SC622

LED Light Management Unit

Charge Pump, 400mA Flash LED, Dual LDOs, and SemWire™ Interface

POWER MANAGEMENT

Features

- Input supply voltage range — 3.0V to 5.5V
- Charge pump modes — 1x, 1.5x and 2x
- Flash LED — 400mA max in flash mode, 250mA max continuous for spotlight
- Two user-configurable 100mA low-noise LDO regulators
- Charge pump frequency — 250kHz
- SemWire™ single wire interface — up to 75kbit/s
- External flash control pin to sync with camera
- Optional 1s flash time out
- Automatic sleep mode (LEDs off) — I_Q = 100µA
- Low shutdown current — 0.1µA (typical)
- Ultra-thin package — 3mm x 3mm x 0.6mm
- Fully WEEE and RoHS compliant

Applications

- Cellular phone flash
- PDA flash
- Camera I/O and core power

Description

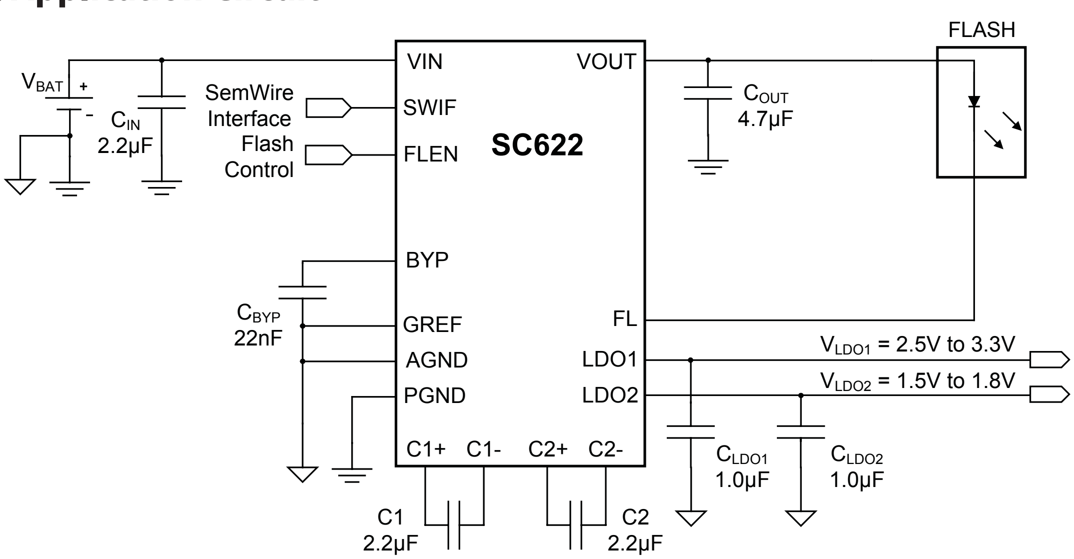
The SC622 is a high efficiency charge pump LED driver using Semtech's proprietary mAhXLife™ technology. Performance is optimized for use in single-cell Li-ion battery applications.

The charge pump provides continuous or bursted current to a flash LED using a dedicated flash driver current sink. The load and supply conditions determine whether the charge pump operates in 1x, 1.5x, or 2x mode. A flash-timeout feature disables the flash if active for longer than 1 second. The SC622 also provides two low-dropout, low-noise linear regulators for powering a camera module or other peripheral circuits.

The SC622 uses the proprietary SemWire™ single wire interface. The interface controls all functions of the device, including flash current and two LDO voltage outputs. The single wire implementation minimizes microcontroller and interface pin counts. The flash/spotlight output is triggered via either the SemWire interface or a dedicated pin.

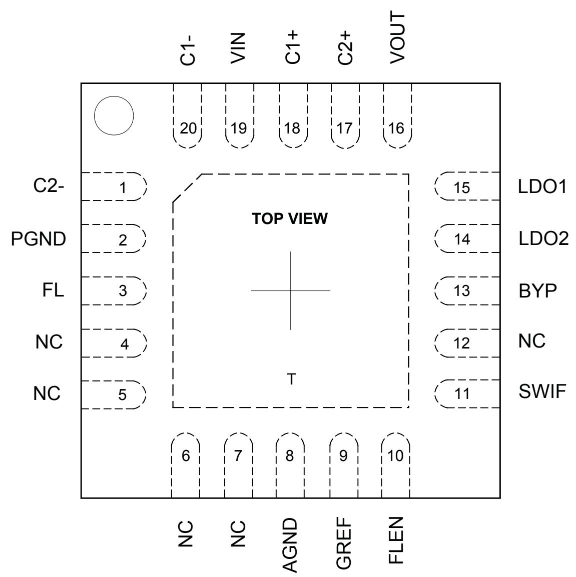
In sleep mode, the device reduces quiescent current to 100µA while continuing to monitor the serial interface. The two LDOs can be enabled when the device is in sleep mode. Total current reduces to 0.1µA in shutdown.

Typical Application Circuit



US Patents: 6,504,422; 6,794,926

Pin Configuration



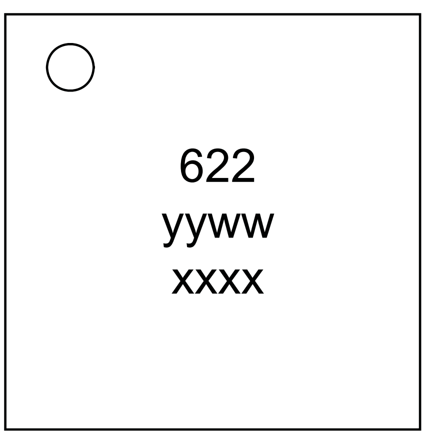
MLPQ-UT-20; 3x3, 20 LEAD
θ_{JA} = 35°C/W

Ordering Information

Device	Package
SC622ULTRT(1)(2)	MLPQ-UT-20 3×3
SC622EVB	Evaluation Board

Notes:
(1) Available in tape and reel only. A reel contains 3,000 devices.
(2) Available in lead-free package only. Device is WEEE and RoHS compliant.

Marking Information



yyww = Date Code
xxxx = Semtech Lot No.

Absolute Maximum Ratings

VIN (V) .... -0.3 to +6.0
VOUT (V) .... -0.3 to +6.0
C1+, C2+ (V) .... -0.3 to (V_{OUT} + 0.3)
Pin Voltage — All Other Pins (V) ....-0.3 to (V_{IN} + 0.3)
VOUT Short Circuit Duration................ Continuous
VLDO1, VLDO2 Short Circuit Duration....... Continuous
ESD Protection Level[1] (kV) 2

Recommended Operating Conditions

Ambient Temperature Range (°C)........ $-40 \le T_A \le +85$
VIN (V) .... $3.0 \le V_{IN} \le 5.5$
VOUT (V) .... $2.5 \le V_{OUT} \le 5.25$

Thermal Information

Thermal Resistance, Junction to Ambient[2] (°C/W) 35
Maximum Junction Temperature (°C) ....+150
Storage Temperature Range (°C)............ -65 to +150
Peak IR Reflow Temperature (10s to 30s) (°C) .... +260

Exceeding the above specifications may result in permanent damage to the device or device malfunction. Operation outside of the parameters specified in the Electrical Characteristics section is not recommended.

NOTES:
(1) Tested according to JEDEC standard JESD22-A114-B.
(2) Calculated from package in still air, mounted to 3" x 4.5", 4 layer FR4 PCB with thermal vias under the exposed pad per JESD51 standards.

Electrical Characteristics

Unless otherwise noted, T_A = +25°C for Typ, -40ºC to +85°C for Min and Max, $T_{J(MAX)}$ = 125ºC, V_{IN} = 3.0V to 4.2V, C_{IN} = C_1 = C_2 = 2.2μF, C_{OUT} = 4.7μF (ESR = 0.03Ω)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Specifications						
Shutdown Current	$I_{Q(OFF)}$	Shutdown, V_{IN} = 4.2V		0.1	2	μA
Total Quiescent Current	I_Q	Sleep (LDOs off), SWIF = V_{IN}		100	160	μA
		Sleep (LDOs on), SWIF = V_{IN}, $V_{IN} > (V_{LDO}$ + 300mV), $I_{LDO} \le$ 200mA		220	340	μA
		Charge pump in 1x mode		3.8	4.65	mA
		Charge pump in 1.5x mode		4.6	5.85	mA
		Charge pump in 2x mode		4.6	5.85	mA
Fault Protection						
Output Short Circuit Current Limit	$I_{OUT(SC)}$	VOUT pin shorted to GND		300		mA
Over-Temperature	T_{OTP}			160		°C
Flash Mode Safety Timer[1]	$t_{FL(MAX)}$	Flash sink active	0.75	1.00	1.25	s

