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MAX77860

USB Type-C, 3A Switch-Mode Buck Charger with Integrated CC Detection, Reverse Boost, and ADC

General Description

The MAX77860 is a high-performance single input switch mode charger that features USB Type-C CC detection capability in addition to reverse boost capability and a Safeout LDO.

This switched-mode battery charger with two integrated switches, provides small inductor and capacitor sizes, programmable battery charging current, and is ideally suited for portable devices such as smartphones, IoT devices, and other Li-ion battery powered electronics. The charger features a single input, which works for both USB and high voltage adapters. It supports USB Type-C CC detection under BC 1.2 specification, and the power-path switch is integrated in the chip. All MAX77860 blocks connected to the adapter/USB pin are protected from input overvoltage events up to 14V. The USB-OTG output provides true-load disconnect and is protected by an adjustable output current limit. It has an input current limit up to 4.0A and can charge a single-cell battery up to 3.15A. When configured in reverse-boost mode, the IC requires no additional inductors to power USB-OTG accessories. The switching charger is designed with a special CC, CV, and die temperature regulation algorithm, as well as I²C programmable settings to accommodate a wide range of battery sizes and system loads. The on-chip ADC can help monitor the charging input voltage/current, battery voltage, charging/discharging current, and the battery temperature.

The MAX77860 communicates through an I²C 3.0 compatible serial interface consisting of a bidirectional serial data line (SDA) and a serial clock line (SCL). The IC is available in a 3.9mm x 4.0mm, 81-bump (9 x 9 array), 0.4mm pitch, wafer-level package (WLP).

Applications

- USB Type-C Charging for 1S Li-ion Applications
- Mobile Point-of-Sale Devices
- Portable Medical Equipment
- Portable Industrial Equipment

Benefits and Features

- Single-Cell Switch Mode Charger
 - Up to 14V Protection
 - 4.0V to 13.5V Input Operating Range
 - Switching Charger with D+/D- Charger Detection
 - Up to 4.0A Input Current Limit with Adaptive Input Current Limit (AICL)
 - Up to 3.15A Battery Charging Current Limit
 - Optional External Sense Resistor
 - CC, CV, and Die Temperature Control
 - Supports USB-OTG Reverse Boost, up to 1.5A Current Limit
 - Master-Slave Charging Capability, up to 6A Charge Current
 - Integrated Battery True-Disconnect FET
 - Rated up to 9A_{RMS}, Discharge Current Limit (Programmable)
- USB Type-C Detection
 - Integrated V_{CONN} Switch
 - CC Pin
 - D+/D- Detection for USB HVDCP
 - BC 1.2 Support
- One Safeout LDO
- I²C-Compatible Interface

Ordering Information appears at end of data sheet.

Simplified Block Diagram

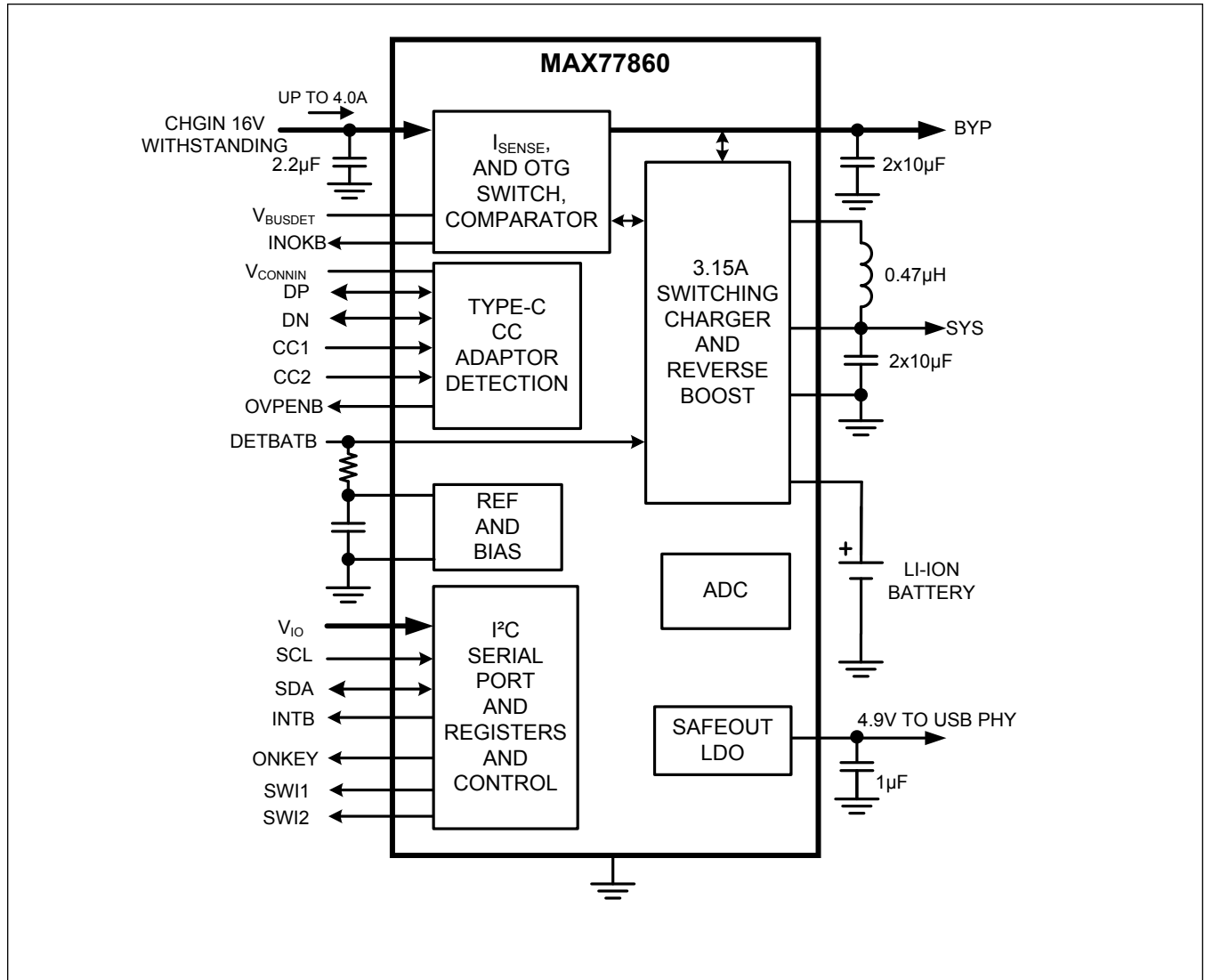


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Absolute Maximum Ratings

Operating Junction Temperature (T _J) Range	-40°C to +85°C	BYP Continuous Current	3A _{RMS}
Junction Temperature (T _J) Range	-40°C to +150°C	CSP to GND	-0.3V, BATT - 0.3V to 6V, BATT + 0.3V
Storage Temperature Range	-40°C to +150°C	CSN to GND	-0.3V, BATT - 0.3V to 6V, BATT + 0.3V
Soldering Temperature (reflow)	+260°C	SLAVE to GND	-0.3V to SYS_A + 0.3V
Switching Charger		ONKEY to GND	-0.3V to BATT + 0.3V
CHGIN to GND	-0.3V to 16V	SW11 to GND	-0.3V to SYS_A + 0.3V
BYP to GND	-0.3V to 16V	SW12 to GND	-0.3V to SYS_A + 0.3V
PVL to GND	-0.3V to 6V	CHGIN to GND	-0.3V to AVL + 0.3V
AVL to GND	-0.3V to 6V	Safeout LDO	
BAT_SP to GND	-0.3V, BATT - 0.3V to 6V, BATT + 0.3V	SAFEOUT to GND	-0.3V to 6V, CHGIN + 0.3V
BATT to GND	-0.3V to 6V	USB Type-C	
SYS to GND	-0.3V to 6V	DP, DN to GND	-0.3V to V _{CCINT} + 0.3V
DETBATB to GND	-0.3V to V _{IO} + 0.3V	CC1, CC2 to GND	-0.3V to V _{CCINT} + 0.3V
V _{BUSDET} to GND	-0.3V to 20V	V _{CONNIN} to GND	-0.3V to V _{CCINT} + 0.3V
OVPENB to GND	-0.3V to AVL + 0.3V	V _{CONNBTEN_SYS} to GND	-0.3V to 6V
BST to PVL	-0.3V to 16V	ADC	
BST to CHGLX	-0.3V to 6V	THMB, THM to GND	-0.3V to BATT + 0.3V
INOKB to GND	-0.3V to SYS + 0.3V	I ² C and Interface Logic	
BAT_SN to GND	-0.3V to 0.3V	V _{IO} to GND	-0.3V to 6V
CHGPG to GND	-0.3V to 0.3V	SDA, SCL to GND	-0.3V to V _{IO} + 0.3V
CHGLX Continuous Current	3.5A _{RMS}	SYS_A, SYS_Q to GND	-0.3V to 6V
CHGPG Continuous Current	3.5A _{RMS}	INTB	-0.3V to SYS_A + 0.3V
SYS Continuous Current	4.5A _{RMS}	TEST_, V _{CCTEST} to GND	-0.3V to 6V
BATT Continuous Current	4.5A _{RMS}	GND_ to GND	-0.3V to 0.3V
CHGIN Continuous Current	3A _{RMS}		

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 Information

81-WLP

Package Code	W813C3+1
Outline Number	21-0775
Land Pattern Number	Refer to Application Note 1891
Thermal Resistance, Four-Layer Board:	
Junction to Ambient (θ _{JA})	49°C/W
Junction to Case (θ _{JC})	N/A

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 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

($V_{SYS} = +3.6V$, $V_{CHGIN} = 0V$, $V_{IO} = 1.8V$, $T_A = -40^\circ C$ to $+85^\circ C$, typical value for T_A is $+25^\circ C$. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY CURRENT						
Shutdown Supply Current (BATT)	I_{SHDN}	All circuits off, BATT = 3.6V		25	50	μA
No Load Supply Current (BATT)	I_{NL}	USB Type-C on, all other circuits off, BATT = 3.6V		90	150	μA
SYS INPUT RANGE						
SYS Undervoltage Lockout Threshold	V_{SYS_UVLO}	V_{BATT} falling, 200mV hysteresis	2.4	2.5	2.6	V
SYS Overvoltage Lockout Threshold	V_{SYS_OVLO}	V_{BATT} rising, 200mV hysteresis	5.2	5.36	5.52	V
Low SYS Thresholds		Range programmable through LSDAC register, V_{SYS} falling, production tested at 3.60V setting		3.6		V
Low SYS Hysteresis		Range programmable through LSHYST register, production tested at 100mV setting		100		mV
THERMAL SHUTDOWN						
Thermal Shutdown Threshold	T_{SHDN}	T_J rising		165		$^\circ C$
Thermal Shutdown Hysteresis				15		$^\circ C$
Thermal Interrupt 1				120		$^\circ C$
Thermal Interrupt 2				140		$^\circ C$
LOGIC AND CONTROL INPUTS						
SCL, SDA Input Low Level		$T_A = +25^\circ C$			$0.3 \times V_{IO}$	V
SCL, SDA Input High Level		$T_A = +25^\circ C$	$0.7 \times V_{IO}$			V
SCL, SDA Input Hysteresis		$T_A = +25^\circ C$		$0.05 \times V_{IO}$		V
SCL, SDA Logic Input Current		$V_{IO} = 3.6V$	-10		+10	μA
SCL, SDA Input Capacitance		(Note 1)		10		pF
SDA Output Low Voltage		Sinking 20mA			0.4	V
Output Low Voltage (INTB)		$I_{SINK} = 1mA$			0.4	V
Output High Leakage (INTB)		$V_{SYS} = 5.5V$, $T_A = +25^\circ C$	-1	0	+1	μA
		$V_{SYS} = 5.5V$, $T_A = +85^\circ C$		0.1		
Interrupt Debounce Filter Timer		LOWSYS		16		ms

