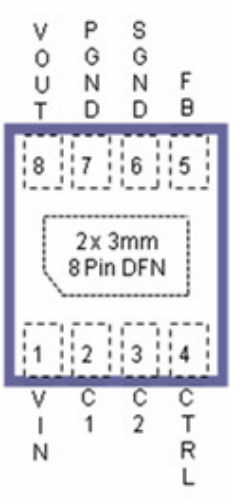
Constant Current Flash Driver in DFN 2mm x 3mm

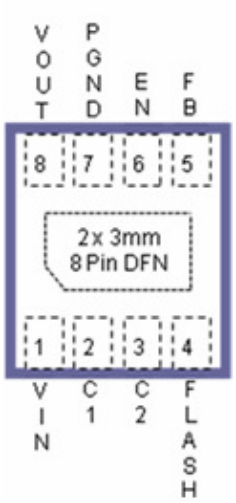
FEATURES

- Output current up to 500mA
- Up to 94% efficiency in 1x mode
- Built-in LED current setting DAC
- One line serial interface
- 2.4MHz switching frequency
- FB Reference voltage adjusts in 10mV steps from 60mV to 360mV
- DAC signal shutdown control
- Power-saving shutdown mode of 10nA
- PWM brightness control for DAC
- Fast turn-on (<150µs)
- 3.5s Timeout function to protect the LED
- Thermal shutdown protection
- Built-in over-voltage and over-current protection
- Fixed output versions available (SP7686A)
- Automatic soft start limits in-rush current
- Lead Free, RoHS Compliant Package: Space saving 8-pin 2x3mm DFN

SP7686



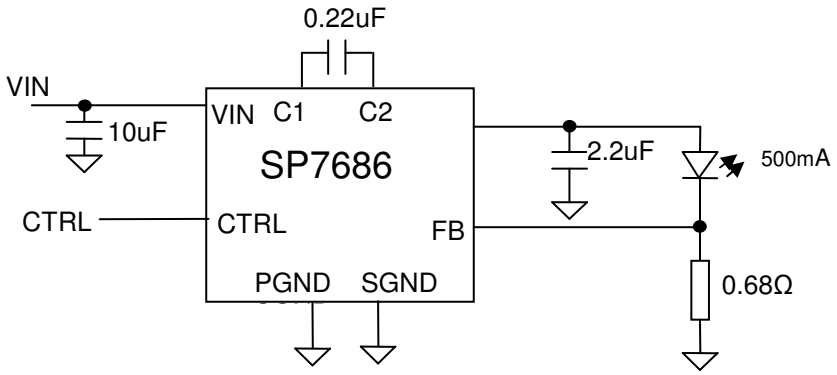
SP7686A

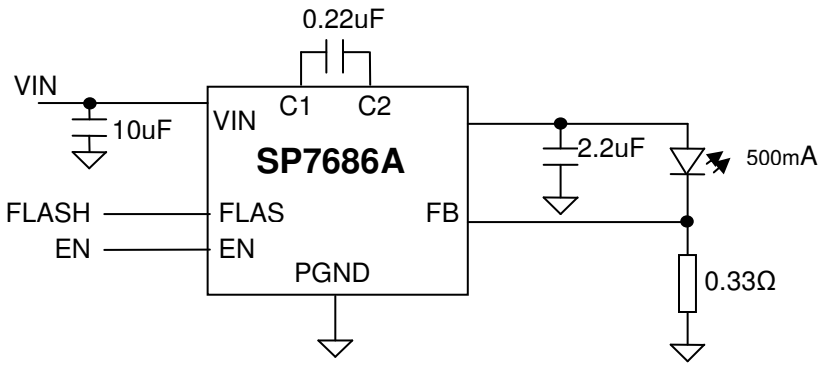


DESCRIPTION

The SP7686 is a current regulated charge pump ideal for powering high-brightness LEDs for camera FLASH applications of up to 500mA. The charge pump automatically switches between step-up and step-down modes ensuring that the LED current does not depend on the forward voltage. A low current sense reference voltage (60mV to 360mV) allows the use of small 0603 current sensing resistors. The SP7686 has a DAC programmable feedback reference voltage allowing the user to precisely set FLASH and TORCH output current levels, while the fixed version SP7686A has set levels of FLASH and TORCH reference voltage. Both parts have over-voltage, over-current, over-temperature and FLASH time-out protection features. The SP7686 is offered in the 2x3mm 8-pin DFN package.

TYPICAL APPLICATION CIRCUITS





ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

V_{IN},…….. .....-0.6V to 6.0V
C1, C2, EN, CTRL, FB, V_{OUT}….. .....-0.6V to V_{IN}+0.3V
Power Dissipation…….. ……..Internally limited[1]
Storage Temperature..…… ……...-65°C to 150°C
Operating Temperature.....-40°C to +85C
2x3mm 8 DFN …… …….…… θ_{JA} = 59°C/W
ESD CTRL pin……..…… ……...+/-1.2kV HBM
ESD all other pins……...+/-2kV HBM
Torch Mode Continuous Current ……..……..200mA

ELECTRICAL SPECIFICATIONS

Unless otherwise specified: V_{IN} = 3.6V, C_{IN}=10µF, C_{OUT}=2.2µF, C_{FLY}=0.22µF, Typical values at T_A=25°C.

♦ Indicates that values apply over the full operating temperature range of -40°C < T_A < 85°C.

PARAMETER	MIN	TYP	MAX		UNITS	CONDITIONS
Operating V_{IN} Range	2.7		5.5	♦	V	
Operating Input Current		2	3		mA	V_{IN} = 2.7 – 5.5V, FLASH = 0V, Iload = 100uA
Shutdown Supply Current		0.01	1		µA	V_{CRTL} < 0.4V for > 350µsec, V_{EN} < 0.4V (SP7686A)
Quiescent Current		300			µA	V_{FB} = 0mV, DAC=00000
FB Voltage for DAC=00000		0		♦	mV	
FB Voltage for DAC=00001		60			mV	
FB Voltage for DAC=11111		360			mV	
FB DAC LSB		10			mV	
FB Voltage Accuracy	-10		10	♦	%	60mV< V_{FB}<360mV, Variation from specified V_{FB}
FB voltage (Fixed version, Torch)	55	60	65	♦	mV	Flash = LOW, (SP7686A)
FB Voltage (Fixed version, Flash)	147	160	173	♦	mV	Flash = HIGH, (SP7686A)
FB Pin Current			0.5	♦	µA	V_{FB} =0.3V
Switching Frequency	2.0	2.4	2.8	♦	MHz	
Equivalent Resistance, 1x mode		0.6	1.4	♦	Ω	V_{IN}=3.6V
Equivalent Resistance, 2x mode		8			Ω	V_{IN}=3.6V
Thermal Regulation			0.01		%/°C	V_{FB} = 60mV
Thermal Shutdown Die Temperature		140			°C	Driver turns off
Thermal Shutdown Hysteresis		15			°C	Driver turns on again
Settle time (T_S) after last count		15	50		µs	
Ctrl Input Data Rate	0.5	1			µsec	CTRL minimum pulse width
Wake-up time (T_{POR}) from V_{IN} off			600	♦	µs	V_{IN} pin low to high, 1 CTRL pulse, V_{FB} =0mV
Wake-up time (T_{ON}) from shutdown			200	♦	µs	1 CTRL pulse or (EN pin low to high SP7686A)
Delay time (T_{DELAY}) from 1st to 2nd pulse		25	75		µs	1st to 2nd CTRL pulse time delay – guaranteed by design
Turn-off time (T_{OFF}) into shutdown			50		µs	EN pin high to low (SP7686A)
Turn-off time (T_{OFFC})into shutdown		200	350	♦	µs	CTRL pin high to low
Time Duration before shutdown	2.8	3.5	4.2	♦	s	V_{FB}>120mV (adj version 11 CTRL pulses), FLASH= high (fixed version)
Logic low voltage			0.4	♦	V	Driver shutdown
Logic high voltage	1.4			♦	V	Driver enabled
CTRL, EN pin current			0.5	♦	µA	(EN pin is SP7686A only)

