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am

AS3630

8A Supercap Flash Driver

General Description

The AS3630 is an inductive high efficient 4MHz dual DCDC step up converter with several sources. It supports the charging of a Supercap, its voltage balancing and a highly efficient DCDC step up from the Supercap to the LED and from VIN to the LED to power the flash LED with up to 8A. The AS3630 supports the pre-charging of the Supercap (to VIN) to reduce the startup time for the flash without reducing the lifetime of the Supercap.

The system concept supports an immediate torch function without first charging the Supercap.

The AS3630 includes flash timeout, over- undervoltage, overtemperature and LED short circuit protection.

The AS3630 is controlled by an I^2C interface for adjustment of the currents and timings, set the end of charge voltage and measure the Supercap and LED parameters through the internal ADC. A dedicated TXMASK/TORCH input can be used for a torch button -or- reducing the battery current if a RF PA is operated at the same time (TX Masking). A hardware enable pin -ON can be used as a reset input.

The AS3630 is available in a space-saving WL-CSP 5x5 balls package measuring only 2.5x2.5x0.6mm and operates over the -30ºC to +85ºC temperature range.

Figure AS3630 – 1:
Key Benefits and Features

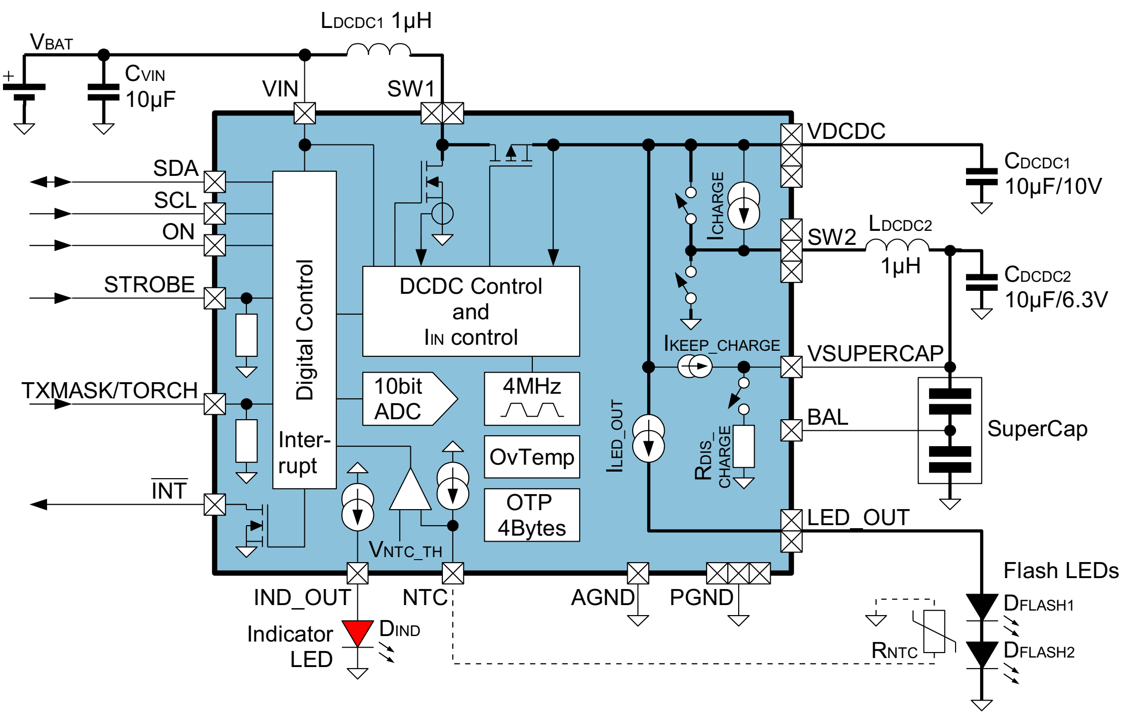
Benefits	Features
Reduce Supercap size	Dual high efficiency boost converter with soft start allows small coils
Instantaneous Torch operation for improved user experience	Immediate Torch functions with charging of the Supercap
Tiny external coils	4MHz fixed frequency DCDC
System Safety	10bit ADC converter for system monitoring with Protection functions: Automatic Flash Timeout timer to protect the LED Overvoltage and undervoltage Protection LED (NTC) and device Overtemperature Protection LED short/open circuit protection
Improved thermal performance (ground = heat sink)	Flash LED(s) cathode connected to ground:

Benefits	Features
Fine control of current to fit to applications	LED currents (fully adjustable by interface) • 8A for 33ms and 6A for 120ms (Flash), 2.9mA - 272mA for torch • 1mA-8mA indicator current
Full control and hardware ON pin for easier system integration	I²C Interface with Interrupt output and ON pin

Applications

The device is ideal for Flash/Torch for mobile phones, DSC and Tablets.

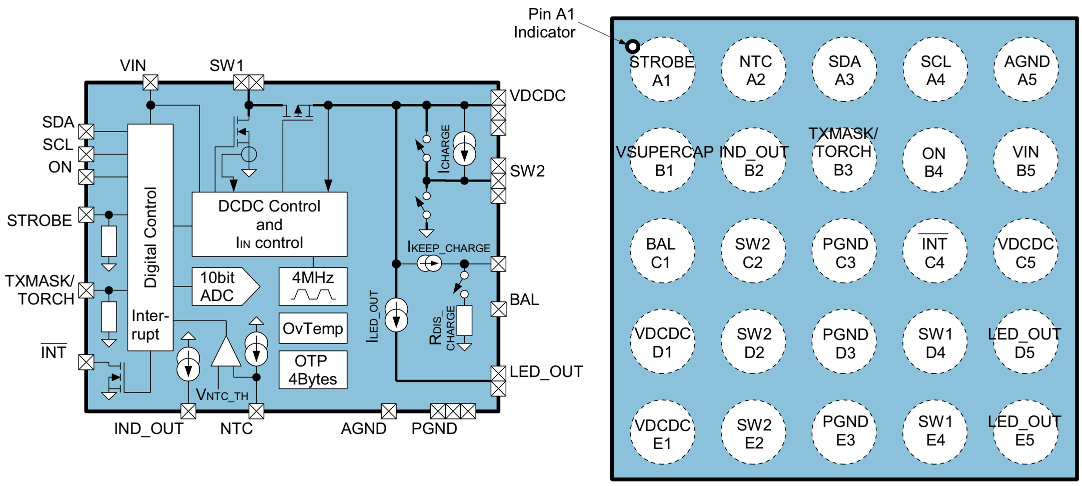
Figure AS3630 – 2:
Typical Operating Circuit



Typical Operating Circuit: Shows the main function blocks of the AS3630.