Electrical Characteristics (continued)

($V_{SYS} = +3.6V$, $V_{CHGIN} = 0V$, $V_{IO} = 1.8V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$, typical value for T_A is $+25^{\circ}C$. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
I²C-COMPATIBLE INTERFACE TIMING FOR STANDARD, FAST, AND FAST-MODE PLUS (Note 1)						
Clock Frequency	f_{SCL}				1000	kHz
Hold Time (Repeated) START Condition	$t_{HD;STA}$		0.26			μs
CLK Low Period	t_{LOW}		0.5			μs
CLK High Period	t_{HIGH}		0.26			μs
Setup Time Repeated START Condition	$t_{SU;STA}$		0.26			μs
DATA Hold Time	$t_{HD;DAT}$		0			μs
DATA Valid Time	$t_{VD;DAT}$				0.45	μs
DATA Valid Acknowledge Time	$t_{VD;ACK}$				0.45	μs
DATA Setup time	$t_{SU;DAT}$		50			ns
Setup Time for STOP Condition	$t_{SU;STO}$		0.26			μs
Bus-Free Time Between START and STOP	t_{BUF}		0.5			μs
Pulse Width of Spikes that must be Suppressed by the Input Filter		(Note 1)		50		ns
I²C-COMPATIBLE INTERFACE TIMING FOR HS-MODE (CB = 100pF) (Note 1)						
Clock Frequency	f_{SCL}	CB = 100pF			3.4	MHz
Hold Time (Repeated) START Condition	$t_{HD;STA}$		160			ns
CLK Low Period	t_{LOW}		160			ns
CLK High Period	t_{HIGH}		60			ns
Setup Time Repeated START Condition	$t_{SU;STA}$		160			ns
DATA Hold Time	$t_{HD;DAT}$		0			ns
DATA Setup time	$t_{SU;DAT}$		10			ns
Setup Time for STOP Condition	$t_{SU;STO}$		160			ns
Pulse Width of Spikes that must be Suppressed by the Input Filter		(Note 1)		10		ns
I²C-COMPATIBLE INTERFACE TIMING FOR HS-MODE (CB = 400pF) (Note 1)						
Clock Frequency	f_{SCL}	CB = 400pF			1.7	MHz
Hold Time (Repeated) START Condition	$t_{HD;STA}$		160			ns

Electrical Characteristics (continued)

($V_{SYS} = +3.6V$, $V_{CHGIN} = 0V$, $V_{IO} = 1.8V$, $T_A = -40^\circ C$ to $+85^\circ C$, typical value for T_A is $+25^\circ C$. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CLK Low Period	t_{LOW}		320			ns
CLK High Period	t_{HIGH}		120			ns
Setup Time Repeated START Condition	$t_{SU;STA}$		160			ns
DATA Hold Time	$t_{HD;DAT}$		0			ns
DATA Setup time	$t_{SU;DAT}$		10			ns
Setup Time for STOP Condition	$t_{SU;STO}$		160			ns
Pulse Width of Spikes that must be Suppressed by the Input Filter		(Note 1)		10		ns

Note 1: Design guidance only, not tested during final test.

Note 2: The CHGIN input must be less than V_{OVLO} and greater than both V_{CHGIN_UVLO} and $V_{CHGIN2SYS}$ for the charger to turn on.

Note 3: The input voltage regulation loop decreases the input current to regulate the input voltage at V_{CHGIN_REG} . If the input current is decreased to $I_{CHGIN_REG_OFF}$ and the input voltage is below V_{CHGIN_REG} , then the charger input is turned off.

Note 4: Production tested in charger DC-DC low-power mode (CHG_LPM bit = '1').

Note 5: Production tested to $\frac{1}{4}$ of the threshold with LPM bit = '1' ($\frac{1}{4}$ FET configuration).

Electrical Characteristics—Charger

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CHGIN INPUT						
Operating Voltage			3.2		V_{OVLO}	V
CHGIN Overvoltage Threshold (Note 2)	$V_{CHGIN-OVLO}$	V_{CHGIN} Rising; CHGIN_OVP = 00	13.4	13.7	14	V
		V_{CHGIN} Rising; CHGIN_OVP = 01	9.9	10.2	10.5	
		V_{CHGIN} Rising; CHGIN_OVP = 10	7.8	8	8.3	
		V_{CHGIN} Rising; CHGIN_OVP = 11	5.65	5.85	6.05	
CHGIN Overvoltage Threshold Hysteresis	$V_{CHGIN-H-OVLO}$	V_{CHGIN} Falling; CHGIN_OVP = 00		300		mV
		V_{CHGIN} Falling; CHGIN_OVP = 01		350		
		V_{CHGIN} Falling; CHGIN_OVP = 10		250		
		V_{CHGIN} Falling; CHGIN_OVP = 11		300		
CHGIN Overvoltage Delay (Note 1)	T_{D-OVLO}	V_{CHGIN} rising, 100mV overdrive, not production tested		10		μs
		V_{CHGIN} falling, 100mV overdrive, not production tested		20		

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{BUSDET} to GND Minimum Turn-On Threshold Range (Note 2)	$V_{V_{BUSDET_UVLO}}$	$V_{V_{BUSDET}}$ rising, 200mV hysteresis, programmable at 4.5V, 4.9V, 5.0V, and 5.1V (Note 2)	4.5		5.1	V
V_{BUSDET} to GND Minimum Turn-On Threshold Accuracy	$V_{V_{BUSDET_UVLO}}$	$V_{V_{BUSDET}}$ rising, 4.5V setting	4.4	4.5	4.6	V
V_{BUSDET} to SYS Minimum Turn-On Threshold (Note 2)	$V_{V_{BUSDET2SYS}}$	$V_{V_{BUSDET}}$ rising, 50mV hysteresis, when valid CHGIN input is detected	$V_{SYS} + 0.12$	$V_{SYS} + 0.20$	$V_{SYS} + 0.28$	V
V_{BUSDET} Turn-On Threshold Delay	T_{D-UVLO}	Not production tested		10		μs
CHGIN Adaptive Current Regulation Threshold Range (Note 3)	V_{CHGIN_REG}	Programmable at 4.2V, 4.6V, 4.7V, and 4.8V (Note 3)	4.2		4.8	V
CHGIN Adaptive Voltage Regulation Threshold Accuracy	V_{CHGIN_REG}	4.8V setting	4.7	4.8	4.9	V
CHGIN Current Limit Range		Programmable, 500mA default, production tested at 500mA, 1800mA, 4000mA settings only	0.1		4	A
CHGIN Supply Current	I_{IN}	$V_{CHGIN} = 2.4V$, the input is undervoltage and R_{INSD} is the only loading, CHGIN_PD_FST = 0 (default)		0.075		mA
		$V_{CHGIN} = 5.0V$, charger disabled, CHGIN_PD_FST = 0 (default)		0.17	0.5	
		$V_{CHGIN} = 5.0V$, charger enabled, $V_{SYS} = V_{BATT} = 4.5V$ (no switching, battery charged), CHGIN_PD_FST = 0 (default)		2.7	4	
V_{CHGIN} Input Current Limit	$I_{INLIMIT}$	$V_{CHGIN} = 5.0V$, charger enabled, $V_{BATT} = 3.8V$, 500mA input current setting, $T_A = +25^{\circ}C$	462.5	487.5	500	mA
		$V_{CHGIN} = 5.0V$, charger enabled, $V_{BATT} = 3.8V$, 1800mA input current setting, $T_A = +25^{\circ}C$	1710	1755	1800	
		$V_{CHGIN} = 5.0V$, charger enabled, $V_{BATT} = 3.8V$, 1800mA input current setting, $T_A = 0^{\circ}C$ to $+85^{\circ}C$	1667	1755	1843	
		$V_{CHGIN} = 5.0V$, charger enabled, $V_{BATT} = 3.8V$, 4000mA input current setting, $T_A = +25^{\circ}C$	3800	3900	4000	
		$V_{CHGIN} = 5.0V$, charger enabled, $V_{BATT} = 3.8V$, 4000mA input current setting, $T_A = 0^{\circ}C$ to $+85^{\circ}C$	3705	3900	4095	

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CHGIN Self-Discharge Down to UVLO Time	t_{INSD}	Time required for the charger input to cause a 10 μ F input capacitor to decay from 6.0V to 4.3V, CHGIN_PD_FST = 0 (default)		100		ms
CHGIN Input Self-Discharge Resistance	R_{INSD}	CHGIN_PD_FST = 0 (default)		35		k Ω
		CHGIN_PD_FST = 1		7.3		
CHGINOK to Start Switching	T_{start}			26		ms
SWITCH IMPEDANCES AND LEAKAGE CURRENTS						
CHGIN to BYP Resistance	R_{IN2BYP}	Bidirectional		0.0144	0.04	Ω
CHGLX High-Side Resistance	R_{HS}			0.0327	0.1	Ω
CHGLX Low-Side Resistance	R_{LS}			0.0543	0.14	Ω
BATT to SYS Dropout Resistance	$R_{BAT2SYS}$			0.0128	0.04	Ω
CHGIN to BATT Dropout Resistance	R_{IN2BAT}	Calculation estimates a 0.04 Ω inductor resistance (R_L) $R_{IN2BAT} = R_{IN2BYP} + R_{HS} + R_L + R_{BAT2SYS}$		0.0999		Ω
CHGLX Leakage Current		CHGLX = CHGPG or BYP, $T_A = +25^\circ C$		0.01	10	μA
		CHGLX = CHGPG or BYP, $T_A = +85^\circ C$		1		
BST Leakage Current		BST = 5.5V, $T_A = +25^\circ C$		0.01	10	μA
		BST = 5.5V, $T_A = +85^\circ C$		1		
BYP Leakage Current		$V_{BYP} = 5.5V$, $V_{CHGIN} = 0V$, $V_{CHGLX} = 0V$, charger disabled, $T_A = +25^\circ C$		0.01	10	μA
		$V_{BYP} = 5.5V$, $V_{CHGIN} = 0V$, $V_{CHGLX} = 0V$, charger disabled, $T_A = +85^\circ C$		1		
SYS Leakage Current		$V_{SYS} = 0V$, $V_{BATT} = 4.2V$, charger disabled, $T_A = +25^\circ C$		0.01	10	μA
		$V_{SYS} = 0V$, $V_{BATT} = 4.2V$, charger disabled, $T_A = +85^\circ C$		1		

