MAX77829 Companion PMIC for Smartphone and Tablet

General Description

The MAX77829 is a high-performance companion PMIC for latest 3G/4G smartphones and tablets. The PMIC includes a single-input 2.0A switched-mode charger with reverse-boost capability and adapter input protection up to 22V (DC) for one-cell Lithium-Ion (Li+) battery, a safeout LDO, and WLED backlight driver supporting up to 25mA/string, 35V output voltage. It also features a dual-channel 1.5A (combined, 750mA/CH) Flash LED driver (with Torch Mode included).

The typical 4MHz switched-mode battery charger with two integrated switches, providing the smallest L/C size, lowest heat and fastest programmable battery-charging current, is ideally suited for portable devices such as headsets and ultra-portable media players. The charger features single input, which works for adapter/USB type inputs. All the MAX77829 blocks connecting to the adapter/USB pin are protected from input overvoltage events. The DC pin is rated to 22V absolute maximum. The USB-OTG output provides true-load disconnect and is protected by an adjustable output current limit (default 900mA, other current limit is also available with different factory setting up to 900mA).

The battery charger drives an external p-channel MOSFET as power-path switch, and its I²C-programmable settings can accommodate a wide range of battery sizes and system loads. When configured in reverse boost mode, the MAX77829 requires no additional inductor to power USB OTG accessories and/or provide illumination to the Flash LED.

The switching charger implements a special CC, CV, and die temperature regulation algorithm; the patented MaxFlash prevents overloading a weak battery, further extending battery life.

The MAX77829 features an I²C 2.0-compatible serial interface consisting of a bidirectional serial data line (SDA) and a serial clock line (SCL).

Benefits and Features

- Highly Integrated Solution
  - Single Input Switched Mode Charger
  - Camera Flash and Torch LED Driver, Dual-Channel 750mA/ch
  - Two-String White LED Backlight Driver, 25mA/ch, 35V OVP
  - One Safeout LDO
- Single High Efficient Switched Mode Charger
  - Supporting Up to 2.0A Charging Current Capability
  - Input-Voltage-Based Automatic Input Current Limit (AICL) Power Management
  - System Voltage Regulator/Battery Charger with External Power Path
  - Various Charging Protection Features
- Single Input Accommodating Standard USB and High Input Voltage Adaptor
  - 22V Absolute Maximum Input Voltage Rating,
  - up to +9.4V Maximum Operating Input Voltage
- USB OTG Capability
  - Reverse Boost Support, Up to 900mA at +5V
  - Programmable Reverse Boost Output Voltage (Up to 5.8V)
- Flexible Programmability
  - I²C 2.0 Serial Interface
- Compact Package
  - 3.64mm x 3.24mm WLP, 8 x 7 Array, 56-Bumps, 0.4mm Pitch

Applications

- Smartphone and Tablets
- Other Li-Ion Battery Power Handheld Devices

Ordering Information ***appears at end of data sheet.***

19-8316; Rev 0; 12/15

maxim integrated™

Absolute Maximum Ratings

DC, BYP to GND .....-0.3V to +22V
LX, BST to GND .....-0.3V to +12V
CS, SYSS, SYS, AVL, PVL, FET_DRV, MBATT, IN_FLED, CHGIND to GND .....-0.3V to +6V
MBATSNSP, MBATSNSN, MBATDET, THM to GND .....-0.3V to +6V
INOK to GND ..... -0.3V to (V_{SYS} + 0.3V)
LX, CHGPG Continuous Current .....$2A_{RMS}$
DC, BYP Continuous Current.....$2A_{RMS}$
FLED to GND ..... -0.3V to (V_{BYP} + 0.3V)
TORCHEN, FLASHEN to GND .....-0.3V to (V_{SYS_A} + 0.3V)
FLED1, FLED2 Current .....$0.8A_{RMS}$
SAFEOUT to GND ..... -0.3V to (V_{DC} + 0.3V)
SAFEOUT Continuous Current 100mA
WLEDOUT, WLED1, WLED2 to GND..... -0.3V to +36V
WLEDGND, WLEDPGND to GND ..... -0.3V to 0.3V
WLEDPWM to GND ..... -0.3V to (V_{SYS} + 0.3V)
WLEDLX Continuous Current .....$1.2A_{RMS}$
VIO to GND .....-0.3V to +6V
SDA, SCL to GND ..... -0.3V to (V_{VIO} + 0.3V)
MRST, RESET, INT to GND .....-0.3V to (V_{SYS_A} + 0.3V)
TEST_, VCCTEST, SYS_ to GND .....-0.3V to +6V
GND_ to GND .....-0.3V to +0.3V
Continuous Power Dissipation (T_A = +70°C)
WLP (derate 25mW/°C above 70°C).....2000mW
Operating Temperature ..... -40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range..... -65°C to +150°C
Soldering Temperature (reflow).....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Package Thermal Characteristics (Note 1)

WLP
Junction-to-Ambient Thermal Resistance (θ_{JA}) .....40°C/W

Note 1: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

Electrical Characteristics

(V_{DC} = 5V, C_{BYP} = 2.2µF, C_{PVL} = C_{AVL} = 10µF, C_{SYS} = 10µF, C_{MBAT} = 4.7µF, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC INPUT						
DC Operating Voltage Range			3.5		V_{OVLO} (min)	V
DC Startup Voltage Range			4.0		V_{OVLO}	V
DC Undervoltage Lockout	V_{UVLO}	DC rising, 500mV hysteresis	3.6	3.8	4.0	V
DC Overvoltage Lockout	V_{OVLO}	DC rising, 3% hysteresis, contact factory for alternate thresholds (5.9V, 7.5V, 9.7V)	6.3	6.5	6.7	V
DC_V Threshold	V_{DC_V}	DC rising, 200mV hysteresis	5.7	5.8	5.95	V
DC Overvoltage Interrupt Delay				16		ms
DC Insertion Debounce Time	t_{DBDC}		100	120	150	ms
DC to SYS Shutdown Threshold		When charging stops, V_{DC} falling, 150mV hysteresis	0	50	100	mV

Electrical Characteristics (continued)

(V_{DC} = 5V, C_{BYP} = 2.2µF, C_{PVL} = C_{AVL} = 10µF, C_{SYS} = 10µF, C_{MBAT} = 4.7µF, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
DC Supply Current	I_{DC}	USB suspend, V_{DC} = 5.5V				0.5	mA
		Charger enabled, f = 4MHz, V_{DC} = 5.5V, V_{SYSMIN} = 3.55V, QBAT off, no load			2		
DC Current Limit	I_{DC_ILIM}	Programmed DCILMT[5:0], minimum			0.1		A
		Programmed DCILMT[5:0], typical			2		
Input Current Limit Accurancy		USB 100mA mode		90	95	100	mA
		USB 500mA mode		450	475	500	
		Programmed to 1.5A		1350	1500	1650	
Adaptive Input Current Limit (AICL) Voltage Threshold	V_{DC_AICL}	DC voltage where charging current is regulated, programmable from 4.0V to 4.6V in 100mV increments (4.5V setting)		4.410	4.5	4.635	V
		DC voltage where the charging current is reset to its minimum value (75mA), AICL_RESET=0			V_{DC_AICL} - 0.1		V
Input Limit Switch		V_{DC} = 5.5V, I_{BYP} = 100mA			50	100	mΩ
LEAKAGE CURRENT							
BST Leakage Current		V_{BST} = V_{LXCHG} = 5.5V, V_{DC}= V_{PGCHG}, V_{SYS} = 3.7V	T_A = +25°C		0.01	10	µA
			T_A = -40°C to +85°C		0.1		
MBATT Reverse-Leakage Current		V_{MBAT} = 4.2V, V_{DC} = 0V	T_A = +25°C		0.01	10	µA
			T_A = -40°C to +85°C		0.1		
BUCK CONVERTER OPERATION							
Switching Frequency		V_{MBAT} = 3.7V			4		MHz
Max Duty Cycle						99.5	%
Minimum On-Time					35		ns
Maximum On-Time					10		µs
Minimum Off-Time					35		ns
Soft-Start Time					1.5		ms
High-Side Resistance		I_{LX} = 100mA, V_{DC} = 5.5V			130	250	mΩ
Low-Side Resistance		I_{LX} = 100mA, V_{DC} = 5.5V			150	220	mΩ
Thermal Regulation Temperature		Programmable-2 bits, see the REGTEMP[1:0]	Minimum		75		°C
			Maximum		120		
			Step size		15		
BATTERY CHARGER							
Pre-Charge Lower Threshold	V_{PQLTH}	V_{MBATT} rising, 125mV hysteresis, contact the factory for alternative selection for 2.1V, 2.2V, 2.3V, 2.4V, 2.5V, 2.6V, 2.7V, 2.8V			2.1		V
Dead-Battery Charge Current	I_{PQLTH}	0V ≤ V_{MBAT} ≤ V_{PQLTH}			40		mA

Electrical Characteristics (continued)

(V_{DC} = 5V, C_{BYP} = 2.2µF, C_{PVL} = C_{AVL} = 10µF, C_{SYS} = 10µF, C_{MBAT} = 4.7µF, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Precharge Upper Threshold	V_{PQUTH}	V_{MBAT} rising, 150mV hysteresis, contact the factory for alternative settings			3.4		V
Precharge Current	I_{PRECHG}	Contact factory for alternative settings, 100mA, 200mA, 300mA, 400mA) with 200mA as default setting			200		mA
CONSTANT CURRENT MODE							
BATT Fast-Charge Current Range	I_{FCHG}	Programmable 50mA steps, RCS = 47mΩ	Minimum		250		mA
			Maximum		2000		
Fast-Charge Current Accuracy (Voltage Across R_{CS})		11.5mV < V_{RCS} < 70.5mV R_{CS} = 47mΩ, V_{RCS} = R_{CS} x I_{CHG}	T_A = +10°C to +45°C	-5		+5	%
			JEITA Safety Region	-65	-50	-35	
CONSTANT VOLTAGE MODE							
Battery Regulation Voltage Range		Programmable with MBATREG[3:0]	Minimum		3.55		V
			Maximum		4.4		
Battery Regulation Voltage Accuracy	V_{MBATT}	When the charger is regulating battery voltage (i.e. top-off mode or fast-charger constant voltage mode), then it will regulate based on MBATREG[3:0]. Charger is regulating battery voltage , $V_{MBATREG}$ = 4.2V (MBATREG[3:0]=0b1011), $V_{MBATREG}$ = 4.35V (MBATREG[3:0]=0b1111)	T_A = +25ºC	-0.5		+0.5	%
			T_A = -40ºC to +85ºC	-1		+1	
			When JEITA is enabled (JEITA_EN=1) and the battery temperature is in the "COOL" Region, the battery regulation voltage will be this much lower than the value programmed by MBATREG[3:0].		150		mV
Battery Refresh Threshold		$V_{MBATREG}$ = 4.2V (MBATREG[3:0]=0b1011), $V_{MBATREG}$ = 4.35V (MBATREG[3:0]=0b1111) After the charger enters the DONE state, it will restart when the battery falls this percentage below $V_{MBATREG}$ (MBATREG[3:0])	CHGRSTRT = 0	1	3	5	%
			CHGRSTRT = 1	2	4	6	
Battery Overvoltage Protection	V_{MBAT_OVP}	$V_{MBATREG}$ = 4.2V (MBATREG[3:0]=0b1011), $V_{MBATREG}$ = 4.35V (MBATREG[3:0]=0b1111) VMBATT threshold over regulation voltage, hysteresis 2.2% (V_{BAT} falling)		102	104	106	%

Electrical Characteristics (continued)

(V_{DC} = 5V, C_{BYP} = 2.2µF, C_{PVL} = C_{AVL} = 10µF, C_{SYS} = 10µF, C_{MBAT} = 4.7µF, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Charge Current Termination Threshold Range	I_{DONE}	I^2C programmable, see I_{TOPOFF}[2:0]. I_{DONE} current independent of JEITA functionality	Minimum		50		mA
			Maximum		400		
			Step size		50		
Charge Current Termination Deglitch Time		2mV overdrive			16		ms
Charge Current Termination Accuracy		I_{DONE} = 200mA		180		224	mA
		I_{DONE} = 50mA		35		70	
VICHG							
VICHG Output Voltage		V_{ICHG_GAIN} = 0, 1.41mV/mA	I_{OUT} = 50mA		70.5		mV
			I_{OUT} = 1000mA	1260	1410	1540	
			I_{OUT} = 1500mA		2150		
CHARGER TIMER							
Dead-Battery and Precharge Time	t_{PRECHG}	USB 500mA mode (t_{PRECHG_500})			14	16	min
		USB 100mA mode (t_{PRECHG_100})			39	45	
Fast-Charge Time Range	t_{FCHG}	I^2C programmable, refer to FCHGTIME[2:0] for detailed values	Minimum		4		hour
			Maximum		16		
Fast-Charge Timer Accuracy		Default 5 hours setting			5	6	hour
Top-Off Time	t_{TOPOFF}	I^2C programmable (See the T_{OPOFFT}[2:0])	Minimum		0		min
			Maximum		60		
			Step size		10		
Top-Off Timer Accuracy		Default 30 minute setting			20		%
Timer Extend Current Threshold		Percentage of fast-charge current below which the timer clock operates at half-speed (when JEITA is enabled)			50		%
REVERSE BOOST							
BYP Reverse Boost Voltage Adjustment Range		Programmable with RBOUT[3:0], 2.6V < V_{SYS} < V_{BYP} - 0.5V	Minimum		3.0		V
			Maximum		5.8		
			Step size		0.025		
Reverse Boost Quiescent Current		Switching			2.1		mA
Reverse Boost Voltage Accuracy		5.1V setting, 0mA < I_{LOAD} < 500mA		4.94	5.1	5.36	V
Reverse Boost Converter Maximum Output Current		V_{SYS} = 3.7V(minimum required SYS voltage to guarantee the boost output current)		1500			mA

Electrical Characteristics (continued)

(V_{DC} = 5V, C_{BYP} = 2.2µF, C_{PVL} = C_{AVL} = 10µF, C_{SYS} = 10µF, C_{MBAT} = 4.7µF, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Reverse Boost Output Voltage Ripple		Discontinuous inductor current (i.e. skip mode)			±50		mV
		V_{BAT} = 3.6V, V_{BYP} = 5.5V, I_{BYP} = 100mA			±50		mV
DC Output Capacitor		Device included				22	µF
Maximum DC Output Current		V_{SYS} = 3.7V		900			mA
DC Output Current Limit	OTGILIM			1000		1970	mA
OTGILIM Interrupt Debounce					30		ms
Reverse Boost Output Voltage Ripple		When DC output current hits OTGILIM	Retry on-time		0.5		ms
			Retry off-time		330		
Inductor Peak Current Limit				3.49	3.9	4.40	A
BYP_UVLO		Falling		4.30	4.35	4.45	V
BYP_UVLO Hysteresis					150		mV
BAT-SYS-FET DRIVER							
FET_DRV Output High		I_{SOURCE} = -1mA		V_{PVL} - 0.2			V
FET_DRV Output Low		I_{SINK}= 1mA				0.2	V
Minimum V_{SYS} Regulation Voltage Range	V_{SYSMIN}	Programmable with V_{SYSREG}[2:0]	Minimum		3.0		V
			Maximum		3.6		
			Step size		0.1		
MBATT to SYS FET Turn-On Threshold		Turn-on threshold (V_{MBATT} rising)			V_{PQUTH}		V
		Turn-off threshold (V_{MBATT} falling)			V_{PQUTH} - 0.15		V
Supplement Mode Threshold Level		Entering supplement mode when V_{SYS} < V_{BAT}		25	40	50	mV
		Exiting supplement mode		10			mV
BATTERY OVERCURRENT THRESHOLD							
Battery Overcurrent Threshold Alarm		$R_{BATRSNS}$ = 5mΩ, BAT2SOC[1:0] = 4.0A setting, overcurrent from BAT to SYS sensed through the 5mΩ resistor, it does not shut off external FET, but provides an overcurrent interrupt through BAT_I to the processor		16	20	24	mV
Battery Overcurrent Debounce Time		4ms setting (programmable from 4ms to 10ms)		3.8	4.0	4.2	ms

Electrical Characteristics (continued)

(V_{DC} = 5V, C_{BYP} = 2.2µF, C_{PVL} = C_{AVL} = 10µF, C_{SYS} = 10µF, C_{MBAT} = 4.7µF, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
BATTERY DETECTION							
Low-Cost Battery Presence Detection Voltage		V_{INI2C} = 1.8V, $V_{\overline{MBATDET}}$ rising, 60mV hysteresis		1.063	1.1	1.136	V
				59.1	61.1	63.1	% V_{INI2C}
High-Cost Battery Presence Detection Voltage		V_{INI2C} = 1.8V, $V_{\overline{MBATDET}}$ rising, 20mV hysteresis		1.454	1.5	1.536	V
		Turn off threshold (V_{MBATT} falling)		80.8	83.3	85.3	% V_{INI2C}
Battery Disconnect Detection Voltage		V_{INI2C} = 1.8V, $V_{\overline{MBATDET}}$ rising, 60Mv hysteresis		1.621	1.65	1.676	V
		Turn-off threshold (V_{MBATT} falling)		90.1	91.6	93.1	% V_{INI2C}
Battery Detection Debounce Timer (BAT_REMOVED)		Programmable with TDEB_BATREM[4:0]	Minimum		0		µs
			Maximum		976		
			Step Size		30.5		
Strong Pullup Resistor		STRONGPUENB=0		2.4	4.7	9.4	kΩ
$\overline{MBATDET}$ Leakage Current		V_{INI2C} = 5.5V, $V_{\overline{MBATDET}}$ = 0V T_A = +25°C		-1	0.01	+1	µA
		V_{INI2C} = 5.5V, $V_{\overline{MBATDET}}$= 0V T_A = +85°C			0.1		
THERMISTOR MONITOR (Thresholds are calculated for R25 = 100kΩ and β = 4050K)							
THM Threshold, Cold, No Charge (-7°C)	T1	V_{THM}/V_{AVL} rising, 2% hysteresis (thermistor temperature falling)		75.4	77.9	80.4	%
THM Cool Threshold (10°C)	T2	V_{THM}/V_{AVL} rising, 2% hysteresis (thermistor temperature falling), Disabled through JEITA_EN register		61.5	64	66.5	%
THM Warm Threshold (45°C)	T3	V_{THM}/V_{AVL} falling, 2% hysteresis (thermistor temperature rising) , Disabled through JEITA_EN register		30.47	32.97	35.47	%
THM Threshold, Hot, No Charge (56°C)	T4	V_{THM}/V_{AVL} falling, 2% hysteresis (thermistor temperature rising)		23.1	25.6	28.1	%
THM Leakage Current		V_{THM} = V_{AVL} or 0V	T_A = +25°C	-0.2	+0.01	+0.2	µA
			T_A = +85°C		0.1		

Electrical Characteristics (continued)

(V_{DC} = 5V, C_{BYP} = 2.2µF, C_{PVL} = C_{AVL} = 10µF, C_{SYS} = 10µF, C_{MBAT} = 4.7µF, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
PVL/AVL OUTPUTS							
Dropout Voltage	V_{DO}	V_{SYS} = 3.6V, I_{AVL} = 30mA, V_{DO} = V_{BYP} - V_{AVL}	V_{DC} = 4.5V		50		mV
			V_{DC} = 0V		18		
Current Limit					400		mA
Maximum Output Current	I_{AVLMAX}			100			mA
AVL/PVL POK Output Threshold		Threshold where internal power rails to charger turns on			2.7		V
AVL/PVL Regulated Output		I_{AVL} = 0V to I_{PVLMAX}, V_{DC} = 5.5V		4.75	5.00	5.25	V
INOK							
Output Low Voltage		I_{SINK} = 1mA				0.4	V
Output High Leakage		V_{SYS} = 5.5V	T_A = +25°C	-1	0	+1	µA
			T_A = +85°C		0.1		
CHGIND							
Output Low Voltage		I_{SINK} = 10mA				0.4	V
Output High Leakage		V_{SYS} = 5.5V	T_A = +25°C	-1	0	+1	µA
			T_A = +85°C		0.1		
THERMAL SHUTDOWN							
Thermal Shutdown Temperature					160		°C
Thermal Shutdown Hysteresis					15		°C
BYP to IN_FLED SWITCH							
IN_FLED Switch Resistance		V_{BYP} = 5.0V, loading = 150mA			160	320	mΩ

LED Flash Driver EC Characteristics

(V_{SYS} = 3.7V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
FLASH DC-DC STEP-UP CONVERTER (Shared with switch mode charger)						
Adaptive Control Range	V_{IN_FLED}	Adaptive controlled	3.3		5.5	V
Adaptive Output Voltage Regulation Threshold		$V_{IN\_FLED-VFLED\_}$, $I_{FLED\_}$ = 750mA		250		mV
Adaptive Regulation Step Size		Smallest step that the output will regulate to		25		mV

