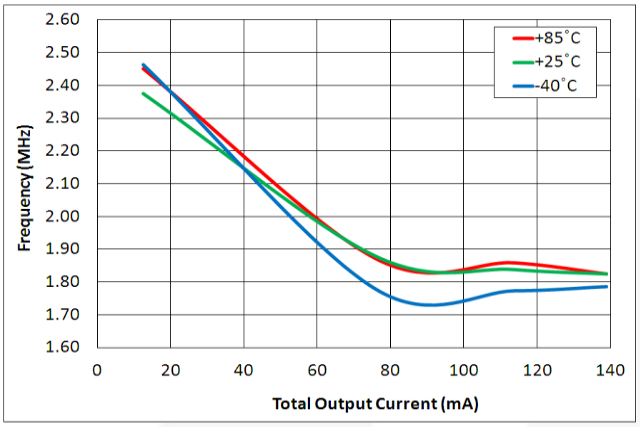


Figure 10. Switching Frequency vs. Total Output Current vs. Temperature

Figure 11. Total LED Current vs. PWM Duty Cycle, I_{LED} = 5 x 28 mA

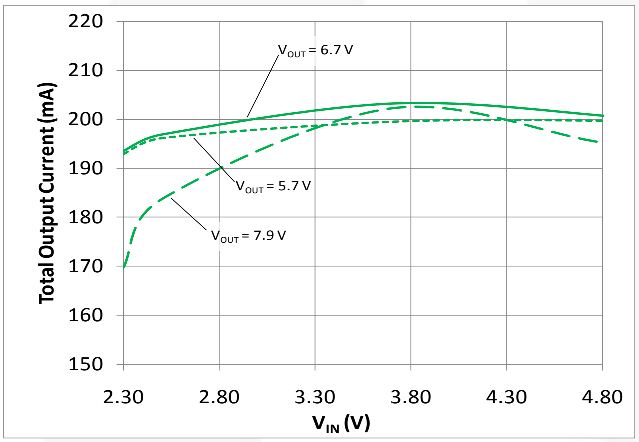


Figure 12. Maximum Output Current vs. Input Voltage vs. Output Voltage

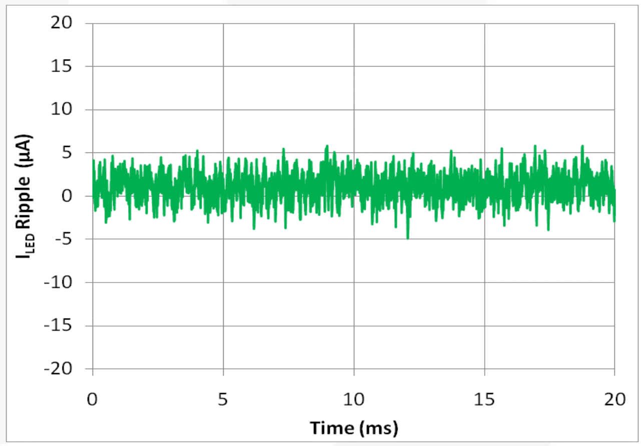


Figure 13. LED Current Ripple, I_{LED} = 5 x 28 mA, BW = 500 kHz

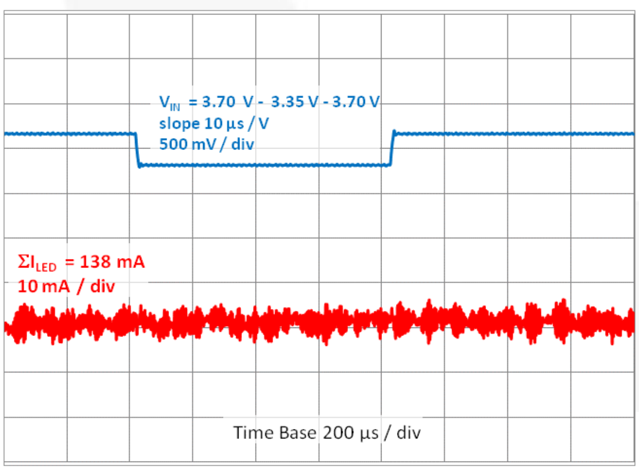


Figure 14. Line Transient Response V_{IN} = 3.70 V - 3.35 V - 3.70 V, I_{LED} = 5 x 28 mA