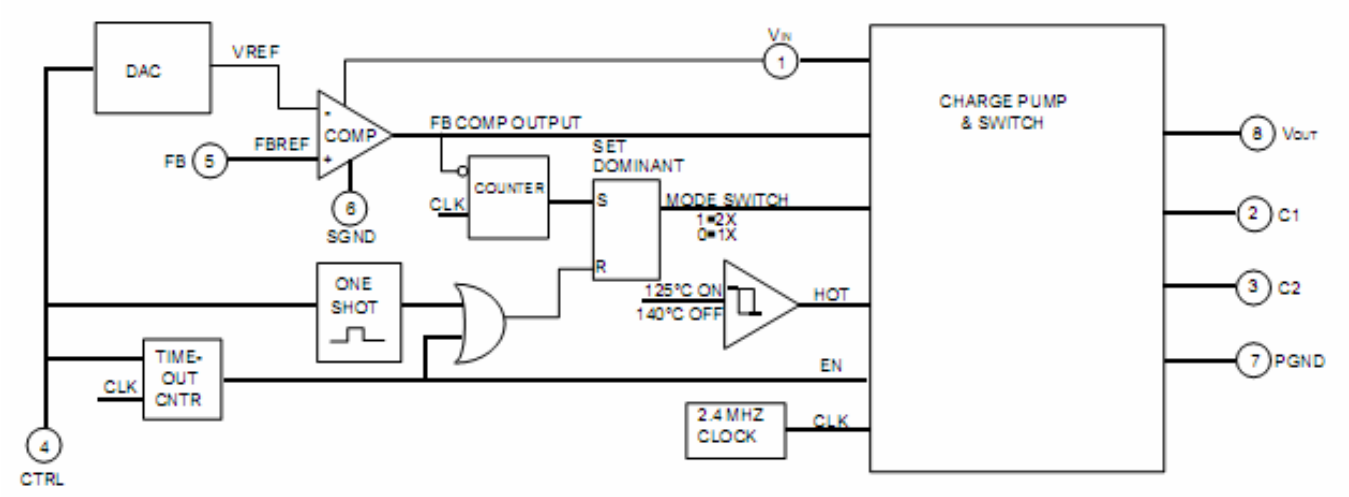
Note 1: Guaranteed maximum allowable power dissipation depends on the ambient temperature.

PIN DESCRIPTION

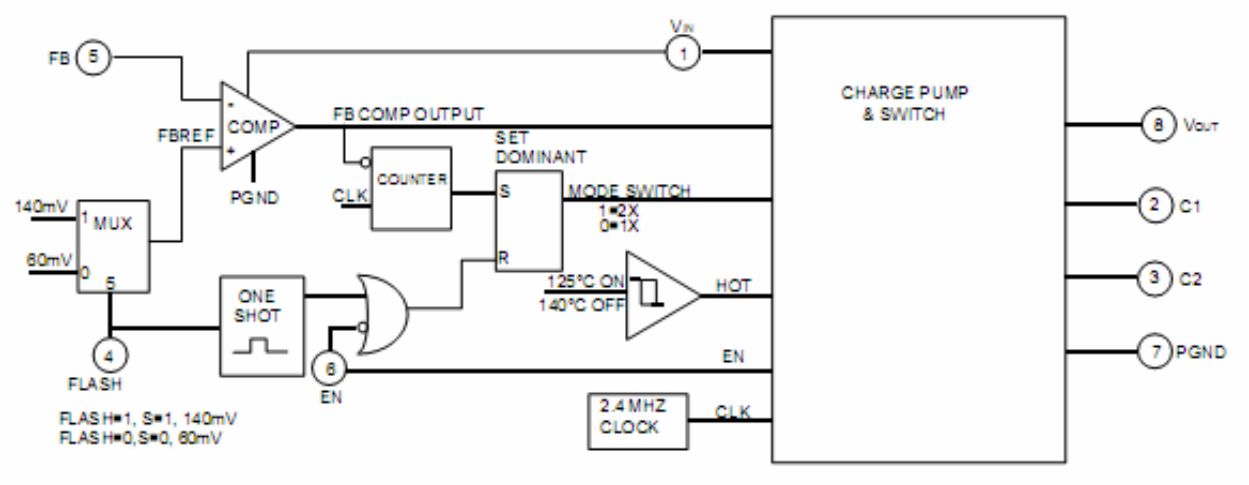
PIN #	PIN NAME	SP7686 PIN DESCRIPTION
1	VIN	Power supply input. Place a 10µF decoupling capacitor next to this pin.
2, 3	C1, C2	Connect an external 0.22µF flying capacitor between these pins
4	CTRL	This pin is used to control LED current. Once enabled the adjustable driver counts positive going edges at this pin and sequentially increases FB voltage with 10mV steps to a maximum 31 steps or 360mV. When this pin is held LOW for longer than 200µs the SP7686 enters shutdown. The part can be enabled using this pin. The first positive edge resets the part. A second positive edge sets the part to VFB=0. A third positive going edge will increase FB voltage to 60mV and subsequent positive edges increment VFB in 10mV steps. The voltage level can increase only and must be reset to zero by the 200µs shutdown timer in order to go to a lower current value. The part will be limited to a 3.5s on time when FB voltage is set to 120mV and above. This pin cannot be left open.
5	FB	Current feedback input. Place an external current sense resistor from this pin to ground. Voltage at this pin will be internally compared to the DAC output (60mV – 360mV).
6	SGND	Ground pin for SP7686 bias and reference (low current).
7	PGND	Ground pin for power (high current).
8	VOUT	Output voltage of the internal charge pump. Connect the LED between this pin and the current sense resistor. Voltage at this pin will be regulated in order to maintain constant LED current. Place a 2.2µF ceramic capacitor next to this pin.

PIN #	PIN NAME	SP7686A PIN DESCRIPTION
1	VIN	Power supply input. Place a 10µF decoupling capacitor next to this pin.
2, 3	C1, C2	Connect an external 0.22µF flying capacitor between these pins
4	FLASH	The fixed current driver (SP7686A) uses the flash pin to switch between two internally preset voltage levels, for Flash and Torch mode. The part is enabled and disabled by the separate ENABLE pin. The part has a 3.5s maximum on time in Flash mode. After a 3.5s timeout occurs the part shuts down and can be enabled by the FLASH or ENABLE pins. This pin cannot be left open.
5	FB	Current feedback input. Place an external current sense resistor from this pin to ground. Voltage at this pin will be internally compared to the DAC output (60mV – 360mV).
6	EN	The fixed current driver (SP7686A) has this enable/shutdown pin. (Logic high = enable, logic low = shutdown). Used to immediately disable the driver and PWM brightness control. There is an internal pull down on this pin.
7	PGND	Ground pin for power (high current).
8	VOUT	Output voltage of the internal charge pump. Connect the LED between this pin and the current sense resistor. Voltage at this pin will be regulated in order to maintain constant LED current. Place a 2.2µF ceramic capacitor next to this pin.

SP7686 FUNCTIONAL DIAGRAM



SP7686A FUNCTIONAL DIAGRAM



The SP7686 is a charge pump regulator designed for converting a Li-Ion battery voltage of 2.7V to 4.2V to drive a white LED used in digital still camera Flash and Torch applications. The SP7686 has two modes of operation which are pin selectable for either Flash or Torch. Flash mode is usually used with a pulse of about 200 to 300 milliseconds to generate a high intensity Flash. Torch can be used continuously at a lower output current than Flash and is often used for several seconds in a digital still camera "movie" mode. The SP7686 also has two modes of operation to control the output current: the 1X mode and 2X mode. Operation begins after the enable pin EN receives a logic high, the bandgap reference wakes up after 200µsec, and then SP7686 goes through a softstart mode designed to reduce inrush current. The SP7686 starts in the 1X mode, which acts like a linear regulator to control the output current by continuously monitoring the feedback pin FB. In 1X mode, if the SP7686 auto detects a dropout condition, which is when the FB pin is below the regulation point for more than 32 cycles of the internal clock, the SP7686 automatically switches to the 2X mode. The SP7686 remains in the 2X mode until one of four things happens: 1) the enable pin EN has been toggled, 2) the Flash pin has changed from high to low, 3) V_{IN} is cycled or, 4) a thermal fault occurs. The 2X mode is the charge pump mode where the output can be pumped as high as two times the input voltage, provided the output does not exceed the maximum voltage for the SP7686, which is internally limited to about 5.5V. In the 2X mode, as in the 1X mode, the output current is regulated by the voltage at the FB pin.