Pin Assignment

Figure AS3630 – 3:
Pin Assignments (Top View)



Pin Description

Figure AS3630 – 4:
Pin Description

Pin Number	Pin Name	Description
A1	STROBE	Digital input with pulldown to control strobe time for flash function[1]
A2	NTC	LED temperature sensor input - connect to NTC and connect its GND with a separate ground wire to AGND
A3	SDA[2]	Digital input, open drain output - serial data input/output for I^2C interface (needs external pullup resistor)
A4	SCL[2]	Digital Input[3] - serial clock input for I^2C mode
A5	AGND	Analog ground - connect to ground (GND)
B1	VSUPERCAP	Supercap connection
B2	IND_OUT	Indicator LED current source output
B3	TXMASK/TORCH	Function 1 • "TXMASK" Connect to RF power amplifier enable signal - reduces currents during flash to avoid a system shutdown due to parallel operation of the RF PA and the flash driver. Function 2 • "TORCH" Operate torch current level without using the I^2C interface to operate the torch without need to start a camera processor (if the I^2C is connected to the camera processor.
B4	ON	Digital Input active high - a logic 1 enables of the AS3630; a logic 0 resets the AS3630
B5	VIN	Positive supply voltage input - connect to supply and make a short connection to input capacitor CVIN and to coil L_{DCDC1}
C1	BAL	Supercap balance pin - balances both single capacitors inside the Supercap
C2	SW2	DCDC converter 2 switching node - make a short connection to the coil L_{DCDC2} and connect all SW2 pins together on top plane
C3	PGND	Power ground - connect to ground (GND) and connect all PGND pins together on top plane
C4	$\overline{INT}$	Open drain interrupt output - active low (needs external pullup resistor)
C5	VDCDC	DCDC converter 1 and 2 output capacitor - make a short connection to CVOUT1 and connect all VDCDC pins together as short as possible

Pin Number	Pin Name	Description
D1	VDCDC	DCDC converter 1 and 2 output capacitor - make a short connection to CVOUT1 and connect all VDCDC pins together as short as possible
D2	SW2	DCDC converter 2 switching node - make a short connection to the coil L_{DCDC2} and connect all SW2 pins together on top plane
D3	PGND	Power ground - connect to ground (GND) and connect all PGND pins together on top plane
D4	SW1	DCDC converter 1 switching node - make a short connection to the coil L_{DCDC1} and connect all SW1 pins together on top plane
D5	LED_OUT	Flash LED current source output and connect all LED_OUT pins together on top plane
E1	VDCDC	DCDC converter 1 and 2 output capacitor - make a short connection to CVOUT1 and connect all VDCDC pins together as short as possible
E2	SW2	DCDC converter 2 switching node - make a short connection to the coil L_{DCDC2} and connect all SW2 pins together on top plane
E3	PGND	Power ground - connect to ground (GND) and connect all PGND pins together on top plane
E4	SW1	DCDC converter 1 switching node - make a short connection to the coil L_{DCDC1} and connect all SW1 pins together on top plane
E5	LED_OUT	Flash LED current source output and connect all LED_OUT pins together on top plane

1. Application Information: The pin STROBE is usually connected directly to the camera processor.
2. When SCL and SDA exchanged, the AS3630 uses a different I^2C address and the functionality of SCL/SDA is also exchanged - see "I^2C Address Selection" on page 43.
3. Only input: The AS3630 does not perform clock stretching.

Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings“ may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under “Operating Conditions” is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure AS3630 – 5:
Absolute Maximum Ratings

Parameter	Min	Max	Units	Comments
VIN, SDA, SCL, ON, STROBE, TXMASK/TORCH, $\overline{INT}$, IND_OUT, NTC and BAL to GND	-0.3	+7.0	V	
SDA, SCL, ON, STROBE, TXMASK/TORCH, $\overline{INT}$, IND_OUT, NTC to GND	-0.3	VIN + 0.3	V	
V_{DCDC}, SW1, SW2, V_{DCDC}, LED_OUT and VSUPERCAP to GND	-0.3	+11	V	
V_{DCDC} to SW1 V_{DCDC} to SW2 V_{DCDC} to LED_OUT VSUPERCAP to BAL	-0.3		V	Diode between • V_{DCDC} and SW1 • V_{DCDC} and SW2 • V_{DCDC} and LED_OUT • VSUPERCAP and BAL
AGND, PGND to GND	0.0	0.0	V	Connect AGND and PGND to GND directly below the ball (short connection required)
Input Pin Current without causing latchup	-100	+100 $+I_{IN}$	mA	Norm: EIA/JESD78
Continuous Power Dissipation (T_A = +70ºC)				
Continuous power dissipation		2770	mW	P_T[1]
Continuous power dissipation derating factor		37	mW/ºC	P_{DERATE}[2]
Electrostatic Discharge				
ESD HBM		±2000	V	Norm: JEDEC JESD22-A114F
ESD MM		±100	V	Norm: JEDEC JESD 22-A115-B

Parameter	Min	Max	Units	Comments
Temperature Ranges and Storage Conditions				
Junction Temperature		+125	ºC	+150ºC internally limited only during flash (max. 20000s)
Storage Temperature Range	-55	+125	ºC	
Humidity	5	85	%	Non condensing
Body Temperature during Soldering		+260	ºC	According to IPC/JEDEC J-STD-020
Moisture Sensitivity Level (MSL)	MSL 1			Represents a max. floor life time of unlimited

1. Depending on actual PCB layout and PCB used.
2. P_{DERATE} derating factor changes the total continuous power dissipation (P_T) if the ambient temperature is not 70ºC. Therefore for e.g. T_{AMB}=85ºC calculate P_T at 85ºC = P_T - P_{DERATE} * (85ºC - 70ºC)

Electrical Characteristics

All limits are guaranteed. The parameters with min and max values are guaranteed with production tests or SQC (Statistical Quality Control) methods.

V_{VIN} = +2.5V to +4.8V, T_{AMB} = -30ºC to +85ºC, unless otherwise specified. Typical values are at V_{BAT} = +3.7V, T_{AMB} = +25ºC, unless otherwise specified.

Figure AS3630 – 6:
Electrical Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
		General Operating Conditions				
V_{VIN}	Supply Voltage		2.5	3.7	4.8	V
$I_{SHUTDOWN}$	Shutdown Current	AS3630 off, V_{BAT}<3.7V, $T_{AMB} \leq$ 50ºC, ON=0		0.5	2.0	µA
$I_{STANDBY}$	Standby Current	AS3630 off, V_{BAT}<3.7V, $T_{AMB} \leq$ 50ºC, ON=1		1.0	10	µA
$I_{PRE\_CHARGE\_LOW\_POWER}$	Supercap pre-charging current	mode_setting = Supercap pre-charge and charge_current =00b		2		µA
T_{AMB}	Operating Temperature		-30	25	85	ºC
		DCDC1/2 Step Up Converter				
V_{DCDC}	DCDC Boost output Voltage (pin V_{DCDC})	DCDC1 (L_{DCDC1}) and/or DCDC2 (L_{DCDC2}) is in operation			10	V
η	Efficiency	DCDC1 (L_{DCDC1}) or DCDC2 (L_{DCDC2})		90		%
f_{CLK}	Operating Frequency	All internal timings are derived from this oscillator	-10%	4.0	+10%	MHz
max_duty_{DCDC}	DCDC1/2 maximum duty cycle			84		%
R_{SW_P1}	DCDC Switch SW1 - V_{DCDC}			100		mΩ
R_{SW_N1}	DCDC Switch SW1 - GND			100		mΩ
R_{SW_P2}	DCDC Switch SW2 - V_{DCDC}			70		mΩ
R_{SW_N2}	DCDC Switch SW2 - GND			100		mΩ

Symbol	Parameter	Conditions		Min	Typ	Max	Units
Supercap Charger / Discharge							
$V_{SUPERCAP\_EOC}$[1]	End of charge voltage for Supercap	Programmable in 90mV steps by register end_of_charge_voltage above 5.5V max. 60000s during lifetime of AS3630	0	4.469	4.57	4.671	V
			1	4.557	4.66	4.763	V
			2	4.646	4.75	4.855	V
			3	4.724	4.83	4.936	V
			4	4.820	4.93	5.036	V
			5	4.900	5.01	5.12	V
			6	4.995	5.11	5.219	V
			7	5.082	5.2	5.31	V
			8	5.170	5.29	5.402	V
			9	5.258	5.38	5.494	V
			Ah	5.345	5.47	5.585	V
			Bh	5.433	5.56	5.677	V
			Ch	5.526	5.65	5.774	V
			Dh	5.616	5.74	5.868	V
			Eh	5.704	5.83	5.96	V
			Fh	5.793	5.92	6.053	V
$I_{SUPERCAP\_CHARGE}$	Pre-charging current of Supercap[2]	Pre-charging and transition (to charge) of Supercap - see Supercap Charging/Discharge/Pre-charge to VIN ; final charging to $V_{SUPERCAP\_EOC}$ is controlled by coil1_peak	charge_current =00b, low quiescent current mode	100	200	300	mA
			01b	380	500	650	
			10b	570	750	975	
			11b	760	1000	1300	
I_{KEEP_CHARGE}	Keeping Supercap charged current	During torch, charge or PWM operation keep VSUPERCAP charged if keep_sc_charged =1			10		mA
R_{DIS_CHARGE}	Discharge resistance for VSUPERCAP	mode_setting = 001b / shutdown and discharge Supercap			250*2		Ω