LED Flash Driver EC Characteristics (continued)

(V_{SYS} = 3.7V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
FLED CURRENT REGULATOR							
IN_FLED Supply Current					1.1		mA
Current Setting for FLED_ (i.e., FLED1 or FLED2)		Current range in Flash mode in 23.436mA/step, powered from IN_FLED (FLED1NUM=0)		23.436		750	mA
		Current range in Torch mode in 23.436mA/step		23.436		375	
Current Accuracy		93mA setting; V_{BYP} = 5V; $V_{FLED\_}$ = 4.2V	T_A = +25°C	-2.5		+2.5	%
			T_A = -40°C to +85°C	-4.5		+6.5	
Current Regulator Dropout		750mA setting, 10% drop in output current, V_{BYP} = 3.3V			220	350	mV
		750mA setting, 1% drop in output current, V_{BYP} = 3.3V			220		
Turn-Off Time		From FLASHEN falling edge or TORCHEN falling edge or timer expire until ramping of current on FLED1/FLED2				1.5	µs
FLED1/FLED2 Current Ramping Down		Time taken for ramping current from 750mA setting to OFF setting			2		µs
FLED1/FLED2 Leakage in Shutdown		V_{IN_FLED} = 5.5V, $V_{FLED\_}$ = 0V	T_A = +25°C		0.01	5	µA
			T_A = +85°C		0.1		µA
PROTECTION CIRCUITS							
Flash Duration Timer		In 62.5ms steps		62.5		1000	ms
Flash Duration Timer Accuracy				-10		+10	%
Flash Safety Timer Reset Inhibit Period		From falling edge of FLASHEN or TORCHEN or register bits until flash safety timer is reset		450		700	µs
Torch Timer Range (Can be Disabled via I²C Programming)		In 0.262s steps		0.262		1.049	s
		In 0.524s steps		1.048		3.146	
		In 1.049s steps		3.145		7.340	
		In 2.097s steps		7.340		15.729	
Torch Timer Accuracy				-10		+10	%
Open LED Protection Threshold		FLED1 enabled			V_{IN_FLED} – 30mV		mV
Shorted LED Protection Threshold		FLED				1.0	V
FLED_ Short Debounce Timer		From FLED_ short detected until FLED_ current regulator is disabled – FLED_ source is disabled after this timer to prevent excessive battery current			1		ms
FLED_ Open Debounce timer		From FLED_ open detected until FLED_ current regulator is disabled – IN_FLED voltage is limited to 5.8V max – FLED_ current source is disabled after this timer			8		ms

LED Flash Driver EC Characteristics (continued)

(V_{SYS} = 3.7V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
MAXFLASH						
Low SYS Detect Threshold Range		In 33mV steps	2.400		3.433	V
Low SYS Voltage Threshold Accuracy				± 2.5		%
Low SYS Voltage Hysteresis Programmable Range		In 100mV steps	100		300	mV
Low SYS Inhibit Timer			256		2048	ms
		Rising in 256µs steps	256		2048	
Low SYS Inhibit Time Accuracy			-10		+10	%
FLASHEN, TORCHEN INPUTS						
Pulldown Resistor			400	800	1600	kΩ
Input Capacitance		(Note 3)		10		pF
Input Low Voltage	V_{IL}				0.54	V
Input High Voltage	V_{IH}		1.26			V

Safeout LDO

(V_{DC} = 5V, V_{BATT} = 3.8V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SAFEOUT						
Output Voltage (Default ON)		5.0V < V_{DC} < 5.5V, $I_{SAFEOUT}$ = 10mA, SAFEOUT[1:0] = 01'b (default)	4.65	4.9	5.15	V
		SAFEOUT[1:0] = 00'b		4.85		V
		SAFEOUT[1:0] = 10'b		4.95		V
		SAFEOUT[1:0] = 11'b		3.3		V
Maximum Output Current			60			mA
Output Current Limit				150		mA
Dropout Voltage		V_{CHGIN} = 5V, I_{OUT} = 60mA		120		mV
Load Regulation		V_{CHGIN} = 5.5V, 30µA < I_{OUT} < 30mA		50		mV
Quiescent Supply Current		Not production tested		72		µA
Output Capacitor for Stable Operation (Note 3)		0µA < $I_{SAFEOUT}$ < 30mA, maximum ESR = 50mΩ	0.7	1		µF
Internal Off-Discharge Resistance				1200		Ω

White LED Backlight Driver

(V_{SYS} = 3.7V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
STEP-UP WLED DRIVER							
Input Voltage Range				2.5		V_{OVLO}	V
Step-Up Converter Quiescent Current		No switching, includes 20µA for each current source			200		µA
Step-Up Converter Shutdown Current		V_{SYS} = 5.2V, All current sources disabled				1	µA
Current Source Quiescent Current		$V_{WLEDOUT}$ = 20V, change in quiescent current when 1 current source is enabled or disabled			20		µA
Step-Up Converter Switching Frequency		BSTEN = 1, LEDPWM duty cycle > 0	WLEDFOSC = 00		0.667		MHz
			WLEDFOSC = 11		1		
Maximum Duty Cycle		WLEDFOSC[1:0] =11		93			%
Soft-Start Duration					10		V/ms
Output Voltage Range				V_{BAT}		35	V
Overvoltage Protection Threshold			WLEDOVP = 1	34.1			
WLEDOUT Leakage Current		$V_{WLEDOUT}$ = 5.5V, V_{SYS} = 5.2V, boost in shutdown (Note 3)	T_A = +25°C		0.12		µA
			T_A = +25°C		2		µA
		$V_{WLEDOUT}$ = 35V, V_{WLEDLX} = 35V, boost in shutdown			25		µA
Current Source Linear Output Range		8-bit linear dimming range (97.656µA/LSB)		0		25	mA
Current Source Dropout Voltage		$I_{WLED\_}$ = 25mA (programmed), ($V_{WLED\_}$ - $V_{WLEDGND}$) measured when $I_{LED\_}$ has dropped to 90% of full-scale programmed level, $V_{WLEDOOUT}$ = 20V, T_A = +25°C			100	180	mV
WLED Current Accuracy		$I_{WLED\_}$ = 25mA, $V_{WLED\_}$ = 0.5V above $V_{WLEDGND}$, $V_{WLEDOUT}$ = 20V, T_A = +25°C		-1		+1	%
WLED Current Matching		Mismatch between W_{LED1} and W_{LED2}, $I_{WLED\_}$ = 25mA, (V_{WLED} - $V_{WLEDGND}$) = 0.5V, $V_{WLEDOUT}$ = 20V, T_A = +25°C		-1		+1	%
WLED Leakage Current in shutdown		$V_{WLEDOUT}$ = 35V, $V_{WLED\_}$ = 35V	T_A = +25°C		0.1	1	µA
			T_A = +85°C		1		µA
WLEDLX Leakage Current		V_{WLEDLX} = 35V, $V_{WLEDOUT}$ = 35V	T_A = +25°C	-5	+0.1	+5	µA
			T_A = +85°C		1		µA
N-Channel On-Resistance		I_{WLEDLX} = 175mA			400		mΩ

White LED Backlight Driver (continued)

(V_{SYS} = 3.7V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
N-Channel Current Limit		Current regulation mode	935	1100	1265	mA
WLED_ Voltage Regulation Maximum		($V_{WLED\_}$ - $V_{WLEDGND}$) below dropout voltage level of highest string		50		mV
WLED_ Voltage Regulation Window		Nonskip mode		125		mV
		Skip mode		487.5		mV
WLEDPWM Input Frequency Range		External PWM input	5		60	kHz
WLEDPWM Input Duty Cycle Range			0		100	%
WLEDPWM Input Current Dimming Range		PWM Duty = 0% to 100%	0		25	mA
WLEDPWM Input Current		V_{SYS} = 2.5V to 5.2V, $V_{WLEDPWM}$ = 0V and 5.2V	-1		+1	µA
WLEDPWM Input Logic High		V_{SYS} = 2.5V and 5.2V	1.2			V
WLEDPWM Input Logic Low		V_{SYS} = 2.5V and 5.2V			0.4	V

General, I2C, Logic, and Thermal

(V_{SYS} = 3.7V, V_{IO} = 1.8V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Shutdown Supply Current	I_{SYS}	All circuits off		15	30	µA
SYS INPUT RANGE						
SYS Operating Voltage		Guaranteed by $V_{SYSUVLO}$ and $V_{SYSOVLO}$	2.8		5	V
SYS Undervoltage Lockout Threshold (SYS UVLO)		V_{SYS} falling, 200mV hysteresis	2.45	2.5	2.55	V
SYS Overvoltage Lockout Threshold (SYS OVLO)		V_{SYS} rising, 200mV hysteresis	5.2	5.36	5.52	V
Low SYS Thresholds		Range programmable via LSDAC register, V_{SYS} falling	2.60		3.35	V
Low SYS Hysteresis		Range programmable via LSHYST register	100		400	mV
THERMAL SHUTDOWN						
Thermal Shutdown Threshold		T_J rising		165		°C
Thermal Shutdown Hysteresis				15		°C
Thermal Interrupt 1				120		°C
Thermal Interrupt 2				140		°C

General, I2C, Logic, and Thermal (continued)

(V_{SYS} = 3.7V, V_{IO} = 1.8V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
LOGIC AND CONTROL INPUTS							
SCL, SDA Input Low Level		T_A = +25°C				0.3 x V_{IO}	V
SCL, SDA Input High Level		T_A = +25°C		0.7 x V_{IO}			V
SCL, SDA Input Hysteresis		T_A = +25°C			0.05 x V_{IO}		V
SCL, SDA Logic Input Current		V_{IO} = 3.6V		-10		+10	µA
SCL, SDA Input capacitance					10		pF
SDA Output Low Voltage		Sinking 20mA				0.4	V
Output Low Voltage $\overline{RESET}$, $\overline{INT}$		I_{SINK} = 1mA				0.4	V
$\overline{MRST}$ Input Low Level		T_A = +25°C				0.4	V
$\overline{MRST}$ Input High Level		T_A = +25°C		1.4			V
$\overline{MRST}$ Input Hysteresis		T_A = +25°C			0.1		V
$\overline{MRST}$ Input Current		V_{SYS} = 5.5V	T_A = +25°C	-2	0	+2	µA
			T_A = +85°C		0.1		
Output High Leakage $\overline{RESET}$, $\overline{INT}$		V_{SYS} = 5.5V	T_A = +25°C	-1	0	+1	µA
			T_A = +85°C		0.1		
Interrupt Debounce Filter Timer		LOWSYS			16		ms
$\overline{RESET}$ Deassert Delay					60		ms
Manual Reset Debounce Timer		The period between ($\overline{MRST}$ = Low) and automatic reboot start			3		s
					4		
					5		
					6		
					7 (default)		
					8		
					9		
					10		

General, I2C, Logic, and Thermal (continued)

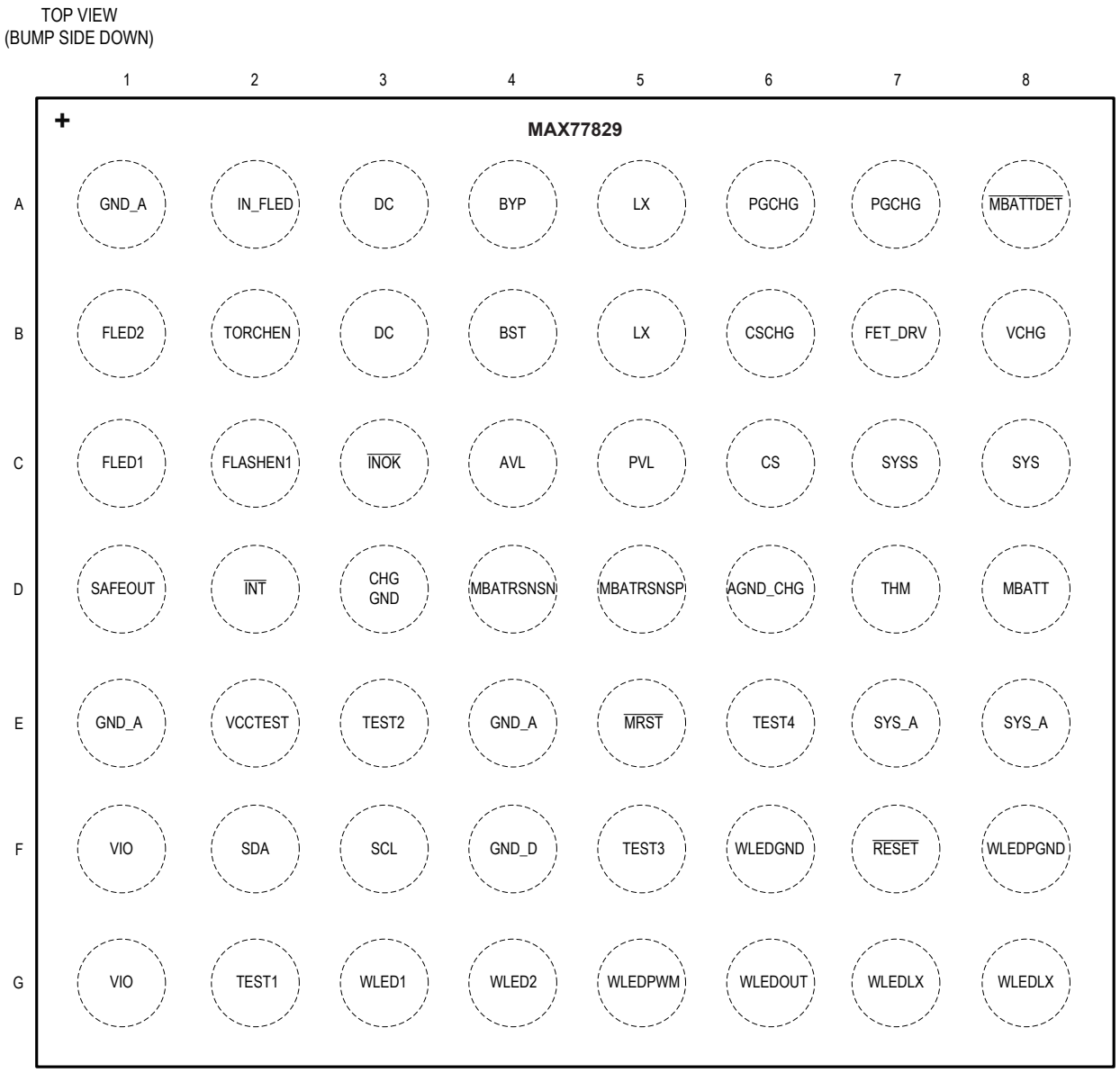
(V_{SYS} = 3.7V, V_{IO} = 1.8V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
I²C INTERFACE (Note 3)						
Clock Frequency			100		400	kHz
Bus-Free Time Between START and STOP			1.3			µs
Hold Time Repeated START Condition			0.6			µs
SCL Low Period			1.3			µs
SCL High Period			0.6			µs
Setup Time Repeated START Condition			0.6			µs
SDA Hold Time			0			µs
SDA Setup time			100			ns
Maximum Pulse Width of Spikes that Must be Suppressed by the Input Filter of Both SDA and SCL Signals				50		ns
Setup Time for STOP Condition			0.26			µs

Note 2: Limits are 100% tested at T_A = +25°C. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization.

Note 3: Note production tested. Guaranteed by design.

Bump Configuration



WLP
(0.4mm pitch)

N.C. PINS ARE FLOATING AND CAN BE CONNECTED AT BOARD-LEVEL IF NEEDED. GROUND ALL TEST PINS (TEST_ AND VCCTEST).

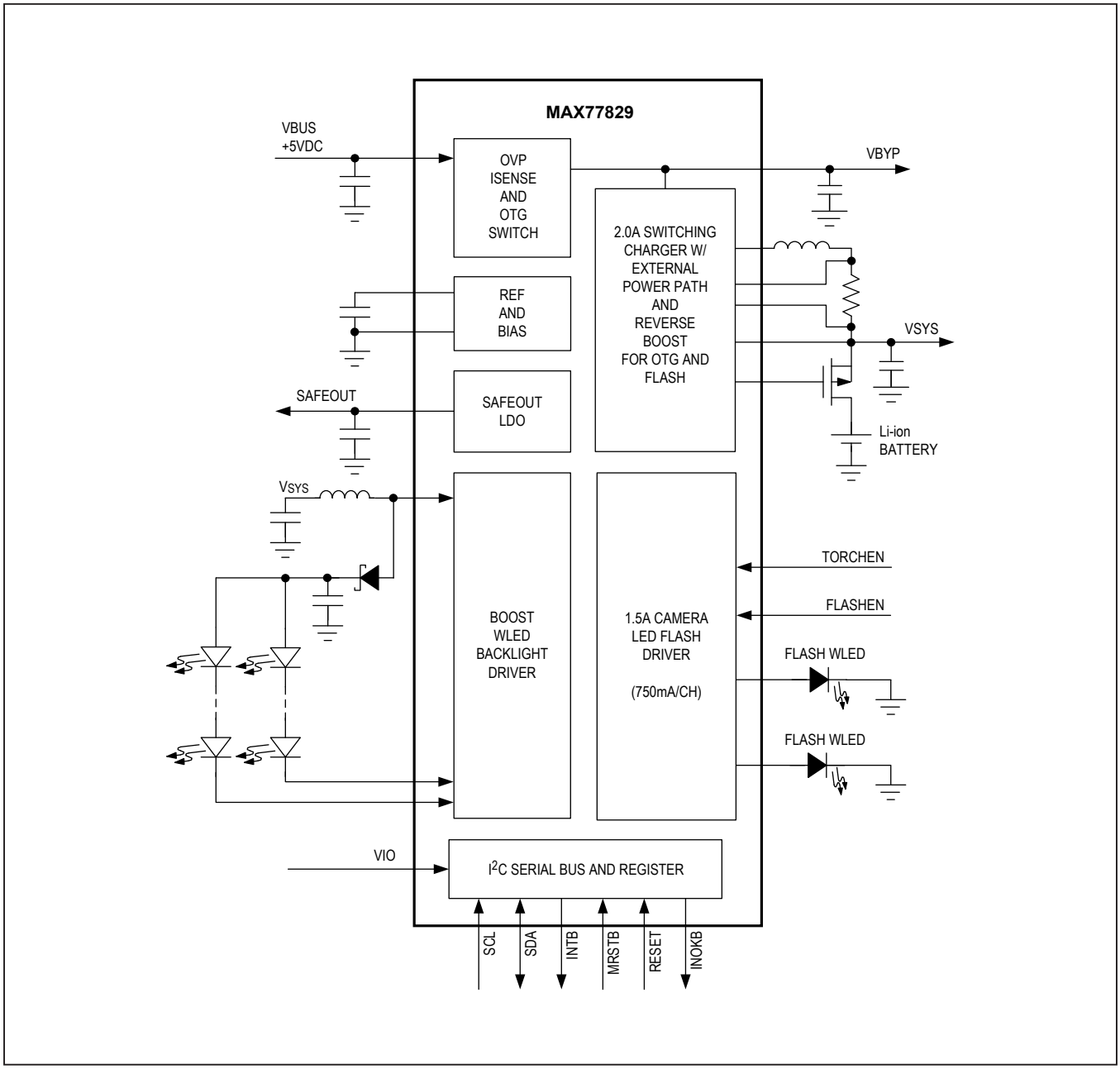
Bump Description

BUMP	NAME	FUNCTION
A3, B3	DC	High-Current Charger Input. Bypass to PGNDC with a 1µF/25V ceramic capacitor. Reverse Boost output.
A4	BYP	Connection Point Between Reverse Blocking MOSFET and High-Side Switching MOSFET. Bypass to PGND with a 4.7µF/25V ceramic capacitor. Reverse boost regulation node.
A5, B5	LX	Buck/Boost Inductor Connection. Connect the inductor between LXCHG and CS.
A6, A7	PGCHG	Power Ground for Charger Step-Down Low-Side FET.
A8	$\overline{\text{MBATDET}}$	Battery Detection Active-Low Input. Connect $\overline{\text{MBATDET}}$ to the ID pin on the battery pack. If $\overline{\text{MBATDET}}$ is pulled to ground, this indicates that the battery is present and the charger starts when valid DC power is present. $\overline{\text{MBATDET}}$ driven high or left unconnected indicates that the battery is not present and the charger will not start. $\overline{\text{MBATDET}}$ is pulled high to AVL through an internal 470kΩ resistor.
B4	BST	High-Side FET Driver Supply. Bypass BST to LXC with a 0.1µF ceramic capacitor.
B6	GSCHG	IC Substrate Ground
B7	FET_DRV	Battery FET Gate Driver
B8	VICHG	Charging Current Monitor
C3	$\overline{\text{INOK}}$	Charger Input Valid Logic Output Flag. Open-drain, active-low output that indicates when valid voltage is present at both CHGIN and SYS. This signal is often needed by the main PMIC or the applications processor.
C4	AVL	Internal Bias Regulator Quiet Analog Bypass Pin. Internal 10Ω connection between PVL and AVL forms LP filter with a 4.7µF external bypass capacitor to GNDCHG.
C5	PVL	Internal Bias Regulator High-Current Output Bypass Pin. Supports internal noisy and high-current gate drive loads. Bypass to PGNDCHG with a minimum 4.7µF ceramic capacitor.
C6	CS	Charger Current Sense Positive Terminal
C7	SYSS	Charger Current Sense Negative Terminal and System Voltage Sense Terminal
C8	SYS	System Power For Linear Charger. Boost supply during startup.
D3	CHGIND	Charging Status Indication. Open-drain, active-low output that indicates when the charging is active.
D4	MBATRSNSN	Battery Current Sense Negative Terminal
D5	MBATRSNSP	Battery Current Sense Positive Terminal
D6	AGND_CHG	Charger Analog Ground
D7	THM	Battery Thermistor Terminal/Battery Detection
D8	MBATT	Battery Positive Terminal. Bypass to AGND with a 4.7µF ceramic capacitor.
C1	FLED1	Flash LED Current Source Output 1. Connect FLED1 to the Anode of a high-brightness LED and Cathode tied to the ground plane. FLED1 has an internal TBDkΩ resistor to GND.
B1	FLED2	Flash LED Current Source Output 2. Connect FLED2 to the Anode of a high-brightness LED and Cathode tied to the ground plane. FLED2 has an internal TBDkΩ resistor to GND.