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
BATT Quiescent Current ($I_{SYS} = 0A$, $I_{BYP} = 0A$)	I_{MBAT}	$V_{CHGIN} = 0V$, $V_{SYS} = 0V$, $V_{BATT} = 4.2V$, external Q_{BAT} is off, $T_A = +25^{\circ}C$		20	30	μA
		$V_{CHGIN} = 0V$, $V_{SYS} = 0V$, $V_{BATT} = 4.2V$, external Q_{BAT} is off, $T_A = +85^{\circ}C$		20		
		$V_{CHGIN} = 0V$, $V_{BATT} = 4.2V$, external Q_{BAT} is on, main battery overcurrent protection disabled, $T_A = +25^{\circ}C$		15.3		
		$V_{CHGIN} = 0V$, $V_{BATT} = 4.2V$, external Q_{BAT} is on, main battery overcurrent protection enabled, $T_A = +25^{\circ}C$		20		
		$V_{CHGIN} = 0V$, $V_{BATT} = 4.2V$, external Q_{BAT} is on, main battery overcurrent protection enabled, $T_A = +85^{\circ}C$		20		
		$V_{SYS} = 4.2V$, $V_{BATT} = 0V$, charger disabled, $T_A = +25^{\circ}C$	0.01	10		
		$V_{SYS} = 4.2V$, $V_{BATT} = 0V$, charger disabled, $T_A = +85^{\circ}C$	1			
	I_{MBDN}	$V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, Q_{BAT} is off, main battery overcurrent protection disabled, charger enabled (done mode), $T_A = +25^{\circ}C$		3	10	
		$V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, Q_{BAT} is off, main battery overcurrent protection disabled, charger enabled (done mode), $T_A = +85^{\circ}C$		3		
	I_{MBAT}	$V_{CHGIN} = 0V$, $V_{BATT} = 4.2V$, external Q_{BAT} is on, main battery overcurrent protection disabled, $T_A = +85^{\circ}C$		15.3		
CHARGER DC-DC BUCK						
Minimum ON Time	t_{ON-MIN}			75		ns
Minimum OFF Time	t_{OFF}			75		ns

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Current Limit (Note 5)	I_{LIM}	$T_A = 0^\circ C$ to $+85^\circ C$, IND = '0 (0.47 μ H inductor option), production tested at $I_{LIM} = 00$ setting, $I_{LIM} = 00$ (3.00A out) (Note 4)	4.15	5.05	5.95	A
		$T_A = 0^\circ C$ to $+85^\circ C$, IND = '0 (0.47 μ H inductor option), production tested at $I_{LIM} = 00$ setting, $I_{LIM} = 01$ (2.75A out) (Note 4)		4.75		
		$T_A = 0^\circ C$ to $+85^\circ C$, IND = '0 (0.47 μ H inductor option), production tested at $I_{LIM} = 00$ setting, $I_{LIM} = 10$ (2.50A out) (Note 4)		4.45		
		$T_A = 0^\circ C$ to $+85^\circ C$, IND = '0 (0.47 μ H inductor option), production tested at $I_{LIM} = 00$ setting, $I_{LIM} = 11$ (2.25A out) (Note 4)		4.15		
		$T_A = 0^\circ C$ to $+85^\circ C$, IND = '1 (1.0 μ H inductor option), production tested at $I_{LIM} = 11$ setting, $I_{LIM} = 00$ (3.00A out) (Note 4)		4.6		
		$T_A = 0^\circ C$ to $+85^\circ C$, IND = '1 (1.0 μ H inductor option), production tested at $I_{LIM} = 11$ setting, $I_{LIM} = 01$ (2.75A out) (Note 4)		4.3		
		$T_A = 0^\circ C$ to $+85^\circ C$, IND = '1 (1.0 μ H inductor option), production tested at $I_{LIM} = 11$ setting, $I_{LIM} = 10$ (2.50A out) (Note 4)		4		
		$T_A = 0^\circ C$ to $+85^\circ C$, IND = '1 (1.0 μ H inductor option), production tested at $I_{LIM} = 11$ setting, $I_{LIM} = 11$ (2.25A out) (Note 4)	3	3.7	4.4	
REVERSE BOOST						
BYP Voltage Adjustment Range		$2.6V/V_{BATT} < 4.5V$, adjustable from 3V to 5.5V, min		3		V
		$2.6V/V_{BATT} < 4.5V$, adjustable from 3V to 5.5V, max		5.5		
Reverse Boost Quiescent Current	I_{BYP}	Not switching: output forced 200mV above its target regulation voltage		1150		μ A
Reverse Boost Converter Maximum Output Current		$3.6V < V_{BATT} < 4.5V$	2			A
Reverse Boost BYP Voltage in OTG Mode	$V_{BYP.OTG}$	5.1V setting	4.94	5.1	5.26	V

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CHGIN Output Current Limit	$I_{CHGIN.OTG.LIM}$	$3.4V < V_{BATT} < 4.5V$, $T_A = +25^\circ C$, OTG_ILIM = 00	500		550	mA
		$3.4V$, $T_A = +25^\circ C$, OTG_ILIM = 01 (Note 1)	900		990	
		$3.4V$, $T_A = +25^\circ C$, OTG_ILIM = 10 (Note 1)	1200		1320	
		$3.4V < V_{BATT} < 4.5V$, $T_A = +25^\circ C$, OTG_ILIM = 11	1500		1650	
Reverse Boost Output Voltage Ripple (Note 1)		Discontinuous inductor current (i.e., skip mode)		± 150		mV
		Continuous inductor current		± 150		
CHARGER						
BATT Regulation Voltage Range	$V_{BATTREG}$	Programmable in 12.5mV steps (4 bits), production tested at 4.2V and 4.5V only	4.2		4.5	V
BATT Regulation Voltage Accuracy		4.2V and 4.5V settings, $T_A = +25^\circ C$	-0.75		+0.75	%
		4.2V and 4.5V settings, $T_A = 0^\circ C$ to $+85^\circ C$	-1		+1	
Fast-Charge Current Program Range		100mA to 3.15A in 50mA steps, production tested at 500mA and 3000mA settings	0.1		3.15	A
Fast-Charge Current Accuracy		Programmed currents $\geq 500mA$, $V_{BATT} > V_{SYSTEMIN}$ (short mode), production tested at 500mA and 3000mA settings, $T_A = +25^\circ C$	-4		+4	%
		Programmed currents $\geq 500mA$, $V_{BATT} > V_{SYSTEMIN}$ (short mode), production tested at 500mA and 3000mA settings, $T_A = 0^\circ C$ to $+85^\circ C$	-5		+5	
		Programmed currents $\geq 500mA$, $V_{BATT} < V_{SYSTEMIN}$ (LDO mode), production tested at 800mA	-10		+10	
Fast-Charge Currents	I_{FC}	$T_A = +25^\circ C$, $V_{BATT} > V_{SYSTEMIN}$, programmed for 3.0A	2880	3000	3120	mA
		$T_A = +25^\circ C$, $V_{BATT} > V_{SYSTEMIN}$, programmed for 0.5A	480	500	520	
Low-Battery Prequalification Threshold	V_{PQLB}	V_{BATT} rising	2.8	2.9	3	V
Dead-Battery Prequalification Threshold	V_{PQDB}	V_{BATT} rising	1.9	2	2.1	V
Prequalification Threshold Hysteresis	V_{PQ-H}	Applies to both V_{PQLB} and V_{PQDB}		100		mV

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Low-Battery Prequalification Charge Current Program Range	IPQLB_RANGE	Default setting = enabled (50mA)	50		400	mA
Low-Battery Prequalification Charge Current	IPQLB	I_PREQUAL = 00 (default)		50		mA
		I_PREQUAL = 01		100		
		I_PREQUAL = 10		200		
		I_PREQUAL = 11	300	400	500	
Dead-Battery Prequalification Charge Current	IPQDB		40	55	80	mA
Charger Restart Threshold Range	VRSTRT	Adjustable, 100, 150, and 200, it can also be disabled	100	150	200	mV
Charger Restart Deglitch Time		10mV overdrive, 100ns rise time		130		ms
Topoff Current Program Range		Programmable from 100mA to 350mA in 8 steps	100		350	mA
Topoff Current Accuracy - Gain (Note 1)		Gain			5	%
Topoff Current Accuracy - Offset (Note 1)		Offset			20	mA
Charge Termination Deglitch Time	tTERM	2mV overdrive, 100ns rise/fall time		30		ms
Charger State Change Interrupt Deglitch Time	tSCIDG	Excludes transition to timer fault state, watchdog timer state		30		ms
Charger Soft-Start Time	tSS	(Note 1)		1.5		ms
BATT TO SYS FET DRIVER						
BATT to SYS Reverse Regulation Voltage	VBSREG	I _{BATT} = 10mA		30		mV
		I _{BATT} = 1A		60		
		Load regulation during the reverse regulation mode		30		mV/A
MINSYS Voltage Accuracy	V _{SYSMIN}	Programmable from 3.4V to 3.7V in 100mV steps, V _{BATT} = 2.8V, tested at 3.4V, 3.6V, and 3.7V settings	-3		+3	%
Maximum SYS Voltage	V _{SYSMAX}	The maximum system voltage: $V_{SYSMAX} = V_{BATREG} + R_{BAT2SYS} \times I_{BATT}$ V _{BATREG} = 4.2V, I _{BATT} = 3.0A		4.245	4.32	V
		The maximum system voltage: $V_{SYSMAX} = V_{BATREG} + R_{BAT2SYS} \times I_{BATT}$ V _{BATREG} = 4.7V, I _{BATT} = 3.0A		4.745	4.82	

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
WATCHDOG TIMER						
Watchdog Timer Period	t_{WD}		80			s
Watchdog Timer Accuracy			-20	0	+20	%
CHARGE TIMER						
Prequalification Time	t_{PQ}	Applies to both low-battery prequalification and dead-battery prequalification modes		35		min
Fast-Charge Constant Current + Fast-Charge Constant Voltage Time	t_{FC}	Adjustable from 4 hrs to 16 hrs in two hour steps including a disable setting		8		hrs
Topoff Time	t_{TO}	Adjustable from 0 min to 70 min in 10 min steps		30		min
Timer Accuracy			-20		+20	%
AVL FILTER						
Internal AVL Filter Resistance				12.5		Ω
THERMAL FOLDBACK						
Junction Temperature Thermal Regulation Loop Setpoint Program Range	T_{JREG}	Junction temperature when charge current is reduced, programmable from $+85^{\circ}C$ to $+130^{\circ}C$ in $+5^{\circ}C$ steps, default value is $+115^{\circ}C$	85		130	$^{\circ}C$
Thermal Regulation Gain	A_{TJREG}	The charge current is decreased 6.7% of the fast-charge current setting for every degree that the junction temperature exceeds the thermal regulation temperature. This slope ensures that the full-scale current of 3.0A is reduced to 0A by the time the junction temperature is $+20^{\circ}C$ above the programmed loop set point. For lower programmed charge currents such as 500mA, this slope is valid for charge current reductions down to 100mA; below 100mA the slope becomes shallower but the charge current still reduced to 0A if the junction temperature is $+20^{\circ}C$ above the programmed loop set point		-150		$mA/^{\circ}C$
BATTERY OVERCURRENT PROTECTION						
Programmable Battery Overcurrent Threshold Alarm	I_{BOVCR}	Overcurrent from BATT to SYS sensed through internal Q_{BAT} FET Programmable range from 3A to 9A in 0.5A/step, default to 4.5A	3		9	A