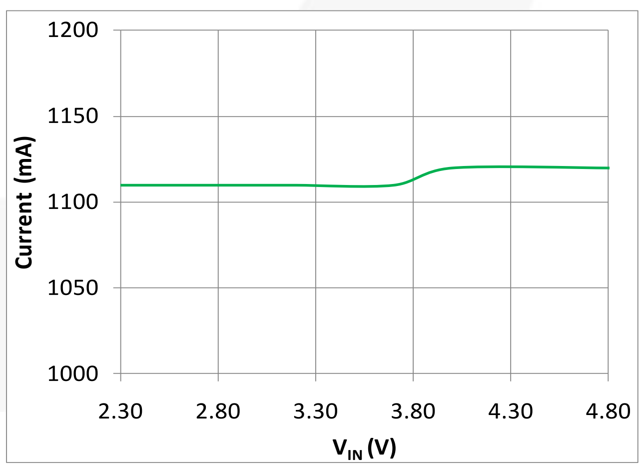


Figure 15. Peak Inductor Current Limit (Closed Loop) vs. Input Voltage

Typical Characteristics

V_{IN} = 3.7 V, T_A = +25°C, I_{LED} = 5 x 28 mA, V_{OUT} = 6.7 V, L1 = 4.7 µH, and C_{OUT} = 10 µF (unless otherwise specified).

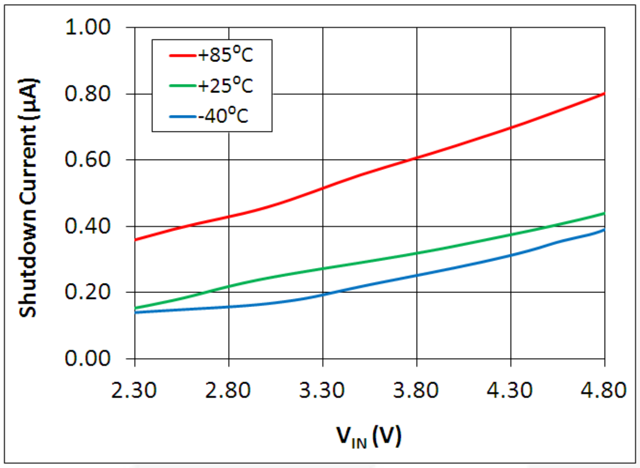


Figure 16. Shutdown Current vs. Input Voltage vs. Temperature

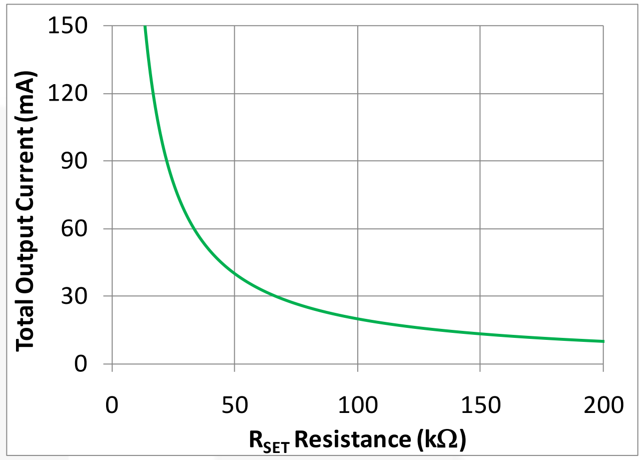


Figure 17. Total Output Current I_{LED} vs. R_{SET} Resistor Value

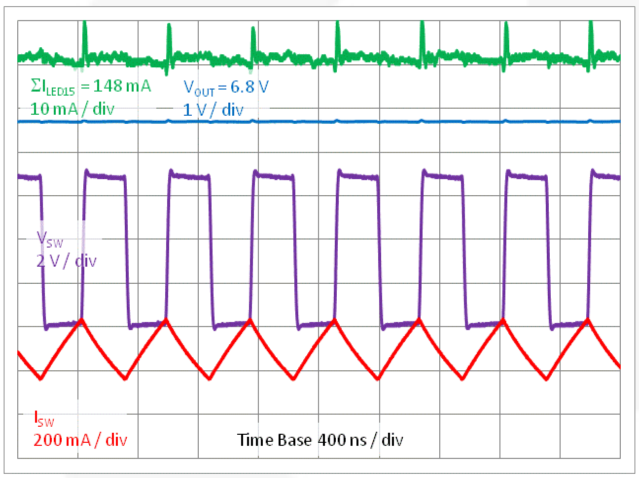


Figure 18. Switch Waveform (V_{OUT}, V_{SW}, I_{SW})

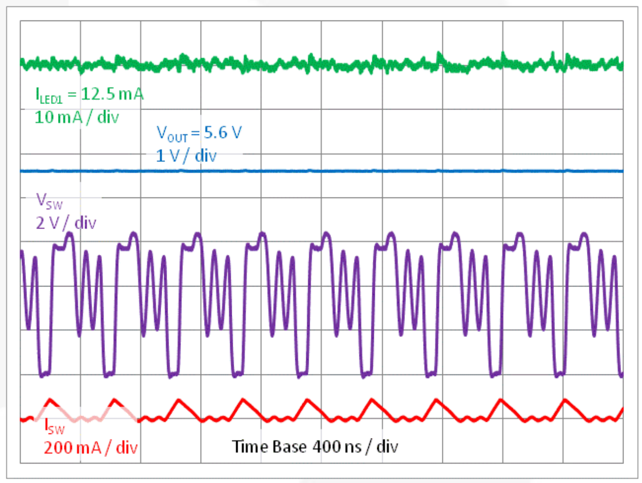


Figure 19. Switch Waveform (V_{OUT}, V_{SW}, I_{SW})