Bump Description (continued)

BUMP	NAME	FUNCTION
A2	IN_FLED	Flash LED Driver Input. Bypass to GND with 4.7µF ceramic capacitor.
B2	TORCHEN	Torch Mode Enable Active-High Logic Input. TORCHEN has on-chip 800kohm pull-down resistor.
C2	FLASHEN1	Flash Strobe #1 Enable Active-High Logic Input. FLASHEN1 has an internal 800kΩ pull-down resistor.
D1	SAFEOUT	Safeout LDO Output. Default 4.9V and on when CHGIN power is valid. Bypass with a 1µF ceramic capacitor to GND.
F6	WLEDGND	Ground for WLED Current Drivers
F8	WLEDPGND	Power Ground for WLED Boost Converter
G3	WLED1	Current Source Output for WLED1 Boost Converter String. When powering series LEDs, the anode of the LED string should connect to LED.
G4	WLED2	Current Source Output for WLED2 Boost Converter String. When powering series LEDs, the anode of the LED string should connect to LED.
G5	WLEDPWM	Content-Based Adaptive Brightness Control Input for LED Boost Converter. WLEDPWM accepts a logic-level PWM signal with a frequency range of 5kHz to 60kHz.
G6	WLEDOUT	Boost Converter Overvoltage Sense Input. Bypass WLEDOUT to WLEDPGND with a 1µF ceramic capacitor.
G7, G8	WLEDLX	WLED Switching Node
D2	$\overline{INT}$	Interrupt Output. Active-low open-drain output.
E5	$\overline{MRST}$	Manual Reset Input for Hardware Reset With Internal Timer
F1,G1	VIO	Digital I/O Supply Input for I^2C Interface
F2	SDA	I^2C Serial Data for MAX77829, Except the Fuel Gauge
F3	SCL	I^2C Serial Clock for MAX77829, Except the Fuel Gauge
F7	$\overline{RESET}$	Reset Output. Active-low open-drain output with timer. Provides manual reset capability to applications processors when the main PMIC is not already providing this function.
A1,E1 E4	GND_A	Analog Ground
E7, E8	SYS_A	Analog SYS Input. Share with SYS_Q
F4	GND_D	Digital Ground
E2	VCCTEST	Test Pin. Connect to ground.
E3	TEST2	Test Pin. Connect to ground.
E6	TEST4	Test Pin. Connect to ground.
F5	TEST3	Test Pin. Connect to ground.
G2	TEST1	Test Pin. Connect to ground.

Functional Diagram



Detailed Description

Main-Battery charger

The MAX77829 charger is a compact, high-frequency, high-efficiency switch-mode charger for a one-cell Lithium ion (Li+) battery with OTG capability and support to drive external p-channel MOSFET power-path. It delivers up to 2.0A of current to the battery from inputs up to 9.4V for DC and withstands transient inputs up to 22V. The typical 4MHz switch-mode charger is ideally suited for small portable devices such as headsets and ultra-portable media players because it minimizes component size and heat. The MAX77829 has programmable automatic input current limiting to protect upstream charging sources from collapsing. Upon request from the host processor, the MAX77829 can run its switching regulator in reverse to support USB 'On the Go' power, +5V at 500mA (default, up to 900mA with different factory setting).

The MAX77829 can manage two outputs independently, battery charging and system power. This allows immediate system operation under missing/deeply discharged battery conditions.

Battery protection features include low voltage prequalification, charge fault timer, die temperature monitoring, battery temperature monitoring and watchdog timer. The battery temperature monitoring adjusts the charge current and termination voltage for safe use of secondary lithium-ion batteries.

Features

- Efficient 4MHz (typ) Switch Mode Charger Supporting 2.0A Charging Current Capability
- USB OTG Supports 500mA at +5V DC (Default Setting, up to 900mA with Different Factory Setting)
- External Power-Path P-MOSFET Driver for No/Dead Battery Support
- Digital Programming via I^2C Interface:
  - Input Current Limit (Up to 2.0A)
  - Fast Charge Current (Up to 2.0A)
  - Termination Current
  - Restart Voltage
  - Safety Timer/Watchdog Timer
- High-Accuracy Voltage and Current Regulation
- Input Current Regulation: ±5%(100mA, 500mA), ±10%(≥ 1A), Default 500mA
- Charger Voltage Regulation: ±0.5% 250C, Adjustable from 3.55V to 4.4V
- Fast Charge Current Regulation: 0.25A to 2.0A ±5%, Default 500mA
- 22V Absolute Maximum Input Voltage Rating
- Up to +9.4V Maximum Operating Input Voltage
- Input Voltage Based Automatic Input Current Limit (AICL)
- Battery/System Load Current Sensing and Limiting
- JEITA Compliance Thermistor Monitoring of Battery Temperature and Adjust Charging Current and Voltage
- Battery Protection:
  - Reverse Leakage Protection Prevents Battery Drainage
  - Input/Output Overvoltage Protection
  - Battery Over Temperature Protection
  - Thermal Regulation and Shutdown
  - Battery Overcurrent Alarm
- System Voltage Regulator/Battery Charger with Power-Path:
  - External p-MOSFET Driver for Power-Path and Battery Charging
  - Supplement Mode to Delivery Current from Battery During Power -Path Operation
- Battery Presence Detection
- Interrupt Status Output
- Input/Output Overvoltage Protection
- Thermal Regulation Protection
- Charging Status Indicator

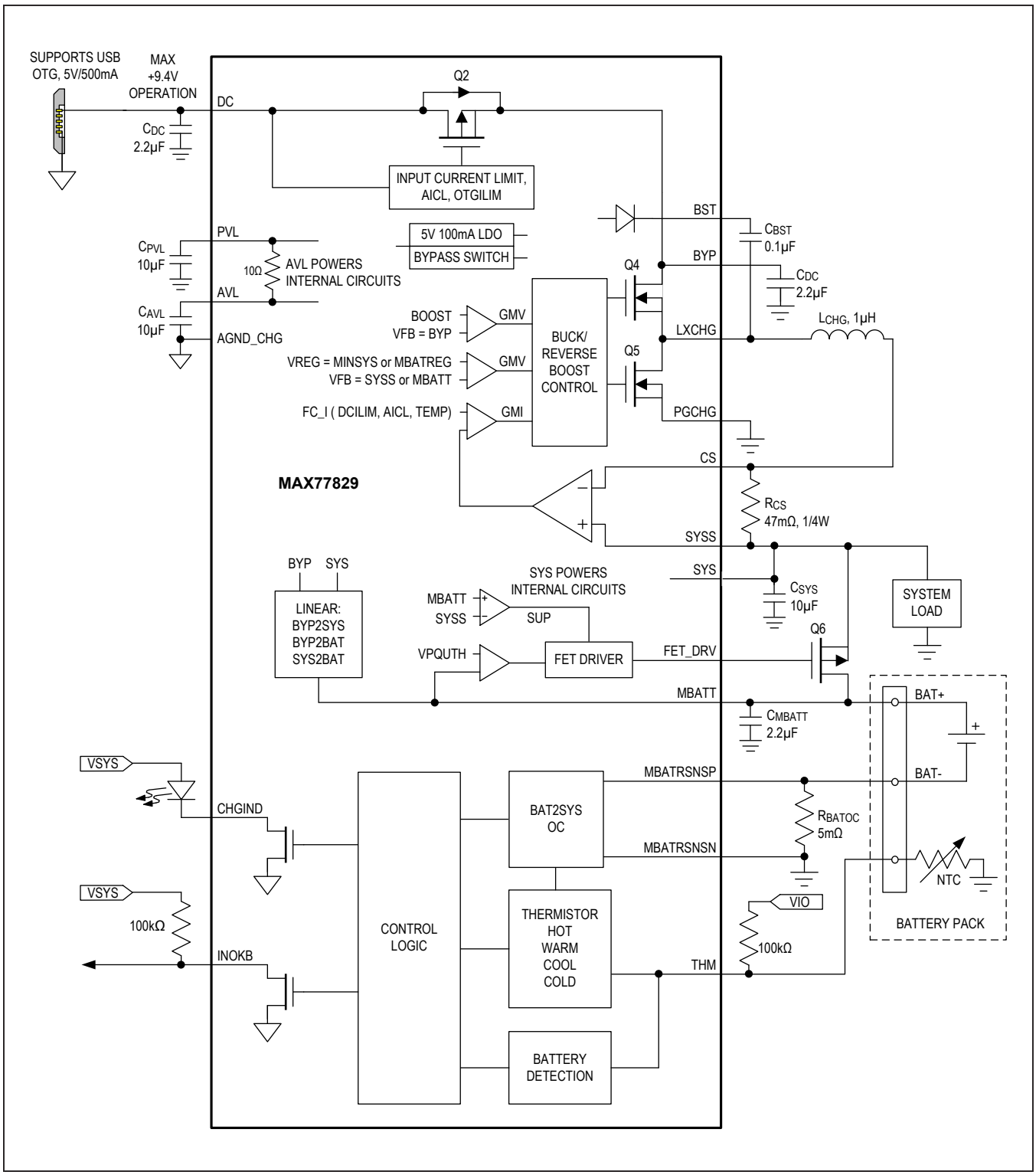


Figure 1. Main-Battery Charger Typical Application Circuit

Inductor Selection

The charger operates with a switching frequency of 4MHz and uses a 1µH or 2.2µH inductor. This operating frequency allows the use of physically small inductors while maintaining high efficiency. The inductor's DC current rating only needs to match the maximum load of the application because the MAX77829 features zero current overshoot during startup and load transients. For optimum transient response and high efficiency, choose an inductor with DC series resistance in the 40mΩ to 120mΩ range. See Table 1 below for suggested inductors and manufacturers.

MBAT Capacitor Selection (C_{MBATT})

Choose the nominal MBAT capacitance (C_{MBATT}) to be 2.2µF. The MBAT capacitor is required to keep the MBAT voltage ripple small and to ensure regulation loop stability. The MBAT capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectric are highly recommended due to their small size, low ESR, and small temperature coefficients. For optimum load-transient performance and very low output voltage ripple, the MBAT capacitor value can be increased above 2.2µF.

As the case sizes of ceramic surface-mount capacitors decreases, their capacitance vs. DC bias voltage characteristic becomes poor. Due to this characteristic, it is possible for 0603 capacitors to perform well while 0402 capacitors of the same value perform poorly. The recommended nominal MBAT capacitance is 2.2µF, however, after initial tolerance, bias voltage, aging, and temperature derating, the capacitance must be greater than 1.5µF. With the capacitor technology that is available at the time the MAX77829 was released to production, the MBAT capacitance is best achieved with a single ceramic capacitor (X5R or X7R) in a 0402 case size. The capacitor voltage ratings should be 6.3V or greater.

SYS Capacitor Selection (C_{SYS})

Choose the nominal SYS capacitance (C_{SYS}) to be 10µF. C_{SYS} is the output capacitor for the step-down converter when charging. Alternatively, C_{SYS} is the input capacitor for the stepup converter when it is operating in OTG mode. C_{SYS} is required to keep the SYS voltage ripple small and to ensure regulation loop stability. In a typical application, SYS also powers many other elements the MAX77829 Power-SoC as well as system elements. Although the sum total of capacitance on SYS may be ~50µF it is critical that a local C_{SYS} is provided to reduce the current loops created by the DC-DC.

C_{SYS} must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectric are highly recommended due to their small size, low ESR, and small temperature coefficients. For optimum load-transient performance and very low output voltage ripple, the MBAT capacitor value can be increased above10µF.

As the case sizes of ceramic surface-mount capacitors decreases, their capacitance vs. DC bias voltage characteristic becomes poor. Due to this characteristic, it is possible for 0603 capacitors to perform well while 0402 capacitors of the same value perform poorly. The recommended nominal C_{SYS} is 10µF, however, after initial tolerance, bias voltage, aging, and temperature derating, the capacitance must be greater than 6µF. With the capacitor technology that is available at the time the MAX77829 was released to production, the SYS capacitance is best achieved with a single ceramic capacitor (X5R or X7R) in an 0603 case size. The capacitor voltage ratings should be 6.3V or greater.

Table 1. Suggested Inductors

MANUFACTURER	SERIES	INDUCTANCE (µH)	ESR (Ω)	CURRENT RATING (mA)	DIMENSIONS (mm)
Taiyo Yuden	MAKK2016	1	0.1	2500	2.0 x 1.6 x 1.0
TDK	TFA2016G	1	0.13	2500	2.0 x 1.6 x 1.0
TDK	MLP2520S	1.0	0.06	1500	2.0 x 2.5 x 1.0
TDK	VLS252012	1	0.105	2700	2.5 x 2.0 x 1.2
TOKO	MIPF2520	2.2	0.05	1500	2.5 x 2.0 x 1.0
TOKO	DFE252012C	1	0.06	2500	2.5 x 2.0 x 1.2
FDK	MIPSA2520D1R0	1.0	0.08	1500	2.5 x 2.0 x 1.2
Murata	LQM2HPN_G0	1.0	0.05	1600	2.5 x 2.0 x 0.6
Murata	LQM32PN1R0MG0	1	0.06	1800	3.2 x 2.5 x 0.9
Coilcraft	EPL2014	1.0	0.059	1600	2.0 x 2.0 x 1.4

BYP Capacitor Selection (C_{BYP})

Choose the nominal BYP capacitance (C_{BYP}) to be 2.2µF. C_{BYP} is the input capacitor for the step-down converter when charging. Alternatively, C_{BYP} is the output capacitor for the reverse boost converter. Larger value of C_{BYP} improves the decoupling for the DC-DC converter, but may cause high DC to BYP inrush currents when an input adapter is connected. To limit the inrush current, C_{BYP} must be no larger than 4.7µF.

C_{BYP} reduces the current peaks drawn from the input power source when charging. Similarly, C_{BYP} reduces the output voltage ripple of the stepup converter when it is operating in OTG mode. The impedance of the input capacitor at the switching frequency should be very low. Ceramic capacitors with X5R or X7R dielectric are highly recommended due to their small size, low ESR, and small temperature coefficients. To fully utilize the +22V input capability of the MAX77829, choose C_{BYP} to have a 25V or greater rating; many applications do not need to utilize the full input capability of the device and find that a 16V rating input capacitor is sufficient.

C_{BYP} is a critical discontinuous current path that requires careful bypassing. In the PCB layout, place C_{BYP} as close as possible to the power pins (BYP and PGCHG) to minimize parasitic inductance. If making connections to C_{BYP} through vias, ensure that the vias are rated for the expected input current so they do not contribute excess inductance and resistance between the bypass capacitor and the power pins. The expected C_{BYP} current is the same as the ISAT (see the *Inductor Selection* section).

C_{BYP} must meet the input ripple current requirement imposed by DC-DC converter. Ceramic capacitors are preferred due to their low ESR and resilience to surge currents. Choose the C_{BYP} capacitor so that its temperature rise due to ripple-current does not exceed approximately +10°C. For a step-down regulator, the maximum input ripple current is half of the output current. This maximum input ripple current occurs when the step-down converter operates as 50% duty cycle (V_{IN} = 2 x V_{BAT}).

BST Capacitor Selection (C_{BST})

Choose the nominal BST capacitance (C_{BST}) to be 0.1µF. C_{BST} is part of a charge pump that creates the high-side gate drive for the DC-DC. If larger values of larger values of C_{BST} are used, ensure that CPVL is always 10 times larger than C_{BST}. The maximum expected working voltage of C_{BST} is the same as the PVL regulation voltage (~5V). However, it is recommended that the C_{BST} has at least 10V rating. With the capacitor technology that is available at the time the MAX77829 was released to production, it is possible to find a 10V ceramic 0.1µF 0201 capacitor however these devices are pushing the limits, and a 10V ceramic 0.1µF 0402 may be more cost effective and readily available.

DC Input Capacitor Selection (C_{DC})

Choose the nominal DC capacitance (C_{DC}) to be 2.2µF. C_{DC} is intended to decouple a charge source and its parasitic impedance. Typically, the charger source at DC is a USB connector's V_{BUS}. Larger values of C_{DC} improve the decoupling of the charger source impedance; however, take care not to exceed the maximum capacitance allowed by the USB specification (i.e. 10µF and 50µC). Note that for the USB input capacitance specification, C_{DC} is effectively in parallel with C_{BYP} and therefore the sum of these two capacitances should be less than 10µF.

The impedance of the CDC at the DC-DC switching frequency should be very low. Ceramic capacitors with X5R or X7R dielectric are highly recommended due to their small size, low ESR, and small temperature coefficients. To fully utilize the +22V input capability of the MAX77829, choose CDC to have a 25V or greater rating; many applications don't need to utilize the full input capability of the device and find that a 16V or 10V rated input capacitor is sufficient.

Charge Current Resistor Selection

Both the top-off current range and fast charge current range depends on the sensing resistor (R_{SNS}). The recommended resistor value is 47mΩ 0.125W ±2%.

$$P_{RSNS} = I^2_{CHARGE} \times R_{SNS}$$

$$P_{RSNS} = (2.0A)^2 \times 0.047\Omega = 0.188W$$

Calculate the CC mode charge current step from the CHGCC voltage setting and sense resistor as follows:

$$I_{CHARGE\_CURRENT\_STEP} = \frac{V(CHGCC)}{R_{SNS}}$$

Table 2 below shows the charge current settings for two sensing resistors.

Table 2.Charge Current Settings for 47mΩ Sense Resistor

BIT	$V_{I(REG)}$(mV)	I_{CHARGE} (mA) R_{SNS} = 47mΩ
$V_{(CHGCC<11110>)}$	70.5	1500
$V_{(CHGCC<10100>)}$	47	1000
$V_{(CHGCC<01010>)}$	23.5	500

Calculate the top-off charge current step as follows:

$$I_{CHARGE\_CURRENT\_STEP} = \frac{V(TOP\_OFF)}{R_{SNS}}$$

Table 3 shows the top-off current settings for two sensing resistors.

DC Input – Fast Hysteretic Step-Down Regulator

When a valid DC input is present, battery charging is supplied by the high-frequency step-down regulator from DC. The step-down regulation point is then controlled by three feedback signals: maximum step-down output current programmed by the input current limit, maximum charger current programmed for the fast charge current and maximum die temperature. The feedback signal requiring the smallest current controls the average output current in the inductor. This scheme minimizes total power dissipation for battery charging and allows the battery to absorb any load transients with minimum voltage disturbance.

A proprietary hysteretic current PWM control scheme ensures fast switching and physically tiny external components. The feedback control signal that requires the smallest input current controls the center of the peak and valley currents in the inductor. The ripple current is internally set to provide 4MHz operation. When the input voltage decreases near the output voltage, very high duty cycle occurs and, due to minimum off-time, 4MHz operation is not achievable. The controller then provides minimum off-time, peak current regulation. Similarly, when the input voltage is too high to allow 4MHz operation due to the minimum off-time, the controller becomes a minimum on-time, valley current regulator. In this way, ripple current in the inductor is always as small as possible to reduce ripple voltage on Battery for a given capacitance. The ripple current is made to vary with input voltage and output voltage in a way that reduces frequency variation. However, the frequency still varies somewhat with operating conditions.