SP7686A

The fixed current driver (SP7686A) uses the flash pin to switch between two internally preset voltage levels, for Flash and Torch mode. The part is enabled and disabled by the separate ENABLE pin. The part has a 3.5s maximum on time in Flash mode. After a 3.5s timeout occurs the part shuts down and can be enabled by the FLASH or ENABLE pins. This pin cannot be left open. When in Flash mode, (Flash = V_{IN}), the FB regulation voltage is set to 160mV. When in Torch mode, (Flash = GND), the FB regulation voltage is set to 60mV. The output current is then set in either Flash or Torch mode by the equation: $I_{OUT} = V_{FB} / R_{SENSE}$.

SP7686

The digital controlled current driver (SP7686) uses the CTRL pin as a serial data input to a DAC to set the FB voltage. The CTRL pin is used to control LED current. Once enabled the adjustable driver counts positive going edges at this pin and sequentially increases the FB voltage from 60mV with 10mV steps to a maximum 31 steps or 360mV. When this pin is held LOW for longer than 200µs the SP7686 enters shutdown. The part can be enabled using this pin. The first positive edge resets the part. A second positive edge sets the part to VFB=0. A third positive going edge will increase FB voltage to 60mV and subsequent positive edges increment VFB in 10mV steps. The voltage level can increase only and must be reset to zero by the 200µs shutdown timer in order to go to a lower current value. The part will be limited to a 3.5s on time when FB voltage is set to 120mV and above. The CTRL pin cannot be left open.

Flash Timeout Protection

Due to the high currents typically available in Flash mode, it is necessary to protect the white LED from damage if left on too long. The SP7686 has a timeout in Flash mode of approximately 3.5 seconds after which it will shutdown operation. Operation will not begin again in Flash mode until the Enable pin has been set Low and then High again.

Overtemperature Protection

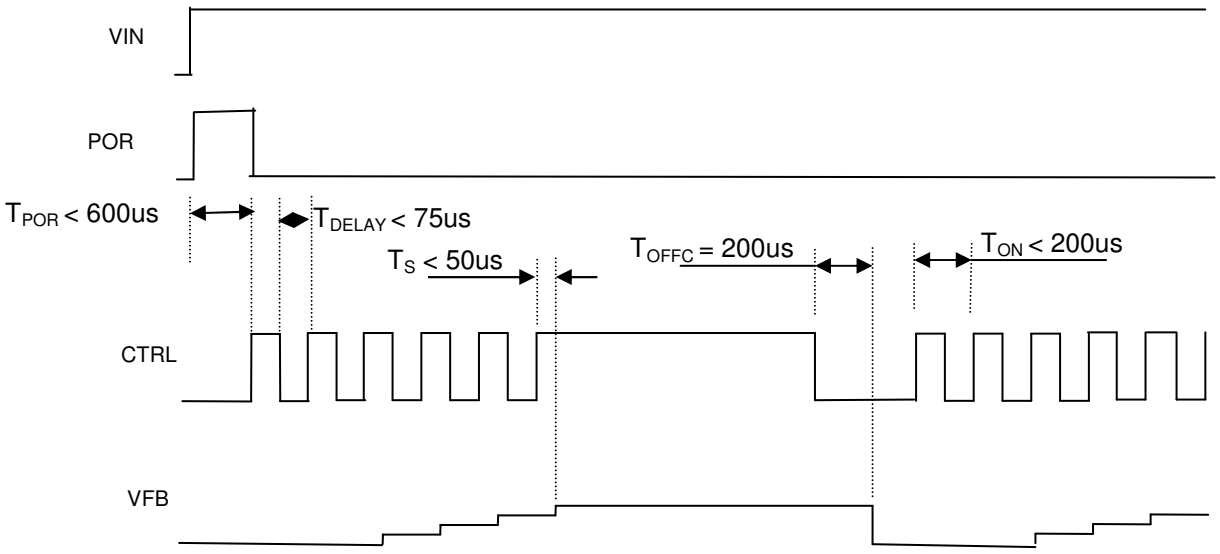
When the temperature of the SP7686 Rises above 140 degrees Celsius, the over temperature protection circuitry turns off the output switches to prevent damage to the device. If the temperature drops back down below 125 degrees Celsius, the part automatically recovers and executes a soft start cycle.

Overvoltage Protection

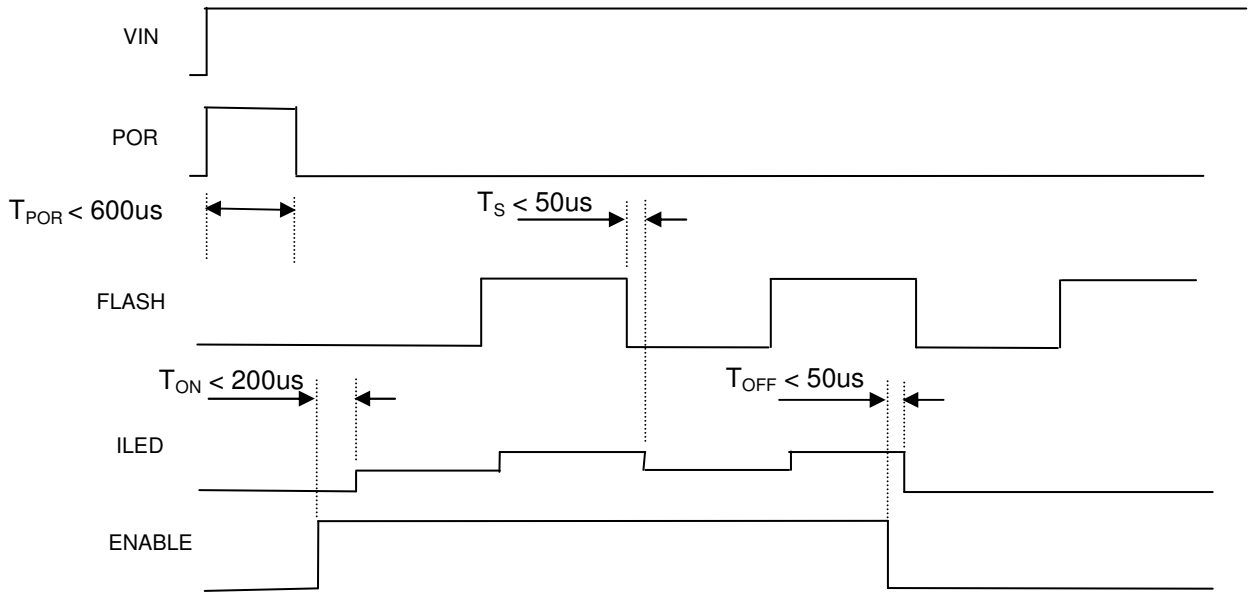
The SP7686 has over voltage protection. If the output voltage rises above the 5.5V threshold, the over voltage protection shuts off all of the output switches to prevent the output voltage from rising further. When the output decreases below 5.5V, the device resumes normal operation.

Overcurrent Protection

The overcurrent protection circuitry monitors the average current out of the V_{OUT} pin. If the average output current exceeds approximately 1.5Amp, then the overcurrent protection circuitry shuts off the output switches to protect the chip.



Timing Diagram for SP7686



Timing Diagram for SP7686A

V_{IN} = 3.6V, Typical Application Circuit, D1 = Luxeon LXCL-PWF3, Ta = 25C unless otherwise noted.