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Battery Overcurrent Debounce Time	t_{BOVRC}	This is the response time for generating the overcurrent interrupt flag	3	6	10	ms
	t_{BOVRC2}	This is the response time from overcurrent interrupt flag to Q_{BAT} turn off		12		
Battery Overcurrent Protection Quiescent Current	I_{BOVRC}			$(3 + I_{BATT})/2$ 2000		μA
System Power-Up Current	I_{SYSPU}		35	50	80	mA
System Power-Up Voltage	V_{SYSPU}	V_{SYS} rising, 100mV hysteresis	1.9	2.1	2.2	V
System Power-Up Response Time	t_{SYSPU}	Time required for circuit to activate from an unpowered state (i.e., main battery hot insertion)		1		μs
SYSTEM SELF-DISCHARGE WITH NO POWER						
BATT Self-Discharge Resistor				600		Ω
SYS Self-Discharge Resistor				600		Ω
Self-Discharge Latch Time				300		ms
DETBATB, INOKB						
DETBATB Logic Threshold	V_{IH}	4% Hysteresis		$0.8 \times V_{IO}$		V
Logic Input Leakage Current	$I_{DETBATB}$			0.1	1	μA
Output Low Leakage (INOKB)		$I_{SINK} = 1mA$			0.4	V
Output High Leakage (INOKB)		$V_{SYS} = 5.5V$, $T_A = +25^\circ C$	-1	0	+1	μA
		$V_{SYS} = 5.5V$, $T_A = +85^\circ C$		0.1		
THERMISTOR MONITOR (The thresholds are calculated for $R_{25} = 10k\Omega$ and $\beta = 3435k$)						
T1: THM Threshold, Cold, No Charge ($0^\circ C$)	T_1	V_{THM}/V_{SYS} rising, 2% hysteresis (thermistor temperature falling), default OTP option	71.68	74.18	76.68	%
T1: THM Threshold, Cold, No Charge ($-7^\circ C$)	T_1	V_{THM}/V_{SYS} rising, 2% hysteresis (thermistor temperature falling), OTP programmable for $-7^\circ C$ (Note 1)	77.51	80.01	82.51	%
THM Leakage Current		$V_{THM} = V_{SYS}$ or 0V, $T_A = +25^\circ C$	-0.2	0.01	+0.2	μA
T4: THM Threshold, Hot, No Charge ($+60^\circ C$)	T_4	V_{THM}/V_{SYS} falling, 2% hysteresis (thermistor temperature rising)	20.44	22.94	25.44	%

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
OVPDRV INPUT FET						
OVPENB Logic Output Low Threshold	$V_{OL.OVPENB}$	$I_{SINK} = 200\mu A$, $V_{OVPENB} = GND$			0.4	V
OVPENB Logic Output High Threshold	$V_{OH.OVPENB}$	$I_{SOURCE} = 200\mu A$, $V_{OVPENB} = V_{AVL} = V_{BATT} = 3.6V$	$0.7 \times V_{AVL}$			V
CHARGER INDICATOR (GPIO)						
Output Low Voltage		$I_{SINK} = 10mA$			0.4	V
Output High Leakage		$V_{SYS} = 5.5V$; $T_A = +25^\circ C$	-1	0	+1	μA
		$V_{SYS} = 5.5V$; $T_A = +85^\circ C$		0.1		
ONKEY						
ONKEY Input Leakage Current	ONKEY I_L	$0V < V_{ONKEY} < 5.5V$, $T_A = +25^\circ C$	-1		+1	μA
ONKEY Rising Threshold	V_{ONKEYR}		$0.3 \times V_{BAT}$			V
ONKEY Falling Threshold	V_{ONKEYF}				$0.7 \times V_{BAT}$	V
ONKEY Debounce Timer	ONKEY TDEB	From ONKEY press to buck-on and Q_{BAT} switch ON		800		msecs
MASTER-SLAVE CHARGING						
SWI Output High Voltage	V_{OH}	$I_{SINK} = 100\mu A$	$V_{SYS} - 0.4$			V
SWI Output Low Voltage	V_{OL}	$I_{SOURCE} = 100\mu A$			0.4	V
SWI Rising Time	T_R	(Note 1)		200		ns
SWI Falling Time	T_F	(Note 1)		200		ns
SWI Input Frequency	F_{SWI}	Inferred to scan test		250		kHz
SWI Turn-On Detection Time	T_{wait_int}	Inferred to scan test		200		μs
SWI Turn-Off Detection Time	T_{off_dly}	Inferred to scan test	50		90	μs
SWI High Time	T_{sH}	Inferred to scan test	5	8	12	μs
SWI Low Time	T_{sL}	Inferred to scan test	5	8	12	μs
SWI Signal Stop Indicate Time	T_{stop}	Inferred to scan test	100			μs
SWI Interrupt Trigger Current	I_{SWI_FAULT}	$T_A = +25^\circ C$			200	μA
SLAVE Input Low Level	V_{IL}	$V_{SYS} = 3.6V$; $T_A = +25^\circ C$			$0.3 \times V_{SYS}$	V
SLAVE Input High Level	V_{IH}	$V_{SYS} = 3.6V$; $T_A = +25^\circ C$	$0.7 \times V_{SYS}$			V

Electrical Characteristics—Charger (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 4.2V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Fast-charge current is set for 1.5A. Done current is set for 150mA. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SLAVE Input Hysteresis	V_{IHYS}	$V_{SYS} = 3.6V$; $T_A = +25^{\circ}C$		$0.05 \times V_{SYS}$		V
SLAVE Input Leakage Current	I_{SLAVE}	$T_A = +25^{\circ}C$	-1	0	+1	μA

Electrical Characteristics—SAFEOUT LDO

($V_{CHGIN} = 5V$, $V_{BATT} = 3.8V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage (Default ON)		$5.0V < V_{CHGIN} < 5.5V$, $I_{OUT} = 10mA$, SAFEOUT = 01 (default)	4.65	4.9	5.15	V
Output Voltage		SAFEOUT = 00		4.85		V
		SAFEOUT = 10		4.95		
		SAFEOUT = 11		3.3		
PSRR (Note 1)		$V_{CHGIN} = 5.5$, $F = 100kHz$, $C_{OUT} = 1\mu F$		60		dB
Maximum Output Current			60			mA
Output Current Limit				150		mA
Dropout Voltage		$V_{CHGIN} = 5V$, $I_{OUT} = 60mA$		120		mV
Load Regulation		$V_{CHGIN} = 5.5V$, $30\mu A < I_{OUT} < 30mA$		50		mV
Quiescent Supply Current		Not production tested		72		μA
Output Capacitor for Stable Operation (Note1)		$0\mu A < I_{OUT} < 30mA$, MAX ESR = 50m Ω	0.7	1		μF
Minimum Output Capacitor for Stable Operation (Note 1)		$0\mu A < I_{OUT} < 30mA$, MAX ESR = 50m Ω		0.7		μF
Internal Off-Discharge Resistance				1200		Ω

Electrical Characteristics—SAR ADC

($V_{CHGIN} = 5V$, $V_{BATT} = 3.6V$, $V_{SYS} = 3.6V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CSP Input Leakage Current	I_{CSP}	$T_A = +25^{\circ}C$	-1	0	+1	μA

Electrical Characteristics—SAR ADC (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 3.6V$, $V_{SYS} = 3.6V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CSN Input Leakage Current	I_{CSN}	$T_A = +25^\circ C$	-1	0	+1	μA
ADC Resolution	RES			8		Bits
V_{BUS} Voltage Range	V_{BUS_RANGE}	$V_{BUS_HV_RANGE} = 0$	2.7		6.3	V
V_{BUS} Voltage Measurement Accuracy	V_{BUS_RES}	$V_{BUS_HV_RANGE} = 0$		14		mV
V_{BUS} Voltage Range	V_{BUS_RANGE}	$V_{BUS_HV_RANGE} = 1$	6.3		14.7	V
V_{BUS} Voltage Measurement Accuracy	V_{BUS_RES}	$V_{BUS_HV_RANGE} = 1$		33		mV
V_{BUS} Current Range	$I_{V_{BUS_RANGE}}$		0		4.1	A
V_{BUS} Current Measurement Accuracy	$I_{V_{BUS_RES}}$			16		mA
V_{BATT} Voltage Range	V_{BATT_RANGE}		2.1		4.9	V
V_{BATT} Voltage Measurement Accuracy	V_{BATT_RES}			11		mV
V_{BATT} Current Range	$I_{V_{BATT_RANGE}}$		0		3.1	A
V_{BATT} Current Measurement Accuracy	$I_{V_{BATT_RES}}$			12		mA
I_{REXT} Current Range	I_{REXT_RANGE}		-10		+10	A
I_{REXT} Current Measurement Accuracy	I_{REXT_RES}			78		mA
Temperature Sensing Range	$TEMP_RANGE$	In terms of (THMB/THMV)	20		80	%
Temperature Sensing Measurement Accuracy	$TEMP_RES$	In terms of (THMB/THMV)		0.24		%
THMB Output Drive	V_{OH_THMB}	$I_{OH_THMB} = -0.5mA$	$V_{SYS} - 0.1$			V
THMB Precharge Time	t_{PRE_THMB}			12.7		ms
THMB Operating Range	V_{THMB}		2.8		V_{SYS}	V
THMB Input Leakage	I_{IN_THMB}	THMB = 5V	-1	0	+1	μA
THMV Input Leakage	I_{IN_THMV}		-1	0	+1	μA

Electrical Characteristics—USB Type-C

($V_{CHGIN} = 5V$, $V_{BATT} = 3.8V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{SYS} Voltage	V_{SYS}		2.45		5.5	V
V_{BUS} Voltage	V_{BUS}			5	20	V