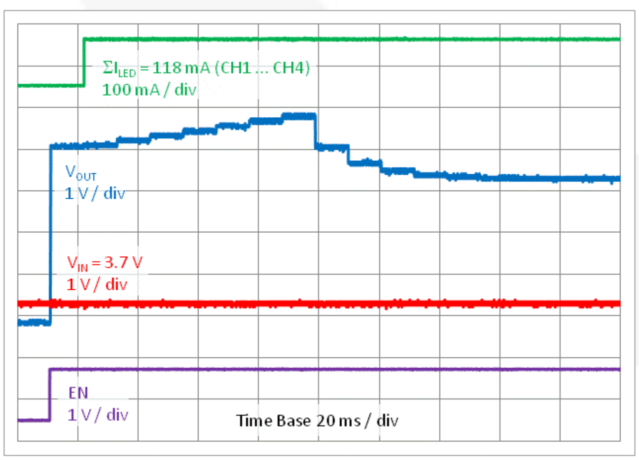


Figure 20. Startup After Enable, Four Strings Connected

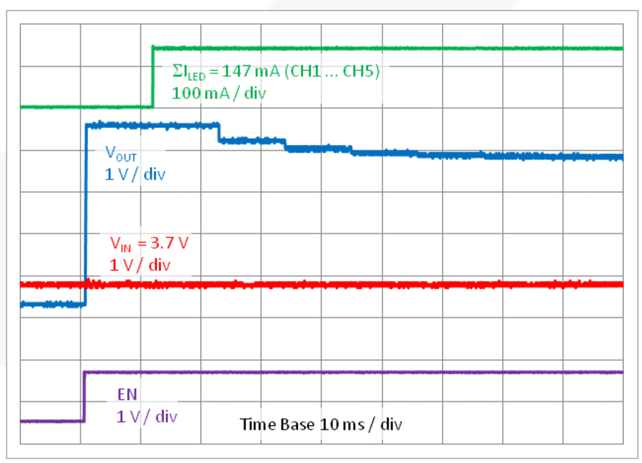


Figure 21. Startup After Enable, Five Strings Connected

Typical Characteristics

V_{IN} = 3.7 V, T_A = +25°C, I_{LED} = 5 x 28 mA, V_{OUT} = 6.7 V, L1 = 4.7 µH, and C_{OUT} = 10 µF (unless otherwise specified).