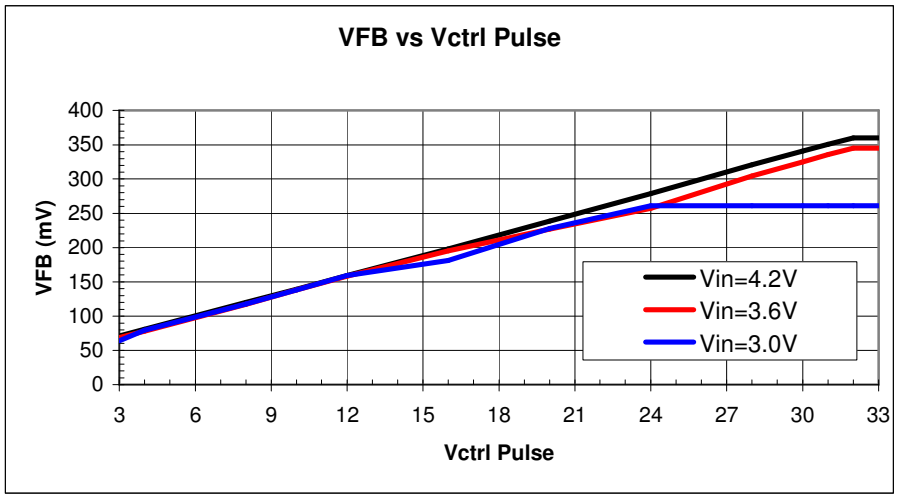


Figure 1. SP7686 VFB Vs VCTRL Pulses

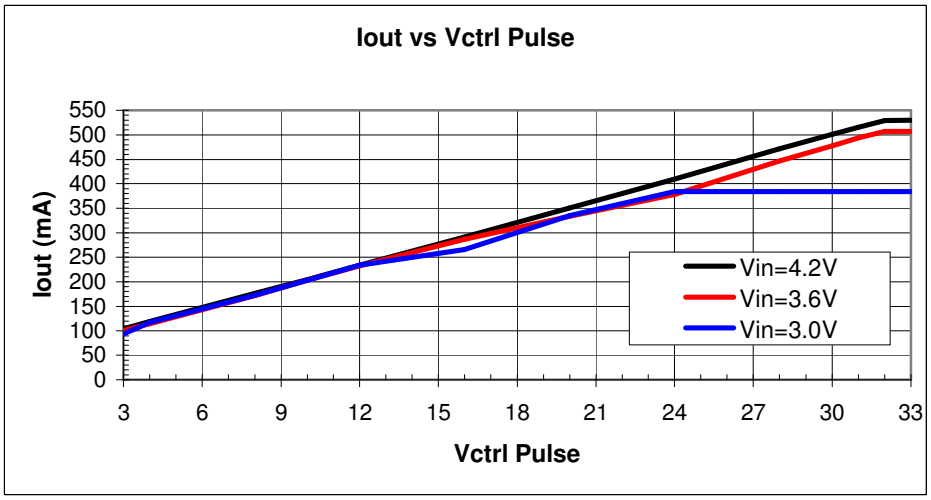


Figure 2. SP7686 I_{OUT} Vs VCTRL Pulses

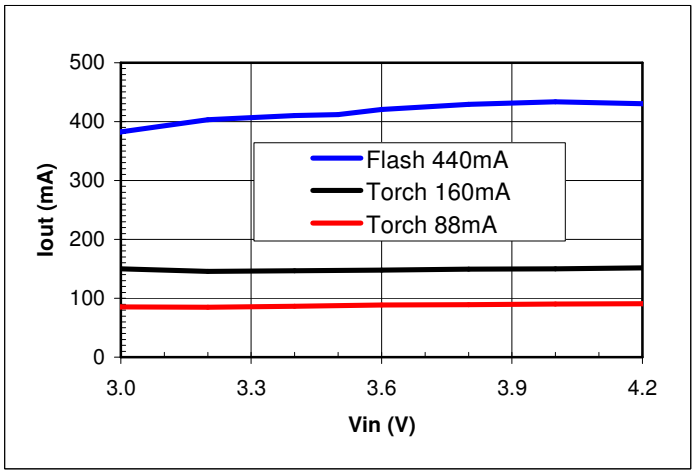


Figure 3. SP7686 Output Current Vs Input Voltage

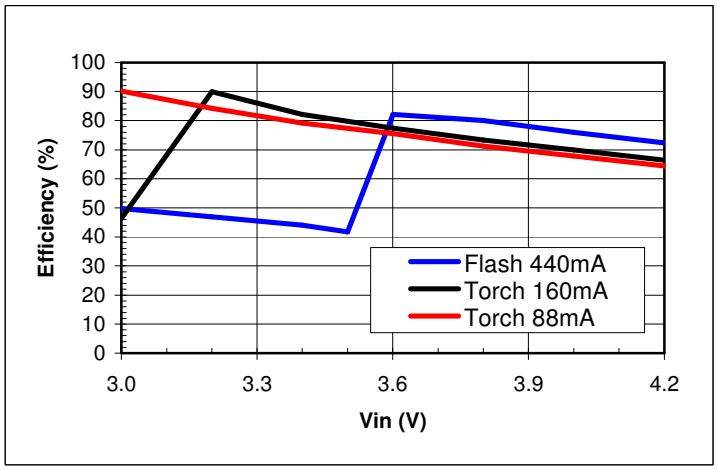


Figure 4. SP7686 Efficiency

V_{IN} = 3.6V, Typical Application Circuit, D1 = Luxeon LXCL-PWF3, T_A = 25˚C unless otherwise noted.