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Electrical Characteristics (continued)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Fault Protection (continued)						
Charge Pump Over-Voltage Protection	V_{OVP}	VOUT pin open circuit, $V_{OUT} = V_{OVP}$ rising threshold	5.3	5.7	6.0	V
Undervoltage Lockout	V_{UVLO}	Decreasing V_{IN}		2.4		V
	$V_{UVLO\text{-}HYS}$			300		mV
Charge Pump Electrical Specifications						
Maximum Total Output Current	$I_{OUT(MAX)}$	$V_{IN} > 3.4V$, $V_{OUT(MAX)} = 4.0V$	400			mA
Flash Current Setting	I_{FL}	Nominal setting for FL	50		400	mA
Flash Current Accuracy	I_{FL_ACC}	$V_{IN} = 3.7V$, $I_{FL} = 400mA$, $T_A = 25°C$	-15		+15	%
1x Mode to 1.5x Mode Falling Transition Voltage	$V_{TRANS1x}$	$I_{OUT} = 100mA$, $V_{OUT} = 3.3V$		3.37		V
1.5x Mode to 2x Mode Falling Transition Voltage	$V_{TRANS1.5x}$	$I_{OUT} = 100mA$, $V_{OUT} = 4.5V$(2)		3.3		V
Current Sink Off-State Leakage Current	I_{BLn}	$V_{IN} = V_{FL} = 4.2V$		0.1	1	µA
Pump Frequency	f_{PUMP}	$V_{IN} = 3.2V$		250		kHz
LDO Electrical Specifications						
LDO1 Voltage Setting	V_{LDO1}	Range of nominal settings in 100mV increments	2.5		3.3	V
LDO2 Voltage Setting	V_{LDO2}	Range of nominal settings in 100mV increments	1.5		1.8	V
LDO1, LDO2 Output Voltage Accuracy	V_{LDO1}, V_{LDO2}	$V_{IN} = 3.7V$, $I_{LDO} = 1mA$	-3.5	±3	+3.5	%
Line Regulation	ΔV_{LINE}	LDO1, $I_{LDO1} = 1mA$, $V_{OUT} = 2.8V$		2.1	7.2	mV
		LDO2, $I_{LDO2} = 1mA$, $V_{OUT} = 1.8V$		1.3	4.8	mV

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Electrical Characteristics (continued)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
LDO Electrical Specifications (continued)						
Load Regulation	ΔV_{LOAD}	V_{LDO1} = 3.3V, V_{IN} = 3.7V, I_{LDO1} = 1mA to 100 mA			25	mV
		V_{LDO2} = 1.8V, V_{IN} = 3.7V, I_{LDO2} = 1mA to 100 mA			20	
Dropout Voltage(3)	V_D	I_{LDO1} = 100mA		100	150	mV
Current Limit	I_{LIM}		200			mA
Power Supply Rejection Ratio	$PSRR_{LDO1}$	2.5V < V_{LDO1} < 3V, f < 1kHz, C_{BYP} = 22nF, I_{LDO1} = 50mA, V_{IN} = 3.7V with 0.5V_{P-P} ripple		50		dB
	$PSRR_{LDO2}$	f < 1kHz, C_{BYP} = 22nF, I_{LDO2} = 50mA, V_{IN} = 3.7V with 0.5V_{P-P} ripple		60		
Output Voltage Noise	$e_{n\text{-}LDO1}$	LDO1, 10Hz < f < 100kHz, C_{BYP} = 22nF, C_{LDO} = 1µF, I_{LDO1} = 50 mA, V_{IN} = 3.7V, 2.5V < V_{LDO1} < 3V		100		μV_{RMS}
	$e_{n\text{-}LDO2}$	LDO2, 10Hz < f < 100kHz, C_{BYP} = 22nF, C_{LDO} = 1µF, I_{LDO2} = 50 mA, V_{IN} = 3.7V		50		
Minimum Output Capacitor	$C_{LDO(MIN)}$			1		µF
Digital I/O Electrical Specifications (FLEN, SWIF)						
Input High Threshold	V_{IH}	V_{IN} = 5.5V	1.6			V
Input Low Threshold	V_{IL}	V_{IN} = 3.0V			0.4	V
Input High Current	I_{IH}	V_{IN} = 5.5V	-1		+1	µA
Input Low Current	I_{IL}	V_{IN} = 5.5V	-1		+1	µA
SemWire Bit Rate	f_{SWIF}		10		75	kbit/s
SemWire Start-up Time(4)	t_{EN}		1			ms
SemWire Disable Time(5)	t_{DIS}		10			ms
SemWire Data Latch Delay(6)	D_{DL}			5		bit

Notes:

(1) Once tripped, flash output will remain disabled until FLEN pin is cycled or reset via serial interface.

(2) Test voltage is V_{OUT} = 4.5V — a relatively extreme LED voltage — to force a transition during test. Typically V_{OUT} = 3.3V for the white LED at 100mA.

(3) Dropout is defined as (V_{IN}-V_{LDO1}) when V_{LDO1} drops 100mV from nominal. Dropout does not apply to LDO2 since it has a maximum output voltage of 1.8V.

(4) The SemWire start-up time is the minimum period that the SWIF pin must be held high to enable the part before commencing communication.

(5) The SemWire disable time is the minimum period that the SWIF pin must be pulled low to shut the part down.

(6) The SemWire data latch delay is the maximum duration after communication has ended before the register is updated.

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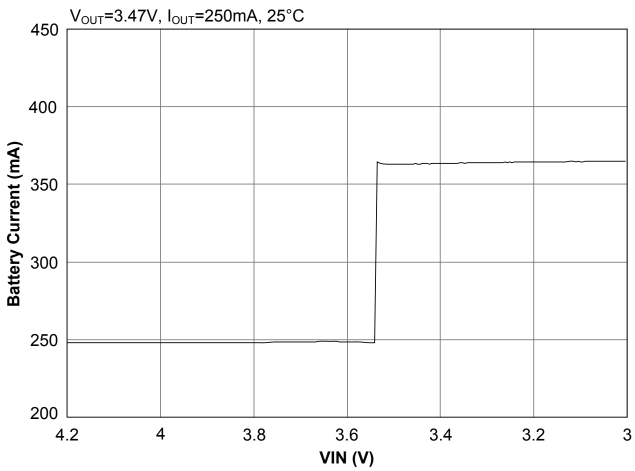
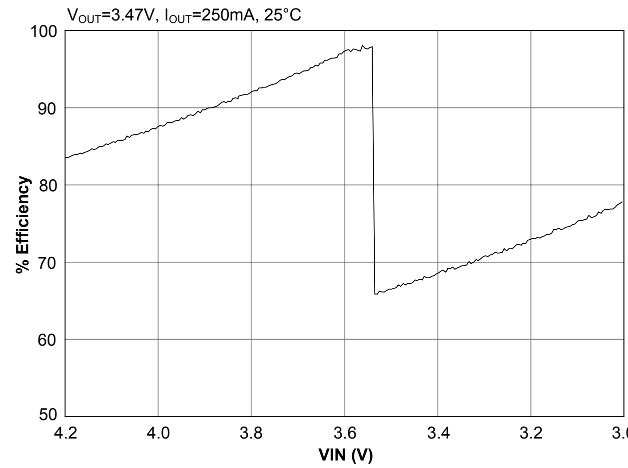
Typical Characteristics