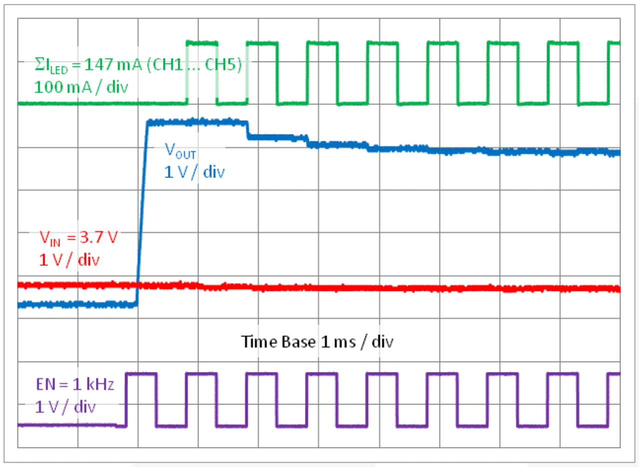


Figure 22. LED PWM Startup, Five Strings Connected

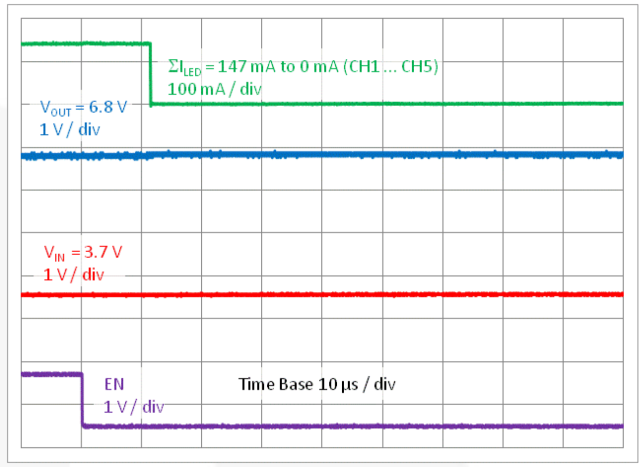


Figure 23. Device Disabled, Five Strings Connected

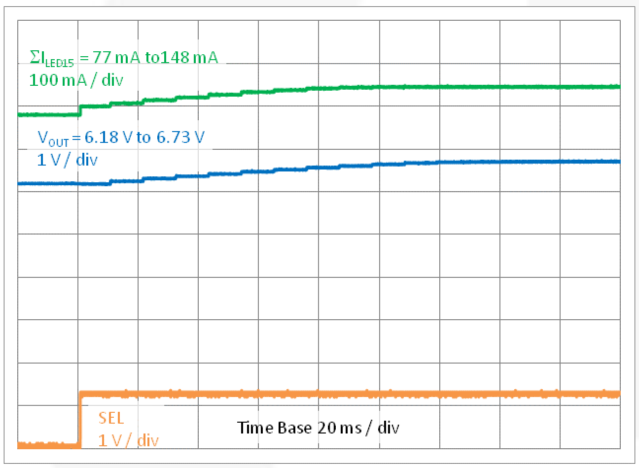


Figure 24. SEL Pin Enabled LED Current Change

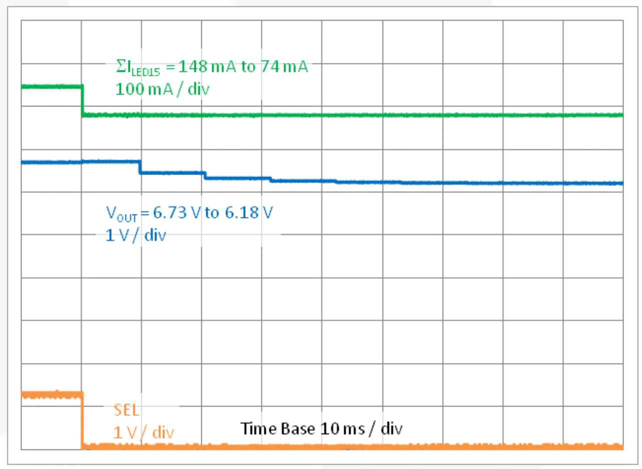


Figure 25. SEL Pin Enabled LED Current Change

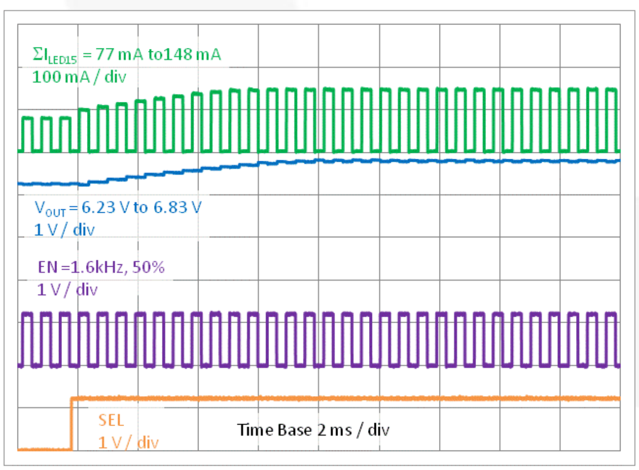


Figure 26. SEL Pin Enabled LED Current Change

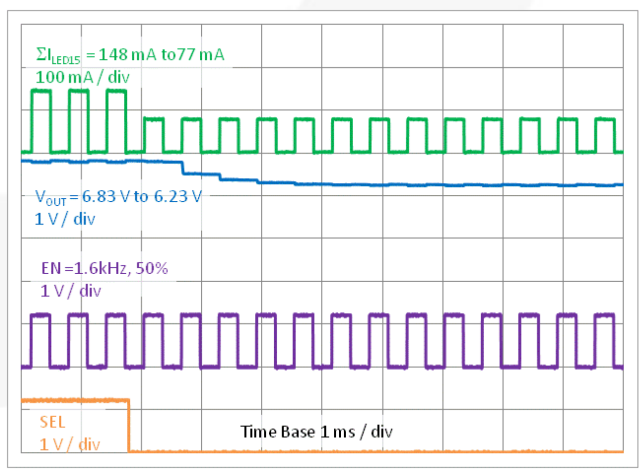


Figure 27. SEL Pin Enabled LED Current Change

Circuit Description

Overview

The FAN5775 is a 1.8 MHz synchronous step-up DC-DC converter with integrated constant-current high-side LED drivers capable of driving one to five LED strings up to five times (5x) 28 mA LED current.

The device starts when at least one LED string is utilized and the EN pin is enabled. The device is disabled 30 ms after setting the EN pin LOW.