<table>
<tr><th>Symbol</th><th>Parameter</th><th colspan="2">Conditions</th><th>Min</th><th>Typ</th><th>Max</th><th>Units</th></tr>
<tr><td colspan="8">LED Current Sources</td></tr>
<tr><td rowspan="4">I_{LED_OUT}</td><td rowspan="4">LED_OUT Current set by led_current</td><td colspan="2">Limited lifetime max. 20000s, mode_setting = flash operation; current specified for each of the two flash LEDs</td><td>10</td><td></td><td>(2x) 3000</td><td rowspan="3">mA</td></tr>
<tr><td colspan="2">mode_setting = torch operation</td><td>10</td><td></td><td>460</td></tr>
<tr><td colspan="2">mode_setting = PWM operation duty cycle defined by led_out_pwm</td><td>10</td><td></td><td>303.9 * duty cycle</td></tr>
<tr><td></td><td>Accuracy, ΔI</td><td>-10</td><td></td><td>+10</td><td>%</td></tr>
<tr><td>$I_{LED\_OUT\_RIPPLE}$</td><td>LED_OUT ripple current</td><td colspan="2">I_{LED}=2500mA, BW=20MHz</td><td></td><td>200</td><td></td><td>mApp</td></tr>
<tr><td rowspan="2">V_{FLASH_COMP}</td><td rowspan="2">Flash current source voltage compliance</td><td rowspan="2">Minimum Voltage between VSUPERCAP and LED_OUT to generate the programmed current (led_current)</td><td>led_current_range =00b or 01b</td><td></td><td></td><td>0.4</td><td rowspan="2">V</td></tr>
<tr><td>10b</td><td></td><td></td><td>0.5</td></tr>
<tr><td rowspan="2">I_{IND_OUT}</td><td rowspan="2">Indicator Current</td><td rowspan="2">Set by ind_current in 1mA steps</td><td>Range</td><td>1.0</td><td></td><td>8.0</td><td>mA</td></tr>
<tr><td>Accuracy, ΔI</td><td>-20</td><td></td><td>+20</td><td>%</td></tr>
<tr><td rowspan="2">V_{LED_OUT}</td><td rowspan="2">LED_OUT-forward voltage measured on pin LED_OUT</td><td colspan="2">led_current_range = 00b…10b</td><td>2.6 x2</td><td></td><td>4.4 x2</td><td>V</td></tr>
<tr><td colspan="2">led_current_range = 11b (4A)</td><td>2.6 x2</td><td></td><td>4.325 x2</td><td>V</td></tr>
<tr><td colspan="8">ADC</td></tr>
<tr><td>Resolution</td><td></td><td colspan="2"></td><td></td><td>10</td><td></td><td>bits</td></tr>
<tr><td rowspan="7">Range</td><td rowspan="7">ADC input range; channel selected by ADC_channel</td><td colspan="2">ADC Code</td><td>'000h'</td><td></td><td>'3FFh'</td><td></td></tr>
<tr><td colspan="2">BAL, VIN, IND_OUT, PGND, TXMASK/TORCH, STROBE, $\overline{INT}$ and ON</td><td>0.0</td><td></td><td>5.866</td><td>V</td></tr>
<tr><td colspan="2">VSUPERCAP</td><td>0.0</td><td></td><td>6.666</td><td>V</td></tr>
<tr><td colspan="2">NTC</td><td>0.0</td><td></td><td>2.2</td><td>V</td></tr>
<tr><td colspan="2">V_{DCDC}</td><td>0.0</td><td></td><td>11</td><td>V</td></tr>
<tr><td colspan="2">LED_OUT</td><td></td><td></td><td>12.1</td><td></td></tr>
<tr><td colspan="5">Tjunc (AS3630 junction temperature, in ºC) = round (((4 * ADC_D9-D2 + ADC_D1-D0) - 324) * -1.05042)</td><td>ºC</td></tr>
</table>

Symbol	Parameter	Conditions		Min	Typ	Max	Units
Averaging	ADC internal averaging filter	Number of conversion per measurement (averaged); measurements can be started immediately, at begin of flash and end of flash - see ADC_convert			4		
Protection and Fault Detection Functions							
$V_{VOUTMAX}$	V_{DCDC} overvoltage protection	DCDC Converter Overvoltage Protection		9.3		10.0	V
I_{LDCDC1}	Current Limit for coil L_{DCDC1} (Pin SW1) measured at 75% PWM duty cycle[3]	Set by coil1_peak and coil1_txmask_curr_red during TXMask	Range	500		3500	mA
			Accuracy, ΔI	-10		+10	%
I_{LDCDC2}	Current Limit for coil L_{DCDC2} (Pin SW1) measured at 75% PWM duty cycle[3]	Set by coil2_peak	Range	1000		6000	mA
			Accuracy, ΔI	-10		+10	%
$V_{LEDSHORT}$	Flash LED short circuit detection voltage	Voltage measured on pin LED_OUT monitored once the LED_OUT current is at or above a minimum current - "Short/Open LED Protection - fault_led" on page 35			1.45		V
T_{OVTEMP}	Overtemperature Protection	Junction temperature			144		ºC
$T_{OVTEMP\ HYST}$	Overtemperature Hysteresis				5		ºC
$t_{FLASHTIMEOUT}$	Flash Timeout Timer	Set by flash_timeout	Range	4		760	ms
			Accuracy, Δt	-10% -2ms		+10% +2ms	
V_{UVLO}	Undervoltage Lockout	Falling V_{VIN}		2.3	2.4	2.5	V
		Rising V_{VIN}		V_{UVLO} +0.05	V_{UVLO} +0.1	V_{UVLO} +0.15	V