Electrical Characteristics—USB Type-C (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 3.8V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V _{CCINT} Voltage	V _{CCINT}	V _{BUS} present	3.6		5.5	V
		No V _{BUS}	2.45		5.5	
V _{REF} Voltage	V _{REF}		1.24375	1.25	1.25625	V
Oscillator Frequency	F _{OSC}		44	50	56	kHz
COMN1/COMP2 Load Resistor	R _{USB}	Load resistor on COMN1/COMP2	3	6.1	12	MΩ
IDCD Supply Voltage Range	V _{DCD}	IDCD enabled and 300kΩ load on DP	3.6		4.5	V
DP/DN Capacitance		All internal resources disconnected—idle state			2	pF
DP/DN Max Operating Voltage	V _{DPDNMAX}				4.5	V
OVDX Comparator Rising Threshold	V _{OVDX_THR}	Rising COMN1/COMP2 threshold with respect to V _{CC1}	0		120	mV
OVDX Comparator Falling Threshold	V _{OVDX_THF}	Falling COMN1/COMP2 threshold with respect to V _{CC1}	-40		+80	mV
V _{DP_SRC} Voltage	V _{DP_SRC} /V _{SR} C06	Accurate over I _{LOAD} = 0 to 200μA	0.5	0.6	0.7	V
V _{DN_SRC} Voltage	V _{DN_SRC} /V _{SR} C06	Accurate over I _{LOAD} = 0 to 200μA	0.5	0.6	0.7	V
V _{D33} Voltage	V _{DP/DM_3p3} V _{SRC} /V _{SRC33}	Tested at zero load and at 200μA load	2.6		3.4	V
V _{DAT_REF} Voltage	V _{DAT_REF}		0.25	0.32	0.4	V
V _{LG_C} Voltage	V _{LG_C}		1.62	1.7	1.9	V
I _{DM_SINK} Current	I _{DM_SINK} /I _{DAT} SINK	Accurate over 0.15V to 3.6V	55	80	105	μA
I _{DP_SRC} Current	I _{DP_SRC} /I _{DCD}	Accurate over 0V to 2.5V	7	10	13	μA
R _{DM_DWN} Resistor	R _{DM_DWN} /R _D WN15		14.25	20	24	kΩ
I _{WEAK} Current	I _{WEAK}		0.01	0.1	0.5	μA
V _{BUS31} Threshold	V _{BUS31}	DP and DN pins, threshold in percent of V _{BUS} voltage 3V < V _{BUS} < 5.5V	26	31	36	%
V _{BUS47} Threshold	V _{BUS47}	DP and DN pins, threshold in percent of V _{BUS} voltage 3V < V _{BUS} < 5.5V	43.3	47	51.7	%
V _{BUS64} Threshold	V _{BUS64}	DP and DN pins, threshold in percent of V _{BUS} voltage 3V < V _{BUS} < 5.5V	57	64	71	%
Charger Detection Debounce	t _{CDDeb}		45	50	55	ms
Primary to Secondary Timer	t _{PDSWait}		27	35	39	ms

Electrical Characteristics—USB Type-C (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 3.8V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Proprietary Charger Debounce	t_{PRDeb}		5	7.5	10	ms
Data Contact Detect Timeout	t_{DCDtmO}		700	800	900	ms
BC 1.2 State Timeout	t_{TMO}		180	200	220	ms
DP/DN Overvoltage Debounce	$t_{OVDxDeb}$		90	100	110	μs
V_{BUS} Supply Current Consumption 12V	I_{VBUS}	$V_{SYS} = 0V$, $V_{BUS} = 12V$, CC1/CC2 open, CC detection enabled, CCDRPPHase = 00b		185		μA
V_{CONN} Source Requirements		Note: Min may need to be adjusted by resistance of V_{CONN} internal switch at 1W load, for V_{CONNIN} Min > 4.9V	4.75		5.5	V
V_{CONN} Bulk Capacitance	C_{VCONN}	Must be on V_{CONN} source	10		220	μF
CC Pin Operational Voltage Range					5.5	V
CC Pin Voltage in DFP 3.0A Mode	V_{CC_PIN}	Measured at CC pins with 126k Ω load, $I_{DFP3.0_CC}$ enable, and $V_{CCINT} \geq 3.65V$	3.1			V
CC Pin voltage in DFP 1.5A Mode	V_{CC_PIN}	Measured at CC pins with 126k Ω load, $I_{DFP1.5_CC}$ enable, and $V_{CCINT} \geq 2.45V$	1.85			V
CC Pin Clamp Requirements		$60\mu A \leq I_{CC_} \leq 600\mu A$		1.1	1.32	V
CC UFP Pulldown Resistance	$R_{DUFP_CC_}$		-10%	5.1K	+10%	Ω
CC DFP 0.5A Current Source	$I_{DFP0.5_CC_}$	$0.25V \leq CC \text{ pin voltage} \leq 1.5V$	-10%	80	+10%	μA
CC DFP 1.5A Current Source	$I_{DFP1.5_CC_}$	$0.45V \leq CC \text{ pin voltage} \leq 1.5V$	-8%	180	+8%	μA
CC DFP 3.0A Current Source	$I_{DFP3.0_CC_}$	$0.85V \leq CC \text{ pin voltage} \leq 2.45V$	-8%	330	+8%	μA
CC RA RD Threshold	$V_{RA_RD0.5}$		0.15	0.2	0.25	V
CC RA RD Hysteresis	$V_{RA_RD0.5_H}$		0.0		0.03	V
CC UFP 0.5A RD Threshold	$V_{UFP_RD0.5}$		0.61	0.66	0.7	V
CC UFP 0.5A RD Hysteresis	$V_{UFP_RD0.5_H}$		0.0		0.03	V
CC UFP 1.5A RD Threshold	$V_{UFP_RD1.5}$		1.16	1.23	1.31	V
CC UFP 1.5A RD Hysteresis	$V_{UFP_RD1.5_H}$		0.0		0.03	V

Electrical Characteristics—USB Type-C (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 3.8V$, $T_A = -40^\circ C$ to $+85^\circ C$ unless otherwise specified, typical values are for $T_A = +25^\circ C$. Limits are 100% tested at $T_A = +25^\circ C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
CC V_{CONN} Detect Threshold	V_{VCONN_DET}		2.10	2.25	2.4	V
CC V_{CONN} Detect Hysteresis	$V_{VCONN_DET_H}$			0.015		V
CC DFP V_{OPEN} Detect Threshold	V_{DFP_VOPEN}		1.50	1.575	1.65	V
CC DFP V_{OPEN} Detect Hysteresis	$V_{DFP_VOPEN_H}$			0.015		V
CC DFP V_{OPEN} with 3.0A Detect Threshold	$V_{DFP_VOPEN3_A}$	$V_{CCINT} \geq 3.5V$	2.45	2.6	2.75	V
CC DFP V_{OPEN} with 3.0A Detect Hysteresis	$V_{DFP_VOPEN3_A_H}$	$V_{CCINT} \geq 3.5V$	0.0		0.03	V
V_{BUS} Valid	V_{BDET}	Rising	3.8	4.12	4.4	V
	V_{BDET_h}	Falling hysteresis		0.7		
V_{BUS} Discharge Value Threshold	V_{SAFE0V}	Falling voltage level where a connected UFP finds V_{BUS} removed	0.6	0.77	0.82	V
V_{BUS} Discharge Value Hysteresis	V_{SAFE0V_h}	Rising hysteresis		100		mV
CC Pin Power-Up Time	$t_{ClampSwap}$	Max time allowed from removal of voltage clamp till 5.1k resistor attached			15	ms
Type-C CC Pin Detection Debounce	$t_{CCDebounce}$		100		200	ms
Type-C Debounce	$t_{PDDebounce}$		10		20	ms
Type-C Quick Debounce	$t_{QDebounce}$		0.9	1	1.1	ms
V_{BUS} Debounce	t_{VBDeb}		9	10	11	ms
V_{SAFE0V} Debounce	$t_{VSAFE0VDeb}$		9	10	11	ms
Type-C Error Recovery Delay	$t_{ErrorRecovery}$		25			ms
Type-C DRP Toggle Time	t_{DRP}		50		100	ms
Duty Cycle of DRP Swap		Duty cycle of swap of UFP to DFP roles	30		70	%
DRP Transition Time	$t_{DRPTransition}$	Time a role swap from DFP to UFP or reverse is completed			1	ms
V_{CONN} Enable Time	$t_{VCONNON}$	Time from when V_{BUS} is supplied in DFP mode in state Attach.DFP.DRPWait			2	ms
V_{CONN} Disable Time	$t_{VCONNOFF}$	Time from UFP detached or as directed by I ² C command until V_{CONN} is removed			35	ms
CC Pin Current Change Time	$t_{SINKADJ}$	Time from CC pin changes state in UFP mode till current drawn from DFP reaches new value			60	ms

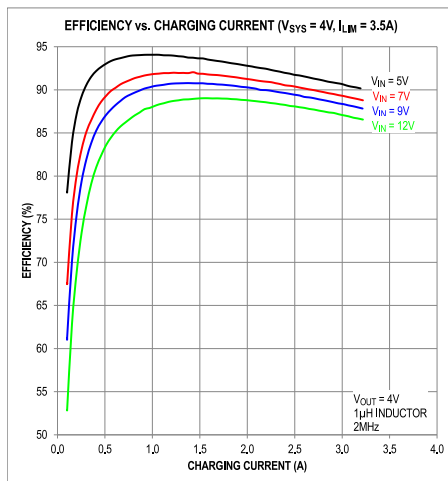
Electrical Characteristics—USB Type-C (continued)

($V_{CHGIN} = 5V$, $V_{BATT} = 3.8V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$ unless otherwise specified, typical values are for $T_A = +25^{\circ}C$. Limits are 100% tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Typical values are not guaranteed.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V _{BUS} On time	t _{VBUSON}	Time from UFP is attached till V _{BUS} on, for reference only			275	ms
V _{BUS} Off Time	t _{VBUSOFF}	Time from UFP is detected till V _{BUS} reaches VSAFE0V, for reference only			650	ms
BVCEN Output Low Voltage		I _{SINK} = 1mA	0.4			V
BVCEN Output High Voltage		I _{SOURCE} = 1mA			V _{SYS} - 0.4	V
GENERAL						
V _{BUS} Supply Current Consumption 12V CC Detection Disabled		V _{SYS} = 0V, V _{BUS} = 12V, CC1/CC2 open, CC detection disabled, CCDRPPHase = 00b		183		μA
V _{BUS} Supply Current Consumption 5V	I _{VBUS5V}	V _{SYS} = 0V, V _{BUS} = 5V, CC1/CC2 open, CC detection enabled, CCDRPPHase = 00b		131		μA
V _{BUS} Supply Current Consumption 5V CC Detection Disabled	I _{VBUS5V_detdis}	V _{SYS} = 0V, V _{BUS} = 5V, CC1/CC2 open, CC detection disabled, CCDRPPHase = 00b		120		μA
SYS Power Supply Current	I _{CCSYS}	V _{BUS} = 0V, V _{SYS} = 4.2V, CC1/CC2 open, CC detection enabled, CCDRPPHase = 00b		45.3		μA
SYS Power Supply Current CC Detection Disabled	I _{CCsys4v2_detdis}	V _{BUS} = 0V, V _{SYS} = 4.2V, CC1/CC2 open, CC detection disabled, CCDRPPHase = 00b		7.2		μA
SYS Power Supply Current 5V	I _{CCsys5v}	V _{BUS} = 0V, V _{SYS} = 5V, CC1/CC2 open, CC detection enabled, CCDRPPHase = 00b		49		μA
SYS Power Supply Current CC Detection Disabled 5V	I _{CCsys5v_detdis}	V _{BUS} = 0V, V _{SYS} = 5V, CC1/CC2 open, CC detection disabled, CCDRPPHase = 00b		10.4		μA
SYS Power Supply Current 3V	I _{CCsys3v}	V _{BUS} = 0V, V _{SYS} = 3V, CC1/CC2 open, CC detection enabled, CCDRPPHase = 00b		40.7		μA
SYS Power Supply Current CC Detection Disabled 3V	I _{CCsys3v_detdis}	V _{BUS} = 0V, V _{SYS} = 3V, CC1/CC2 open, CC detection disabled, CCDRPPHase = 00b		4		μA
CC DETECTION						
V _{CONN} On Resistance	R _{VCONN_ON}	200mA load, V _{CONNIN} = 4.9V		0.4	0.75	Ω
CC Pin Clamp Requirements (5.5V)		I _{CC_} ≤ 2mA		5.25	5.5	V