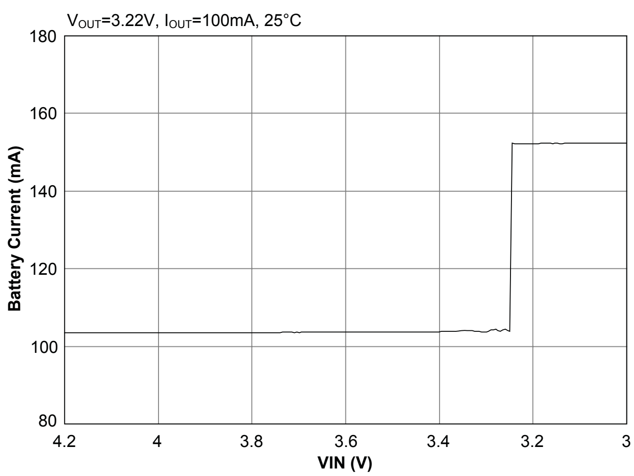
Battery Current — 250mA Spotlight



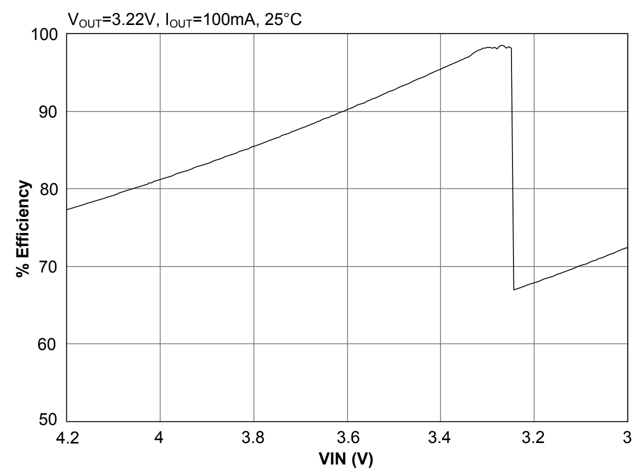
Efficiency — 250mA Spotlight



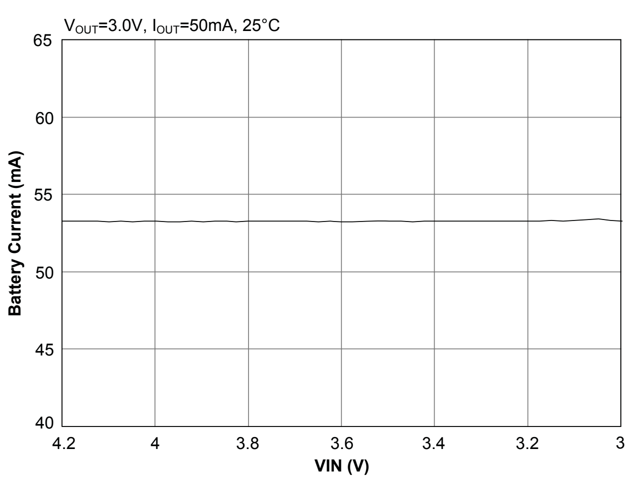
Battery Current — 100mA Spotlight



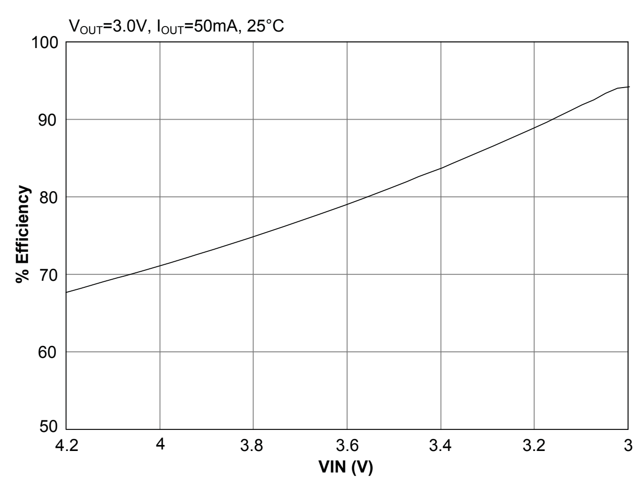
Efficiency — 100mA Spotlight



Battery Current — 50mA Spotlight

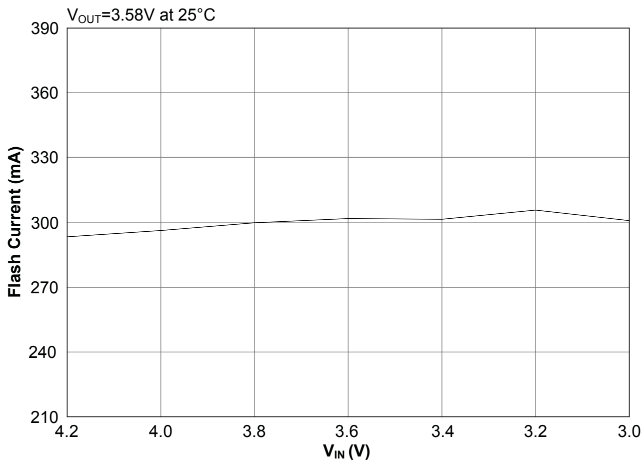


Efficiency — 50mA Spotlight

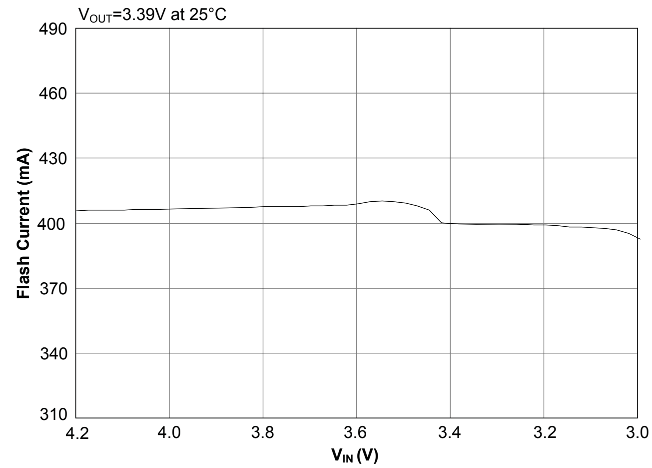


Typical Characteristics (continued)

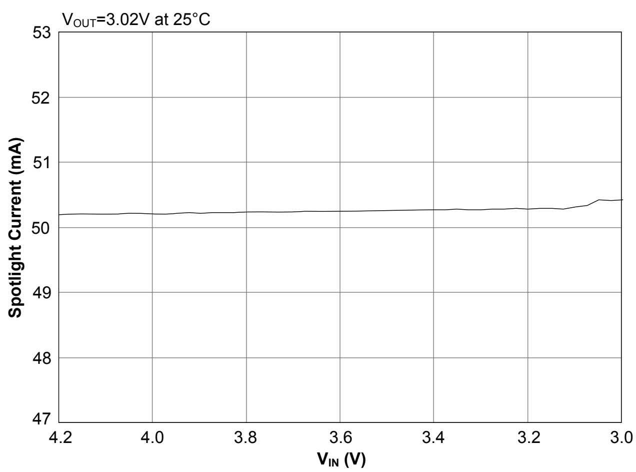
Flash Current — 300mA



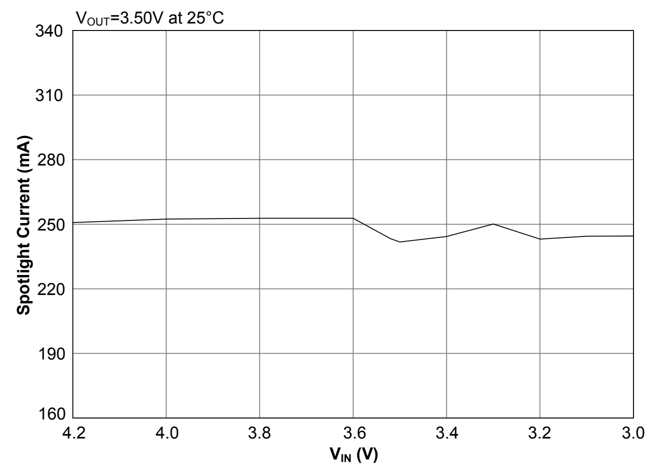
Flash Current — 400mA



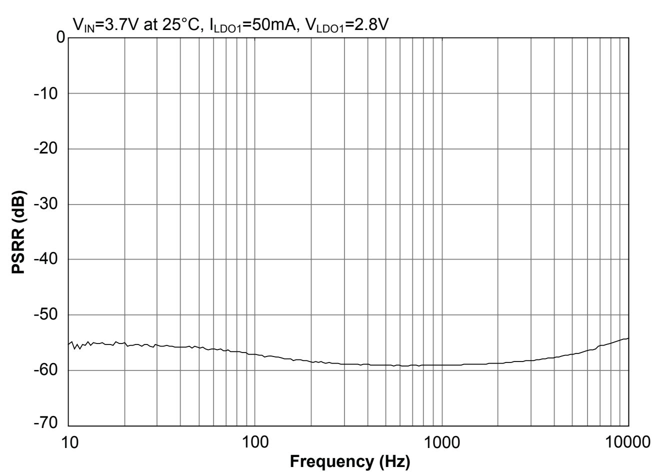
Spotlight Current — 50mA



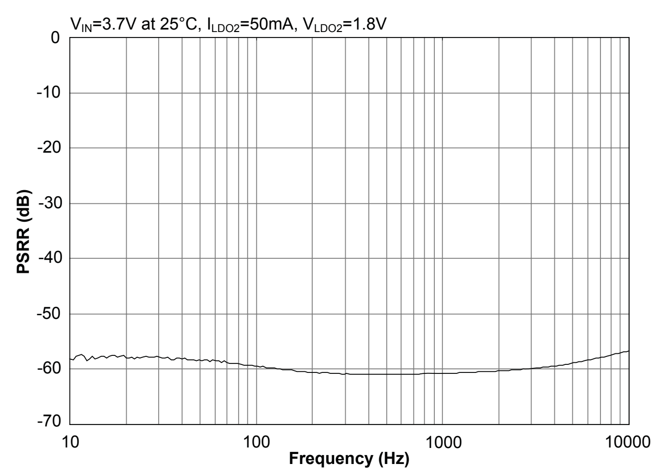
Spotlight Current — 250mA



PSRR vs. Frequency (LDO1)



PSRR vs. Frequency (LDO2)