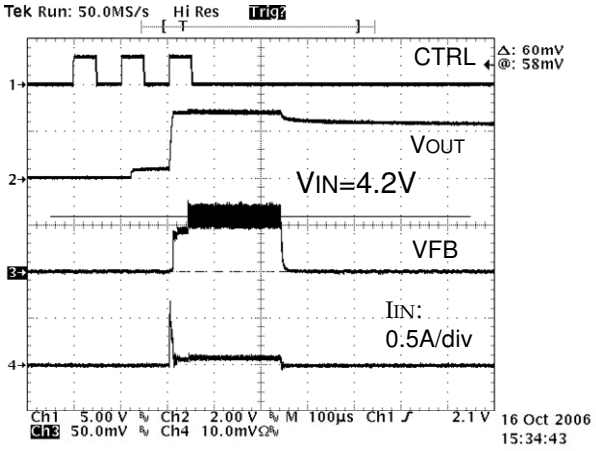


Figure 5. SP7686 Startup with 3 CTRL Pulses

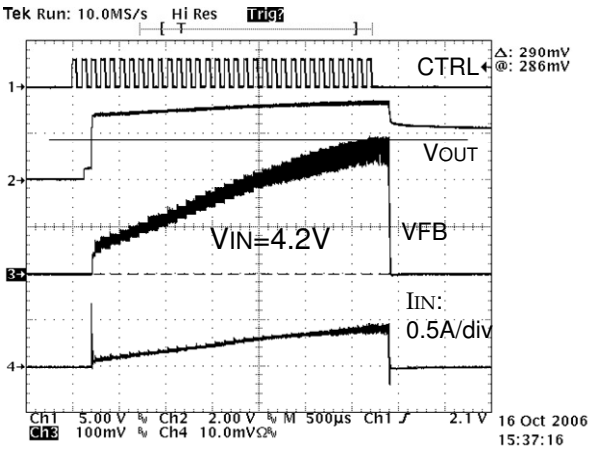


Figure 6. SP7686 Startup with 32 CTRL Pulses

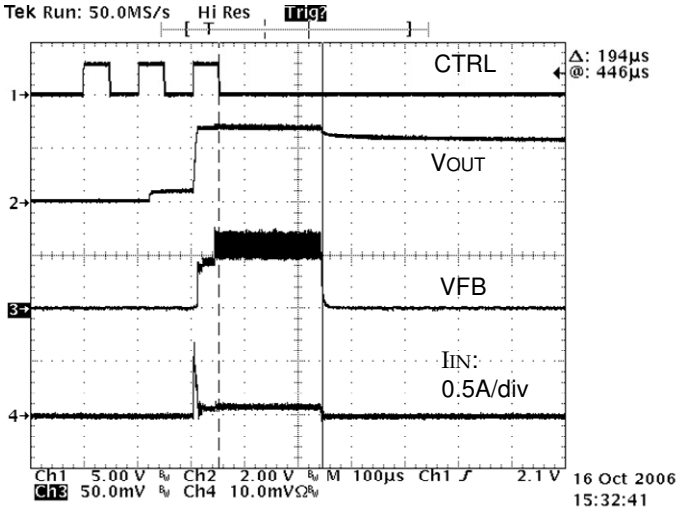


Figure 7. SP7686 Turn-off time into SHDN

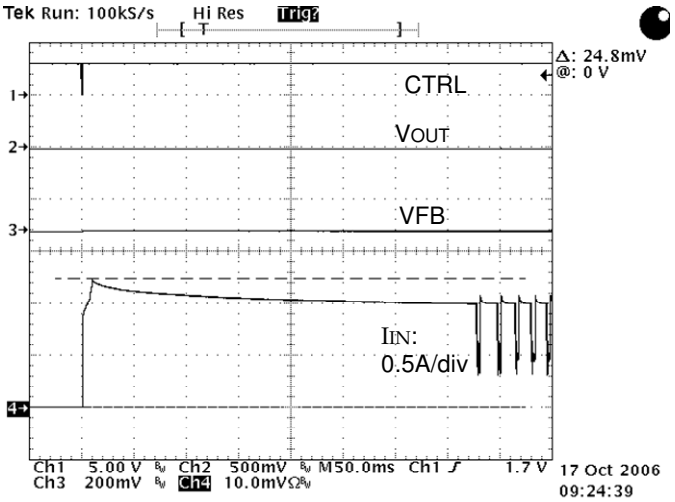


Figure 8. SP7686 Vout Shorted to GND, V_{IN} = 5.5V

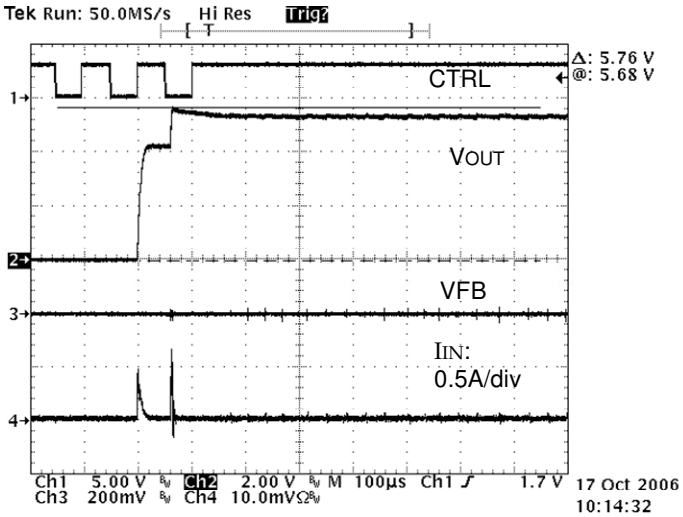


Figure 9. SP7686 LED Open, V_{IN} = 4.2V

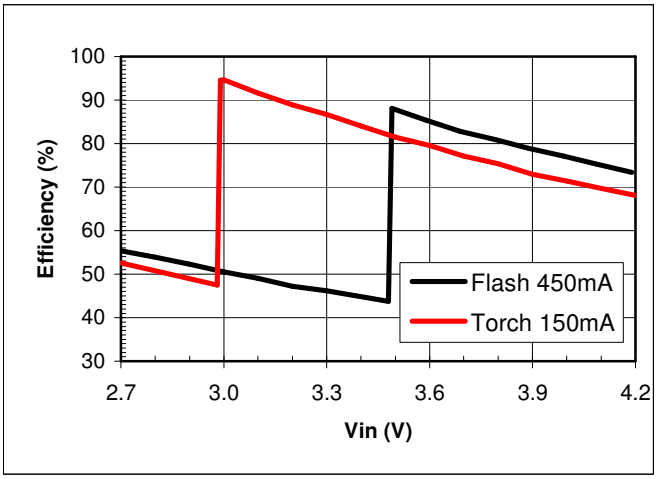


Figure 10. SP7686A Efficiency

V_{IN} = 3.6V, Typical Application Circuit, D1 = Luxeon LXCL-PWF3, T_A = 25˚C unless otherwise noted.

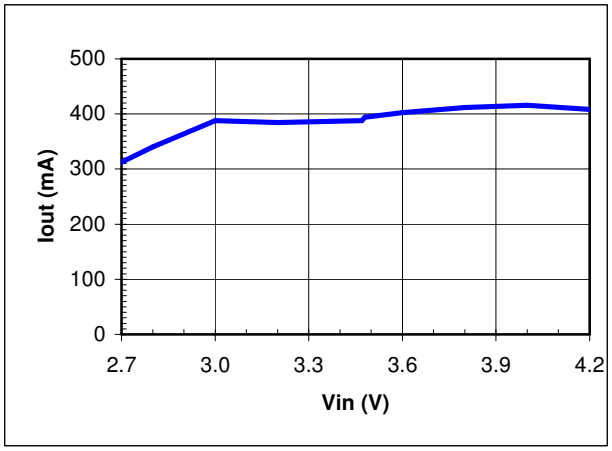


Figure 11. SP7686A Torch Mode Output Current

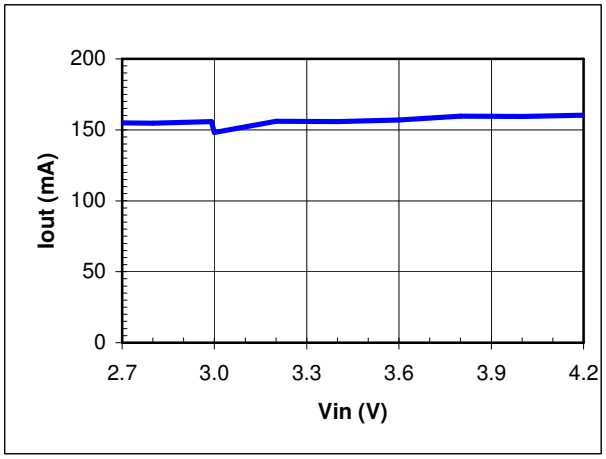


Figure 12. SP7686A Flash Mode Output Current

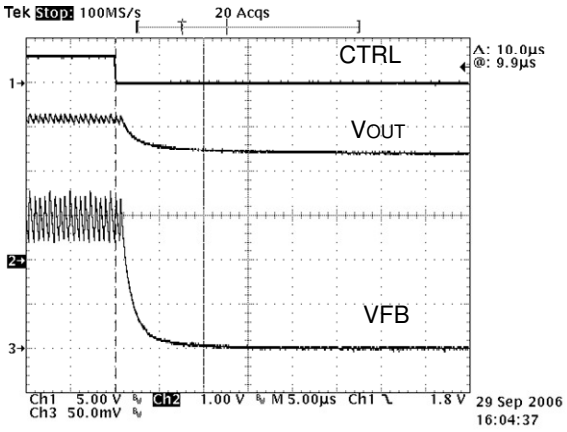


Figure 13. SP7686A Turn-off to Shutdown, V_{IN}=4.2V

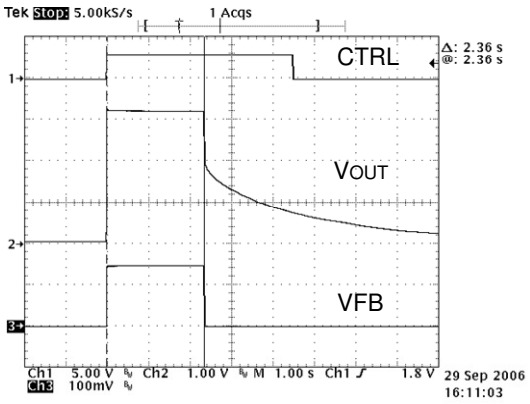


Figure 14. SP7686A Time-out Flash to Shutdown, V_{IN}=4.2V

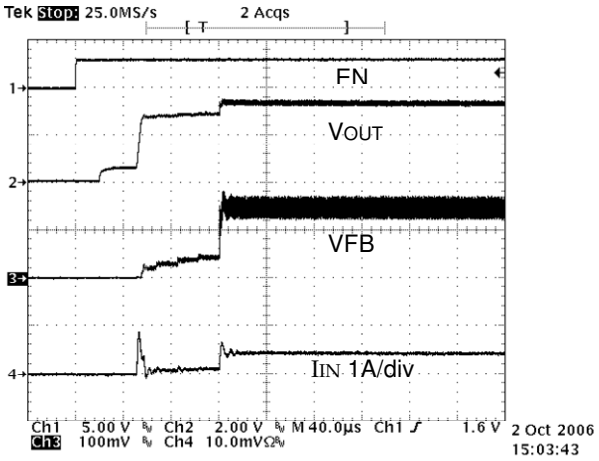


Figure 15. SP7686A Flash Mode 1X, V_{IN}=4.2V

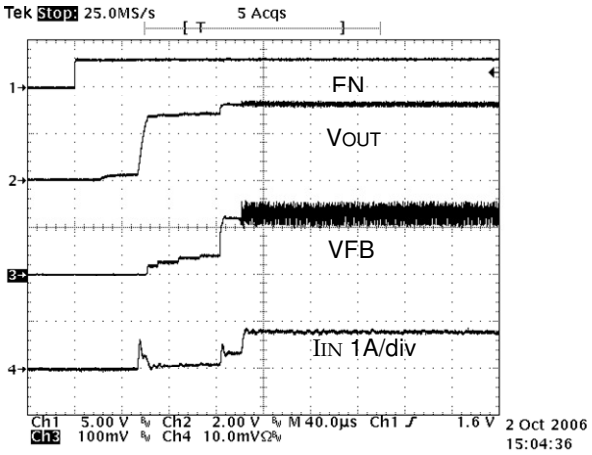


Figure 16. SP7686A Flash Mode 2X, V_{IN}=3.4V

V_{IN} = 3.6V, Typical Application Circuit, D1 = Luxeon LXCL-PWF3, T_A = 25˚C unless otherwise noted.