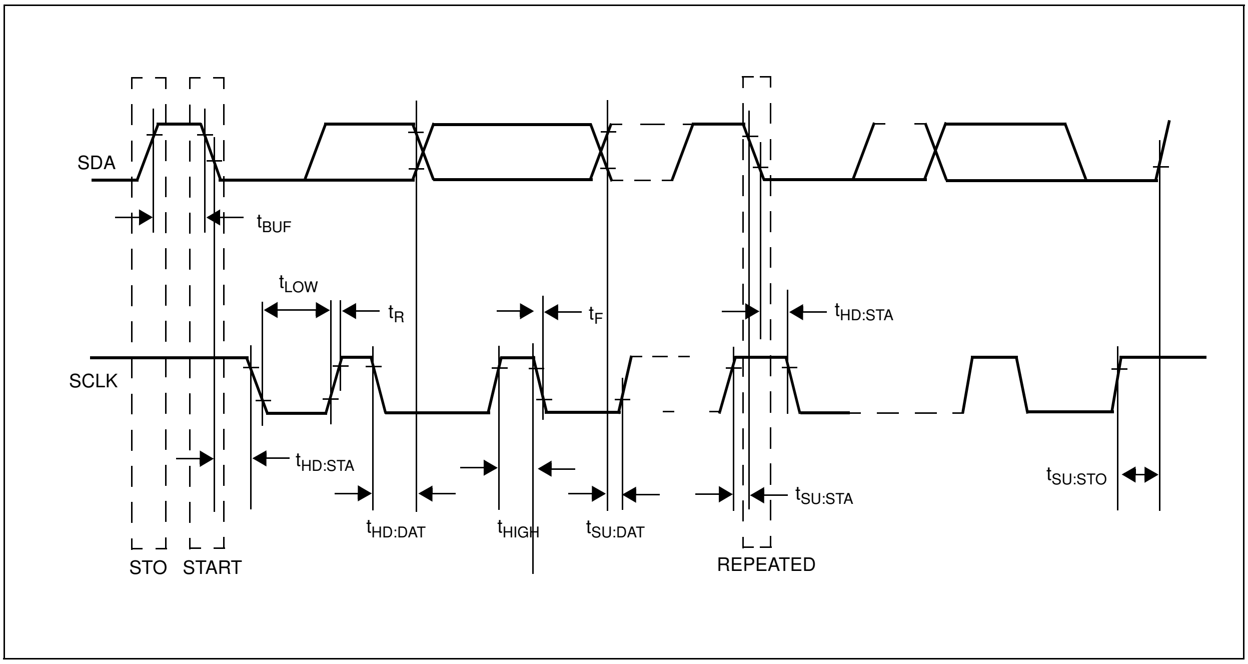
Symbol	Parameter	Conditions		Min	Typ	Max	Units
Protection and Fault Detection Functions - NTC							
I_{NTC}	NTC Current Source	Adjustable by NTC_current in 40µA steps, V(NTC) ≤ 1.7V	0		off		
			1	34.4	40	45.6	µA
			2	72	80	88	µA
			3	110	120	130	µA
			4	147	160	173	µA
			5	184	200	216	µA
			6	220	240	260	µA
			7	257	280	303	µA
			8	294	320	346	µA
			9	331	360	389	µA
			Ah	368	400	432	µA
			Bh	404	440	476	µA
			Ch	441	480	519	µA
			Dh	478	520	562	µA
			Eh	515	560	605	µA
			Fh	552	600	648	µA
V_{NTC_TH}	Threshold for overtemperature	If ntc_on=1 and the voltage on NTC drops below V_{NTC_TH}, any flash/torch or PWM operation of LED_OUT is stopped			1.0		V
Digital Interface							
V_{IH}	High Level Input Voltage	Pins SDA, SCL, ON, STROBE and TXMASK/TORCH		1.28		V_{VIN}	V
V_{IL}	Low Level Input Voltage			0.0		0.5	V
V_{OL}	Low Level Output voltage	Pin $\overline{INT}$ and SDAat 2mA		0		0.2	V
I_{LEAK}	Leakage current V_{VIN} or GND	Pins SDA, SCL, ON		-1.0		+1.0	µA
$R_{PULLDOWN}$	Pulldown current to GND	Pins TXMASK/TORCH, STROBE	1.8V on pad		35		kΩ
$t_{DEBTORCH}$	torch debounce time	TXMASK/TORCH input in torch mode			7.5		ms

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{DEBTXMASK}$	debounce timer	TXMASK/TORCH input in TXMask mode - see “TXMASK” on page 28		2.1		µs
I^2C Mode Timings (page 14)						
f_{SCLK}	SCL Clock Frequency		0		400	kHz
t_{BUF}	Bus Free Time Between a STOP and START Condition		1.3			µs
$t_{HD:STA}$	Hold Time (Repeated) START Condition[4]		0.6			µs
t_{LOW}	LOW Period of SCL Clock		1.3			µs
t_{HIGH}	HIGH Period of SCL Clock		0.6			µs
$t_{SU:STA}$	Setup Time for a Repeated START Condition		0.6			µs
$t_{HD:DAT}$	Data Hold Time[5]		0		0.9	µs
$t_{SU:DAT}$	Data Setup Time[6]		100			µs
t_R	Rise Time of Both SDA and SCL Signals		$20 + 0.1C_B$		300	ns
t_F	Fall Time of Both SDA and SCL Signals		$20 + 0.1C_B$		300	ns
$t_{SU:STO}$	Setup Time for STOP Condition		0.6			µs
C_B	Capacitive Load for Each Bus Line	C_B — total capacitance of one bus line in pF			400	pF
$C_{I/O}$	I/O Capacitance (SDA, SCL)				10	pF

1. In pre-charge the Supercap is always charged close to V_{VIN}; therefore $V_{SUPERCAP\_EOC} \geq V_{VIN}$ is possible
2. In order to reduce the total charging time of the Supercap, it is recommended to keep the Supercap pre-charged at VIN (can be enabled/disable by mode_setting)
3. Due to slope compensation of the current limit, the current limit changes with duty cycle
4. After this period, the first clock pulse is generated.
5. A device must internally provide a hold time of at least 300ns for the SDA signal (referred to the V_{IHMIN} of the SCL signal) to bridge the undefined region of the falling edge of SCL.
6. A fast-mode device can be used in a standard-mode system, but the requirement $t_{SU:DAT}$ = to 250ns must then be met. This is automatically the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line t_R max + $t_{SU:DAT}$ = 1000 + 250 = 1250ns before the SCL line is released.

Timing Diagrams

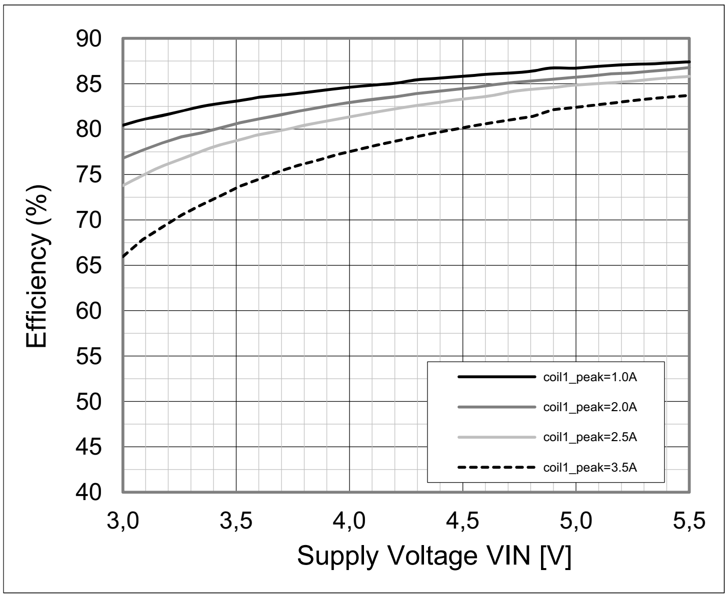
Figure AS3630 – 7:
I^2C Mode Timing Diagram



Typical Operating Characteristics

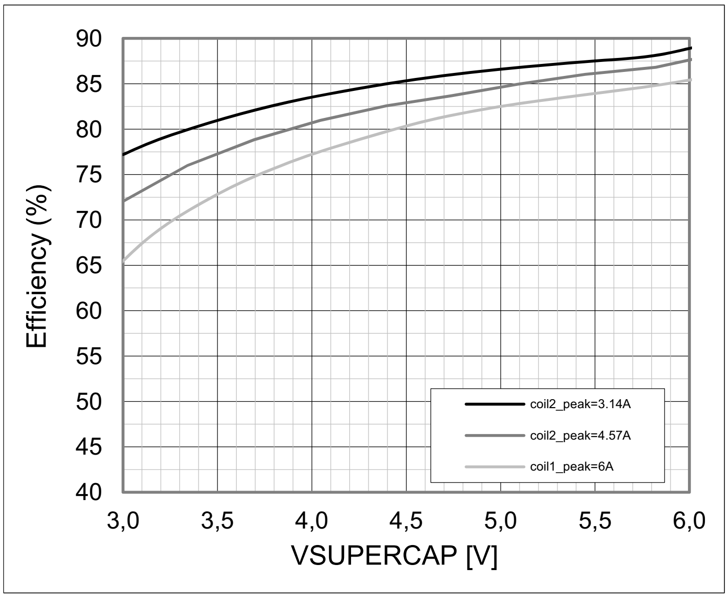
All measurements are performed at V_{VIN}=3.7V and T_{AMB}=25°C. LED = LXCL-LW07.