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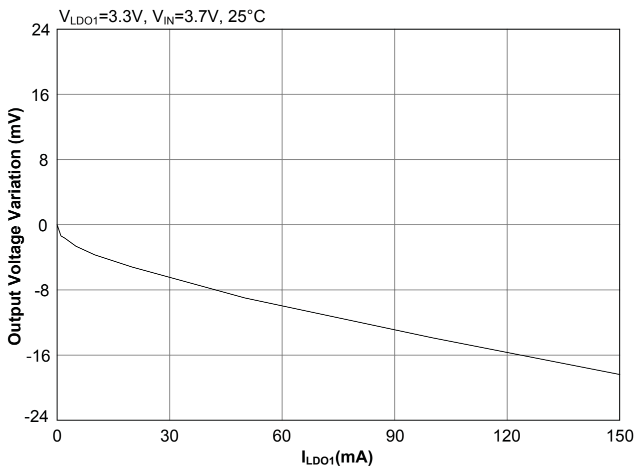
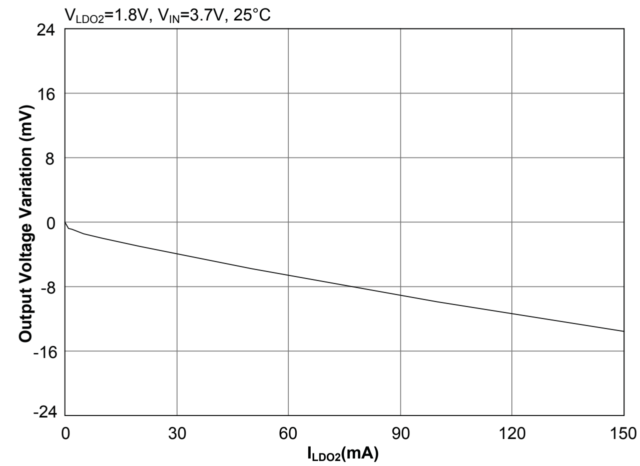
Typical Characteristics (continued)

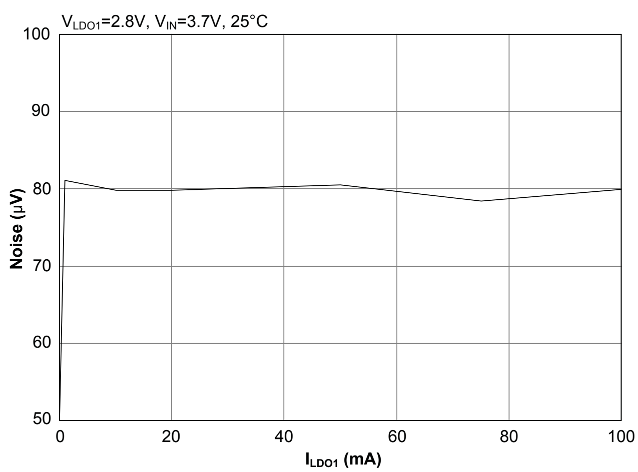
Load Regulation (LDO1)



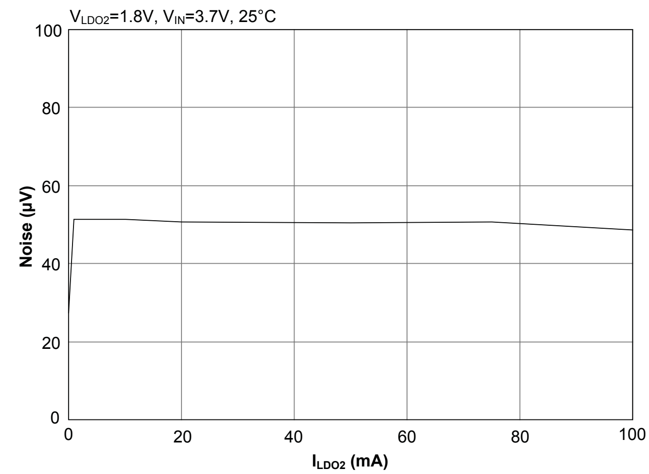
Load Regulation (LDO2)



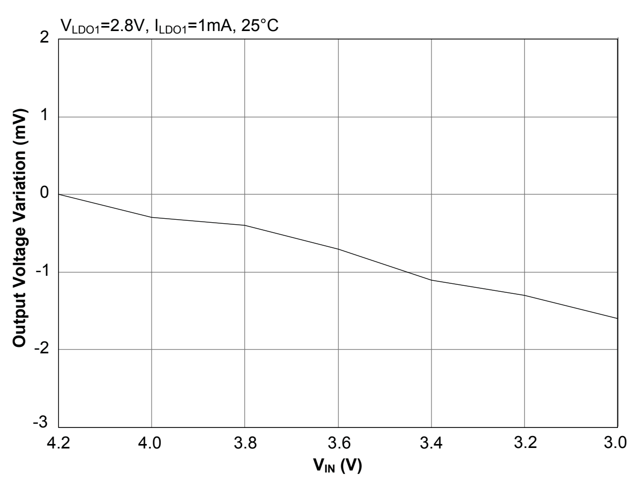
Noise vs Load Current (LDO1)



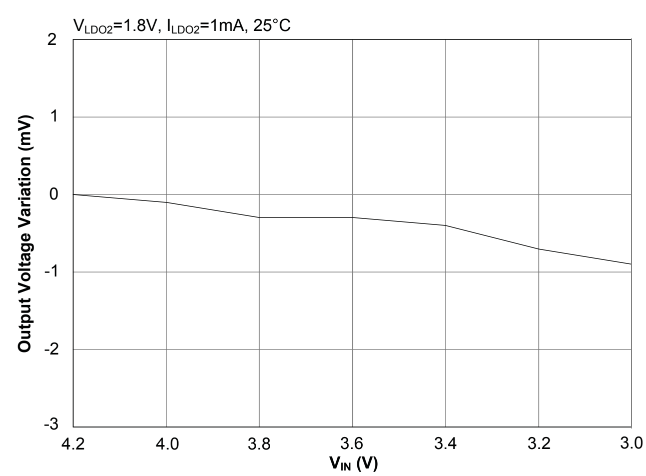
Noise vs Load Current (LDO2)



Line Regulation (LDO1)



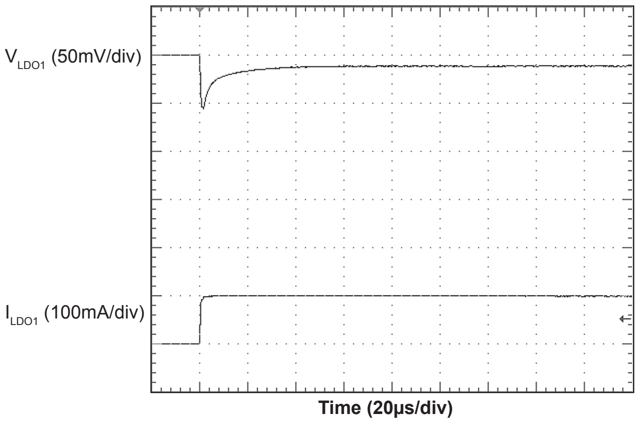
Line Regulation (LDO2)



Typical Characteristics (continued)

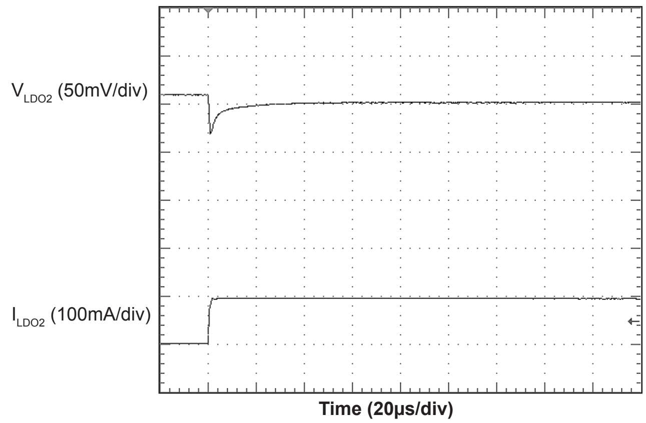
Load Transient Response (LDO1) — Rising Edge

V_{IN}=3.7V, V_{LDO1}=2.8V, I_{LDO1}=1 to 100mA



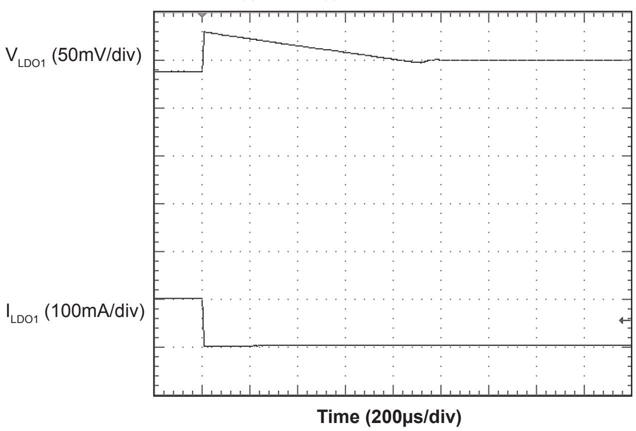
Load Transient Response (LDO2) — Rising Edge