Soft-Start

To prevent input current transients, the rate of change of the input current (di/dt) and charge current is limited. When the input is valid, the charge current ramps from 0mA to the fast-charge current value in 1.5ms. Charge current also soft-starts when transitioning from the prequalification state to the fast-charge state. There is no di/dt limiting when transitioning from the done state to the fast-charge state.

PVL and AVL

As shown in Figure 1, AVL is the output of a 5V/100mA linear regulator when power from BYP is available. If only power from SYS is available, then PVL is connected to SYS with a bypass switch. When AVL is greater than 2.7V the internal control circuits for the charger are enabled. Connect a 10µF ceramic capacitor from AVL to AGND (CAVL). Powering external loads from AVL is acceptable, provided that they do not consume more than 100mA.

PVL powers the gate drivers and BST for the main-battery charger's step-down regulator, it also charges the BST capacitor. PVL is the filtered version of AVL. The filter consists of an internal 10Ω resistor and the PVL external bypass capacitor (10µF). This filter creates a 100kHz lowpass filter that cleans the 4MHz switching noise from the analog portion of the MAX77829. Connect a 10µF ceramic capacitor from PVL to PGCHG (CPVL). Powering external loads from PVL is NOT recommended.

Thermistor Input (THM)

The THM input connects to an external negative temperature coefficient (NTC) thermistor to monitor battery or system temperature. Charging is suspended when the thermistor temperature is out of range. The charge timers are suspended and hold their state but no fault is indicated. When the thermistor comes back into range, charging resumes and the charge timer continues from where it left. Connecting THM to GND disables the thermistor monitoring function.

Table 3. Top-off Current Settings for 47mΩ Sense Resistor

BIT	$V_{(TOP-OFF)}$	$I_{(TOP-OFF)}$(mA) R_{SNS} = 47mΩ
$V_{(Top-off<>)}$	9.4	200
$V_{(Top-off<>)}$	4.7	100
$V_{(Top-off<>)}$	2.35	50

Table 4. Suggested P-Channel MOSFET

MANUFACTURER	PART NUMBER	PART DESCRIPTION	DIMENSIONS
Vishay	SiA443DJ	PFET, 20V, SC70 Power Pak	2.05mm x 2.05mm x 1.0mm = 4.2mm3
	Si4435DDY	PFET, 30V, SO-8	6.2mm x 5.0mm x 1.75mm
Fairchild	FDMA905P	PFET, 20V, SC70	2mm x 2mm x 1mm = 4mm3

Since the thermistor monitoring circuit employs an external bias resistor from THM to AVL, the thermistor is not limited only to 10kΩ (at 25ºC). Any resistance thermistor can be used as long as the value is equivalent to the thermistors +25°C resistance. For example, with a 10kΩ at RTB resistor, the charger enters a temperature suspend state when the thermistor resistance falls below 3.97kΩ (too hot) or rises above 28.7kΩ (too cold). This corresponds to 0°C to +50°C range when using a 10kΩ NTC thermistor with a beta of 3500K. The general relation of thermistor resistance to temperature is defined by the following equation:

$$R_{THRM} = R_{25} \times e^{\left(\beta\left(\frac{1}{T+273} - \frac{1}{298}\right)\right)}$$

Where:

R_{THRM} = resistance in Ω of the thermistor at temperature T in °C.

R_{25} = resistance in Ω of the thermistor at +25ºC.

β = material constant of the thermistor, which typically ranges from 3000K to 5000K.

T = temperature of the thermistor in °C.

Some designs might prefer other thermistor temperature limits. Threshold adjustment can be accommodated by charging R_{TB}, connecting a resistor in series and/or in parallel with the thermistor, or using a thermistor with different B. For example, a +45ºC hot threshold and 0°C cold threshold can be realized by using a thermistor with a B to 4250K and connecting 120kΩ in parallel. Since the thermistor resistance near 0°C is much higher than it is near +50°C, a large parallel resistance lowers the cold threshold, while only slightly lowering the hot threshold. Conversely, a small series resistance raises the cold threshold, while only slightly raising the hot threshold. Raising R_{TB}, lowers both the hot and cold threshold, while lowering R_{TB} raises both thresholds.

Note that since AVL is active whenever valid input power is connected at DC, thermistor bias current flows at all times, even when charging is disabled. With a 10kΩ thermistor and a 10kΩ pullup to AVL, this results in an additional 250µA load. This load can be reduced to 25µA by instead using a 100kΩ thermistor and 100kΩ pull-up resistor.

Thermal Foldback

Thermal foldback maximizes the battery charge current while regulating the MAX77829 junction temperature. When the die temperature exceeds TREG, a thermal limiting circuit reduces the battery charge-current target until the charge current reaches 25% of the fast-charge current setting. The charger maintains 25% of the fast-charge current until the die temperature reaches TSHDN. Please note that the MAX77829 is rated for a maximum ambient temperature of +85°C. Furthermore, although the maximum die temperature of the MAX77829 is +150°C, it is common industry practice to design systems in such a way that the die temperature never exceeds +125°C. Limiting the maximum die temperature to +125°C extends long-term reliability.

Boost Mode

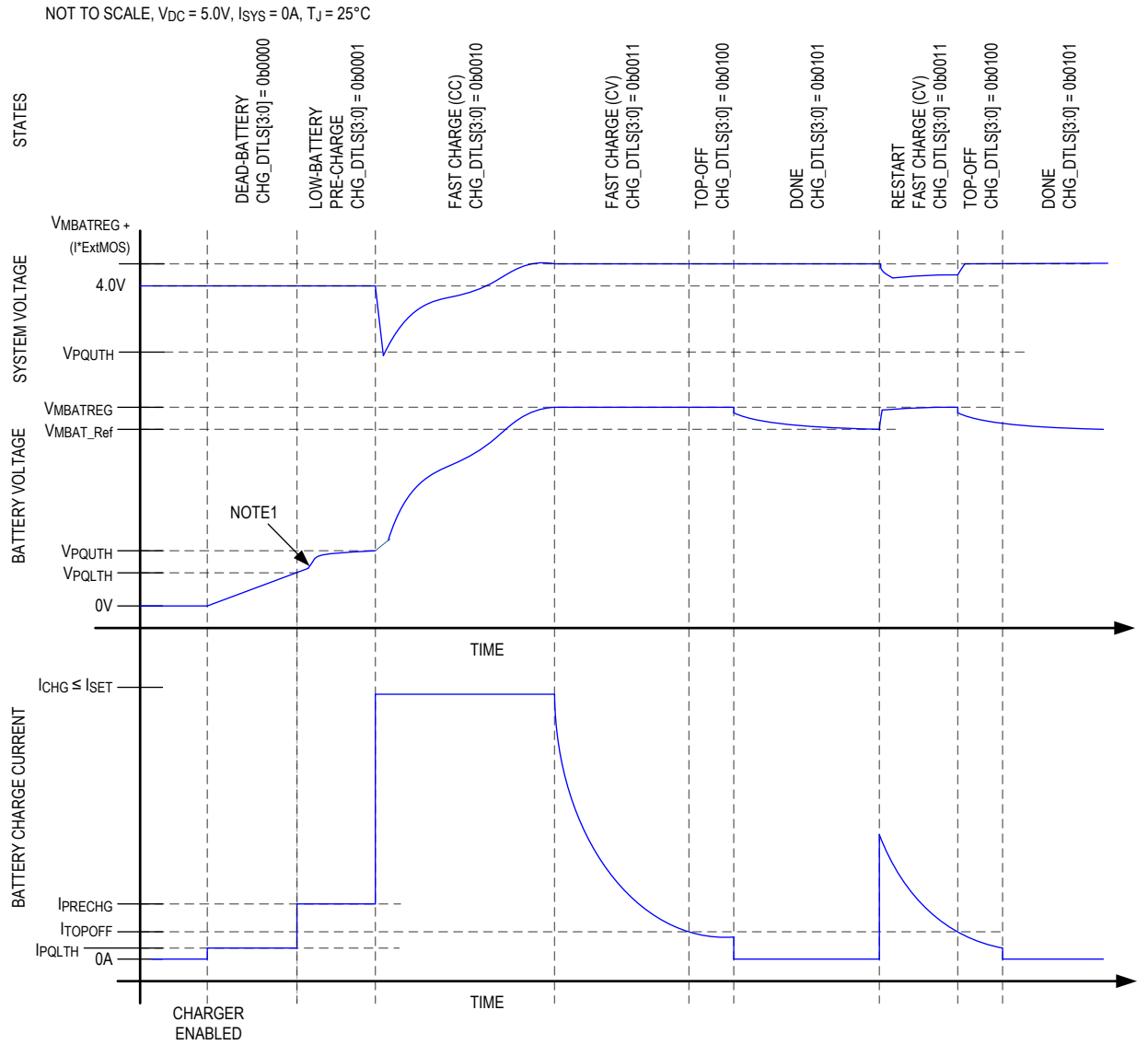
When enabled as a boost converter, in the absence of a valid charger input, the DC-DC converter is allowed to operate as a boost converter. The boost output voltage is regulated to 5.1V. The boost switches at 4MHz and is capable of delivering up to 500mA. The processor must enabled OTG mode by software via OTGEN bit. The reverse blocking switch allows the delivery of power to the charger input.

Table 5. Calculated Values for Different Thermistors

PARAMETER	VALUE						
$R_{THM\ at}$ T_A = +25°C	10,000	10,000	10,000	47,000	47,000	100,000	100,000
Thermistor Beta (βΩ)	3380	3940	3940	4050	4050	4250	4250
$R_{TB(Ω)}$	10,000	10,000	10,000	47,000	47,000	100,000	100,000
$R_{TP(Ω)}$	OPEN	OPEN	301,000	OPEN	1,200,000	OPEN	1,800,000
$R_{TS(Ω)}$	SHORT	SHORT	499	SHORT	2,400	SHORT	6,800
Resistance at T1_n15(Ω)	61,788	61,788	77,248	290,410	380,716	617,913	934,027
Resistance at T1_0(Ω)	29,308	29,308	31,971	137,750	153,211	293,090	343,283

Charger States

The MAX77829 utilizes several charging states to safely and quickly charge batteries. Figure 2 shows an exaggerated view of a Li+/Li-Poly battery progressing through the following charge states when the die and battery are close to room temperature: dead-battery → precharge → fast-charge → top-off → done.



NOTE1: A TYPICAL LI+/LI-POLY HAS AN INTERNAL BATTERY PACK PROTECTION CIRCUIT THAT WILL OPEN THE BATTERY CONNECTION WHEN THE BATTERY'S CELL VOLTAGE IS LOWER THAN A DEAD BATTERY THRESHOLD ($V_{PQLTH.FALLING}$~2.5V). TO GET THE PACK PROTECTION TO CLOSE AGAIN, THE CL12 CHARGES THE BATTERY CAPACITOR WITH I_{DBAT} UNTIL THE VOLTAGE EXCEEDS V_{PQLTH}. THEN THE CL12 CHARGES THE BATTERY CAPACITOR WITH I_{PRECHG}. WHEN THE BATTERY CAPACITOR'S VOLTAGE EXCEEDS $V_{PQUTH.RISING}$, THEN THE POWER-PATH FET CLOSES WHICH CONNECTS THE CELL TO THE CL12 CHARGER.

Figure 2. Li+/Li-Poly/LiFePO4 Charge Profile

Charger Disabled State

When DC is low or the input voltage is out of range, the MAX77829 disables the charger. To exit this state, the input voltage must be within its valid range.

Dead-Battery State

When a deeply discharged battery is inserted with a voltage of less than V_{PQLTH}, the MAX77829 disabled the switching charger and linearly charges with I_{PQLTH}. Once V_{BAT} increases beyond V_{PQLTH}, the MAX77829 transitions to the precharge state. This state prevents the MAX77829 from dissipating excessive power in the event of a shorted battery.

Precharge State

The precharge state occurs when the battery voltage is greater than V_{PQLTH} and less than V_{PQUTH}.

In this state, the dead-battery linear and system to battery linear charger turns on to provide I_{PRECHG} current to SYS. If the MAX77829 remains in this state for longer than t_{PRECHG}, then the MAX77829 transitions to the timer fault state. A normal battery typically stays in the prequalification state for several minutes or less and when the battery voltage rises above V_{PQUTH}, the MAX77829 transitions to the fast-charge constant current state.

Fast Charge Constant Current State

The fast-charge constant current state occurs when the battery voltage is greater than V_{PQUTH} and less than V_{BATREG}. In this state, the switching charger is on and delivering current to the battery. The total battery current is IFC. If the MAX77829 remains in this state and the fast-charge constant voltage state for longer than t_{FC}, then the MAX77829 transitions to the timer fault state. When the battery voltage rises to V_{BATREG}, the MAX77829 transitions to the fast-charge constant voltage state. When JEITA is enabled (JEITA_EN = 1), the fast-charge constant current is set to 50% of programmed value when -10°C < THM <15°C, and 100% of programmed value when 15°C < THM < 60°C.

The MAX77829 dissipates the most power in the fast-charge constant current state. This power dissipation causes the internal die temperature to rise. If the die temperature exceeds T_{REG}, I_{FC} is reduced.

If there is low input voltage headroom (V_{DC} – V_{MBAT}), then I_{FCHG} decreases due to the impedance from IN to BAT.

Fast Charge Constant Voltage State

The fast-charge constant voltage state occurs when the battery voltage is at the VMBATREG[3:0] and the charge current is greater than I_{DONE}. In this state, the switching charge is on and delivering current to the battery. The MAX77829 maintains V_{BATREG} and monitors the charge current to detect when the battery consumes less than the DONE current. When the charge current decreases below the I_{DONE} threshold, the MAX77829 transitions to the top-off state. If the MAX77829 remains in the fast-charge constant current state for longer than t_{FCHG}, then the MAX77829 transitions to the timer fault state.

Top-Off State

The top-off state occurs when the battery voltage is at V_{BATREG} and the battery current decreases below I_{DONE} current. In this state, the switching charger is on and delivers current to the battery. The MAX77829 maintains V_{BATREG} for a specified time. When this time expires, the MAX77829 transitions to the DONE state. If the charging current increases to I_{DONE} + 200mA before this time expires, then the charge reenters the fast-charge constant voltage state.

Done State

The MAX77829 enters its done state after the charge has been in the top-off state for topoff. In this state, the switching charger is off and no current is delivered to the battery. If the system load presented to the battery is low << 10µA, then a typical system can remain in the done state for many days. If left in the done state long enough, the battery voltage decays below the restart threshold (V_{MBAT_REF}) and the MAX77829 transitions back into the fast-charge state. There is no soft-start (di/dt limiting) during the done-to-fast-charge state transition.

Timer Fault State

The timer fault state occurs when either the prequalification or fast-charge timers expire. In this state, the charger is off. The charger can exit this timer fault state by cycling input power.

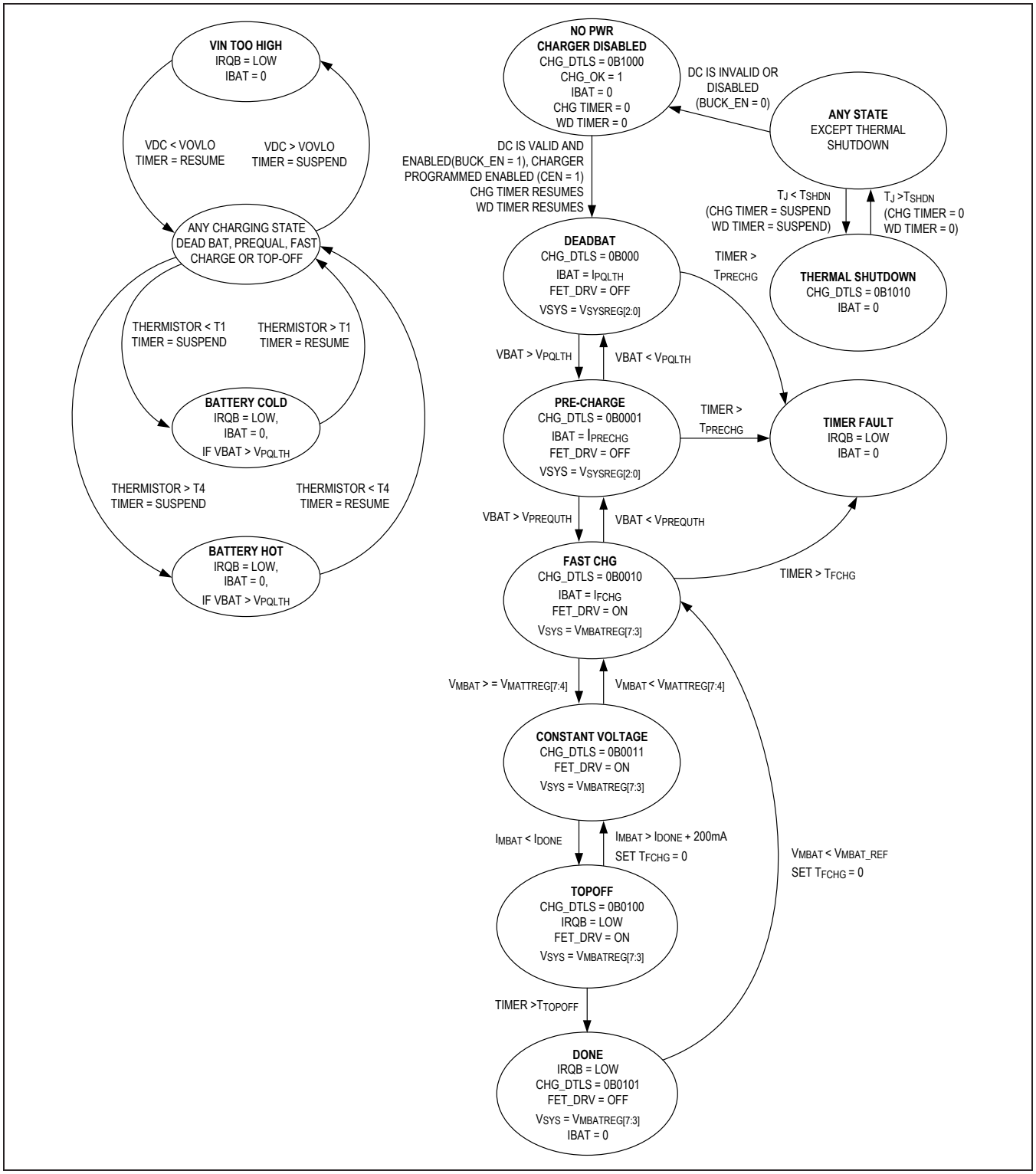


Figure 3. Charging State Diagram

Input Current Limit

The default settings of the I_{DC_ILIM} control bits are such that when a charge source is applied to DC, the MAX77829 will turn on its DC-DC converter in BUCK mode, limit V_{SYS} to V_{SYSMIN}, and limit the charge source current to 500mA. All control bits are reset on global shutdown.

Automatic Input Current Limit (AICL)

The MAX77829 includes the Automatic Input Current Limit (AICL) feature for the DC input. The amplifiers required for sensing the currents and associated logic circuitry for making decisions and changing the battery-charger current are fully integrated in the ICs. This not only helps in reducing cost but also improves the speed of system response.

The MAX77829 AICL works by monitoring the current being drawn from DC and comparing it to the programmed current limit. The current limit is set based on the current-handling capability of the USB. Generally, this limit is chosen to optimally fulfill the system power requirements while achieving a satisfactory charging time for the batteries. If the AC-adapter current exceeds the set threshold, the charger responds by cutting back on the charger current, thereby keeping the current drawn from the AC adapter within the set limit. This AICL feature allows for reducing the AC adapter size and cost. The input current limit has two control inputs, one based on voltage and one based on current. The voltage input monitors the input voltage, and when it drops below the desired input (VDC_AICL), it generates a flag (AICL) to decrement the fast-charge current.

When the voltage comparator initially trips at VDC_AICL, fast-charge current decrements at a slow rate, allowing the charger output to settle until the voltage on DC returns above this voltage threshold. Once the DC voltage resolves itself, the current delivery of the adapter is maximized. In the event of a limited input current source, an example being a 500mA adaptor plugged into a 1A input current limit setting, a second voltage comparator set at VDC_AICL - 100mV triggers and throttles the fast-charge current to a minimum of 75mA. Once the DC voltage corrects itself to above VDC_AICL, the fast-charge level is checked every 16ms to allow the system to recover if the available input power increases.

The current-limit input monitors the current through the input FET and generates a flag (DC_I) to decrement the fast-charge current when the input limit is exceeded. The fast-charge current is slowly decremented until the input-limit condition is cleared. At this point, the fast-charge current is maintained for 16ms and is then sampled again.