Figure AS3630 – 8:
Efficiency vs. Supply Voltage V_{IN} for DCDC1



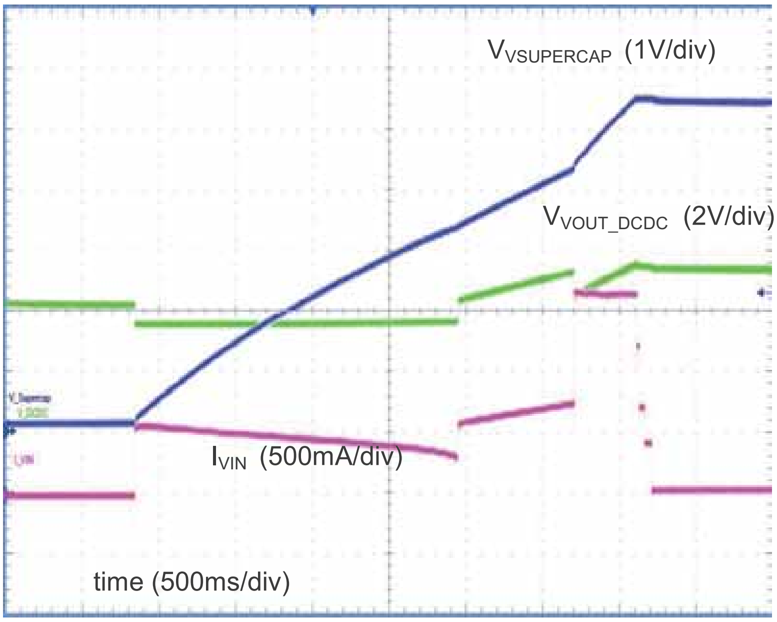
Efficiency vs. Supply Voltage: Shows efficiency (P_{OUT}/P_{IN}) of internal DCDC1 (V_{IN} to V_{DCDC}) vs. different supply voltages.

Figure AS3630 – 9:
Efficiency vs. $V_{SUPERCAP}$ for DCDC2



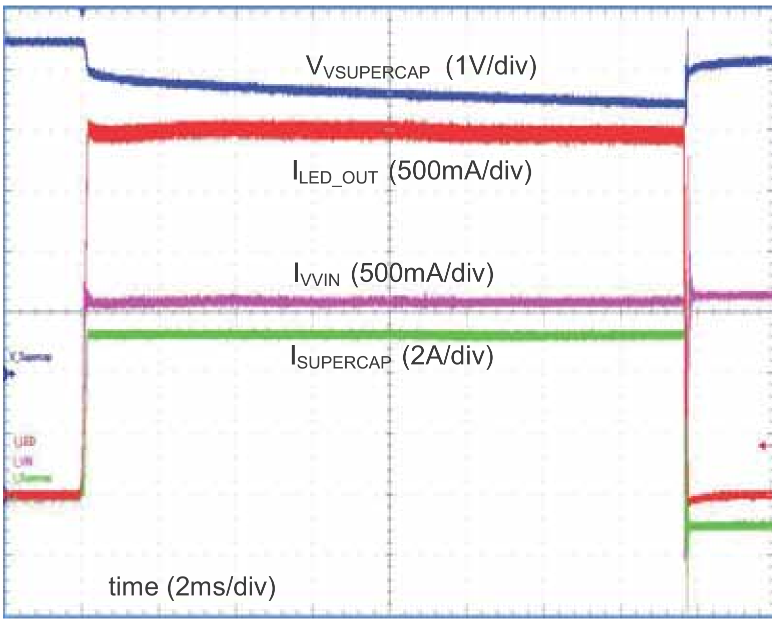
Efficiency vs. Supply Voltage: Shows efficiency (P_{OUT}/P_{IN}) of internal DCDC2 ($V_{SUPERCAP}$ to V_{DCDC}) vs. voltage on $V_{SUPERCAP}$ while discharging from 6V down to 3V.

Figure AS3630 – 10:
Supercap Charging Cycle



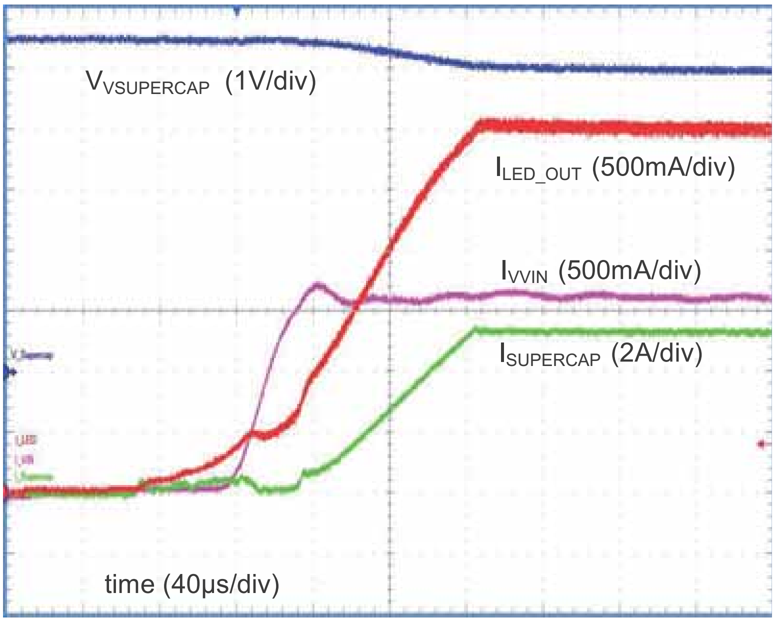
Supercap charging cycle: Shows all phases for charging of the Supercap starting from Pre-charge to transitions to charge until end of charge.

Figure AS3630 – 11:
Complete Flash Cycle



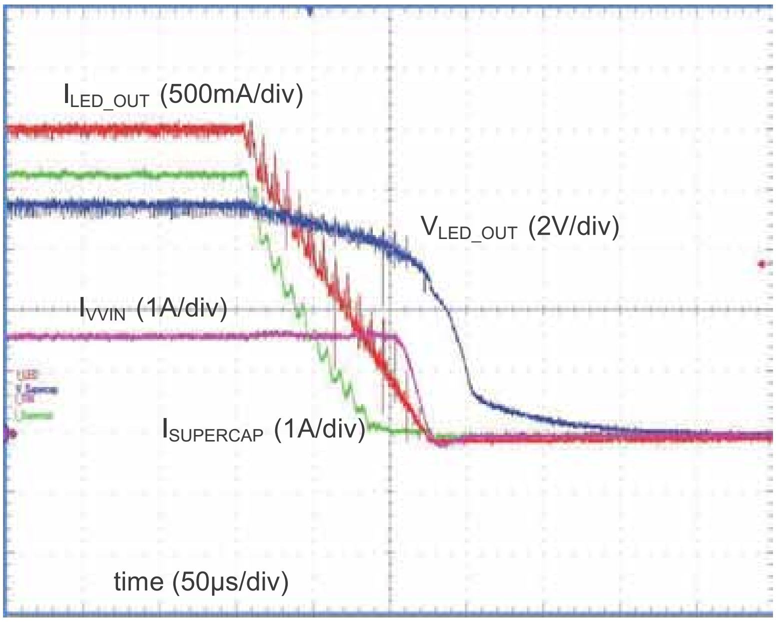
Complete flash cycle: Shows a complete LED flash cycle, flash time=16ms, I_{LED_OUT}=3A, automatic re-charge enabled at end of flash cycle.