V_{IN}=3.7V, V_{LDO2}=1.8V, I_{LDO2}=1 to 100mA



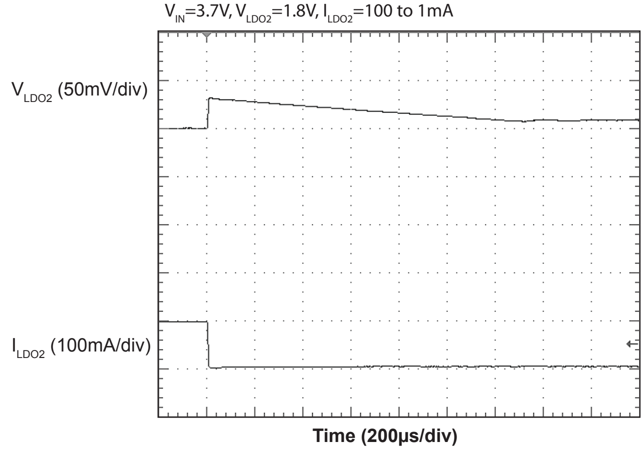
Load Transient Response (LDO1) — Falling Edge

V_{IN}=3.7V, V_{LDO1}=2.8V, I_{LDO1}=100 to 1mA



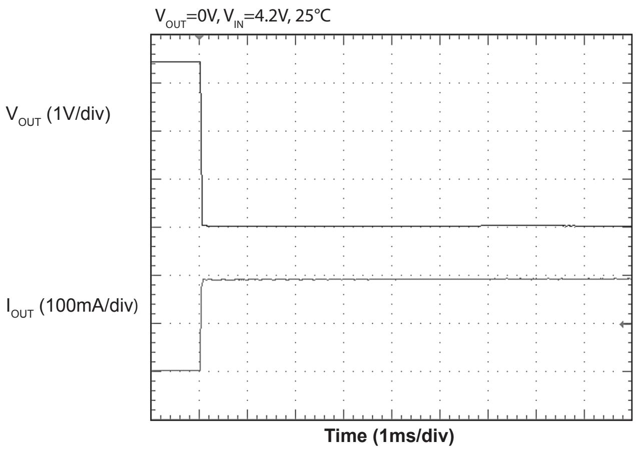
Load Transient Response (LDO2) — Falling Edge

V_{IN}=3.7V, V_{LDO2}=1.8V, I_{LDO2}=100 to 1mA

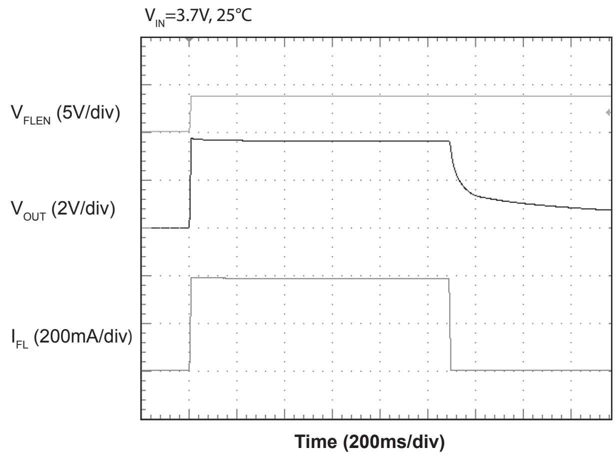


Typical Characteristics (continued)

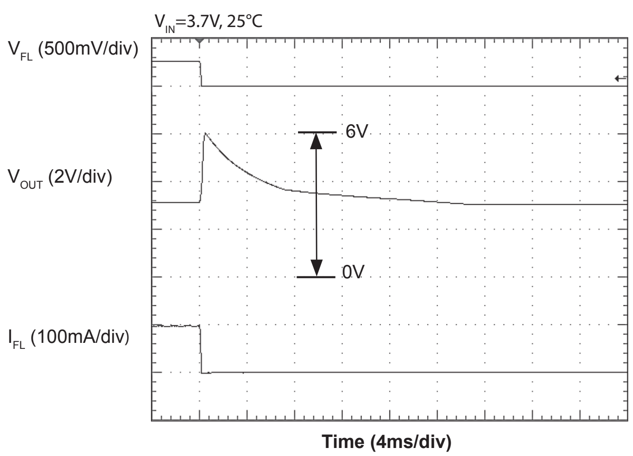
Output Short Circuit Current Limit



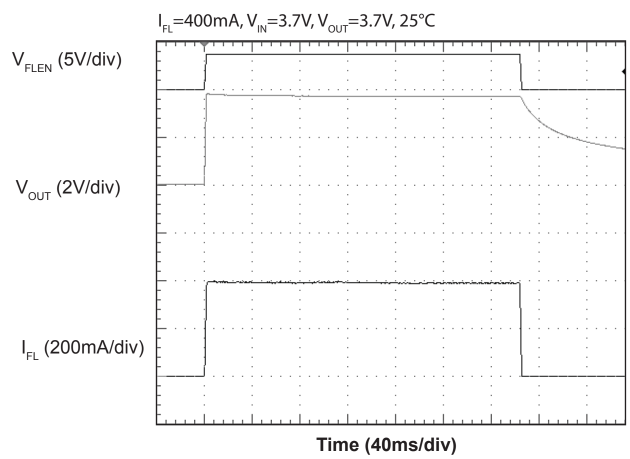
Flash Mode Safety Timer



Output Open Circuit Protection



Flash Current Pulse



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Pin Descriptions

Pin #	Pin Name	Pin Function
1	C2-	Negative connection to bucket capacitor 2 — requires a 2.2µF capacitor connected to C2+
2	PGND	Ground pin for high current charge pump and Flash LED driver
3	FL	Current sink output for flash LED(s)
4	NC	Unused pin — do not terminate
5	NC	Unused pin — do not terminate
6	NC	Unused pin — do not terminate
7	NC	Unused pin — do not terminate
8	AGND	Analog ground pin — connect to ground and separate from PGND current
9	GREF	Ground reference — connect to ground
10	FLEN	Control pin for flash LED(s) — high = ON, low = OFF
11	SWIF	SemWire single wire interface pin — used to enable/disable the device and to set up all internal registers (refer to Register Map and SemWire Interface sections)
12	NC	Unused pin — do not terminate
13	BYP	Bypass pin for voltage reference — connect with a 22nF capacitor to AGND
14	LDO2	Output of LDO2 — connect with a 1µF capacitor to AGND
15	LDO1	Output of LDO1 — connect with a 1µF capacitor to AGND
16	VOUT	Charge pump output — all LED anode pins should be connected to this pin — requires a 4.7µF capacitor to PGND
17	C2+	Positive connection to bucket capacitor 2 — requires a 2.2µF capacitor connected to C2-
18	C1+	Positive connection to bucket capacitor 1 — requires a 2.2µF capacitor connected to C1-
19	VIN	Battery voltage input — connect with a 2.2µF capacitor to PGND
20	C1-	Negative connection to bucket capacitor 1 — requires a 2.2µF capacitor connected to C1+
T	THERMAL PAD	Thermal pad for heatsinking purposes — connect to ground plane using multiple vias — not connected internally