Battery Detection

The MAX77829 charger detects insertion and removal of battery packs under various conditions. When a valid power source is detected on DC pin, the battery detection state machine is enabled. The first task is to determine the type of detection method used for predicting battery present condition. The voltage level on the $\overline{MBATDET}$ pin is used to determine the presence of either a low-cost battery or a smart battery.

JEITA Description

The MAX77829 safely charges a single Li+ cell in accordance with JEITA specifications. The MAX77829 monitors the battery temperature while charging and automatically adjusts the fast-charge current and/or charge termination voltage as the battery temperature varies.

In safety region 1, the MAX77829 automatically reduces the fast-charging current for T_{MBATT} < +10°C and reduces the charge termination voltage from 4.200V (±25mV) to 4.075V (±25mV) for T_{MBATT} > +45°C. The fast-charge current is reduced to 50% of the nominal fast-charge current. When battery charge current is reduced by 50%, the timer is doubled.

In safety region 2, the IC automatically reduces the charge termination voltage from 4.200V (±25mV) to 4.075V (±25mV) for T_{MBATT} < +10°C and for T_{MBATT} > +45°C. The fast-charge current is not changed in safety region 2.

The customer can disable T2 and T3 temperature scaling for voltage and current by programming JEITA_EN bit to disable (JEITA_EN=0). In this case, only T1 and T4 temperature region will be enabled.

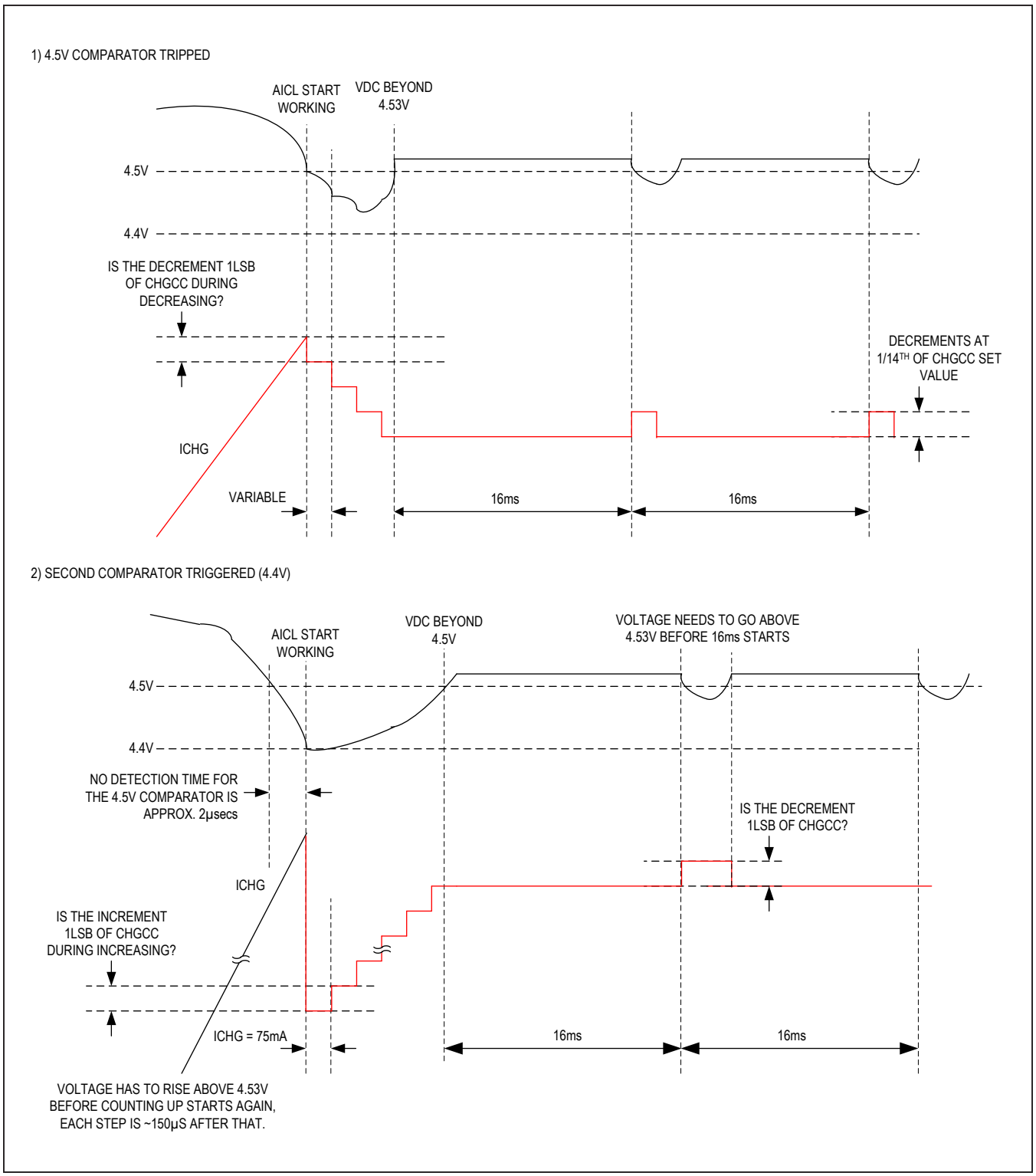


Figure 4. Automatic Input Current Limit Diagram

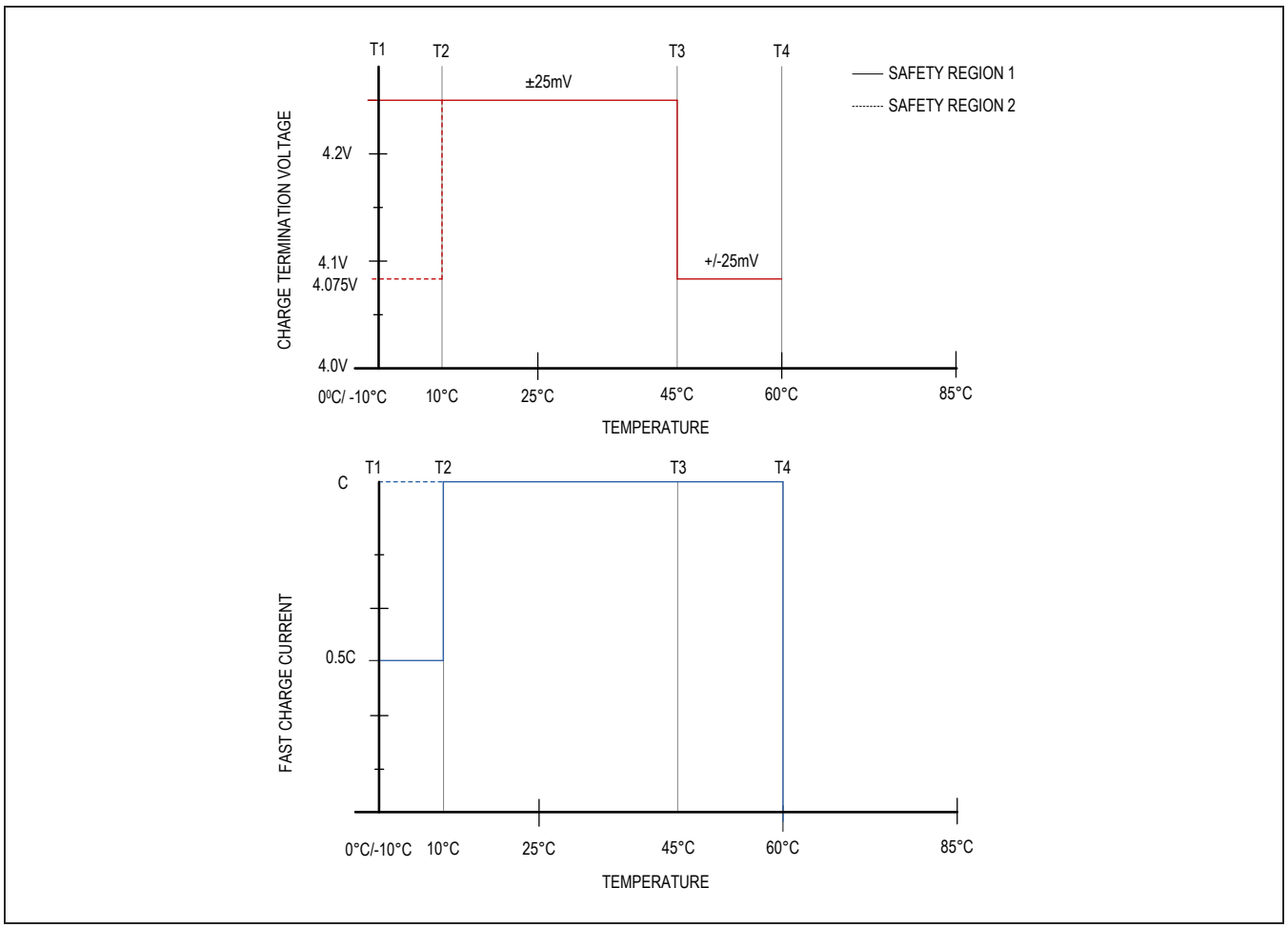


Figure 5. JEITA Safety Region

LED Flash Driver

Description

The flash driver integrates an adaptive PWM step-up DC-DC converter (shared with switch-mode charger module) and two high-side current regulators cable of delivering up to 750mA/ch for flash applications and 187.5mA/ch for torch mode. A serial interface controls the step-up output voltage setting, the torch/flash current, and the torch/flash timers. When valid V_{DC} is present, flash LED driver operates only when $V_{DC} < V_{DC\_V}$.

Features

- Step-Up DC-DC Converter
  - Adaptive Regulation for Driving The LED Directly
  - See the Charger Section for Feature List
- FLASH Current Regulator
  - 2x High-Side Current Regulators Simplifies PCB Heat Sinking
  - Low Dropout Specification 160mV (typ) at 750mA
  - I²C Programmable Flash Output Current (11.72mA to 750mA in 64 steps) Per Channel
  - I²C Programmable Torch Output Current (11.72mA to 187.5mA in 16 steps) Per Channel
- Programmable Flash Safety Timer (62.5ms to 1000ms in 16 steps) – This Timer Cannot Be Disabled
- Programmable Torch Timer (262ms to 15.728s in 16 steps) – or Continuous Torch Current (Disable Option On The Torch Timer)
- MaxFlash System Lock-up Protection
- Open/Short LED Protection
- Dedicated FLASHEN and TORCHEN Inputs

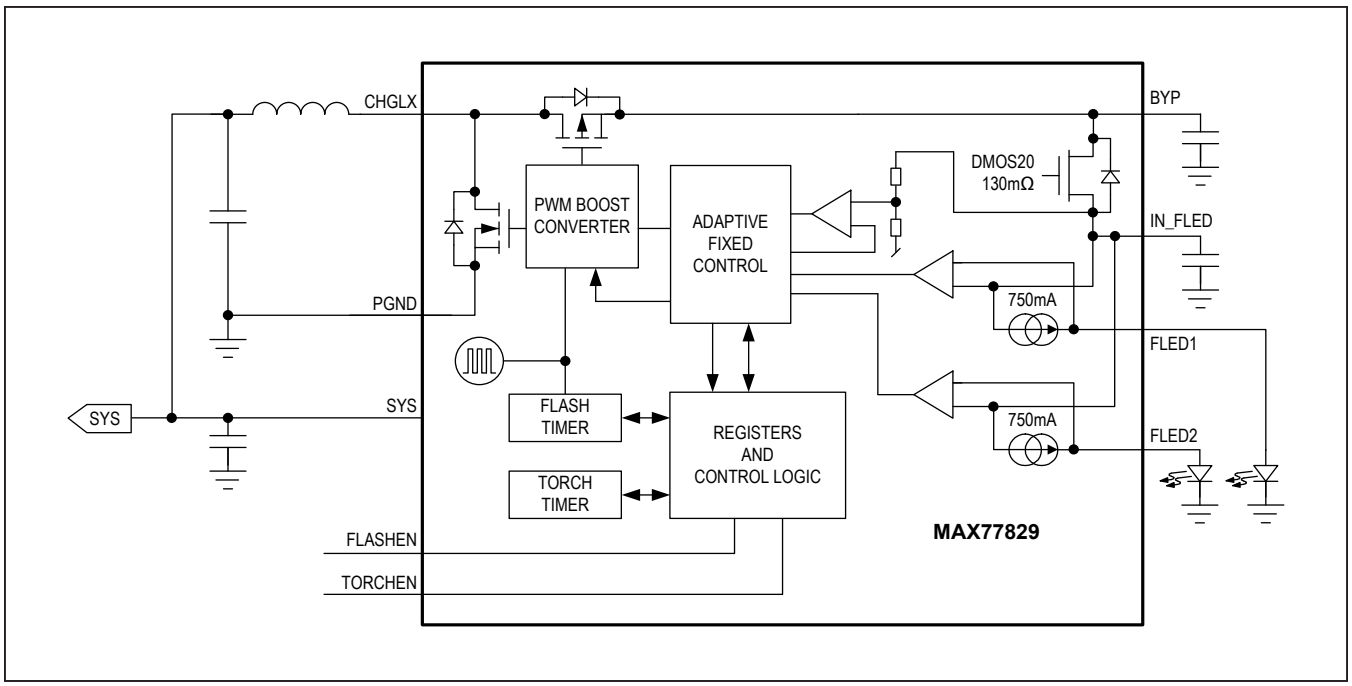


Figure 6. Functional Diagram for Charger Reverse Boost Converter and Current Sources

Boost Converter

The MAX77829 flash driver integrates an adaptive PWM step-up DC-DC converter (shared with switched mode charger module) and two high-side current regulators capable of delivering up to 750mA each, for flash applications. The serial interface controls individual output on/off, the step-up output voltage setting, the torch/flash current, and the torch/flash timer duration settings.

Current Source (FLED1 and FLED2)

The MAX77829 provides two high-side, low-dropout, linear current regulators. The LED current regulators can operate in either Torch or Flash mode. Each current source is programmable and regulated up to 375mA in Torch mode and up to 750mA in Flash mode. FLED current is programmable with 23.436mA/LSB resolution in Torch and Flash modes.

Torch mode can be enabled either using the serial interface or by logic control using the TORCHEN or FLASHEN inputs. See the description of the FLASH_EN register for more information about programming the FLED enable behavior. Torch mode provides continuous lighting when enabled. The time duration is controlled through the Torch timer, enabling the user to limit the duration of torch light from 0.262s to 15.73s, or enabled indefinitely, allowing the user to keep the LED on as long as a movie is being recorded.

Flash mode can also be enabled either using the serial interface or by logic control using the TORCHEN or FLASHEN inputs. See the description of the FLASH_EN register for more information about programming the FLED enable behavior. Flash mode provides a limited-duration light pulse for camera functions. In Flash mode, the time duration is limited by an internal timer (FLASH_TMR_DUR[3:0]). See the *Flash Safety Timer* section for greater detail on this function. The output current in Flash mode is programmable from 23.436mA to 750mA. The settings above 625mA are allowed only if FLEDNUM = 0.

If both Flash and Torch modes are enabled at the same time, Flash mode is assigned with higher priority. Once the flash event is done, the current regulator will then return to torch mode, if this mode is still enabled via software.

When the flash LED current ramps up via (1) toggle FLASHEN or TORCHEN pins; (2) set TORCH_FLED_EN or FLASH_FLED_EN bits; (3) set TORCH_I or FLASH_I register values from a lower value to a higher value; atypical 12.5mA/µs of di/dt rate is applied on the flash LED current during the current transition.

Flash Mode

In Flash mode, each LED current source provides from 23.436mA to 750mA of output current. Flash mode can be enabled by driving FLASHEN or TORCHEN high or through the serial interface, depending on register settings. Flash duration is also programmable through the serial interface.

FLASHEN/TORCHEN

The FLASHEN or TORCHEN logic inputs or the serial interface can enable/disable the FLED_ current regulator in Flash Mode and in Torch Mode.

If the FLED is enabled for both Torch and Flash mode at the same time, Flash mode has priority. Once the Flash safety timer expires, the current regulator then returns to Torch mode. If the safety timer is disabled, Torch mode current continues until disabled through the serial interface.

Configuring how the LED responds to FLASHEN or TORCHEN is accomplished by setting bits in the FLASH_EN register.

Flash Safety Timer

The Flash safety timer is activated any time Flash mode is enabled. The Flash safety timer, programmable from 62.5ms to 1000ms via serial interface, limits the duration of Flash mode to the programmed Flash safety timer duration. This timer can be configured to operate either as a one-shot timer or maximum flash duration timer. In one-shot mode, the flash function is initiated on the rising edge of FLASHEN, TORCHEN, or the serial register bits and terminated based on the programmed value of the safety timer (see Figure 7). In maximum flash timer mode, flash function remains enabled as long as FLASHEN, TORCHEN, or the serial register command is high, unless the pre-programmed safety timer times out (see Figure 8).

Once Flash mode is disabled, by the FLASHEN or TORCHEN logic inputs, register command, or Flash safety timer, the flash must be off for a minimum flash debounce timer (500µs – 600µs), before it can be reinitiated (see Figure 11). This prevents spurious events from re-enabling Flash mode. This time is described in the *Electrical Characteristics* table as the Flash Safety Timer Reset Inhibit Period.

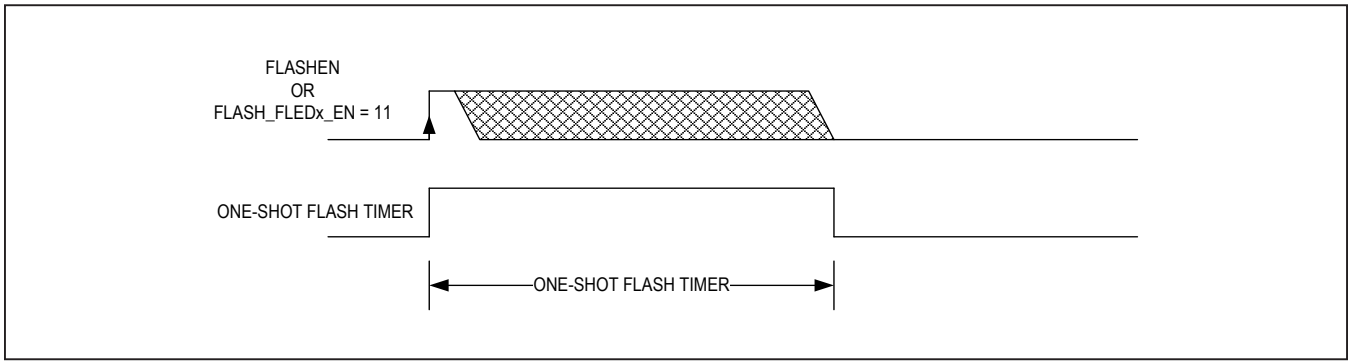


Figure 7. One Shot Flash Timer Mode

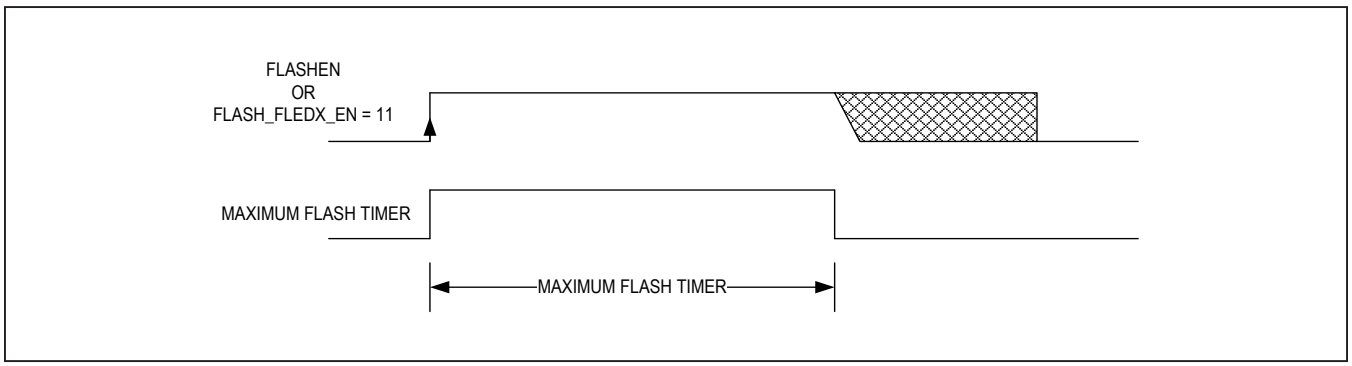


Figure 8. Maximum Flash Timer Mode

Torch Mode

In Torch mode, the LED current source provides from 11.72mA to 3187.5mA of output current for each channel. Torch mode is enabled through the TORCHEN or FLASHEN inputs or through the serial interface. Torch mode duration is programmable through the serial interface, and can be programmed to remain on indefinitely.