The V_{OUT} voltage is internally set to 200 mV above the highest LED string voltage and is sampled at every falling LED PWM cycle. For 100% duty cycle, the LED-pin voltage is sampled and the V_{OUT} voltage is refined every 10 ms.

The LED strings can be disabled by connecting them to VOUT, shorting them to GND, or leaving them disconnected. If the LED string is temporarily disabled or shorted, the device must be restarted to enable the string again.

The LED drivers work independently and allow multiple LED voltages. Therefore, many types of LEDs can be driven at the same time and some strings can be used to drive a single LED while other channels are driving two LEDs in series. The V_{OUT} voltage is defined by the highest LED voltage and the LED driver dropout voltage is increased to provide the LED string a specific voltage. If the voltage difference between the LED strings is large, the system efficiency may decrease.

LED Current

RSET Mode

In RSET Mode, SEL is LOW and the LED string current is set by the resistor, R_{SET}, between the ISET and GND pins. The same current is applied across all strings such that the total output current: $I_{OUT} = 5 \times I_{LED} = 5 \times 20$ mA = 100 mA if R_{SET} = 25 kΩ and all LED strings are used. In general, the LED string current can be calculated as follows:

$$I_{LED} = \frac{500}{R_{SET}} \quad (1)$$

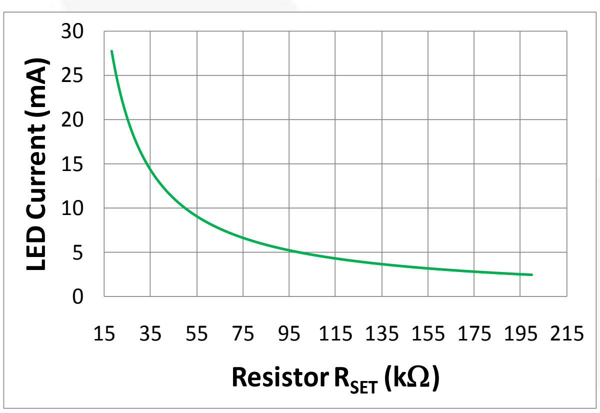


Figure 28. LED Current vs. R_{SET} Value

R_{SET} minimum resistance is internally limited and the device shuts down and requires a new startup if the R_{SET} resistor attempts to set a higher LED current *(see the LED Over-Current Protection – section below)*.

The R_{SET} value is monitored continuously and it can be changed on the fly. If the R_{SET} value is changed, the output current is smoothly changed to a new R_{SET} value. However, there must always be a R_{SET} value within a specified range (18 kΩ to 200 kΩ).

FULL Mode

In FULL Mode, the LED current is determined by a programmable internal resistor. FULL Mode is enabled when SEL is HIGH. The default output LED current for an un-programmed device is 28 mA. The LED current is set back to R_{SET} defined value (RSET Mode) when SEL pin is LOW.

FULL Mode LED current can be programmed by pulsing the SEL pin. The programmed value is held until the device is reprogrammed or reset by dropping the supply voltage to 0 V. For example, if the device's FULL Mode value is programmed to 27 mA; this is the value of the LED current held by the device when SEL is HIGH. To return to the default value, the device FULL Mode value has to be reprogrammed to 28 mA. Note that the minimum current of 25 mA can be programmed by applying one SEL LOW pulse (1 µs to 25 µs). Keep the minimum pulse width longer than 0.1 ms to prevent accidental FULL-value programming.

The FAN5775 has to be active when FULL Mode current is programmed (EN pin is HIGH or LED PWM is applied). The LED current is set accordingly to a programmed (or default) value. The SEL pin has to be HIGH at least for a defined initial time t_{INIT}, after which the programming sequence can be enabled. The device counts all SEL rising edges within a time window, t_{WINDOW}, then adjusts the LED current. The full-scale LED current has a range of 25 mA to 28 mA and is determined by:

- 1 rising edge = 25 mA
- 2 rising edges = 26 mA
- 3 rising edges = 27 mA
- 4 or more rising edges = 28 mA (default value)

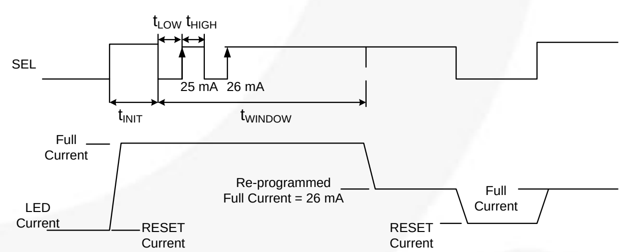


Figure 29. Timing Diagram for SEL Pin (FULL Current Reprogrammed from Default Value of 28 mA to 26 mA)