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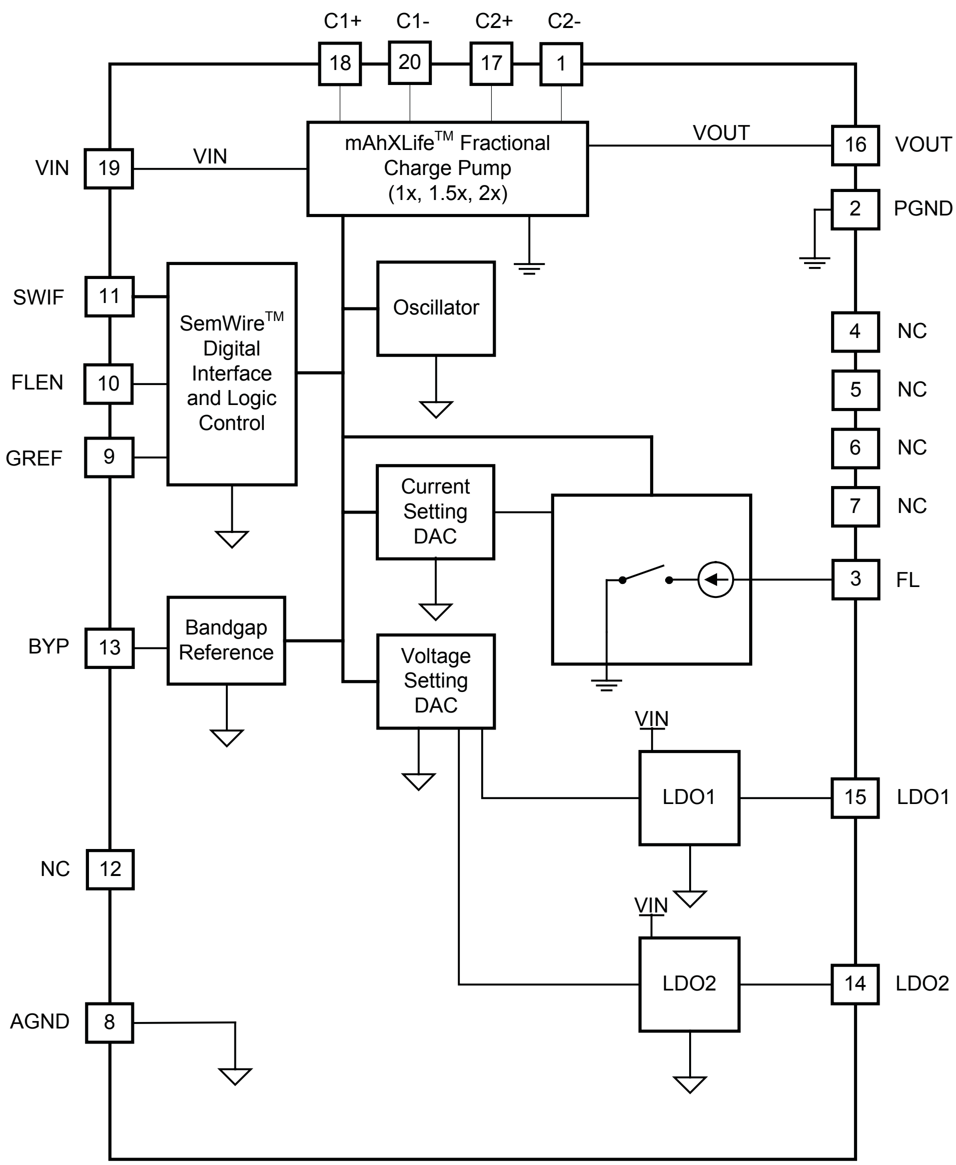
Block Diagram



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Applications Information

General Description

This design is optimized for handheld applications supplied from a single Li-Ion cell and includes the following key features:

- A high efficiency fractional charge pump that supplies power to the flash LED
- An LED flash output that provides up to 400mA of momentary current or up to 250mA of continuous spotlight current
- Two adjustable LDOs with outputs ranging from 2.5V to 3.3V for LDO1 and 1.5V to 1.8V for LDO2, adjustable in 100mV increments
- A SemWire single wire interface that provides control of all device functions

High Current Fractional Charge Pump

The flash output is supported by a high efficiency, high current fractional charge pump output at the VOUT pin. The charge pump multiplies the input voltage by 1, 1.5, or 2 times. The charge pump switches at a fixed frequency of 250kHz in 1.5x and 2x modes and is disabled in 1x mode to save power and improve efficiency.

The mode selection circuit automatically selects the 1x, 1.5x or 2x mode based on circuit conditions. Circuit conditions such as low input voltage, high output current, or high LED voltage place a higher demand on the charge pump output. A higher numerical mode may be needed momentarily to maintain regulation at the VOUT pin during intervals of high demand, such as the high current of an LED flash or the droop at the VIN pin during a supply voltage transient. The charge pump responds to these momentary high demands, setting the charge pump to the optimum mode (1x, 1.5x or 2x), as needed to deliver the output voltage and load current while optimizing efficiency. Hysteresis is provided to prevent mode toggling.

The charge pump requires two bucket capacitors for low ripple operation. One capacitor must be connected between the C1+ and C1- pins and the other must be connected between the C2+ and C2- pins as shown in the typical application circuit diagram. These capacitors should be equal in value, with a minimum capacitance of 2.2μF to support the charge pump current requirements. The device also requires a 2.2μF capacitor on the VIN pin and a 4.7μF capacitor on the VOUT pin to minimize noise and support the output drive requirements. Capacitors with X7R or X5R ceramic dielectric are strongly recommended for their low ESR and superior temperature and voltage characteristics. Y5V capacitors should not be used as their temperature coefficients make them unsuitable for this application.

LED Flash and Spotlight Current Sink

A single output current sink is provided to drive both flash and spotlight functions. In flash mode, this current sink provides up to 400mA for a flash LED or array of parallel LEDs. Flash current settings are in 50mA increments from 50mA to 400mA. The FLEN pin directly triggers the FLASH function when pulled high, or it can be wired to VIN to enable software control via the serial interface.

In spotlight mode, the output can be set for up to 250mA of continuous current. Settings are available in 50mA increments from 50mA to 250mA. Continuous operation above 250mA is not recommended due to high power dissipation.

Flash and Spotlight Safety Timer

A safety timer disables the flash and spotlight output current sink if the sink remains active for an extended period. The timer protects the SC622 and the LED from high power dissipation that can cause overheating. The timer's default state is on, but the timer may be disabled via the serial interface to allow continuous output current in spotlight mode. The safety timer affects only the FL pin and will turn off the sink after a period of 1 second. The timer may be reset by either forcing the FLEN pin low or by resetting the Flash/Spotlight control bits via the interface.

Programmable LDO Outputs

Two low dropout (LDO) regulators are provided for camera module I/O and core power. Each LDO has at least 100mA of available load current with ±3.5% accuracy. The minimum current limit is 200mA, so outputs greater than 100mA are possible at somewhat reduced accuracy.

SEMTECH

Applications Information (continued)

A 1µF, low ESR capacitor should be used as a bypass capacitor on each LDO output to reduce noise and ensure stability. In addition, it is recommended that a minimum 22nF capacitor be connected from the BYP pin to ground to minimize noise and achieve optimum power supply rejection. A larger capacitor can be used for this function, but at the expense of increasing turn-on time. Capacitors with X7R or X5R ceramic dielectric are strongly recommended for their low ESR and superior temperature and voltage characteristics. Y5V capacitors should not be used as their temperature coefficients make them unsuitable for this application.

Shutdown State

The device is disabled when the SWIF pin is low. All registers are reset to default condition when SWIF is low.

Sleep Mode

When the LED is off, sleep mode is activated. This is a reduced current mode that helps minimize overall current consumption by turning off the clock and the charge pump while continuing to monitor the serial interface for commands. Both LDOs can be powered up while in sleep mode.

SemWire Single Wire Interface Functions

All device functions can be controlled via the SemWire single wire interface. The interface is described in detail in the SemWire Interface section of the datasheet.

Protection Features

The SC622 provides several protection features to safeguard the device from catastrophic failures. These features include:

- Output Open Circuit Protection
- Over-Temperature Protection
- Charge Pump Output Current Limit
- LDO Current Limit
- LED Float Detection

Output Open Circuit Protection

Over-Voltage Protection (OVP) is provided at the VOUT pin to prevent the charge pump from producing an excessively high output voltage. In the event of an open circuit at VOUT, the charge pump runs in open loop and the voltage rises up to the OVP limit. OVP operation is hysteretic, meaning the charge pump will momentarily turn off until V_{OUT} is sufficiently reduced. The maximum OVP threshold is 6.0V, allowing the use of a ceramic output capacitor rated at 6.3V with no fear of over-voltage damage.

Over-Temperature Protection

The Over-Temperature (OT) protection circuit helps prevent the device from overheating and experiencing a catastrophic failure. When the junction temperature exceeds 160°C, the device goes into thermal shutdown with all outputs disabled until the junction temperature is reduced. All register information is retained during thermal shutdown.

Charge Pump Output Current Limit

The device also limits the charge pump current at the VOUT pin. When VOUT is shorted to ground, the typical output current limit is 300mA. The current limiting is triggered by an output under-voltage lockout below 2V. The output returns to normal when the short is removed and VOUT is above 2.5V. Above 2.5V, a typical current limit of 1A applies.

LDO Current Limit

The device limits the output currents of LDO1 and LDO2 to help prevent it from overheating and to protect the loads. The minimum limit is 200mA, so load current greater than the rated 100mA can be used with degraded accuracy and larger dropout without tripping the current limit.

LED Float Detection

Float detect is a fault detection feature of the LED current sink output. If the output is programmed to be enabled and an open circuit fault occurs at the current sink output, the output will be disabled to prevent a sustained output OVP condition from occurring due to the resulting open loop.