Figure AS3630 – 12:
Startup of Flash Cycle



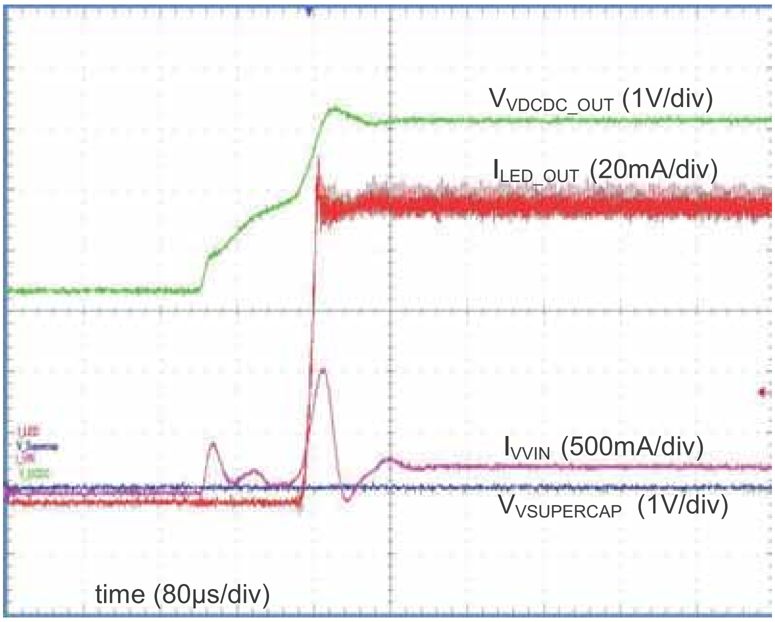
Startup flash cycle: Shows detailed (zoomed) of startup of a flash cycle, I_{LED_OUT}=3A.

Figure AS3630 – 13:
Shutdown of Flash Cycle



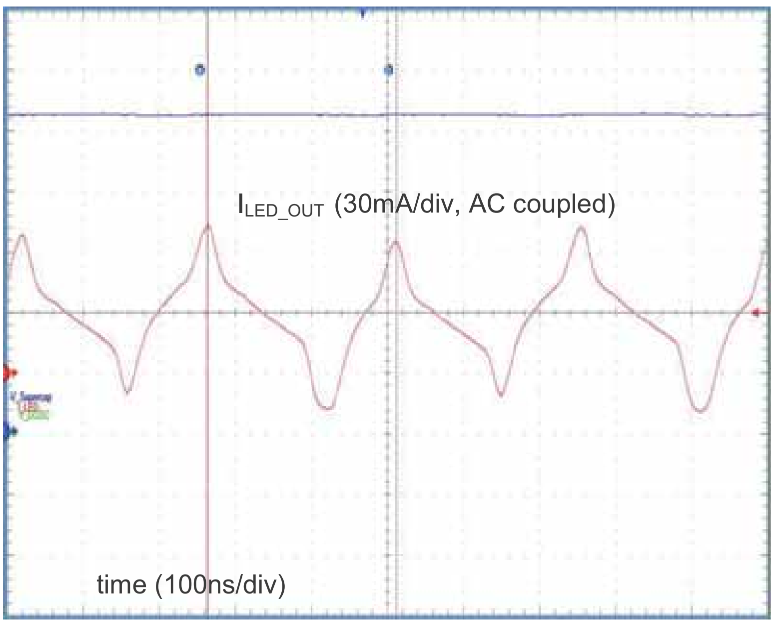
Shutdown flash cycle: Shows detailed (zoomed) of rampdown of a flash cycle, I_{LED_OUT}=2.5A.

Figure AS3630 – 14:
Torch Cycle



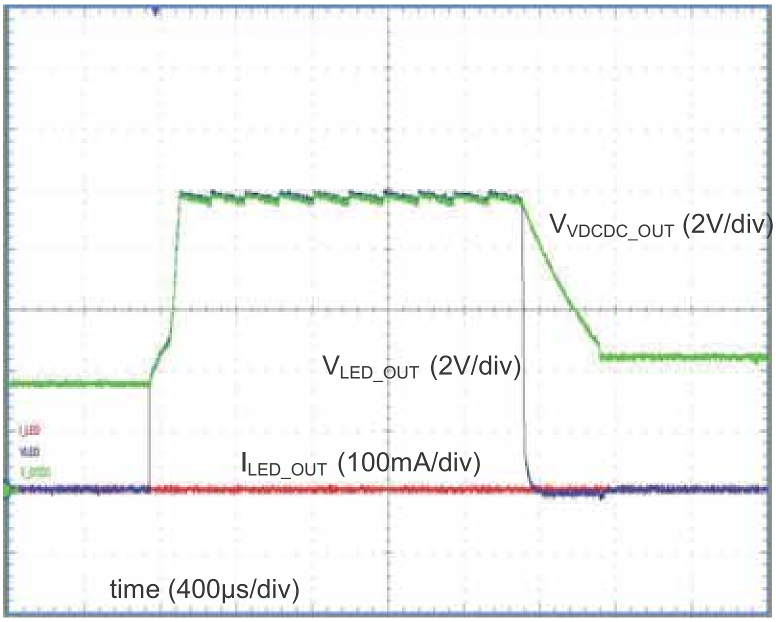
Torch cycle: Shows a torch operation. To operate the torch no charging of the Supercap is required (see voltage on VSUPERCAP), I_{LED_OUT}=100mA.

Figure AS3630 – 15:
ILED_OUT Ripple Waveform



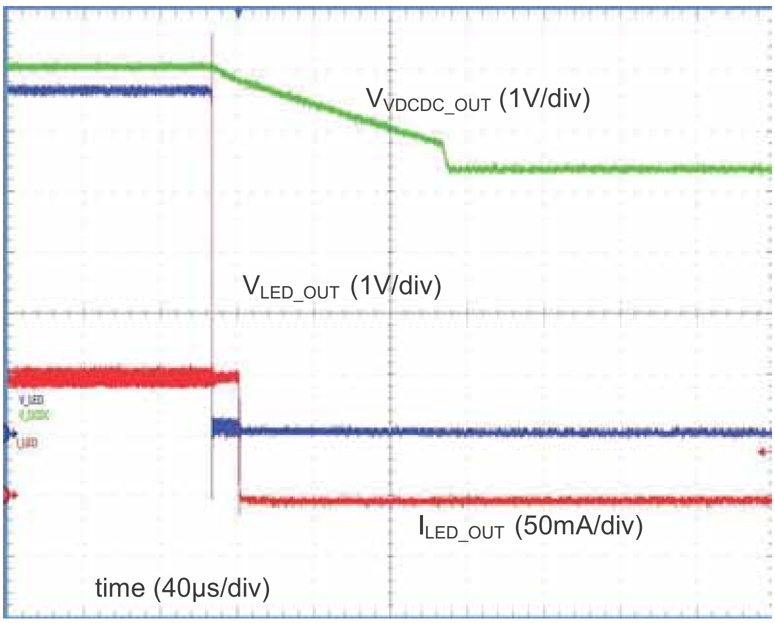
ILED_OUT ripple: Current ripple measured on ILED during flash with I_{LED_OUT}=2A.