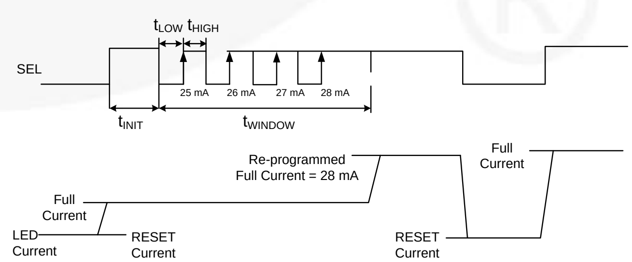


Figure 30. Timing Diagram for SEL Pin (FULL Current is Reprogrammed to 28 mA)

Startup

Setting EN HIGH enables the device and VOUT rises to 7.5 V. The FAN5775 starts to step up or down to the appropriate regulated voltage using its soft-start current limit. LED strings shorted to ground, strings floating, and strings connected to VOUT are disabled at the startup. If all strings are disabled, the device is shut down and it tries to restart at a rising LED PWM or every 10 ms if EN is HIGH.

If V_{OUT} cannot reach 7.5 V within 1.2 ms after an enable cycle, the device attempts to restart.

PWM Dimming

A LED PWM signal of 100 Hz to 1600 Hz can be applied to EN pin to control LED1-5 light intensity. The LED current is a linear function of the LED PWM duty cycle from 100% down to 0.4% or 5 µs, whichever is greater. The FAN5775 can be started by a PWM signal with a low duty cycle to enable smooth startup. The SEL pin cannot be used for PWM dimming due to long settling time.

Under-Voltage Lockout (UVLO)

The Under-Voltage Lockout circuitry turns off all MOSFETs and the device remains in a very low quiescent current state until V_{IN} rises above the UVLO threshold.

LED Short-Circuit Protection (SCP)

The LED driver is disabled and LED output current is limited to 0.5 µA when a LED pin voltage is below 1.25 V. This limit shall be applied within one LED PWM cycle, or 10 ms, whichever elapses first. The LED driver enabling requires a device disabling sequence (EN LOW for 33 ms).

If all the LED pin voltages are below 1.25 V (and all channels are thus individually disabled), the device goes into Shutdown Mode and tries to restart at a rising LED PWM or every 10 ms if EN is HIGH.

Over-Voltage Protection (OVP)

When the regulator is active, it monitors the VOUT pin. If the V_{OUT} voltage reaches 9.0 V, the regulator stops switching until the capacitor at VOUT discharges to a level below 8.5 V.

LED-Open Detection

If the V_{LED} channel voltage is detected above 8.30 V, the channel is disabled. The LED driver enabling requires a device disabling sequence (EN LOW for 33 ms).

If all LED pin voltages exceed 8.30 V (and all channels are thus individually disabled), the device goes into Shutdown Mode and tries to restart at a rising LED PWM or every 10 ms if EN is HIGH.

LED Over-Current Protection (OCP)

The LED output current is set either by R_{SET} resistor (when SEL is LOW) or by programmable internal resistor (activated when SEL is HIGH). The R_{SET} value of 15.6 kΩ (~32 mA LED current) or less activates the LED over-current protection and the device is shut down. The device tries to restart at a rising LED PWM or every 10 ms if EN is HIGH

Inductor Over-Current Protection (ILIM)

The PWM converter is protected against overload through cycle-by-cycle current limit using a fixed internal limit. The device is otherwise working normally – only the maximum inductor current is limited.

Thermal Shutdown

If the die temperature exceeds +150°C, reset occurs and remains in effect until the die cools down to +125°C; at which time, the circuit enters the normal soft-start sequence.

Applications

PCB Layout Guidelines

A separate ground plane is recommended to minimize noise. Place the FAN5775 device, inductor (L_1), C_{IN} and C_{OUT} capacitors, and their interconnections on the same side of the board. High-current paths from the supply voltage to the SW pin via the inductor, and GND pin to ground plane, are recommended as low-resistance paths. Minimize the SW pin capacitance to realize optimum system efficiency. Keep the VOUT-pin-to-C_{OUT}-capacitor path as short as possible to minimize the inductance of the VOUT-pin-to-C_{OUT} for low V_{OUT} ripple voltage. Keep the ISET-pin-to-R_{SET} resistor path away from noisy signals (SW pin) to minimize crosstalk from the SW pin to the ISET pin.