Enabling Torch Mode

The current sources in Torch mode is independently enabled either through the TORCHEN or FLASHEN inputs or through the serial interface as programmed by the TORCH_FLED_EN bits in the FLASH_EN register. If Flash mode and Torch mode are enabled at the same time, Flash mode is given the higher priority.

Torch Safety Timer

The Torch safety timer is activated any time Torch mode is enabled and the Torch Safety Timer Disable bit is set to 0.

The torch safety timer, programmable from 262ms to 15.7s via the serial interface, limits the duration of Torch mode to the programmed Torch safety timer duration. This timer can be configured to operate either in one-shot timer or maximum torch duration timer. In one-shot mode, the torch function is initiated on the rising edge of the TORCH_FLED_EN register bit or TORCHEN or FLASHEN inputs and terminated based on the programmed value of the safety timer (see Figure 10). In maximum torch timer mode, torch function remains enabled as long as TORCH_FLED_EN is a '11' or TORCHEN or FLASHEN is held high, unless the preprogrammed safety timer times out (see Figure 11).

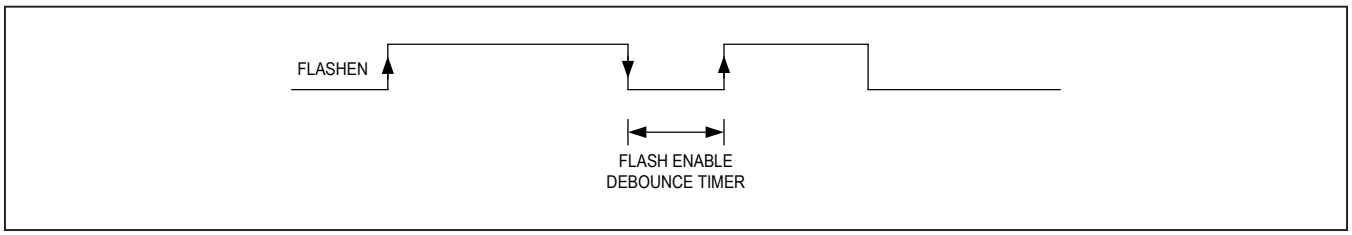


Figure 9. Flash Debounce Timer

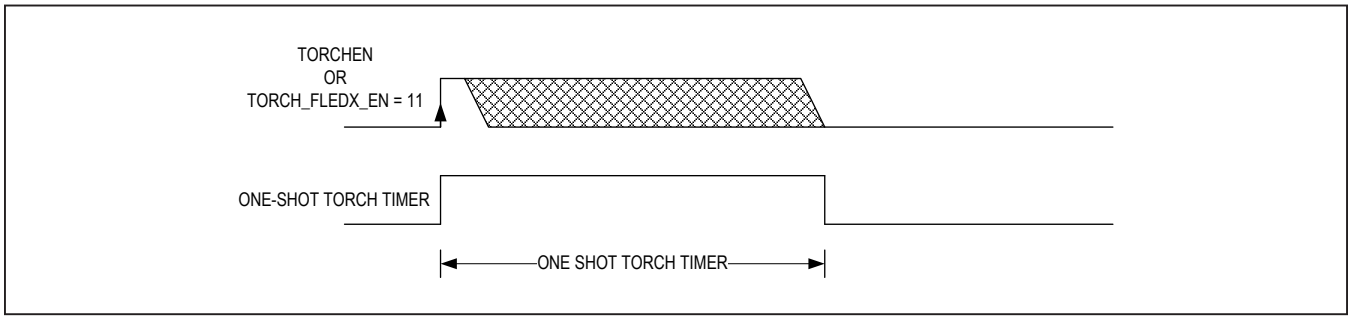


Figure 10. One Shot torch Timer Mode

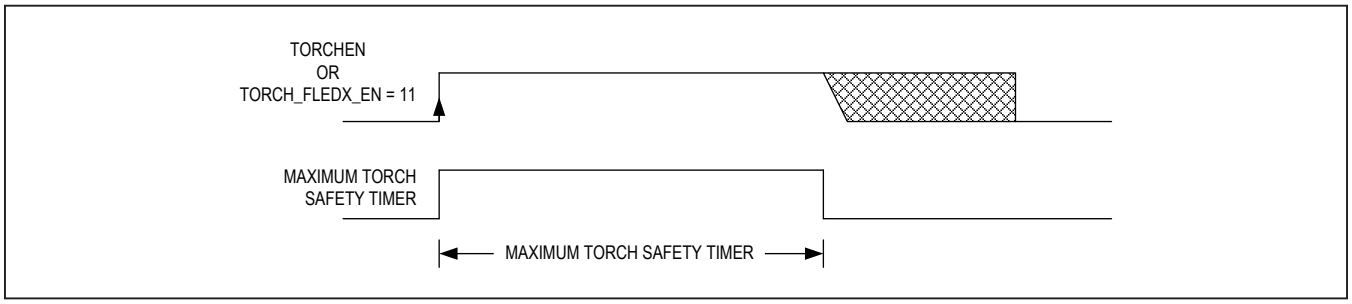


Figure 11. Maximum torch Timer Mode

The Torch safety timer can be disabled by setting the Torch safety timer disable bit to 1. In this case, the FLEDs will stay lit in Torch mode until the enable command (TORCHEN, FLASHEN, or serial interface) is deasserted, or Flash mode is initiated (since Flash mode has higher priority than Torch mode).

MAXFLASH Function

Note that MAXFLASH will detect a drop on V_{SYS} and not V_{BATT}.

During high load currents of a battery cell, the voltage will momentarily drop due to internal ESR of the battery, together with serial impendence form the battery to the load. For equipment requiring a minimum voltage for stable operation, the ESR of the battery needs to be calculated in order to estimate maximum current that can be drawn from the battery without making the cell voltage drop below this critical threshold. If this is not done, the power-down voltage will have to be set artificial high, reducing run time of the battery-operated equipment.

For applications like camera flash, movie light, or torch light the ESR of the system needs to be measured to calculate the maximum current that can be consumed by the flash to insure that at the end of the flash the battery voltage has not dropped below the minimum required battery voltage for the remaining system.

Since the ESR of a battery cell is dependent on load current, temperature, age of cell, and other parameters this ESR measurement has to be done during the start of each event in order to ensure that the current ESR of the battery cell is correct.

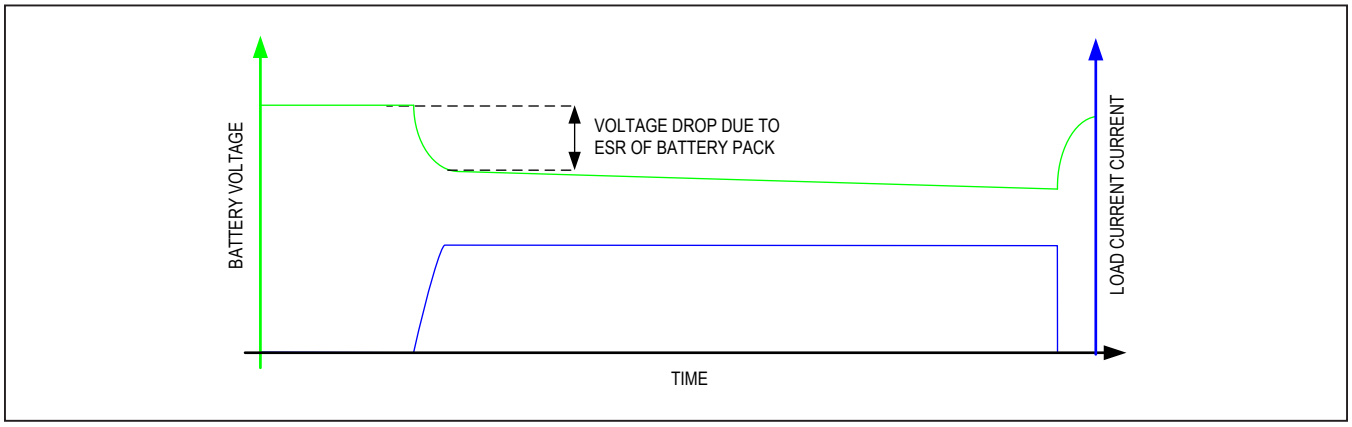


Figure 12. Voltage Drop Due to Battery ESR

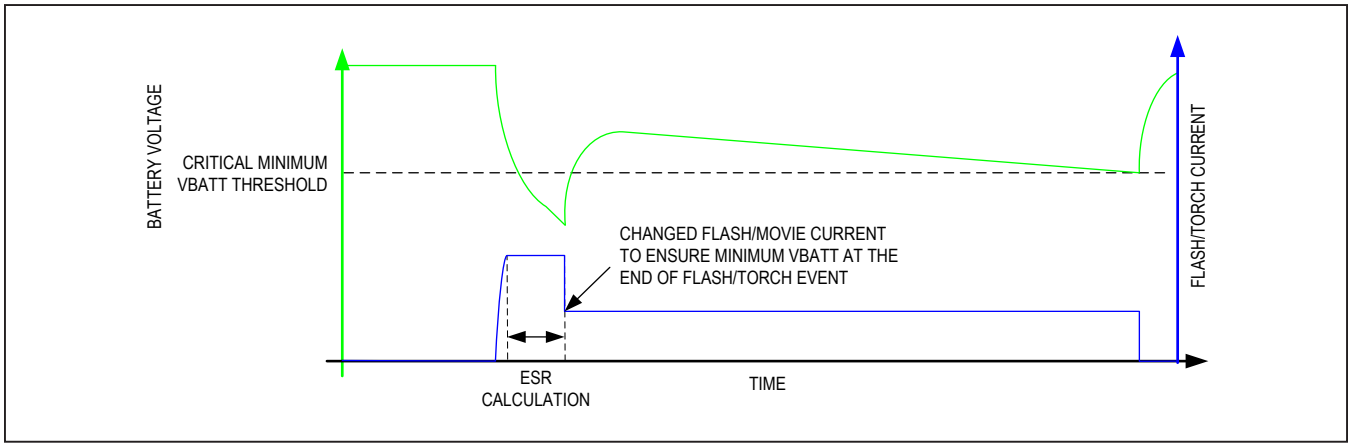


Figure 13. Using ESR Calculation to Insure Minimum Battery Voltage at the End of FLASH/TORCH Event Normal Case

In most cases, the camera flash is triggered by the camera module itself. Therefore, the ESR measurement of the battery has to be measured in real time during the initial flash event.

Since most systems contain many complex functions that are operated independent of each other, the current load might change during the FLASH/TORCH duration.

If another application within the system starts significantly drawing more current during the FLASH/TORCH duration, this can cause the battery voltage to drop below the minimum required battery voltage for the system, hence causing spurious events.

On the other hand, if an application is going from a high-current mode to a lower current mode during the FLASH/TORCH event, the battery voltage at the end of the FLASH/TORCH duration will be above the minimum battery voltage. This means that the actual FLASH/TORCH current could have been set higher for the remaining duration, allowing highest possible output current to be utilized.

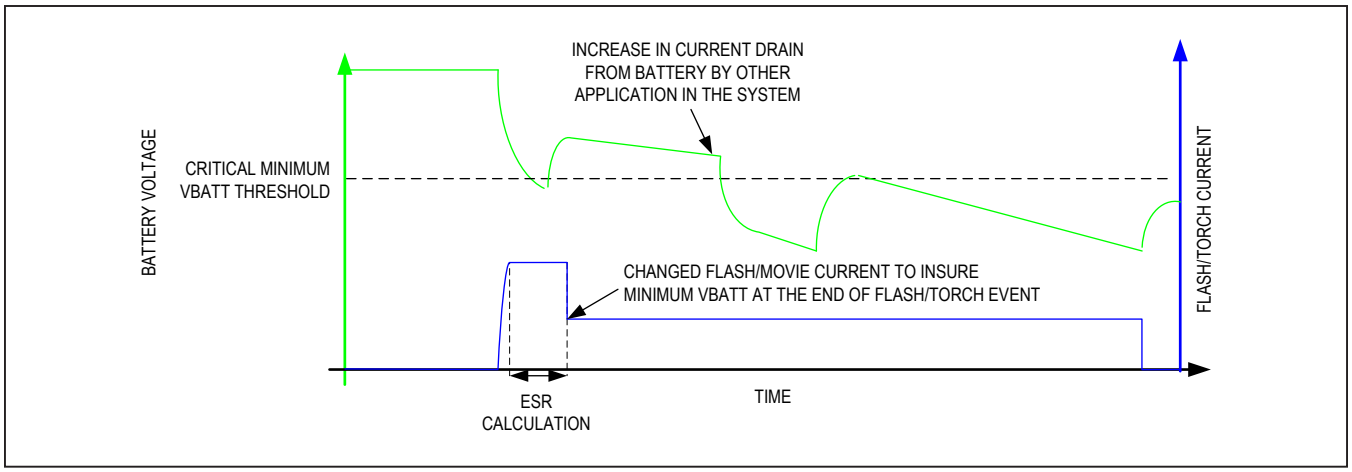


Figure 14. Using ESR Calculation to Ensure Minimum Battery Voltage at the End of FLASH/TORCH Event, with an Additional Load Event During the FLASH/TORCH Event

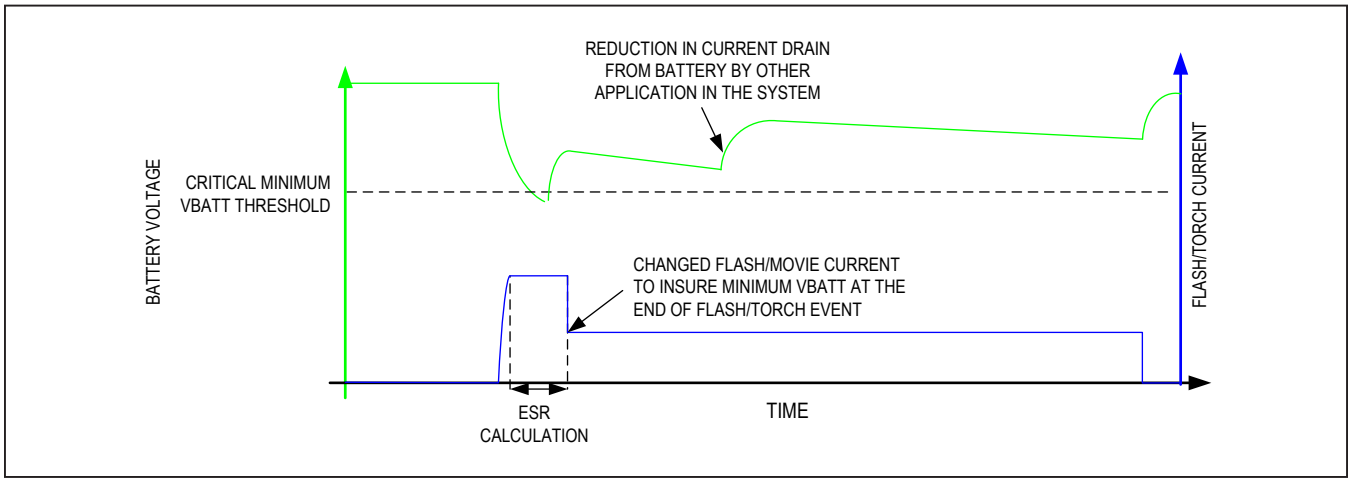


Figure 15. Using ESR Calculation to Ensure Minimum Battery Voltage at the end of FLASH/MOVIE Event with Load Release During FLASH/MOVIE Event

To avoid having to measure the ESR of the battery cell and still achieve the goal of insuring that the battery voltage does not drop below a predefined threshold, an alternative circuit can be used.

During a FLASH/TORCH event, the input voltage of the device is monitored (input Kelvin-connected to the battery cell, referred to as V_{BATT}). If the input voltage drops below a predefined threshold, referred to as MAXFLASH_TH, this is an indication that the FLASH/TORCH event is drawing more current than the battery can support.

As a reaction to this event, the current regulator driving the FLASH/TORCH will reduce output current in one step. This will reduce the input current, hence reducing the current drawn from the battery. Since the battery current is now reduced, V_{BATT} will start to rise due to the internal ESR of the battery cell.

The current regulator will then implement a user-defined delay, referred to as $t_{LB\_TMR\_F}$, for falling edge detection and $t_{LB\_TMR\_R}$ for rising edge detection. The V_{BATT} is then sampled again and compared to the MAXFLASH_TH. If V_{BATT} is still below this MAXFLASH_TH threshold the current regulator will reduce output current once again to insure that minimum V_{BATT} is available for the remaining of the system. If V_{BATT} is above the MAXFLASH_TH threshold plus a user-defined hysteresis, referred to as MAXFLASH_HYS, the current regulator will increase the output current one step, only if present output current is less than user-defined output current. If the MAXFLASH_HYS event is set to “000” then the flash current will only be reduced as a result of the low system voltage regardless if the voltage recovers again. The LED current is not allowed to increase again.

This will continue for the entire duration of the FLASH/TORCH event, ensuring that the FLASH/TORCH output current is always maximized for the specific operation conditions.

Open/Short Protection

The flash module monitors the FLED voltage to detect any open or short LEDs. An open fault is detected when the voltage on FLED rises above V_{BYP} – 30mV (typ) for 8ms (typ), and short fault is detected when the voltage on FLED drops below 1.0V (max) (referenced to GND) for 1ms (typ). The fault detection provides a continuous monitor of the current regulator’s status. Once a fault is detected, the current regulator is disabled and the status is latched into the interrupt register bit. This allows the processor to determine the operating condition of the MAX77829. Depending on the state of the interrupt mask bits, the MAX77829 can pull down on the $\overline{INT}$ pin when the flash open/short interrupt occurs.

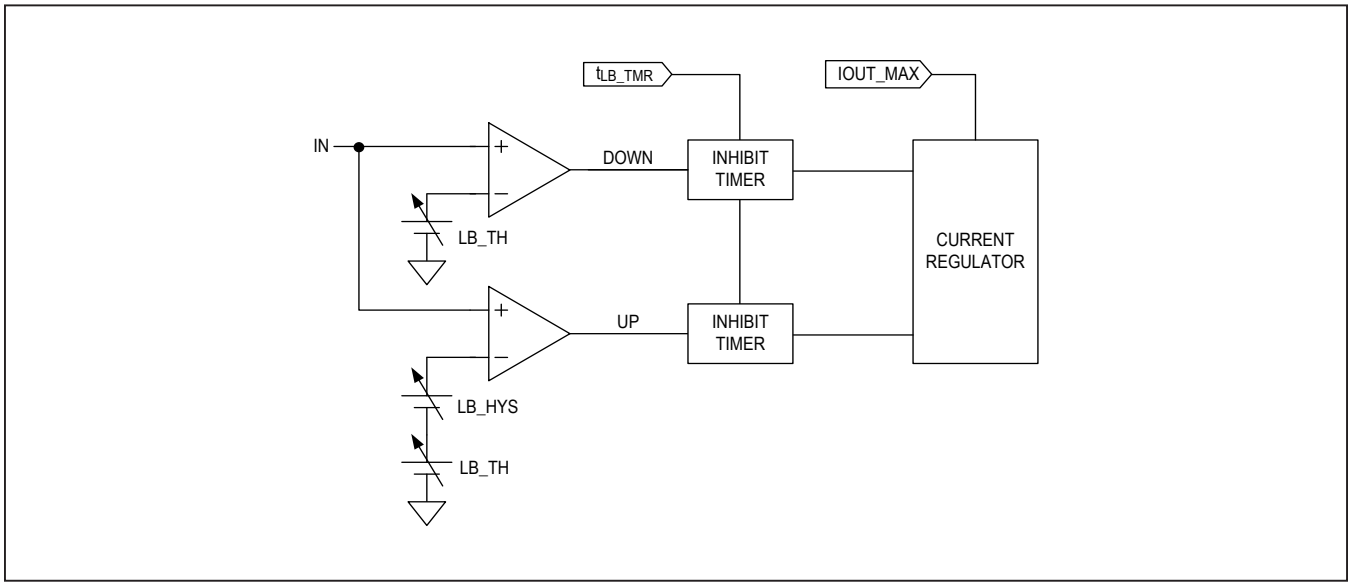


Figure 16. Block Diagram of MAXFLASH Function

Safeout LDO

The safeout LDO is a linear regulator that provides an output voltage of 3.3V, 4.85V, 4.9V, or 4.95V and can be used to supply low voltage-rated USB systems. The SAFEOUT linear regulator turns on when $V_{CHGIN} \geq 3.2V$ and SFOUT_EN = logic high (from MUIC), regardless of Charger Enable or $\overline{DETBAT}$. SAFEOUT is disabled when CHGIN is greater than the overvoltage threshold (5.90V typ). The safeout LDO integrate high-voltage MOSFET to provide 20V protection at their inputs, which are internally connected to the charger input at CHGIN.