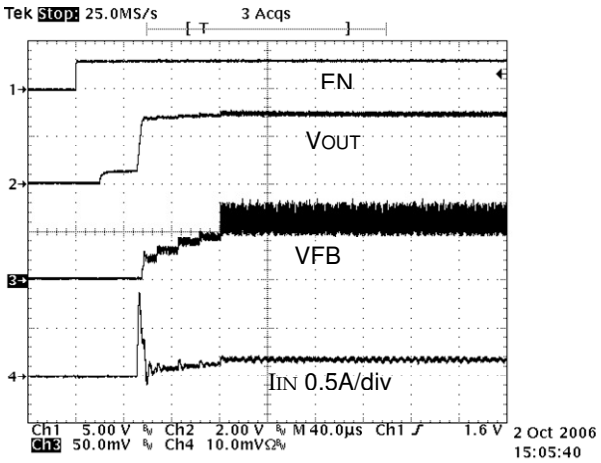


Figure 17. SP7686A Torch Mode 1X, V_{IN}=4.2V

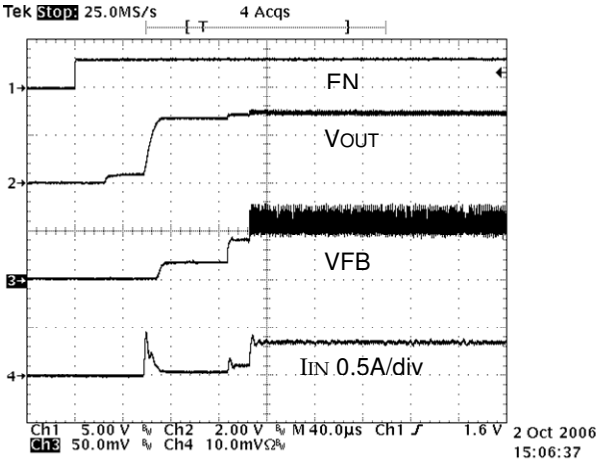


Figure 18. SP7686A Torch Mode 2X, V_{IN}=2.9V

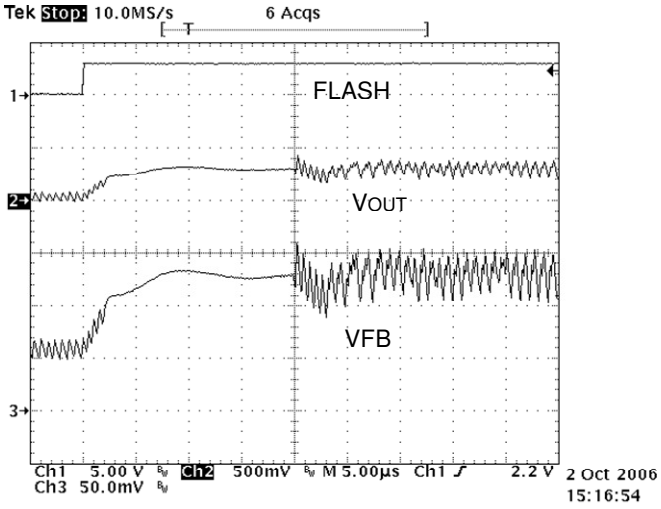


Figure 19. SP7686A 1X Torch to 2X Flash, V_{IN}=3.3V

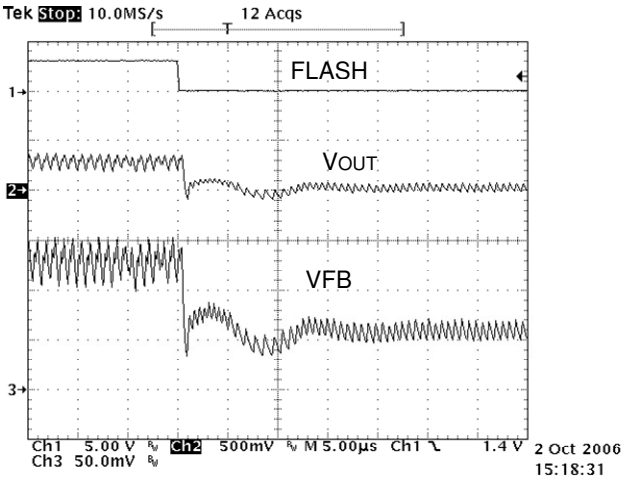


Figure 20. SP7686A 2X Flash to 1X Torch, V_{IN}=3.3V

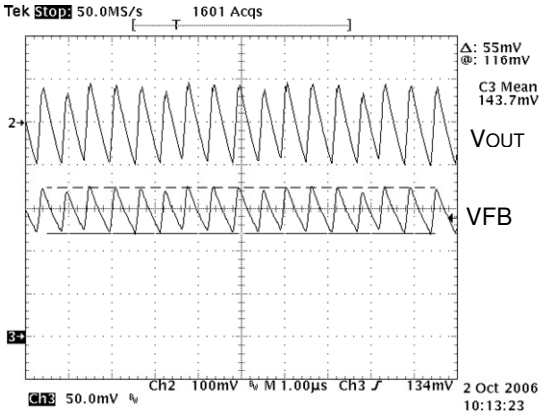


Figure 21. SP7686A Flash 1X Ripple, V_{IN}=4.2V

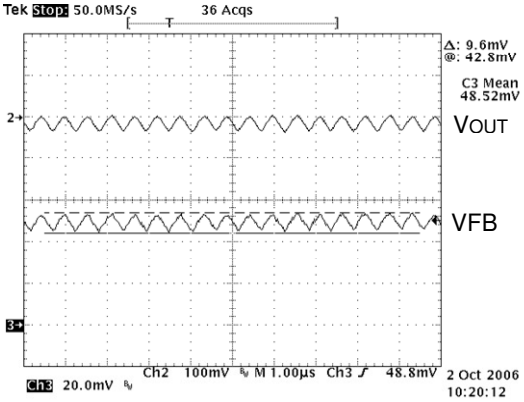


Figure 22. SP7686A Torch 1X Ripple, V_{IN}=3.0V

The SP7686 can be used with multiple LEDs in parallel as shown below. For best performance, the LEDs should be in a single package, preferably from a single die to have better matching for forward voltage V_F for a given forward current I_F. In practice, if the V_F of one LED is higher than the others, it will consume a larger I_F, which will raise its temperature which will then cause its V_F to reduce, correcting the imbalance. The overall current will be the sum of the individual currents, for example $I_{TOTAL} = 4*I_{LED}$.