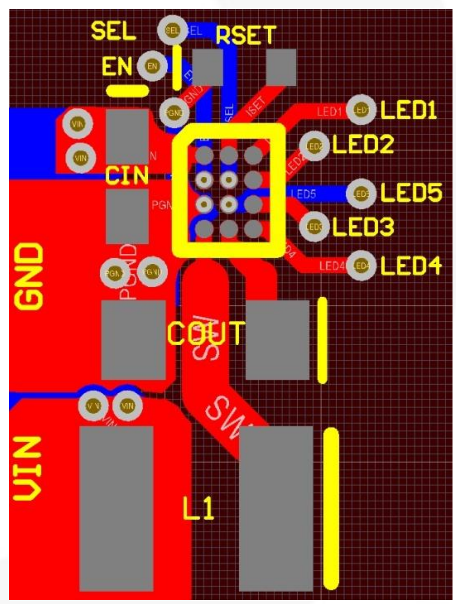


Figure 31. Recommended PCB Layout

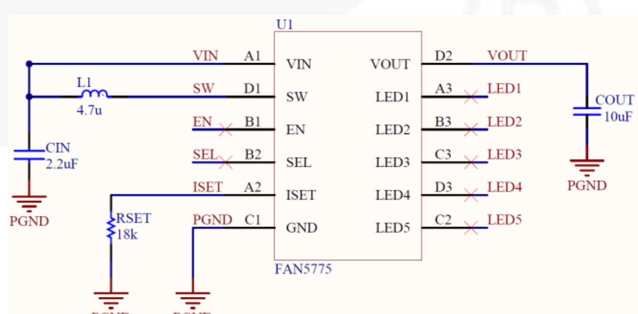


Figure 32. Schematic for Recommended Layout

External Component Selection

Four external components are required to power the FAN5775: an inductor between the VIN and SW pins, a storage capacitor at the output, a storage capacitor at the input, and a reference resistor at the ISET pin.

The inductor's minimum inductance requirement is 1.5 µH with a DCR ≤ 155 mΩ at 1000 mA bias current at 1.8 MHz frequency. A lower inductance drops the efficiency, while a higher inductance reduces the output ripple.

The minimum capacitance for the output capacitor is 4.8 µF at 5 V. Note that the ceramic capacitor value depends on the DC bias voltage. Check the datasheet of the capacitor to make sure the capacitor meets all specifications.

An input capacitor of 2.2 µF is recommended to improve device's transient behavior. Ensure the V_{IN} supply voltage is ripple-free for optimal device performance.

The reference resistor value is ≥ 18 kΩ. The LED current accuracy is defined by this resistor and a high-precision resistor with low temperature dependency is recommended.

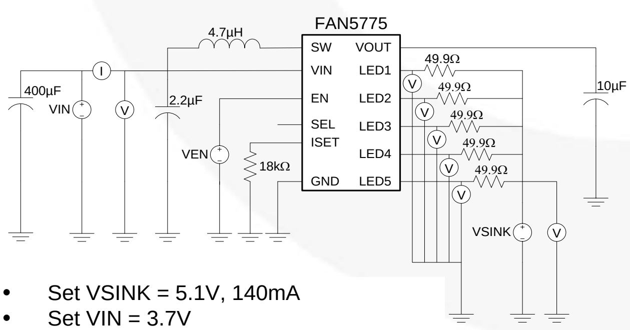
Measuring System Efficiency

The system efficiency can be measured using resistors of 49.9 Ω to each of the LED1-5 outputs *(see Figure 33 for the set-up of this measurement)*. The resistors are tied together and connected to a DC voltage source (V_{SINK}) with a volt meter in parallel. DC voltage sources are for VIN and VEN. Once this set-up is ready and set with values stated in Figure 33; measure V_{IN}, I_{IN}, V_{LED1} to V_{LED5}, V_{SINK}, and I_{SINK}. Calculate the system efficiency with Equation 2. LED voltages are not exactly the same, so each must be measured separately.

The system efficiency (η_{SYSTEM}) is calculated as follows:

$$\eta_{SYSTEM} = \sum_{i=1}^{5} \frac{I_i V_i}{I_{IN} V_{IN}} \qquad (2)$$

where I_i is LED(i) channel current; V_i is LED(i) channel voltage; I_{IN} is supply current (rms); V_{IN} is supply voltage (rms). LED current I_i is calculated on calibrated LED string resistors R_i = 49.9 Ω + ΔR_i, where i = 1 to 5.



- Set VSINK = 5.1V, 140mA
- Set VIN = 3.7V
- Set VEN = 1.2V
- Measure VIN, IIN, VLED1...5, and VSINK
- Calculate efficiency