SAFEOUT is default ON at 4.9V.

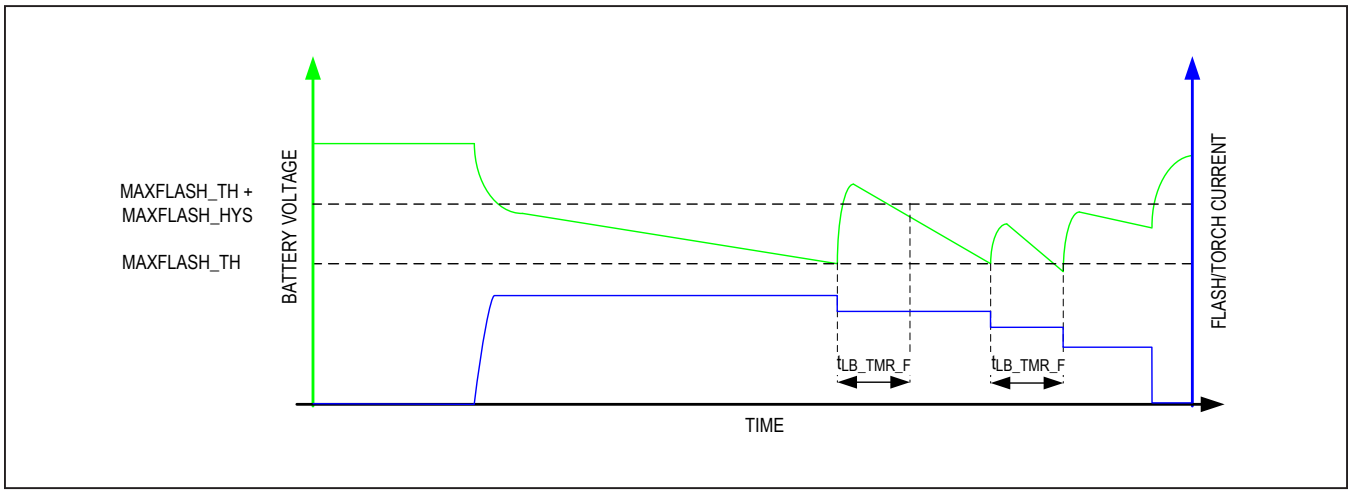


Figure 17. Example 1 of MAXFLASH Function Operation

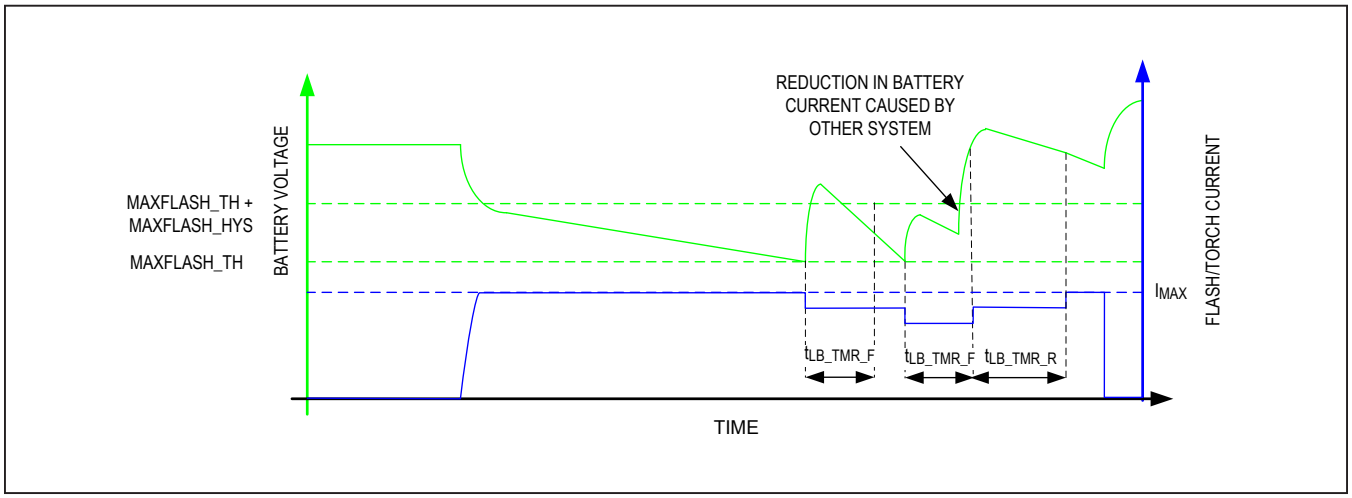


Figure 18. Example 2 of MAXFLASH Function Operation

WLED Backlight Driver

Step-Up Converter

The MAX77829 LED boost converter operates from a 2.5V to $V_{SYSOVLO}$ input supply. Due to duty-cycle limitations, full output power is only available for input voltages > 2.8V. For low input voltages (2.5V to 2.8V), maximum LED output current is available as shown in Table 6.

The MAX77829 LED boost converter utilizes a peak-current limited architecture. In the event of a serious overload, where the converter is operating at its current limit for 16ms, an interrupt is generated, and the processor can determine the appropriate course of action.

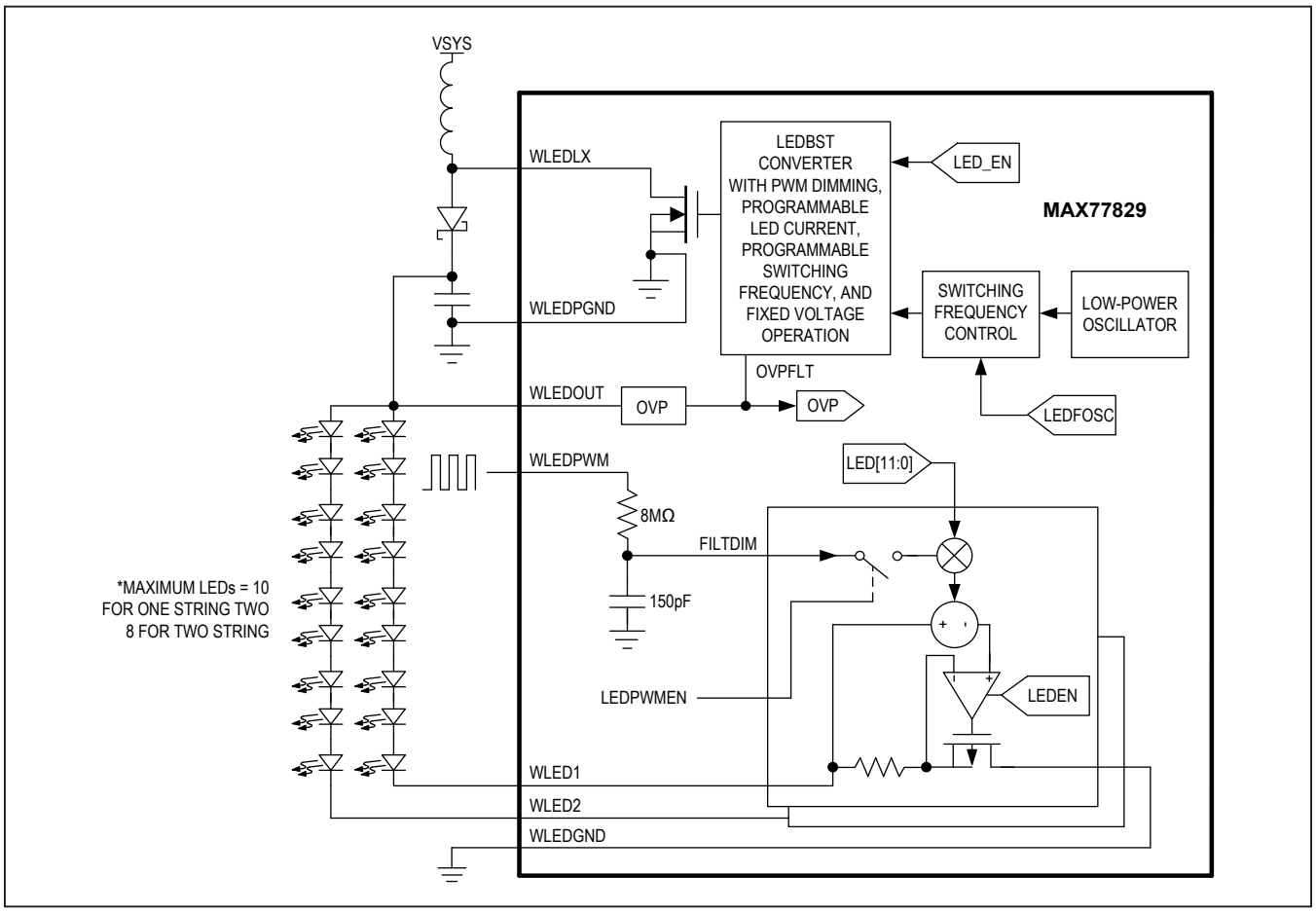


Figure 19. Functional Diagram for WLED Boost Converter and Current Source

Table 6. Maximum LED Output Current

V_{SYS}	2 STRINGS OF 8		2 STRINGS OF 6		1 STRING OF 10	
	1.47MHz	2.2MHz	1.47MHz	2.2MHz	1.10MHz	733kHz
3.0V	24.9mA	24.9mA	24.9mA	24.9mA	**TBD**	**TBD**
2.9V	24.9mA	21mA	24.9mA	24.9mA	**TBD**	**TBD**
2.8V	24.9mA	17mA	24.9mA	24.9mA	**TBD**	**TBD**
2.7V	23mA	14mA	24.9mA	24.9mA	**TBD**	**TBD**
2.6V	20mA	11mA	24.9mA	24.9mA	**TBD**	**TBD**
2.5V	18mA	8mA	24.9mA	21mA	**TBD**	**TBD**

The step-up converter switches at a fixed frequency of 2.2MHz to allow the use of small external components. Lower switching frequency can be selected through the serial interface to provide higher efficiency and/or avoid noise-sensitive frequency bands.

Overvoltage Protection

The MAX77829 is protected against open-circuited LED strings. In the event that the LED string is open, and the step-up converter is enabled, the WLEDOUT pin senses the output voltage of the step-up converter, and regulates the step-up output voltage at the OVP threshold. An interrupt (if unmasked) is generated when the step-up converter reaches the OVP threshold.

To optimize efficiency for the number of WLEDs used, the OVP threshold is programmable via WLEDOVP bit in WLEDBSTCNTL1 register. 28V (max) OVP setting is ideal for supporting up to 8 WLEDs in series while the 35V (max) OVP setting is needed for supporting up to 10 WLEDs in series.

Current Sources

The MAX77829 provides a low-side current source with 8-bit resolution for programming the LED current. A single register programs the output current in both sources. Both current sources can be programmed to respond to, or ignore, the WLEDPWM dimming input with a single bit.

The MAX77829 current source features a low-dropout voltage, increasing overall efficiency. When driving the maximum number of series LEDs, the current sources may enter dropout when the LED current is programmed near the maximum value. In this case, the current sources regulates with a 100mV (typ) voltage drop, and provide as much current as allowed by the forward voltage of the LEDs.

Setting the Current Limit

The two WLED Strings feature linear dimming with 8-bit resolution (97.656µA per LSB).

In addition to the internal LED current control offered through the MAX77829 step-up converter, an external PWM signal may be applied to the WLEDPWM input for content-adaptive brightness control. The WLEDPWM input accepts signals with frequency between 5kHz and 60kHz, although optimal performance (minimized LED current ripple) is attained with PWM frequencies ≥ 15kHz. The WLEDPWM input linearly decreases the LED current in strings 1 and 2 and is enabled through the serial interface.

WLED1 and WLED2 each have individual current sources, and both strings or any individual string may be enabled at any time. WLED1 and WLED2 share a common current setting register, so strings 1 and 2 always have the same LED current, if enabled.

Mismatched LED strings can also be supported by the MAX77829. In the event that LED strings with different LED count are being powered at the same time, the string with the fewest number of LEDs will see a higher voltage drop across the current driver causing higher power consumption.

The WLED_ current sources provide up to 24.9mA for powering the LED backlight. Under certain operating conditions, such as when powering the maximum number of LEDs in series, the WLED_ current sources operates in a dropout condition, in which 24.9mA may no longer be provided to the LED string.

Enabling CABC Dimming (WLEDPWM Input)

The MAX77829 supports a CABC dimming signal from the processor to linearly decrease the backlight intensity based on the video signal content. The WLEDPWM input accepts a PWM signal in the 5kHz to 60kHz range, with optimal performance (minimized LED current ripple) attained for PWM dimming frequency > 15kHz. The WLEDPWM signal is internally RC filtered (corner frequency 500Hz), and is then used to decrease the reference voltage to the current DAC for strings 1 and 2. Two bits in Boost Converter Control Register 1 (LEDPWM1EN and LEDPWM2EN) independently program strings 1 and 2 to respond to or ignore the WLEDPWM signal. If one of the current sources (WLED1 or WLED2) is disabled, this current source ignores the WLEDPWM signal.

In the event that a 0% duty cycle is applied to the WLEDPWM input, the converter does not shut down, but instead continues to regulate the WLEDOUT voltage. The output current at the WLED_ pins is close to zero.

Top System Management

Main Bias

The main bias includes voltage and current references for all circuitry that runs from the V_{SYS} node. It includes a 0.3% accurate voltage reference that is used by various blocks. The current bias is generated from the reference voltage and trimmed to be within 1.5% and is zero-TC. The current bias is converted to a voltage to route to other blocks.

The V_{REF} block generates a 1.25V zero-TC reference voltage. I_{BIAS} takes V_{REF} as input and generates a V_{IBIAS} voltage that will track RPH variation and TC. Instead of generating a current output, a bias voltage for current is generated to be distributed to different blocks.

It saves the number of top level routing lines for bias current at the expense of requiring a bias current generation circuit, generating current as V_{IBIAS}/RPH.

System Faults

The MAX77829 monitors the system for the following faults:

- SYS Undervoltage Lockout
- SYS Overvoltage Lockout
- SYS Low Threshold Detection
- Thermal Shutdown

SYS Faults

The system monitors the SYS node for undervoltage, overvoltage, and low threshold events. The following describes the IC behavior if any of these events is to occur. The SYS Low Threshold Detection is configurable via registers.

SYS undervoltage lockout prevents the regulators from being used when the input voltage is below the operating range. When the voltage from SYS to GND (V_{SYS}) is less than the undervoltage lockout threshold ($V_{SYSUVLO}$), the MAX77829 enters its global shutdown state.

SYS overvoltage lockout is a fail-safe mechanism and prevents the regulators from being used when the input voltage is above the operating range. The absolute maximum ratings state that the SYS node withstands is up to 6V. The SYS OVLO threshold is set to 5.3V (typ) – ideally V_{SYS} should not exceed the battery charge termination threshold. Systems must be designed such that V_{SYS} never exceeds 4.8V (transient and stead-state). If the V_{SYS} should exceed $V_{SYSOVLO}$ during a fault, the MAX77829 enters its global shutdown state.

When V_{SYS} voltage falls below its low threshold (V_{SYSL}), the MAX77829 initiates a LOWSYS interrupt. The low-SYS detection circuitry is enabled by default but can be disabled using the LSEN bit to reduce current consumption. V_{SYSL} is configurable using LSDAC register bits. Choose V_{SYSL} based on the system requirements and battery capacity.

The V_{SYSL} hysteresis (V_{LSHYST}) is configurable using LHYST register bits. Choose V_{LSHYST} based on your system peak currents and battery impedance. V_{LSHYST} should be set sufficiently high to avoid oscillation in and out of the low-SYS state due to system peak currents.

Since the main battery is typically connected to the SYS node (through the internal BATT to SYS switch), this circuit also functions as a low BATT comparator.

Thermal Fault

The MAX77829 has one centralized thermal circuit for sensing die temperature. If temperature increases above 165°C (T_{SHDN}) a thermal shutdown event occurs and the MAX77829 enters its global shutdown state.

In addition to the 165°C threshold, interrupts are generated when the die temperature reaches 120°C and 140°C.

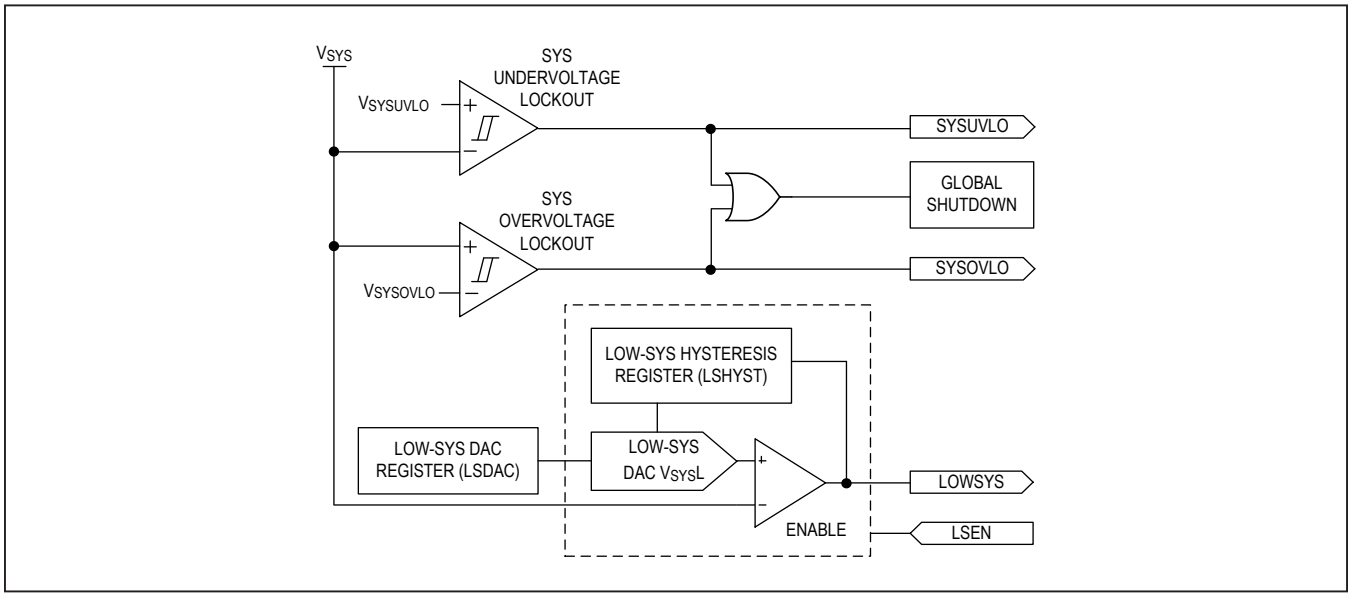


Figure 20. V_{SYS} Fault Monitor Functional Block Diagram

There is a 15°C thermal hysteresis. After thermal shutdown, if the die temperature cools by 15°C, the thermal shutdown bus is deasserted and DVDD LDO can be enabled again.

The main battery charger has an independent thermal control loop which will not cause thermal shutdown. In the event that the charger thermal overload occurs, only the charger will turn OFF.

Shutdown Events

The MAX77829 has a POR bus that goes to all blocks except the fuel gauge. The POR signal turns off these blocks and resets their registers to a default state under the following conditions:

- SYS Undervoltage Lockout
- SYS Overvoltage Lockout
- Overtemperature Fault (165°C) - This signal has hysteresis, if the die temperature hits 150°C, this signal is deasserted. This should not cause a turn-on event; turn-on events are listed in the *Thermal Fault* section. In other words, this signal is latched.
- Manual Reset ($\overline{MRST}$ pulled low for 7s default).

I²C Interface

The I²C serial bus consists of a bidirectional serial-data line (SDA) and a serial-clock input (SCL). The IC is a slave-only device, relying upon a master to generate a clock signal. The master initiates data transfer to and from the IC and generates SCL to synchronize the data transfer.

I²C is an open-drain bus. Both SDA and SCL are bidirectional lines, connected to a positive supply voltage through a pullup resistor. They both have Schmitt triggers and filter circuits to suppress noise spikes on the bus to assure proper device operation. A bus master initiates communication with the IC as a slave device by issuing a START condition followed by the IC address. The IC address byte consists of 7 address bits and a read/write bit (R/$\overline{W}$). After receiving the proper address, the IC issues an acknowledge bit by pulling SDA low during the ninth clock cycle. Figure 21 shows the I²C slave addresses for each functional block.