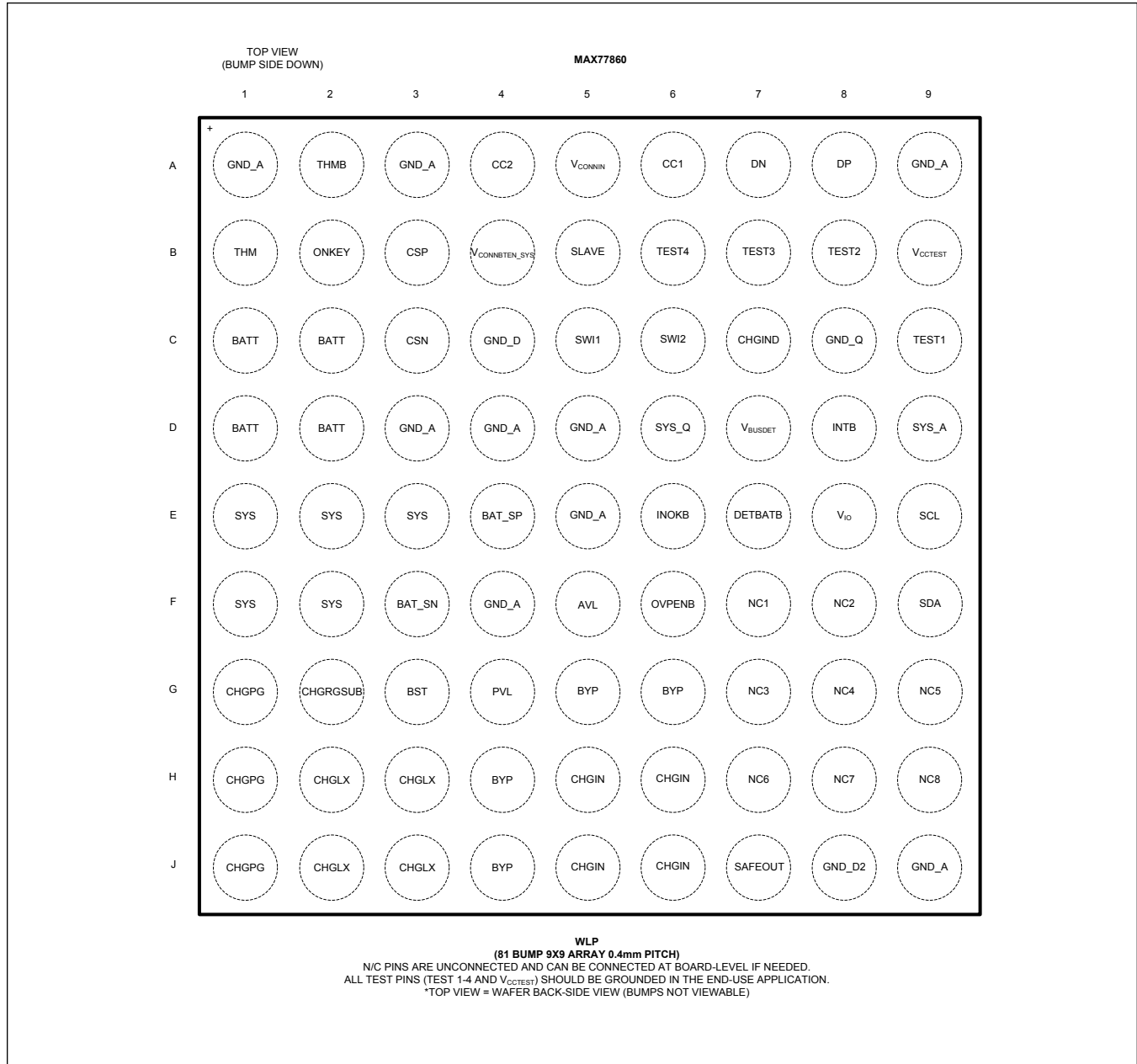
Typical Operating Characteristics

($T_A = +25$ to $+50^\circ\text{C}$, unless otherwise noted.)



Pin Configuration

MAX77860



Pin Description

PIN	NAME	FUNCTION	REF SUPPLY	TYPE
D6	SYS_Q	Quiet SYS Input		Power
D9	SYS_A	Analog SYS Input	2	Power
A1, A3, A9, D3, D4, D5, E5, F4, J9	GND_A	Analog Ground. Short to GND_D, GND_D2 and GND_Q.	GND	GND
C4	GND_D	Digital Ground Connection. Short to GND_D2, GND_A, and GND_Q.	1	GND
C8	GND_Q	Quiet Ground Connection. Short to GND_A, GND_Q, GND_D, and GND_D2.	1	GND
J8	GND_D2	Digital Ground Connection. Short to GND_D, GND_A, and GND_Q.		GND
E1, E2, E3, F1, F2	SYS	System Power Connection. Connect system loads to this node. Bypass with 2 x 10 μ F/10V ceramic capacitors from SYS to CHGPG ground plane.	5	Power
H5, H6, J5, J6	CHGIN	High Current Charger Input. Bypass to CHGPG with a 2.2 μ F/25V ceramic capacitor. It also serves as the reverse boost output.	CHGIN	Power
G5, G6, H4, J4	BYP	CHGIN Bypass Pin. This pin can see up to OVP limit. Output of adapter input current limit block and input to switching charger. BYP is also the boost converter output when the charger is operating in 'reverse boost' mode. Bypass with 2 x 10 μ F/25V ceramic capacitors from BYP to CHGPG ground plane.		
H2, H3, J2, J3	CHGLX	Charger Switching Node. Connect the inductor between CHGLX and SYS.	4	
G3	BST	High-side FET Driver Supply. Bypass BST to CHGLX with a 0.1 μ F/6.3V ceramic capacitor.	1	
G1, H1, J1	CHGPG	Charger Power Ground Connection	2	GND
G2	CHGRGSUB	Substrate Charger Ground Connection	1	GND
F5	AVL	Analog Voltage Level. Output of on-chip 5V LDO used to power on-chip, low-noise circuits. Bypass with a 2.2 μ F/10V ceramic capacitor to GND. Powering external loads from AVL is not recommended, other than pulldown resistors.	1	
G4	PVL	Internal bias regulator high current output bypass pin. Supports internal noisy and high current gate drive loads. Bypass to PGND with a minimum 10 μ F/10V ceramic capacitor.	1	
C7	CHGIND	Charging Status Indication GPIO output. Open-drain, option to tie to charger as an active-low output that indicates when the charging is active.	AVL	I/O
C1, C2, D1, D2	BATT	Battery Power Connection. Connect to the positive terminal of a single-cell (or parallel cell) Li-ion battery. Bypass BATT to CHGPG ground plane with a 10 μ F/10V ceramic capacitor.	4	
E4	BAT_SP	Battery Positive Differential Sense Connection. Connect to the positive terminal close to the battery.	BATT	
F3	BAT_SN	Battery Negative Differential Sense Connection. Connect to the negative or ground terminal close to the battery.	BATT	

Pin Description (continued)

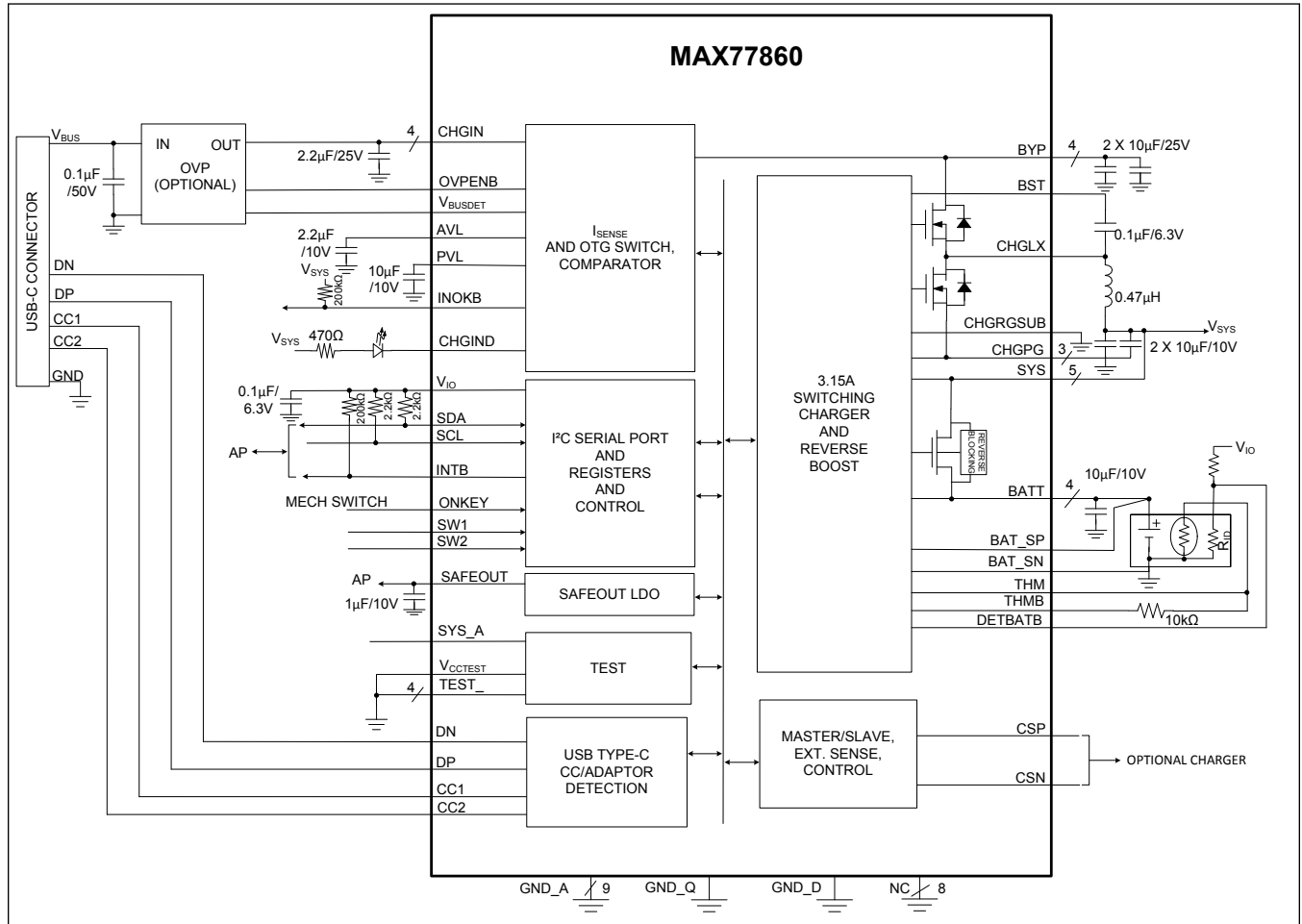
PIN	NAME	FUNCTION	REF SUPPLY	TYPE
E6	INOKB	Charger input valid, active-low logic output flag. Open-drain output indicates when valid voltage is present at both CHGIN and SYS.	1	
E7	DETBATB	Battery Detection Active-Low Input. Connect this pin to the ID pin on the battery pack. If DETBATB is pulled below 80% of the externally applied V_{IO} voltage, this is an indication that the battery is present and the charger starts when valid CHGIN and/or WCIN power is present. If DETBATB is driven high to V_{IO} voltage or left unconnected, this is an indication that the battery is not present and the charger does not start. DETBATB is pulled high to V_{IO} pin through an off-chip pullup resistor.	1	
B2	ONKEY	ONKEY is an active-low signal with default 1000ms debounce timer. When no charging source is available at CHGIN, enable DISQIBS bit (DISIBS = 1) with I ² C to set the device in ship mode. With a healthy battery, pressing the ONKEY longer than the debounce timer re-enables the Q _{BAT} switch and the device exits ship mode.	AVL	
F6	OVPENB	Logic-low enable pin enables the external overvoltage protection IC.	1	
D7	V _{BUSDET}	Input Voltage Detection Pin. This input pin is a voltage clamped version of the input voltage and is used to trigger the device OVLO/UVLO features. Connect a 1 μ F ceramic capacitor between this pin and CHGPG (ground).	1	
B5	SLAVE	Input pin to indicate if slave charger is connected. Short to GND_A—no slave charger connected. Short to SYS_A—slave charger connected.		
C5	SWI1	Data Input/Output. Open-drain, 1-wire interface pin for slave 1.	1	
C6	SWI2	Data Input/Output. Open-drain, 1-wire interface pin for slave 2.		
B3	CSP	Slave-Charger Sense Current Positive Input. Option to add a 10m Ω sense resistor from CSP to CSN to have current sense information return to the master for processing. If slave charging is unused, short this pin to BATT.	1	
C3	CSN	Slave-Charger Sense Current Negative Input. Option to add a 10m Ω sense resistor from CSP to CSN to have current sense information return to the master for processing. If slave charging is unused, short this pin to BATT.		
J7	SAFEOUT	Safeout LDO Output. Default 4.9V and on when CHGIN power is valid. Bypass with a 1 μ F/10V ceramic capacitor to GND.	1	
E8	V _{IO}	Digital I/O Supply Input for I ² C interface	1	
F9	SDA	I ² C Serial Data	1	
E9	SCL	I ² C Serial Clock	1	
D8	INTB	Interrupt Output. Active-low, open-drain output.	1	
B1	THM	Thermistor Connection. Determine battery temperature using ratiometric measurement.	1	