Figure 33. Circuit Diagram to Measure System Efficiency

Flashlight Example

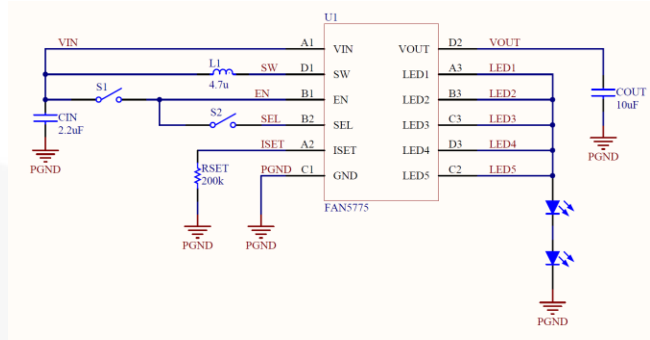


Figure 34. Schematic for Flashlight Applications

To use the FAN5775 as a LED flashlight driver, as shown in Figure 34, connect VIN to the battery voltage and add a single-pole switch S1 (either mechanical or electrical) from EN to VIN. Pull-down resistors on the EN pins disable the device when the switch is in a non-conducting state. The SEL pin can be connected to VIN voltage by switch S2 for higher output current. In the example above, SEL LOW current is 5 x 2.5 mA = 12.5 mA while SEL HIGH current is 5 x 28 mA = 140 mA (default). The SEL pin can be connected to ground.

RSET Value Change Example

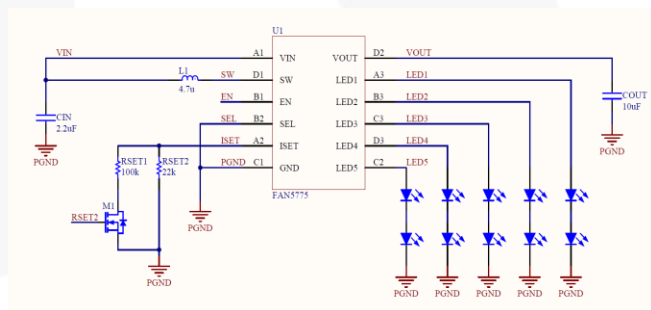
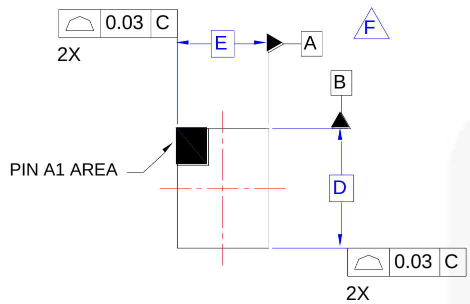


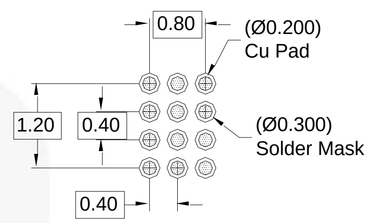
Figure 35. Schematic for RSET Change Example

The output current can be changed on-the-fly by switching another resistor (RSET1 in Figure 35) in parallel to RSET2 and the output current changes accordingly (RSET2 = 22 kΩ → 22.7 mA LED channel current and RSET1 || RSET2 = 18 kΩ → 27.7 mA LED channel current). Select a low-capacitance switch to keep the output current clean – this is especially important if PWM control is applied on the EN pin.

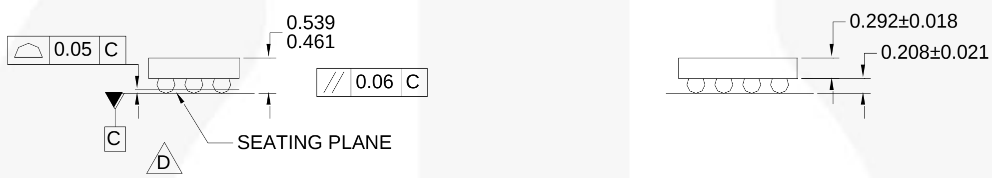
Physical Dimensions



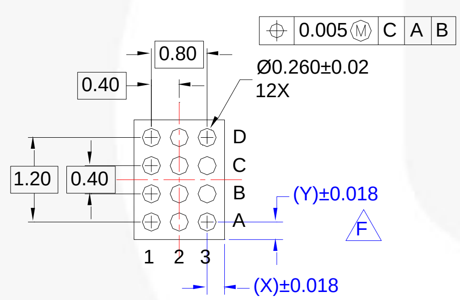
TOP VIEW



RECOMMENDED LAND PATTERN
(NSMD PAD TYPE)



SIDE VIEWS



BOTTOM VIEW

NOTES:

A. NO JEDEC REGISTRATION APPLIES.

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.

D. DATUM C IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.

E. PACKAGE NOMINAL HEIGHT IS 500 MICRONS ±39 MICRONS (461-539 MICRONS).

F. FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.

G. DRAWING FILENAME: MKT-UC012ADrev1.

Figure 36. 12-Bump, Wafer-Level Chip-Scale Package (WLCSP) 1.41 x 1.80 x 0.50 mm, 0.40 mm Pitch

Product-Specific Dimensions

Product	D	E	X	Y
FAN5775UCX	1.800 mm	1.410 mm	0.305 mm	0.300 mm

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Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
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