Applications Information (continued)

PCB Layout Considerations

The layout diagram in Figure 1 illustrates a proper two-layer PCB layout for the SC622 and supporting components. Following fundamental layout rules is critical for achieving the performance specified in the Electrical Characteristics table. The following guidelines are recommended when developing a PCB layout:

- Place all bypass and decoupling capacitors — C1, C2, CIN, COUT, CLDO1, CLDO2, and CBYP as close to the device as possible.
- All charge pump current passes through VIN, VOUT, and the bucket capacitor connection pins. Ensure that all connections to these pins make use of wide traces so that the resistive drop on each connection is minimized.
- The thermal pad should be connected to the ground plane using multiple vias to ensure proper thermal connection for optimal heat transfer.

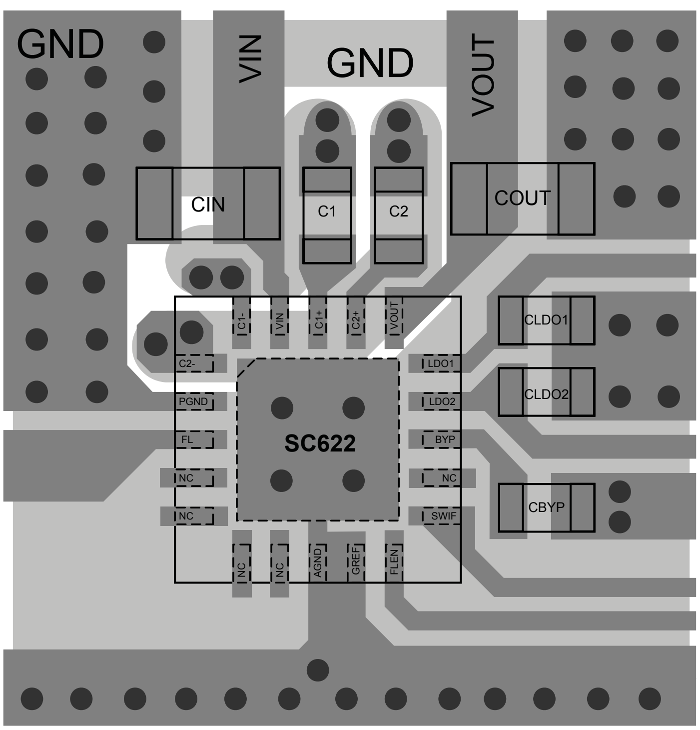


Figure 1 — Recommended PCB Layout

- Make all ground connections to a solid ground plane as shown in the example layout (Figure 3).
- If a ground layer is not feasible, the following groupings should be connected:
  - PGND — CIN, COUT
  - AGND — Ground Pad, CLDO1, CLDO2, CBYP
- If no ground plane is available, PGND and AGND should be routed back to the negative battery terminal as separate signals using thick traces. Joining the two ground returns at the terminal prevents large pulsed return currents from mixing with the low-noise return currents of the LDOs.
- Both LDO output traces should be made as wide as possible to minimize resistive losses.

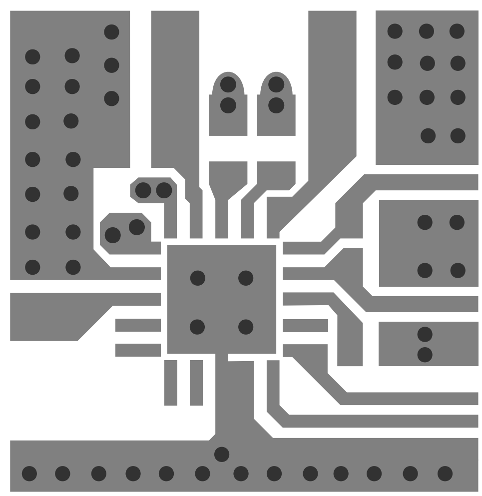


Figure 2 — Layer 1

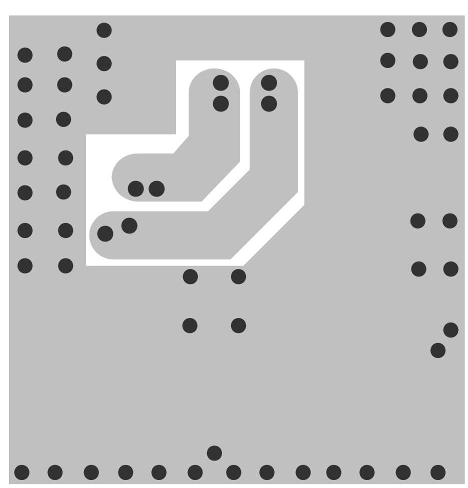


Figure 3 — Layer 2

Register Map

Address	D7	D6	D5	D4	D3	D2	D1	D0	Reset Value	Description
0x02	0[(1)]	0[(1)]	0[(1)]	FLTO	FL_2	FL_1	FL_0	FL/SPLB	0x10	Flash/Spotlight Control
0x03	0[(1)]	LDO2_2	LDO2_1	LDO2_0	LDO1_3	LDO1_2	LDO1_1	LDO1_0	0x00	LDO Control

Notes:
(1) 0 = always write a 0 to these bits

Register and Bit Definitions

Flash/Spotlight Control Register (0x02)

This register is used to configure the flash time-out feature, the flash or spotlight current, and select flash or spotlight current ranges.

FLTO

This bit is used to enable the flash safety time-out feature. The default state is enabled with FLTO = 1. If this bit is set, the device will turn off the flash after a nominal period of 1s. Two ways to re-enable the flash function after a safety time-out are:

- Pull the FLEN pin low to re-enable the flash function
- Clear and re-write FL[2:0]

FL[2:0]

These bits are used to set the current for the flash current sink when configured for flash or spotlight by the FL/SPLB bit. Bits FL[2:0] set the flash or spotlight current, as shown in Table 1.

Table 1 — Flash/Spotlight Control Bits

FL_2	FL_1	FL_0	FL/SPLB	Flash/Spotlight Current (mA)
0	0	0	0	OFF
0	0	1	0	50
0	1	0	0	100
0	1	1	0	150
1	0	0	0	200
1	0	1	0	250
1	1	0	0	250
1	1	1	0	250
0	0	0	1	OFF
0	0	1	1	300[(1)]
0	1	0	1	350[(1)]
0	1	1	1	400[(1)]
1	0	0	1	400[(1)]
1	0	1	1	400[(1)]
1	1	0	1	400[(1)]
1	1	1	1	400[(1)]

Note:
(1) When on continuously, the device may reach the temperature limit with 300mA and higher.

Register and Bit Definitions (continued)

FL/SPLB

This bit is used to select either the flash or spotlight current ranges. If this bit is set, the FL current sink can be used to drive a flash of maximum duration 500ms and the current range will be the high (flash) current range. If this bit is cleared, the FL current sink can be used to drive a continuous spotlight at a lower current and the current range will be the lower (spotlight) current range, as shown in Table 1.

LDO Control Register (0x03)

This register is used to enable the LDOs and to set their output voltages.

LDO2[2:0]

These bits are used to set the output voltage of LDO2, as shown in Table 2.

Table 2 — LDO2 Control Bits

LDO2_2	LDO2_1	LDO2_0	LDO2 Output Voltage
0	0	0	OFF
0	0	1	1.8V
0	1	0	1.7V
0	1	1	1.6V
1	0	0	1.5V
101 through 111 are not used			OFF

LDO1[3:0]

These bits set the output voltage of LDO1, as shown in Table 3.

Table 3 — LDO1 Control Bits

LDO1_3	LDO1_2	LDO1_1	LDO1_0	LDO1 Output Voltage
0	0	0	0	OFF
0	0	0	1	3.3V
0	0	1	0	3.2V
0	0	1	1	3.1V
0	1	0	0	3.0V
0	1	0	1	2.9V
0	1	1	0	2.8V
0	1	1	1	2.7V
1	0	0	0	2.6V
1	0	0	1	2.5V
1010 through 1111 are not used				OFF

SemWire Interface

Semwire Interface Functions

The SWIF pin is a write-only single wire interface. It provides the capability to address up to 32 registers to control device functionality. The protocol for using this interface is described in the following subsections.

Driving the SWIF Pin

The SWIF pin should be driven by a GPIO from the system microcontroller. The output level can be configured as either a push-pull driver (TTL or CMOS levels) or as an open drain driver with an external pull-up resistor.

Enabling the Device

The SWIF pin must be pulled from low to high for a period of greater than 1ms (t_{EN}) to enable the device into the sleep state. In the sleep state, the device bandgap is active, UVLO monitoring is active, and the serial interface is monitored for communication.

Automatic Sleep State

If the flash current sink is disabled, the device automatically enters the sleep state in order to minimize the current draw from the battery. When in sleep mode, the charge pump and oscillator are both disabled. The LDOs remain on if enabled.

Disabling the Device

The SWIF pin must be pulled from high to low for a period greater than 10ms (t_{DIS}) in order to shut down the device. In this state the device remains disabled until the SWIF pin is pulled high for a period greater than 1ms. All registers return to the default state, resetting all bits to zero except for FLT0, which defaults to one.