Pin Description (continued)

PIN	NAME	FUNCTION	REF SUPPLY	TYPE
A2	THMB	Pullup voltage for THM pin pullup resistor that can be switched to save power.	1	
C9	TEST1	Test I/O Pin. Ground this pin in the application.	V _{CC} TEST	
B8	TEST2	Test I/O Pin. Ground this pin in the application.	1	
B7	TEST3	Test I/O Pin. Ground this pin in the application.	1	
B6	TEST4	Test I/O Pin. Ground this pin in the application.	1	
B9	V _{CC} TEST	Test Mux Supply. Ground this pin in the application.	1	
A7	DN	Common Negative Output 1. Connect to D- on mini/micro USB connector.	1	
A8	DP	Common Positive Output 2. Connect to D+ on mini/micro USB connector.	1	
A6	CC1	Type-C CC pin 1, can be connected in parallel with USB power delivery transceiver.		
A4	CC2	Type-C CC pin 2, can be connected in parallel with USB power delivery transceiver.		
A5	V _{CONN} NIN	5V power supply for supplying power to the unused CC pin if required.		
B4	V _{CONN} BTEN_S YS	Output pin, used to enable external V _{CONN} boost.		
F7, F8, G7, G8, G9, H7, H8, H9	NC1–NC8	No connection. Connect to GND.		

Functional Diagrams

Functional Block Diagram



Detailed Description

Switching Charger

The MAX77860 includes a full featured switch-mode charger for a one-cell lithium ion (Li+) or lithium polymer (Li-polymer) battery. The current limit for CHGIN input is independently programmable from 0 to 4.0A in 33.3mA steps allowing the flexibility for connection to either an AC-to-DC wall charger or a USB port. The CHGIN input current limit default is set between 100mA and 500mA (programmed default).

It also integrates a charging source detector based on signatures from USB D+/D- lines with a USB Type-C connector CC pin detector. The USB data lines are probed using a USB Battery Charging Specification revision 1.2 compliant scheme and additional proprietary charger type detection. Type-C detector supports USB Type-C DRP (dual role port) and other applications.

The synchronous switch-mode DC-DC converter can operate at either 2MHz or 4MHz switching frequency, which is ideal for portable devices due to the flexibility of using small components while eliminating excessive heat generation. The DC-DC converter can be operated in either buck or reverse-boost mode. When charging the battery, the DC-DC converter operates as a buck converter. In this mode, it operates from 3.2V to 14V input source and provides up to 3.15A charging current (programmable) to the battery. When operating in reverse-boost mode, the DC-DC converter uses energy from the main battery to boost the voltage at BYP. The boosted BYP voltage can then be used for the USB OTG function.

The IC makes the best use of the limited adapter power and the battery's power at all times to supply up to 3.15A continuous (4A peak) current from the buck to the system. Additionally, supplement mode provides additional current from the battery to the system up to 4.5A_{RMS}, and the BATT to SYS switch has overcurrent protection (see the [Main-Battery Overcurrent Protection](#) section for more information). Adapter power that is not used for the system goes to charge the battery.

Maxim's proprietary process technology allows for low- $R_{DS(ON)}$ devices in a small solution size. The total dropout resistance from adapter power input to the battery is 0.15 Ω (typ) assuming that the inductor has 0.04 Ω of ESR. This 0.15 Ω typical dropout resistance allows for charging a battery up to 3.15A from a 5V supply.

Safety features ensure reliable charging, such as charge timer, watchdog, junction thermal regulation, over/under voltage protection, short circuit protection, etc., are also implemented on the IC.

Features

- Single-Cell Switch-Mode Battery Charger
 - Adapter/USB Input
 - Up to 14V Adapter Charging (The OVLO level of the external input switch connected to CHGIN should be set lower than MAX77860 OVLO.)
 - Up to 4.0A Input Current Limit (programmable)
- Battery Charge Current (up to 3.15A)
 - CC, CV, and Die Temperature Control
 - Support for External Battery Disconnect FET
 - Support for Battery Discharge Overcurrent protection up to 6A_{RMS} (programmable)
- Reverse Boost Capability
 - Supports USB-OTG Accessories
 - Up to 5.1V/2A
 - Programmable OCP Threshold
- Support for USB Battery Charger rev 1.2 Detection
 - Data Contact Detection (DCD)
 - Detects all USB defined sources
 - Standard USB Port
 - Charging Downstream Port

- Dedicated Charging Port
- Adapter Type Detection
- Manual Restart of Charger Detection
- Support USB Type-C (rev 1.1) Including:
 - USB Type-C
 - Integrated V_{CONN} Switch
 - CC Pin
 - Supports 20V Pull (through 10k min external resistor) Source Requirement
 - Dead Battery Clamp Allowing for Unpowered Upstream Facing Port (UFP) Identification
- Single Safeout LDO
- I²C Serial Interface

USB Data Contact Detection

The USB plugs are designed so that when the plug is inserted into the receptacle, the power pins make contact before the data pins. The result is that V_{CHGIN} makes contact before the data pins make contact.

To ensure that the data pins have made contact, BC 1.2 makes it optional to detect when the data pins have made contact. To detect when the data pins have made contact, the data pins are prebiased so at least one of the data pins changes state. Therefore, when a change in data pin state is detected, the charger proceeds to identify the type of attached port.

DP and DN

The internal USB full speed/low speed transceiver is brought out to the bi-directional data pins DP and DN. These pins are ESD protected up to $\pm 15\text{kV}$. Connect these pins to a USB “B”/costume connector through external 20Ω series resistors. The IC provides an automatic switchable $1.5\text{k}\Omega$ pullup resistor for D- (low speed) and D+ (high speed).

Adapter Detection

When an adapter is present on the V_{CHGIN} , the IC examines the device that is inserted to identify the type of adapter. The possible adapter types are:

- Dedicated charger
- Non-compliant dedicated chargers
- Charger downstream port (host or hub)
- USB 2.0 (host or hub) low power
- USB 2.0 (host or hub) high power

Each of these devices have different current capabilities as shown in [Table 1](#).

Table 1. Supported Adapter Types

ADAPTER TYPE	OUTPUT VOLTAGE	OUTPUT CURRENT
Dedicated Charger	4.75V to 5.25V at $I_{load} < 500\text{mA}$ 2.0V to 5.25V at $I_{load} \geq 500\text{mA}$	500mA to I_{max}
Charger Downstream Port	4.75V to 5.25V at $I_{load} < 500\text{mA}$	500mA to 900mA for low-speed and full-speed
	2.0V to 5.25V at $I_{load} \geq 500\text{mA}$	500mA to 1.5A for low-speed and full-speed
Apple 500mA	4.75V to 5.25V at $I_{load} < 500\text{mA}$	500mA maximum
Apple 1A	4.75V to 5.25V at $I_{load} < 1\text{A}$	1A maximum
Apple 2A	4.75V to 5.25V at $I_{load} < 2\text{A}$	2A maximum
Apple 12W	4.75V to 5.25V at $I_{load} < 2.4\text{A}$	2.4A maximum
Samsung 2A	4.75V to 5.25V at $I_{load} < 2\text{A}$	2A maximum
USB 2.0 Low Power	4.25V to 5.25V	100mA maximum

Table 1. Supported Adapter Types (continued)

USB 2.0 High Power	4.75V to 5.25V	500mA maximum
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Charging Status Indicator

The IC has a charging status indicator to notify the user of various charging states as shown in [Figure 1](#).

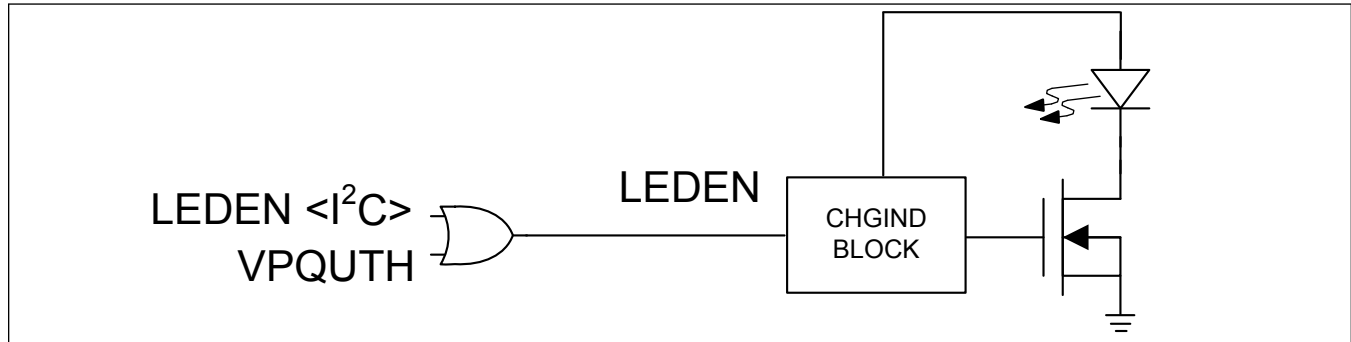


Figure 1. Charging Status Indicator

Dead Battery State

When the battery is dead and below prequal threshold, LED0 is set up to blink with 50ms ON time in 1s period. LEDEN<I²C> bit is enabled by default.