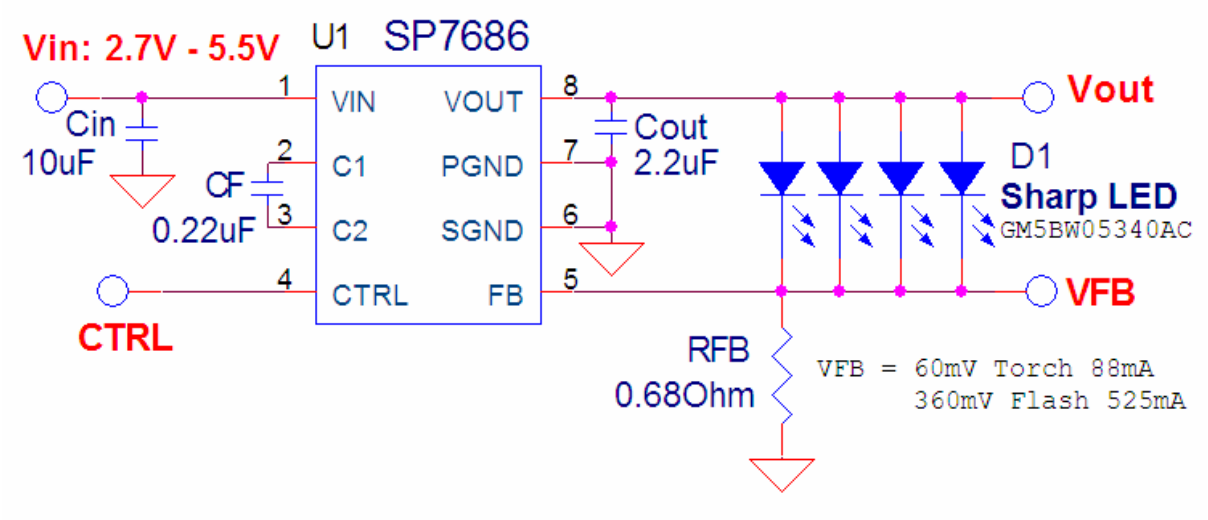


Figure 23. SP7686 with 4 LEDs in parallel

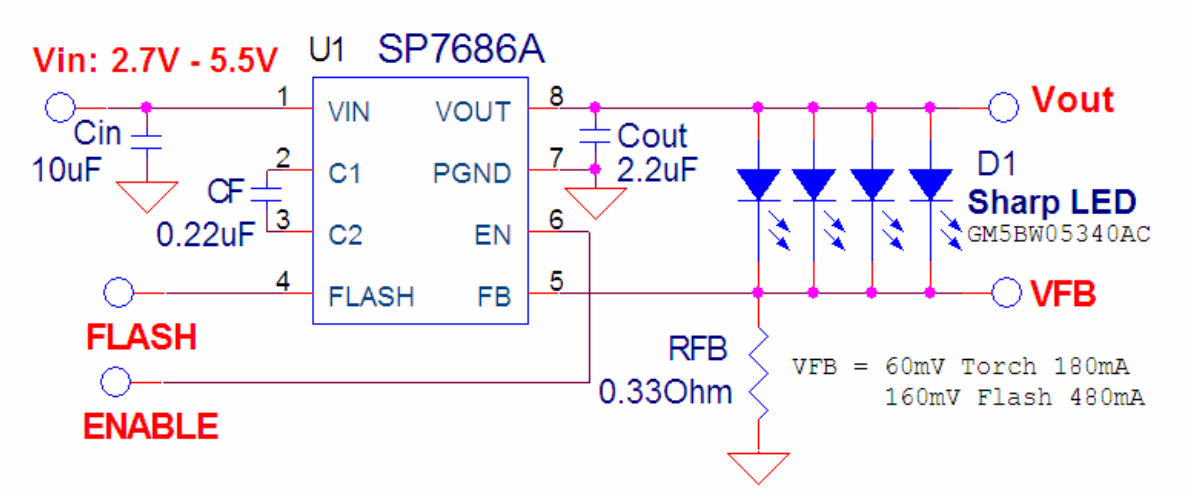


Figure 24. SP7686A with 4 LEDs in parallel

The SP7686 charge pump circuit requires 3 capacitors: 10µF input, 2.2µF output and 0.22µF fly capacitor are typically recommended. For the input capacitor, a value of 10µF will help reduce input voltage ripple for applications sensitive to ripple on the battery voltage. All the capacitors should be surface mount ceramic for low lead inductance necessary at the 2.4MHz switching frequency of the SP7686 and to obtain low ESR, which improves bypassing on the input and output and improves output voltage drive by reducing output resistance. Ceramic capacitors with X5R or X7R temperature grade are recommended for most applications. A selection of recommended capacitors is included in Table 1 below.

The input and output capacitors should be located as close to the V_{IN} and V_{OUT} pins as possible to obtain best bypassing, and the returns should be connected directly to the PGND pin or to the thermal pad ground located under the SP7686. The fly capacitor should be located as close to the C1 and C2 pins as possible. See the RECOMMENDED LAYOUT section for details on the recommended layout.

To obtain low output ripple, a value of 2.2µF is recommended for C_{OUT}. For all output currents the value for CFLY of 0.22µF is recommended. For best regulation and low input current ripple the input capacitor value of 10µF is recommended. A smaller 4.7µF for Cin will work but input voltage ripple will increase and may effect regulation.

Resistor Selection for SP7686A

The 7686A part has fixed FB voltages in Torch and Flash modes so the sense resistor R_{SENSE} is determined by the value needed in the Torch or Flash mode for the desired output current by the equation:

R_{SENSE} = VFB/ I_{OUT} where VFB = 60mV (Torch Mode)

R_{SENSE} = VFB/ I_{OUT} where VFB = 160mV (Flash Mode)

Once the R_{SENSE} resistor has been selected for one mode, the I_{OUT} can be selected for the other mode using the following equation:

$I_{OUT} = V_{FB} / R_{SENSE}$

Using an example of Torch current of 180mA and Flash current of 450mA, calculated R_{SENSE} for Torch is 0.06 /0.180 = 0.333 Ohms. Use a standard value of 0.33 Ohms. I_{OUT} for Flash mode is 0.16/0.33 = 480mA

The power obtained in the Flash mode would be:

P_{FLASH} = VFB *I_{OUT} = 160mV*480mA ~ 77mW.

The typical 0603 surface mount resistor is rated 1/10 Watt continuous power and 1/5 Watt pulsed power, more than enough for this application. For other applications, the P_{FLASH} power can be calculated and resistor size selected. The R_{SENSE} resistor is recommended to be size 0603 for most applications. The range of typical resistor values and sizes are shown here in Table 2.

Manufacturers/ Website	Part Number	Capacitance/ Voltage	Capacitor Size/Type/Thickness	ESR at 100KHz
TDK/www.tdk.com	C1005X5R0J224K	0.22uF/6.3V	0402/X5R/0.55mm	0.05
TDK/www.tdk.com	C1005X5R0J105K	1uF/6.3V	0402/X5R/0.55mm	0.03
TDK/www.tdk.com	C1608X5R0J225K	2.2uF/6.3V	0603/X5R/0.9mm	0.03
TDK/www.tdk.com	C1608X5R0J475K	4.7uF/6.3V	0603/X5R/0.9mm	0.02
TDK/www.tdk.com	C1608X5R0J107M	10uF/6.3V	0603/X5R/0.9mm	0.02
Murata/www.murata.com	GRM155R60J224KE19D	0.22uF/6.3V	0402/X5R/0.55mm	0.05
Murata/www.murata.com	GRM155R60J105KE19D	1uF/6.3V	0402/X5R/0.55mm	0.03
Murata/www.murata.com	GRM188R60J225KE19D	2.2uF/6.3V	0603/X5R/0.8mm	0.03
Murata/www.murata.com	GRM188R60J475KE19D	4.7uF/6.3V	0603/X5R/0.8mm	0.02
Murata/www.murata.com	GRM188R60J106ME19D	10uF/6.3V	0603/X5R/0.9mm	0.02

Table 1. Capacitor Selection

Part Reference	Value	Tolerance	Size	Manufacturers
RSENSE	0.22ohms	1% or 5%	0603	Panasonic or Vishay
RSENSE	0.27ohms	1% or 5%	0603	Panasonic or Vishay
RSENSE	0.33ohms	1% or 5%	0603	Panasonic or Vishay
RSENSE	0.39ohms	1% or 5%	0603	Panasonic or Vishay
RSENSE	0.47ohms	1% or 5%	0603	Panasonic or Vishay
RSENSE	0.56ohms	1% or 5%	0603	Panasonic or Vishay
RSENSE	0.68ohms	1% or 5%	0603	Panasonic or Vishay

Table 2. Resistor Selection

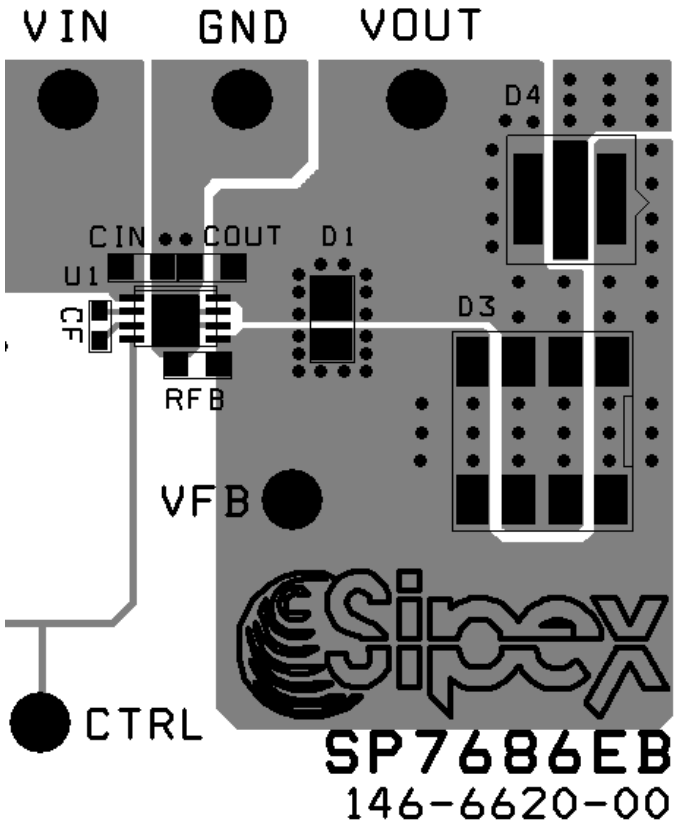
Resistor Selection for SP7686

The SP7686 part uses an internal 5 bit DAC to set the LED current. The DAC input is at the CTRL pin. The user inputs a pulse train of up to 1MHz to set the LED current. The DAC sets the feedback voltage point from 60mV to 360mV in 10mV steps. The LED current is determined by the equation:

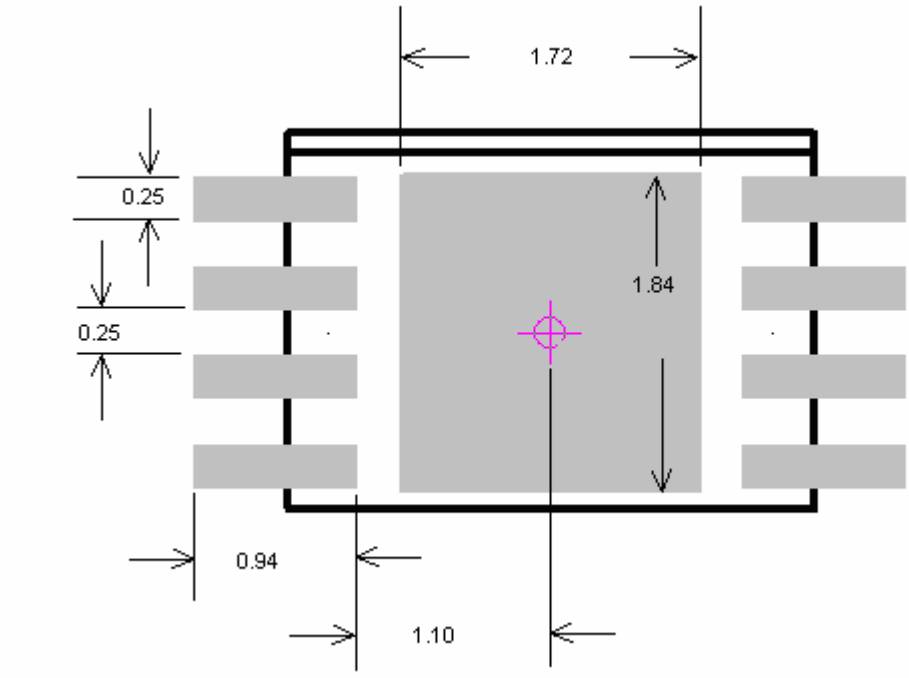
$I_{LED} = V_{FB}/R_{SENSE}$

The curves below show the feedback and LED currents for the CTRL pin pulse count and standard R_{SENSE} resistor values.

After the desired count is reached the CTRL input must remain high to hold the count. If the CTRL pin goes low for more than 200µs the part will shutdown. See the timing diagrams in the Typical Performance Characteristics. The first pulse turns on the SP7686. The first pulse needs to occur at least 600µsec after V_{IN} is applied in order to activate after the power on reset (POR). The second pulse resets the DAC to 0. The timing between the first and second pulse needs to be 25µsec typical to as long as 75µsec. After the second pulse the feedback voltage remains at ground. The third pulse sets the feedback voltage to 60mV. Subsequent pulses set the feedback voltage in 10mV steps as shown in the Typical Performance Characteristics.

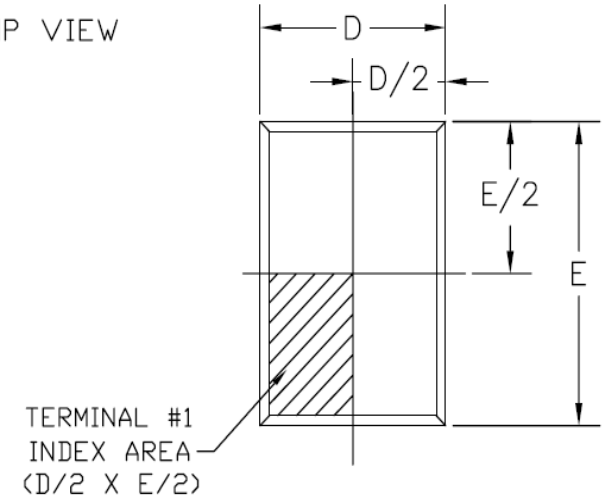


Footprint Drawing: PCB Footprint for 2x3mm 8pin DFN Package (JEDEC MO-229) All Dimensions in millimeters

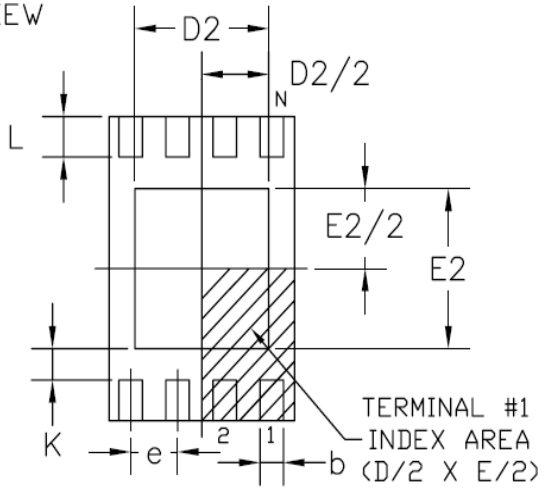


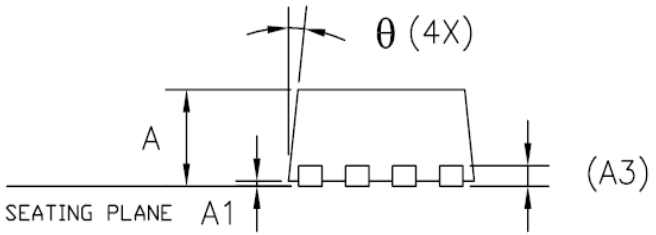
REVISION HISTORY			
REV.	DISCRIPTION	DATE	APP'D
A	DRAWING ORIGINATION	08/18/05	JL
B	MODIFY DRAWING FORMAT	07/17/06	JL

TOP VIEW



BOTTOM VIEW





SIDE VIEW

8LD 2x3 DFN JEDEC MO-229 Variation VCED-2						
SYMBOLS	DIMENSIONS IN MM (Control Unit)			DIMENSIONS IN INCH (Reference Unit)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.80	0.90	1.00	0.032	0.036	0.039
A1	0.00	0.02	0.05	0.000	0.001	0.002
A3	0.20 REF			0.008 REF		
b	0.18	0.25	0.30	0.007	0.010	0.012
D	2.00 BSC			0.079 BSC		
D2	1.50	—	1.75	0.059	—	0.069
E	3.00 BSC			0.118 BSC		
E2	1.60	—	1.90	0.063	—	0.075
e	0.50 BSC			0.020 BSC		
L	0.30	0.40	0.50	0.012	0.016	0.020
K	0.20	—	—	0.008	—	—
θ	0°	—	14°	0°	—	14°
N	8			8		
ND	4			4		

Solved by Sipex	SIPEX CORPORATION	
	8 PIN 2x3 DFN PACKAGE OUTLINE	
Packaging Approval:	Drawing No: 8-PIN 2x3 DFN	
By: JL Date: 07/17/06	Revision: B	Sheet: 1 OF 1

Ordering Information

Part Number	Package	RoHS	MIN Temp (°C)	MAX Temp (°C)	Status	Pack Type / Quantity	MSL Level
SP7686AER-L	DFN8	▪	-40	85	Active	Bulk	L1 @ 250ºC
SP7686AER-L/TR	DFN8	▪	-40	85	Active	Tape & Reel 3000	L1 @ 250ºC
SP7686ER-L	DFN8	▪	-40	85	Active	Bulk	L1 @ 250ºC
SP7686ER-L/TR	DFN8	▪	-40	85	Active	Tape & Reel 3000	L1 @ 250ºC

For further assistance:

Email: Sipexsupport@sipex.com
WWW Support page: http://www.sipex.com/content.aspx?p=support
Sipex Application Notes: http://www.sipex.com/applicationNotes.aspx

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