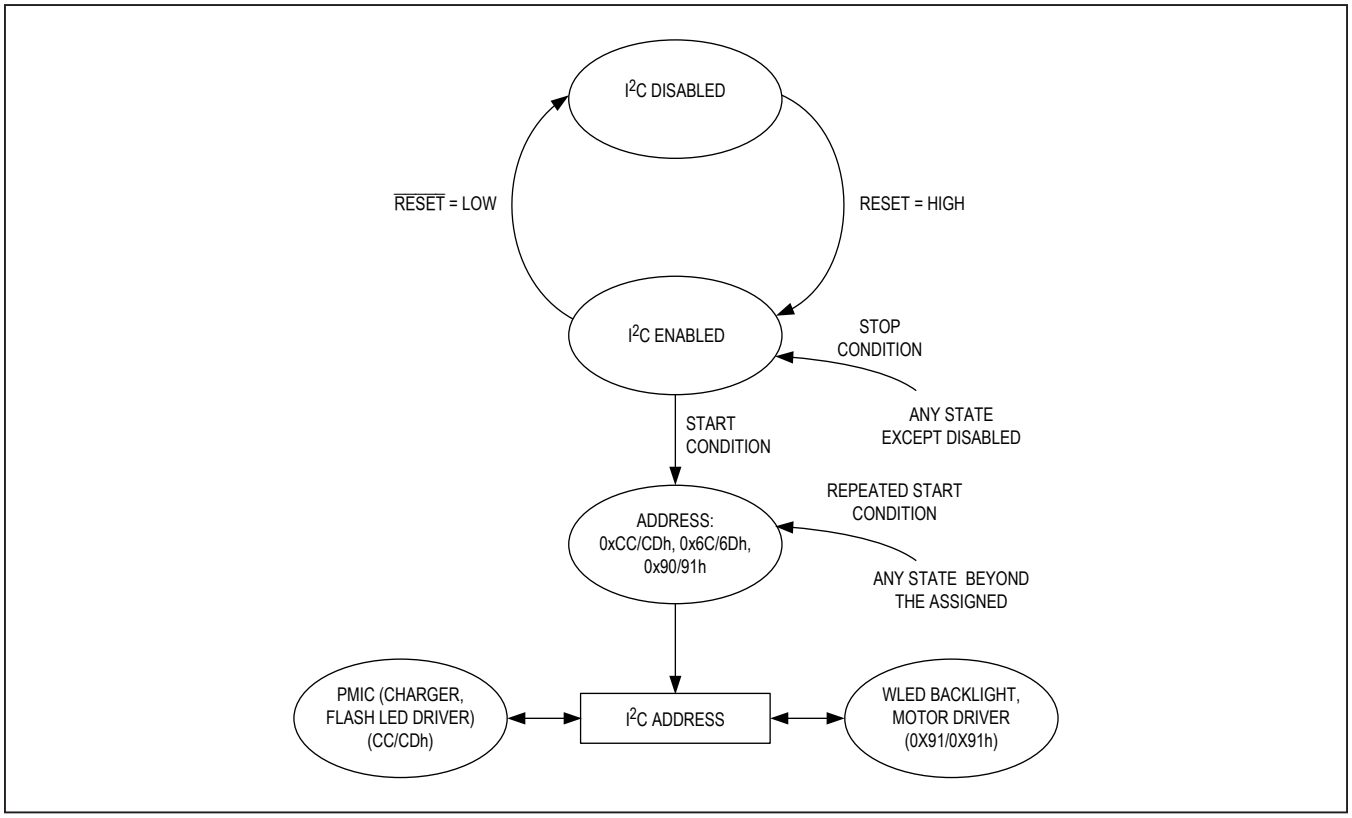


Figure 21. I²C State Diagram

I²C Bit Transfer

Each data bit, from the most significant bit to the least significant bit, is transferred one by one during each clock cycle. During data transfer, the SDA signal is allowed to change only during the low period of the SCL clock and it must remain stable during the high period of the SCL clock (Figure 22).

I²C Start And Stop Conditions

Both SCL and SDA remain high when the bus is not busy. The master signals the beginning of a transmission with a START (S) condition by transitioning SDA from high to low while SCL is high. When the master has finished communicating with the IC, it issues a STOP (P) condition by transitioning SDA from low to high while SCL is high. The bus is then free for another transmission (Figure 23). Both START and STOP conditions are generated by the bus master.

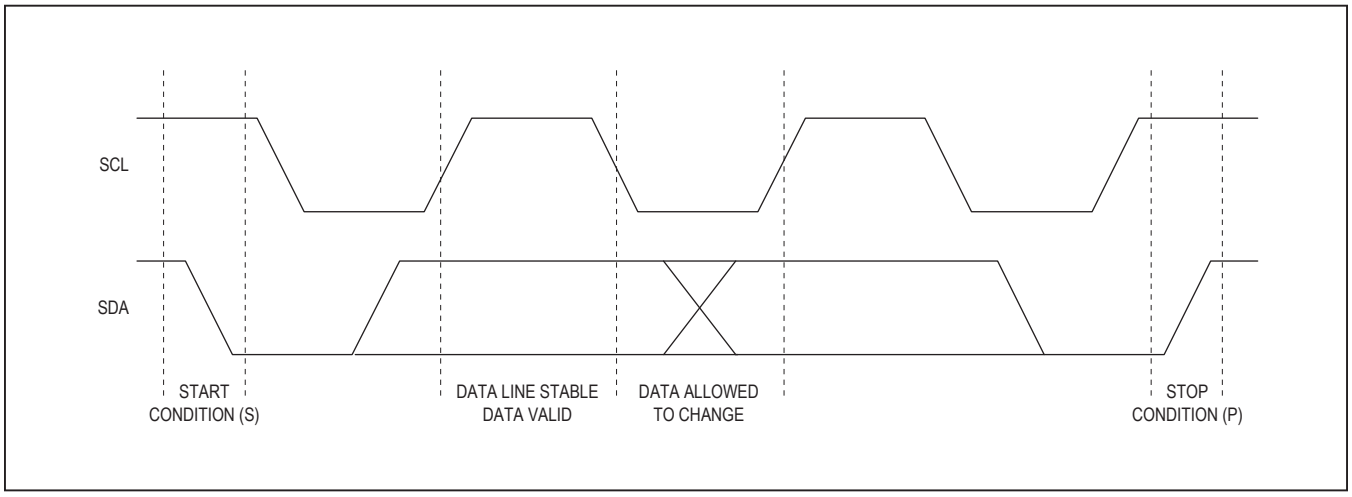


Figure 22. I²C Bit Transfer

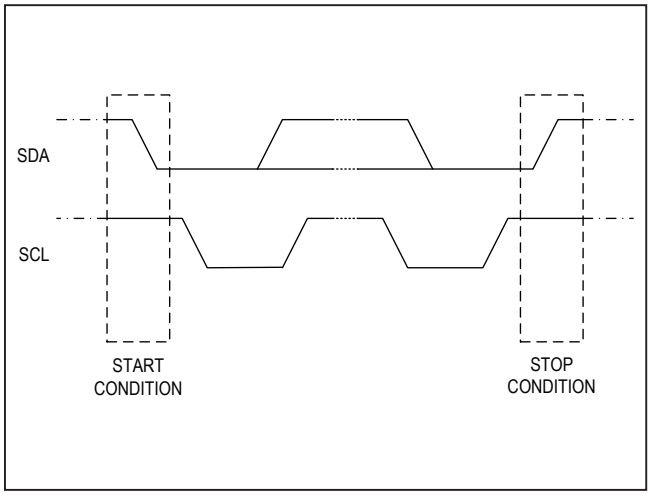


Figure 23. I²C Start and Stop Conditions

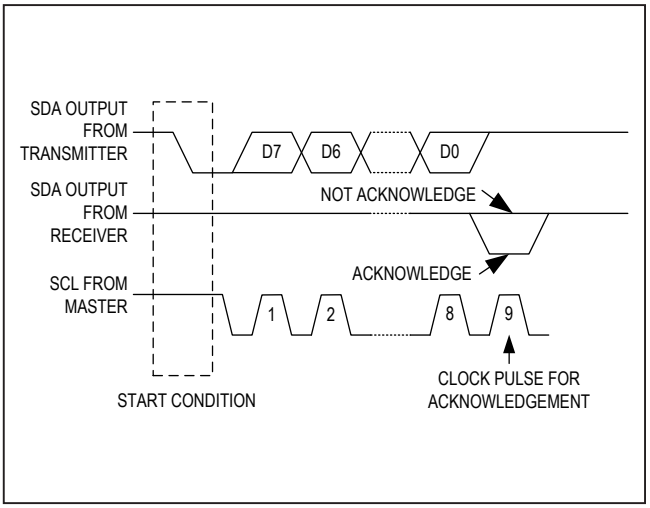


Figure 24. I²C Acknowledge

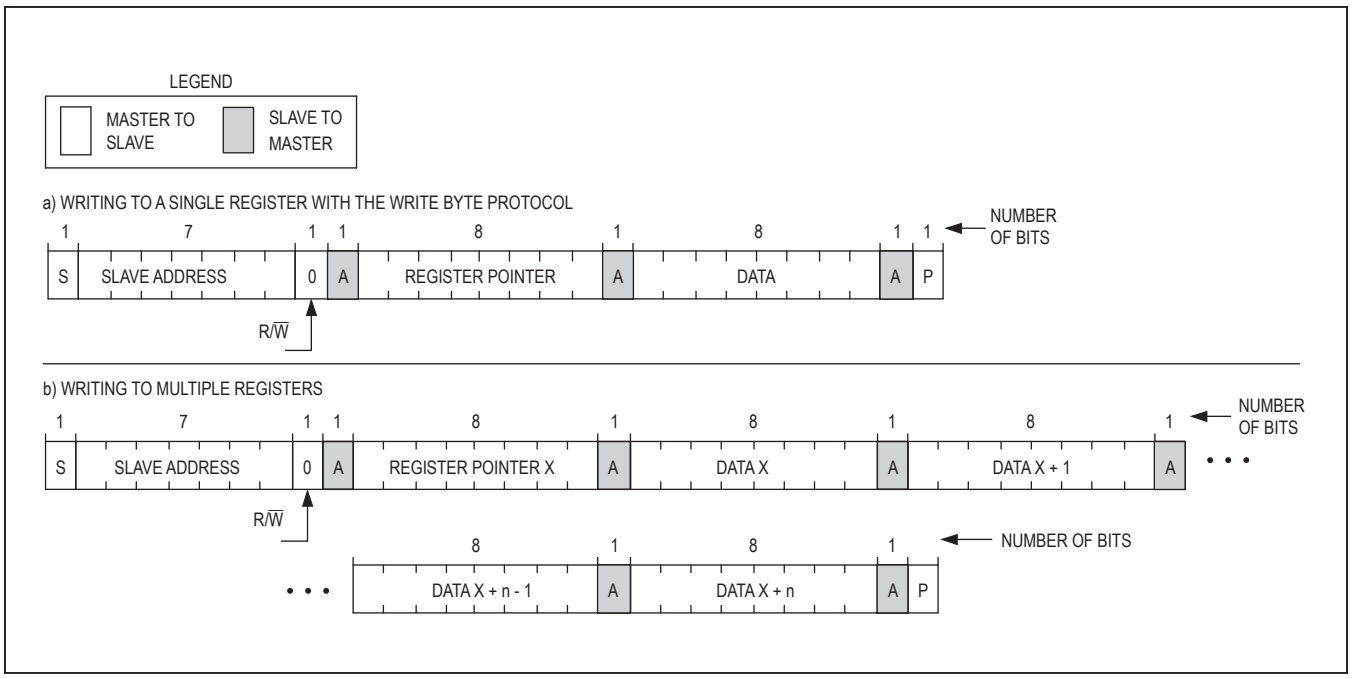


Figure 25. Master Transmits (Write Mode)

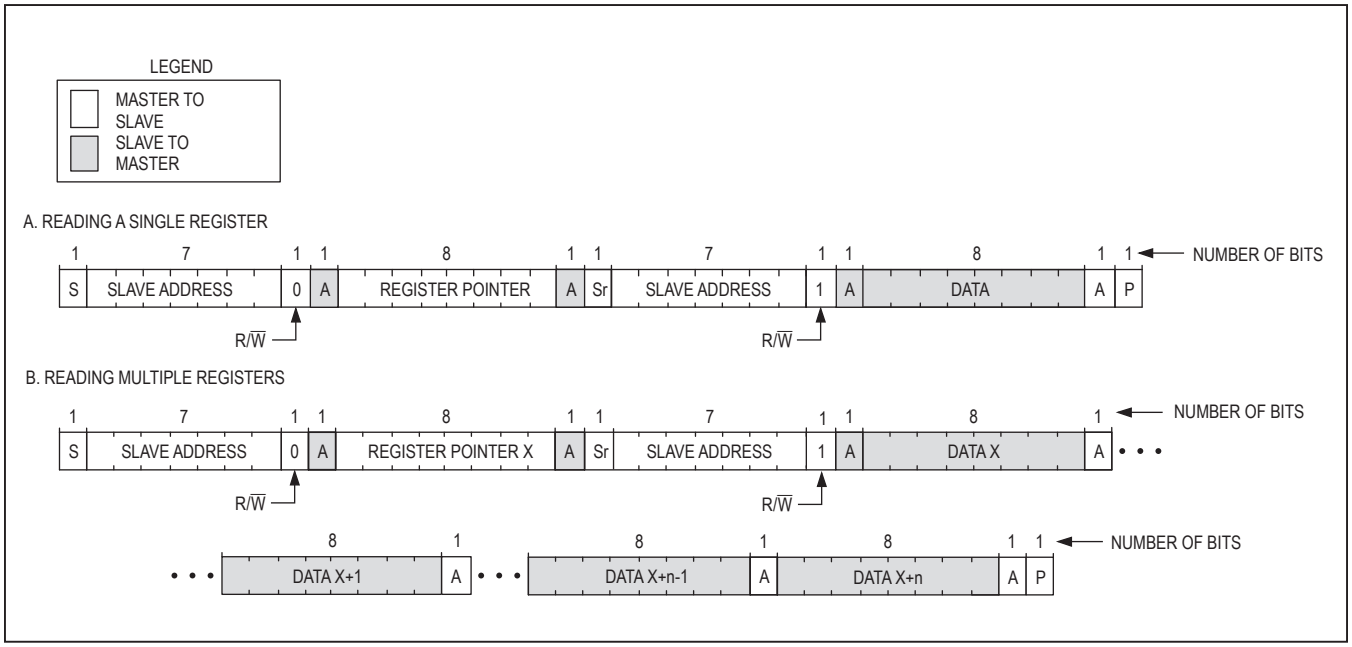


Figure 26. Master Reads Register Data Without Setting Register Address (Read Mode)

I2C Acknowledge

The number of data bytes between the Start and Stop conditions for the Transmitter and Receiver are unlimited. Each 8-bit byte is followed by an acknowledge bit. The acknowledge bit is a high-level signal put on SDA by the transmitter during which time the master generates an extra acknowledge related clock pulse. A slave receiver which is addressed must generate an acknowledge after each byte it receives. Also a master receiver must generate an acknowledge after each byte it receives that has been clocked out of the slave transmitter.

The device that acknowledges must pull down the SDA line during the acknowledge clock pulse, so that the SDA line is stable low during the high period of the acknowledge clock pulse (setup and hold times must also be met). A master receiver must signal an end of data to the transmitter by not generating an acknowledge on the last byte that has been clocked out of the slave. In this case, the transmitter must leave SDA high to enable the master to generate a Stop condition.

Multibutton Manual Reset

$\overline{MRST}$ is the manual reset input for hardware reset. Falling edge of $\overline{MRST}$ and minimum 7s (default) low initiate the automatic power reboot. The debouncing time is programmable ranging from 3s to 10s (with 1s per step). After the debouncing timer expires, the $\overline{RESET}$ output asserts and all the MAX77829 registers return to their default values. The $\overline{RESET}$ output is intended to reset the host system's main PMIC and/or applications processor in case they do not already have manual reset inputs of their own. When the manual reset feature is not required, pull $\overline{MRST}$ above logic-high input.

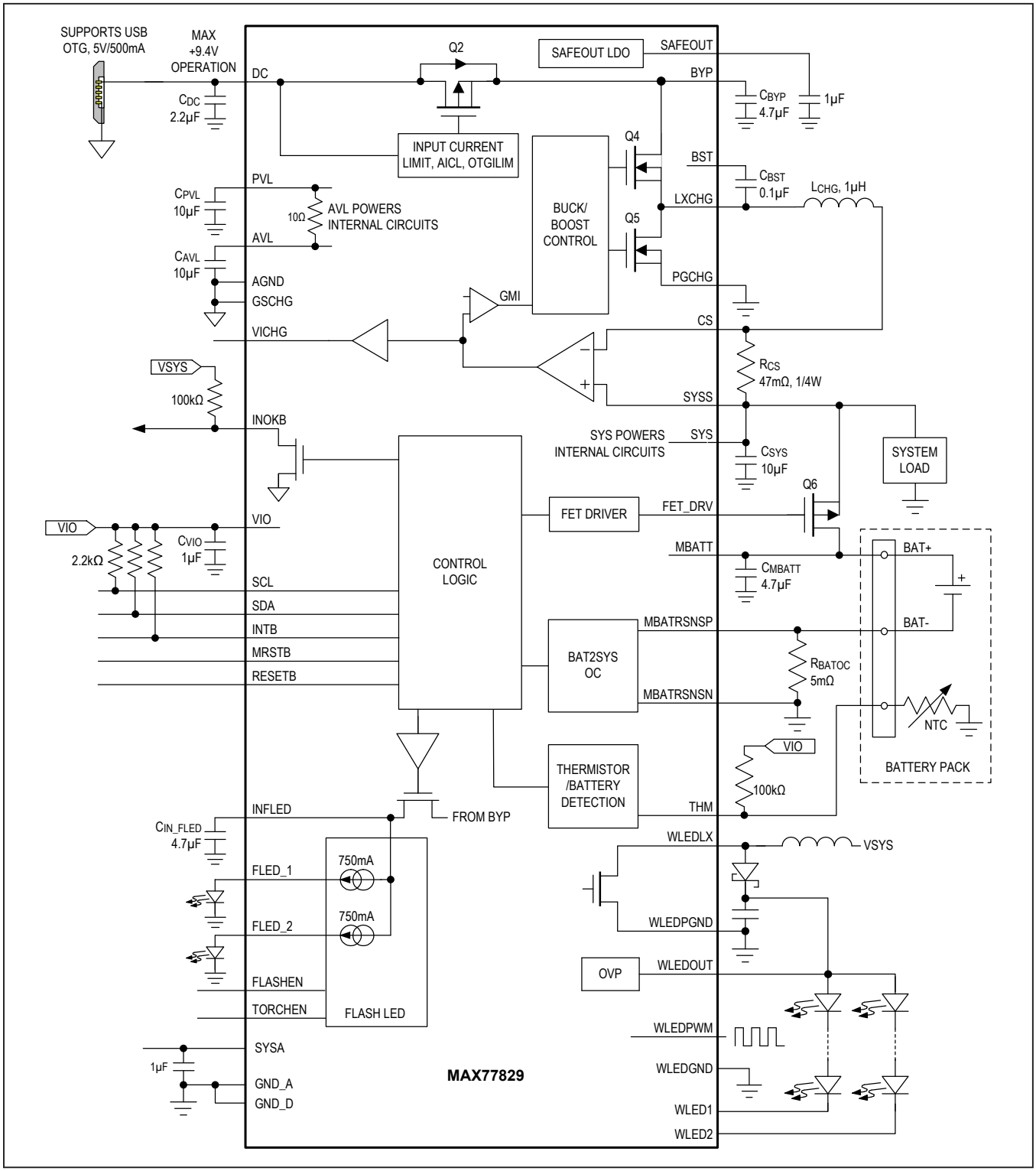
$\overline{INT}$

The MAX77829 interrupts indicate to the application processor that the status of the MAX77829 has changed. $\overline{INT}$ asserts low whenever one or more interrupts are toggled, and those interrupts are not masked. The application processor may read the interrupts in two steps. First, the AP reads the INTSRC register. This is a read-only register indicating which functional block is generating the interrupt, i.e. charger, flash, or other blocks. Depending on the result of the read, the next step is to read the actual interrupt registers pertaining to the functional block.

For example, if the application processor reads 0x02 from INTSRC register, it means the top-level PMIC block has an interrupt generated. The next step is to read the INT1 register of the PMIC functional block.

$\overline{INT}$ becomes high (cleared) as soon as the read sequence of the last INT_ register that contains an active interrupt starts. All interrupts can be masked to prevent $\overline{INT}$ from being asserted for masked interrupts. A mask bit in the INTM register implements masking. The INTSRC register can still provide the actual interrupt status of the masked interrupts, but $\overline{INT}$ is not asserted.

Typical Application Circuit



Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX77829EWN+	-40°C to +85°C	56 WLP 0.4mm pitch, 3.64mm x 3.24mm

Chip Information

PROCESS: CMOS

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
56 WLP	W563F3+1	**21-1038**	Refer to **Application Note 1891**

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	12/15	Initial release	—