Figure AS3630 – 16:
Open LED Detection Waveform



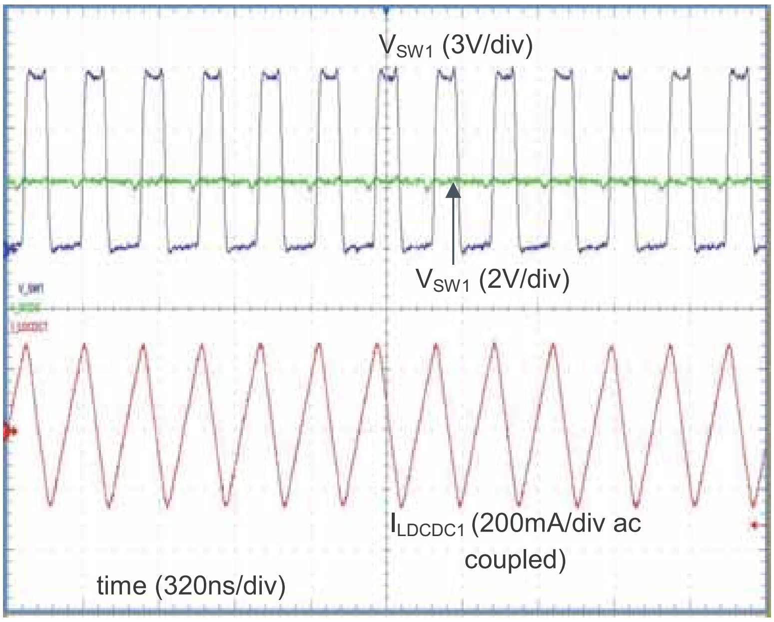
Open LED detection: Detailed measurement for detection of an open LED (LED disconnected) in torch mode.

Figure AS3630 – 17:
Short LED Detection Waveform



Short LED detection: Detailed measurement for detection of a shorted LED (short during operation).

Figure AS3630 – 18:
Switching Waveform



Switching waveform: Detailed measurement of the DCDC converters in operation during flash.

Detailed Descriptions

The AS3630 is a highly efficient dual DCDC Supercap charger charging and balancing the Supercap and operating a LED flash at up to 8A current.

The principle of operation of a AS3630 is as follows:

1. Charge the Supercap on VSUPERCAP to e.g. 5.5V - see Supercap Charging/Discharge/Pre-charge to VIN
2. Torch (or PWM) operation of the LED does not depend on a charge Supercap - see "Torch/PWM Operation" on page 25.
3. Use DCDC1 to step up from VIN to V_{DCDC} to source one part of the LED_OUT current; in parallel use DCDC2 to step up from -VSUPERCAP to V_{DCDC} to source the remaining part of the flash current - see Flash Operation.

Using this approach a very high current flash operation can be performed using considerable low current from the battery (usually batteries have a defined strict current limit, so the full flash current cannot be supplied directly from the battery only).

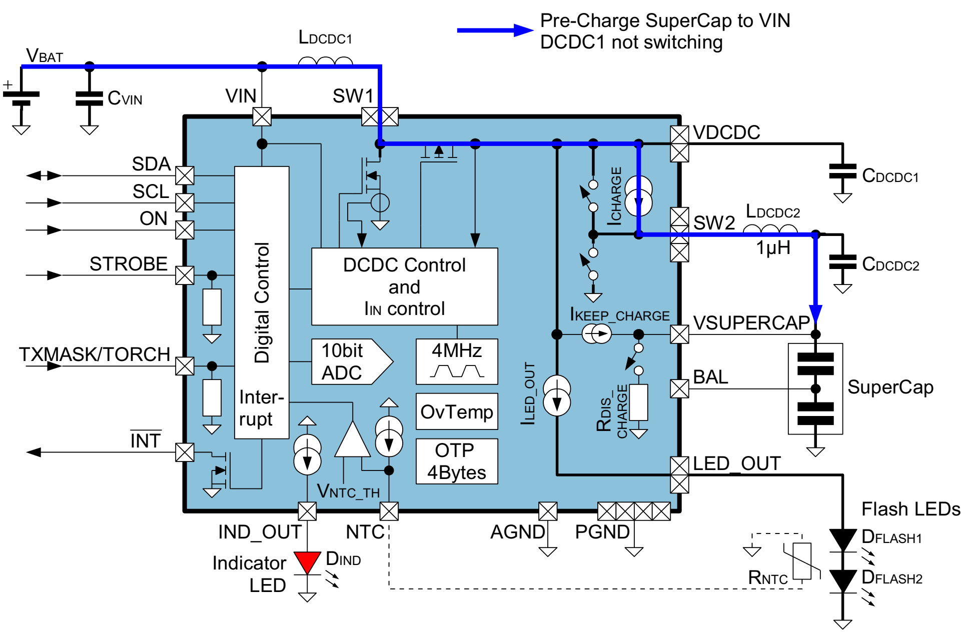
Supercap Charging/Discharge/Pre-charge to VIN

The charging of the Supercap is performed in following steps:

- **Pre-Charge** - (see Figure below): Charge the Supercap close to VIN - initiated by setting mode_setting = Supercap pre-charge[1], [2]:
  The switch between SW1 and V_{DCDC} is closed and I_{CHARGE} (set by charge_current) is used to control the charging current. Use charge_current=00b for a special low power mode only consuming $I_{PRE\_CHARGE\_LOW\_POWER}$.

1. This mode is usually used during standby of the system - the Supercap is kept at VIN; this will reduce the charging time, when the camera is operated and the Supercap has to be charged to its final end of charge voltage (e.g. 5.5V)
2. In pre-charge the Supercap is always charged close to V_{VIN}; therefore VSUPERCAP_EOC ≥ V_{VIN}

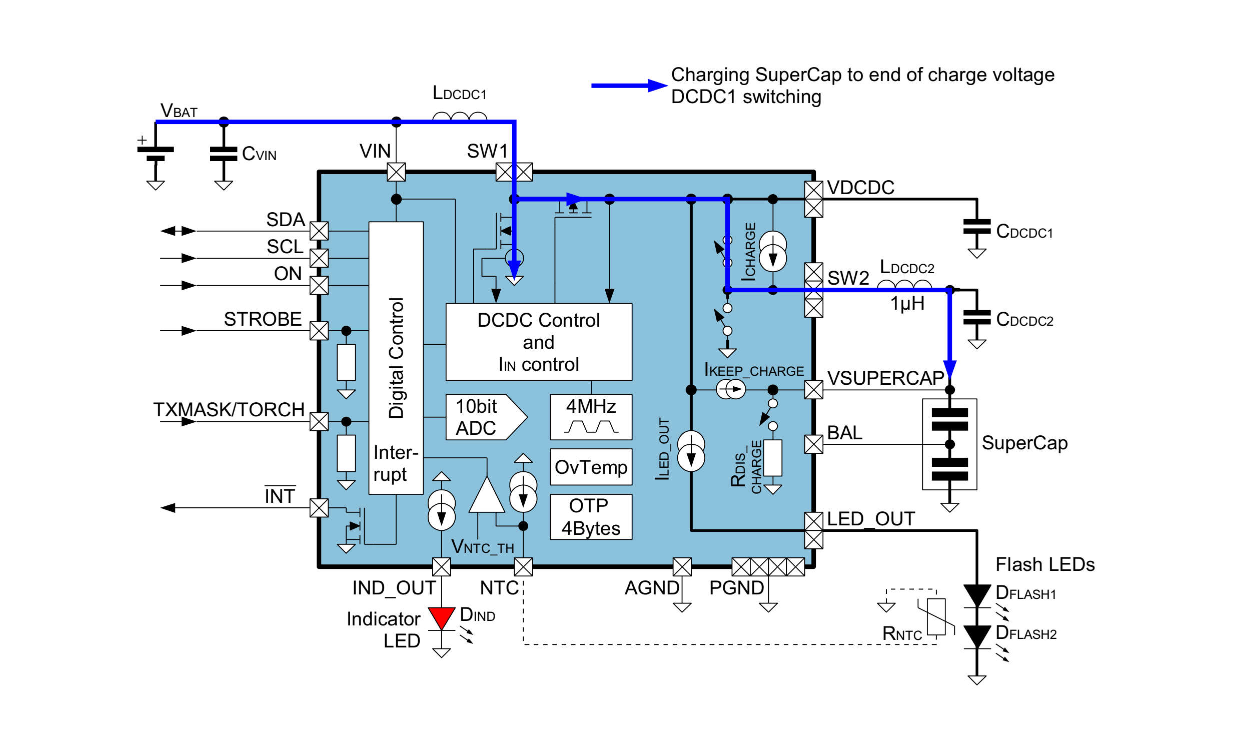
Figure AS3630 – 19:
Supercap Pre-charging