SemWire Communication Protocol and Timing

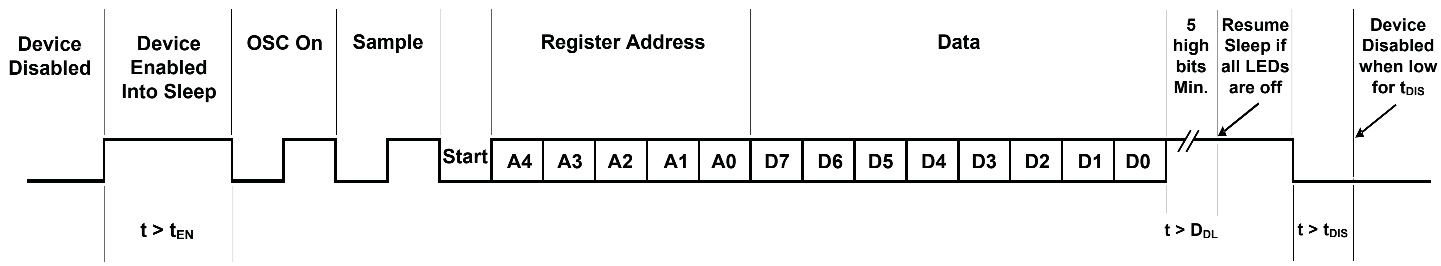
The following six step communication sequence controls all device functions when the device is enabled.

1. OSC On — The SWIF pin is toggled low for one bit duration and high for one bit duration in order to enable the oscillator. The oscillator is turned off in the sleep state to minimize quiescent current.
2. Sample — The SWIF pin is toggled low for one bit duration and high for one bit duration. During this time, the device samples the bit rate and determines the bit rate at which the register address and data values that follow will arrive. The sample rate is at least 20 times the bit rate ensuring robust communication synchronization.
3. Start — The SWIF pin is pulled low for one bit duration, which starts communication with the target register.
4. Address — The next 5 bits are the address of the target register — MSB first, LSB last.
5. Data — The next 8 bits are the data written to the target register — MSB first, LSB last.
6. Standby — After the last data bit is sent, the SWIF pin is pulled high for 5 bit durations to return the device to standby before another data write can take place. If all LEDs are disabled, the device will go back to sleep mode.

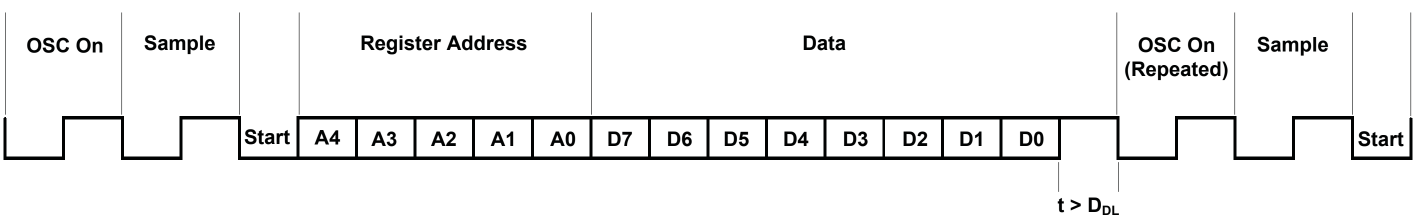
NOTE: The bit rate must be set by the host controller to a rate that is between the minimum and maximum frequencies listed in the Electrical Characteristics section.

SemWire Interface (continued)

Single Write Operation

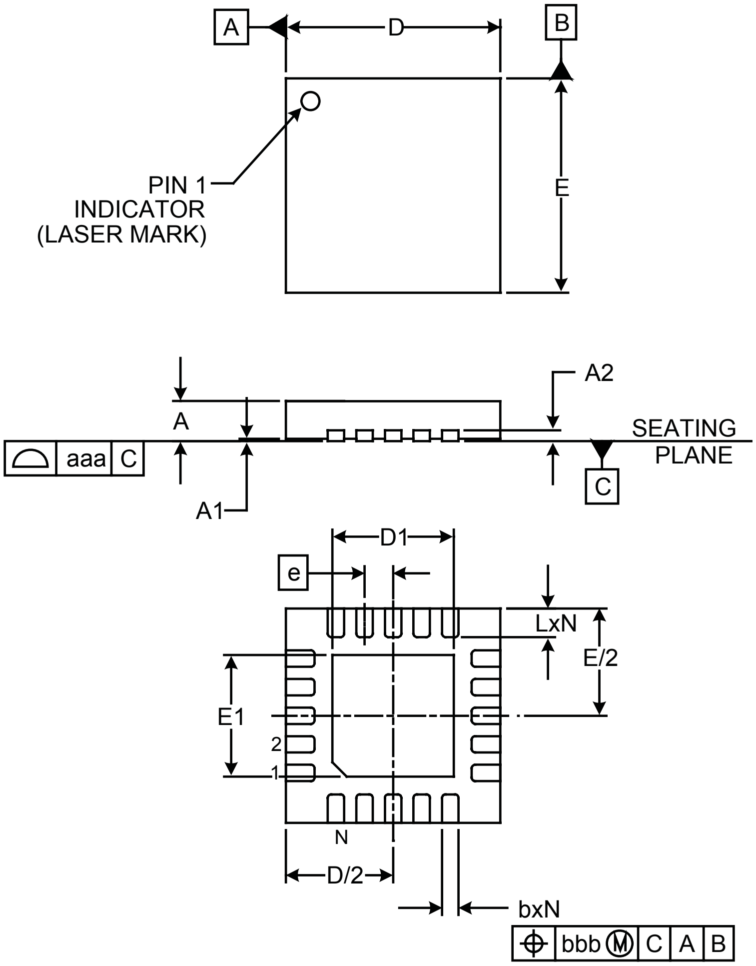


Concatenated Write Operation



To concatenate write operations, repeat Osc On, Sample and Start after the DO bit of the previous sequence as shown.

Outline Drawing — MLPQ-UT-20 3x3

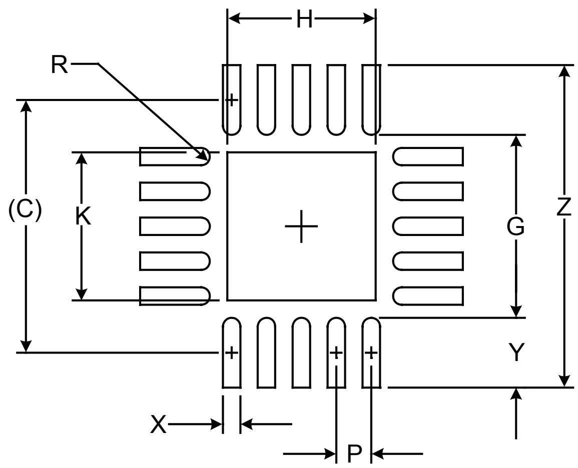


DIMENSIONS						
DIM	INCHES			MILLIMETERS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	.020	-	.024	0.50	-	0.60
A1	.000	-	.002	0.00	-	0.05
A2	(.006)			(0.1524)		
b	.006	.008	.010	0.15	0.20	0.25
D	.114	.118	.122	2.90	3.00	3.10
D1	.061	.067	.071	1.55	1.70	1.80
E	.114	.118	.122	2.90	3.00	3.10
E1	.061	.067	.071	1.55	1.70	1.80
e	.016 BSC			0.40 BSC		
L	.012	.016	.020	0.30	0.40	0.50
N	20			20		
aaa	.003			0.08		
bbb	.004			0.10		

NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
3. DAP is 1.90 x 190mm.

Land Pattern — MLPQ-UT-20 3x3



DIMENSIONS		
DIM	INCHES	MILLIMETERS
C	(.114)	(2.90)
G	.083	2.10
H	.067	1.70
K	.067	1.70
P	.016	0.40
R	.004	0.10
X	.008	0.20
Y	.031	0.80
Z	.146	3.70

NOTES:

1. CONTROLLING DIMENSIONS ARE IN MILLIMETERS (ANGLES IN DEGREES).
2. THIS LAND PATTERN IS FOR REFERENCE PURPOSES ONLY. CONSULT YOUR MANUFACTURING GROUP TO ENSURE YOUR COMPANY'S MANUFACTURING GUIDELINES ARE MET.
3. THERMAL VIAS IN THE LAND PATTERN OF THE EXPOSED PAD SHALL BE CONNECTED TO A SYSTEM GROUND PLANE. FAILURE TO DO SO MAY COMPROMISE THE THERMAL AND/OR FUNCTIONAL PERFORMANCE OF THE DEVICE.

Contact Information

Semtech Corporation
Power Management Products Division
200 Flynn Road, Camarillo, CA 93012
Phone: (805) 498-2111 Fax: (805) 498-3804

www.semtech.com