- **Transition**[3] between pre-charge -> charge: Once the voltage on VSUPERCAP is close to V_{VIN} and mode_setting = “Supercap charge”, the DCDC1 converter is started and the current source I_{CHARGE} between V_{DCDC} and VSUPERCAP is used to finally charge VSUPERCAP to V_{VIN}

3. To avoid a current peak at VIN if the VSUPERCAP is connected to VIN, but its voltage is still below VIN

Figure AS3630 – 20:
Supercap Charging



- **Charging** - (see Figure above): Once the voltage on VSUPERCAP ≥ VIN and mode_setting = "Supercap charge", the main charging can start: The DCCD1 converter is operated and the switch between V_{DCDC} and SW2 is closed. The charging current in this phase is defined by the L_{DCDC1} peak current limit (programmed by coil1_peak).
  Once the voltage on VSUPERCAP reaches end_of_charge_voltage[4], the peak current through L_{DCDC1} is reduced to 500mA. Charging is finished when the voltage on VSUPERCAP again reaches end_of_charge_voltage. Then the flash status_eoc is set and if enabled by status_eoc_mask, $\overline{\text{INT}}$ is pulled low.
  If keep_sc_charged=1, AS3630 will continuously check the voltage on VSUPERCAP if it drops below end_of_charge_voltage and automatically recharge the Supercap with 5mA.
- **Keep charge:** Even in torch or PWM operation[5] of the LED connected to LED_OUT the charge on VSUPERCAP can be maintained by setting keep_sc_charged=1. Then the current source I_{KEEP_CHARGE} will be used to charger VSUPERCAP from V_{DCDC} (without exceeding end_of_charge_voltage).

4. In pre-charge the Supercap is always charged close to VVIN; therefore VSUPERCAP_EOC ≥ VVIN
5. In these modes DCDC2 is not used as LED_OUT can be driven directly with DCDC1 from VIN.

- **Shutdown:** Setting mode_setting="shutdown or external torch mode (leave Supercap charged)" will keep the Supercap charged and disables the balancing circuit.It can be forced on if bal_force_on is set. If the voltage voltage on V_{DCDC} is above 5.35V, the Supercap will be discharged until V_{DCDC} is below 5.3V before shutdown mode is entered.
- **Shutdown and Discharge:** Setting mode_setting="shutdown and discharge Supercap" will slowly discharge the Supercap through RDIS_CHARGE[6] .
- **Pre-Charge after Charge or Flash:** Setting mode_setting="pre charge Supercap (to VIN)" will discharge the Supercap to approximately V_{VIN}-0.3V by using RDIS_CHARGE. Afterwards the Supercap is charged to V_{VIN} as shown in Figure 19.

Note: If the Supercap is charged above 5.5V it will be discharged to 5.5V even if the mode is set to "shutdown or external torch mode (leave Supercap charged)" to protect the Supercap.
If during pre-charge, transition or charging operation, the junction temperature exceed T_{OVTEMP}, the operation is temporarily stopped and automatically resumes, when the junction temperature has dropped below T_{OVTEMP}-$T_{OVTEMPHYST}$.

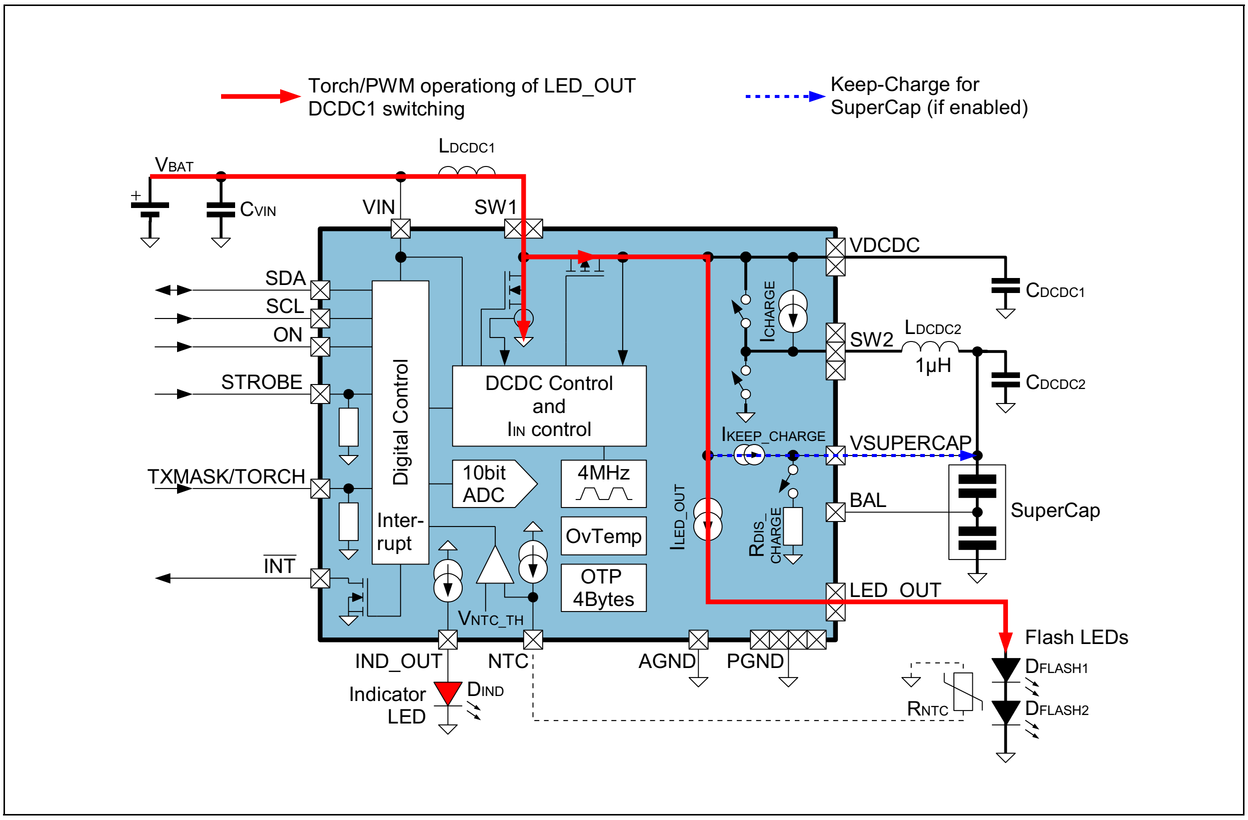
The Supercap balancing circuit keeps both parts of the Supercap at the same voltage level - see Balancing Circuit - Pin BAL.

6. Implemented by a resistor between VSUPERCAP and BAL and another resistor between BAL and GND.

Torch/PWM Operation

Due to its concept, a torch or PWM operation can be performed without even charging the Supercap (this allows instantaneous video light or torch light):

Figure AS3630 – 21:
Immediate Torch (=Video Light) or PWM Operation



After setting mode_setting = "Torch" or "PWM Operation"[7] the step-up DCDC1 converter is used to generate -V_{DCDC} sufficiently high enough to drive the I_{LED_OUT} current (controlled by led_current). If keep_sc_charged (page 51)=1, VSUPERCAP is charged by the current source I_{KEEP_CHARGE} (without exceeding end_of_charge_voltage) to maintain the charge on the Supercap during this operating mode.

7. In PWM operation the current source I_{LED_OUT} is PWM modulated with a duty cycle set by led_out_pwm.