Prequal Battery State

When the battery is dead and below prequal threshold, LED0 is set up to blink with 50ms ON time in 1s period. The LEDEN<I²C> bit is enabled by default.

Fast-Charge Battery State

When the battery is in fast-charge state, CHGIND LED is set up to be enabled 100%. The LEDEN<I²C> bit can be programmed to disable, but is enabled by default.

Fast-Charge Constant Voltage State

When the battery is in fast-charge state, CHGIND LED is set up to be enabled 100%. The LEDEN<I²C> bit can be programmed to disable, but is enabled by default.

Topoff State

When the battery is in topoff-charge state, CHGIND LED is set up to blink with 50% ON time in 1s. The LEDEN<I²C> bit can be programmed to disable, but is enabled by default.

Done State

When the battery is in done-charge state, CHGIND LED is set up to be disabled.

External Input OVP Driver

The driving circuit of external OVP on the input side is taken from the IC charger. The use of this feature is as follows:

- Blocking FET from input transient voltage during USB insertion/removal event.
- The polarity of the driving signal logic can be OTP programmable.

Input Current Limit

The default settings of the CHGIN_ILIM and MODE control bits are such that when a charge source is applied to CHGIN, the IC turns its DC-DC converter on in BUCK mode, limits V_{SYS} to V_{BATREG} , and limits the charge source current to 500mA. All control bits are reset on global shutdown.

Input-Voltage Regulation Loop and Adaptive Input Current Limit (AICL)

An input-voltage regulation loop ensures proper charger operation even when it is attached to power sources with poor transient load responses. The loop improves performance with relatively high resistance charge sources that exist when long cables are used or devices are charged with noncompliant USB hub configurations. Additionally, this input-voltage regulation loop improves performance with current limited adapters. If the IC's input current limit is programmed above the current limit threshold of given adapter, the input voltage loop allows the IC to regulate at the current limit of the adapter. Finally, the input-voltage regulation loop allows the IC to perform well with adapters that have poor transient load response times.

The input-voltage regulation loop automatically reduces the input current limit in order to keep the input voltage at V_{CHGIN_REG} . If the input current limit is reduced to $I_{CHGIN_REG_OFF}$ (50mA, typ) and the input voltage is below V_{CHGIN_REG} , then the charger input is turned off. The input-voltage regulation loop automatically reduces the input current limit to keep the input voltage at V_{CHGIN_REG} (programmable). If the input current limit is reduced to $I_{CHGIN_REG_OFF}$ (50mA, typ) and the input voltage is below V_{CHGIN_REG} , then the charger input is turned off.

After operating with the input-voltage regulation active, a BYP_I interrupt is generated, BYP_OK is cleared, and $BYP_DTLS = 0b1xxx$. To optimize input power when working with a current limited charge source, monitor the BYP_DTLS while decreasing the input current limit. When the input current limit is set below the limit of the adapter, the input voltage rises. Although the input current limit is lowered, more power can be extracted from the input source when the input voltage is allowed to rise. For example, optimum use of input-voltage regulation with an adapter programmed to 0.5A current limit and having a cable resistance between 300m Ω and 3 Ω .

Battery Detect Input Pin (MDETBATB)

DETBATB is tied to the ID pin of the battery pack. If DETBATB is pulled below 80% of V_{IO} pin voltage, this is an indication that the main battery is present and the battery charger starts upon valid CHGIN. If DETBATB is left unconnected or equal to V_{IO} voltage, this indicates that the battery is not present and the charger does not start upon valid CHGIN, see [Figure 4](#). DETBATB is internally pulled to BATT through an external resistor. The DETBATB status bit is valid when BATT is not present.

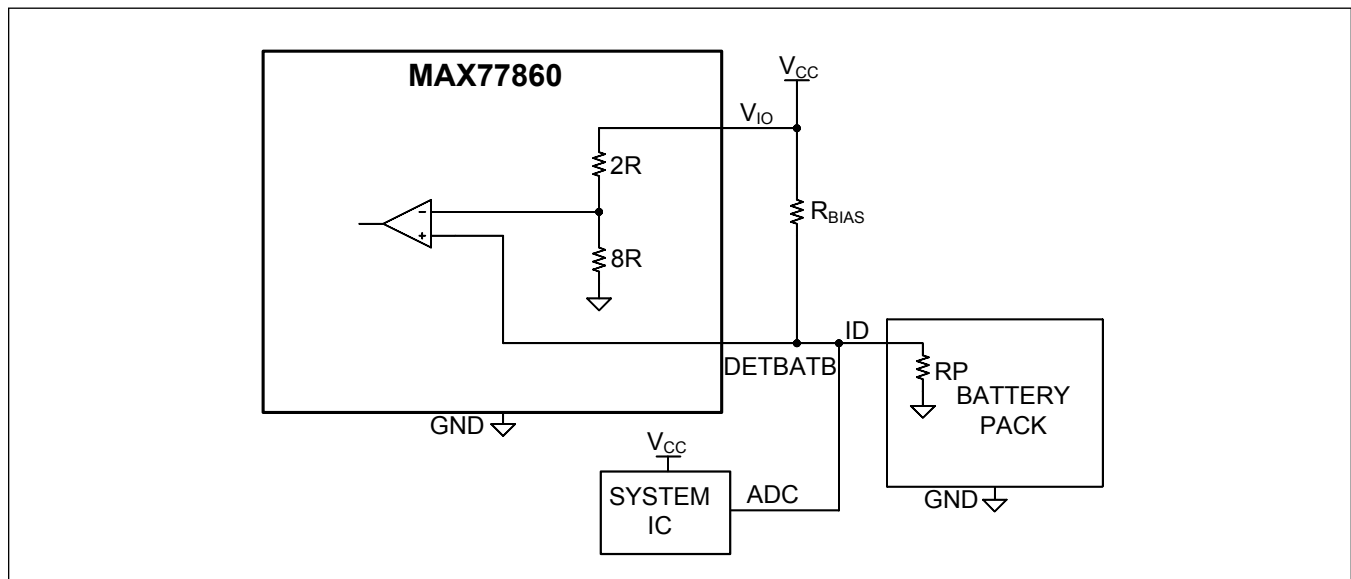


Figure 2. DETBATB Internal Circuitry and System Diagram

Charge States

The IC utilizes several charging states to safely and quickly charge batteries as shown in Figure 3. An exaggerated view of a Li+/Li-Poly battery is shown in Figure 4 when there is no system load and the die and battery are close to room temperature as it progresses through the following charge states:

1. Prequalification
2. Fast-charge
3. Topoff
4. Done

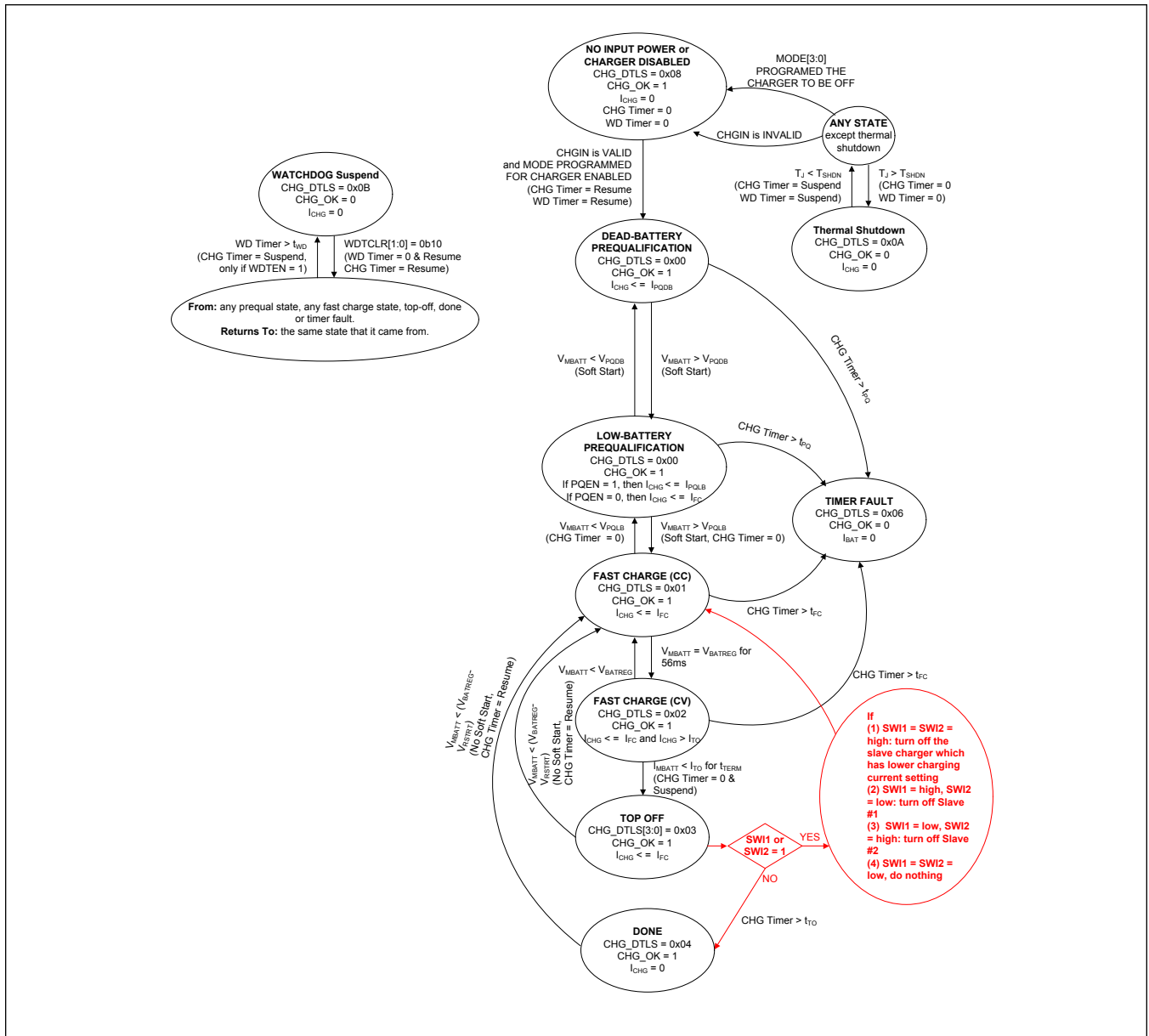


Figure 3. Charger State Diagram

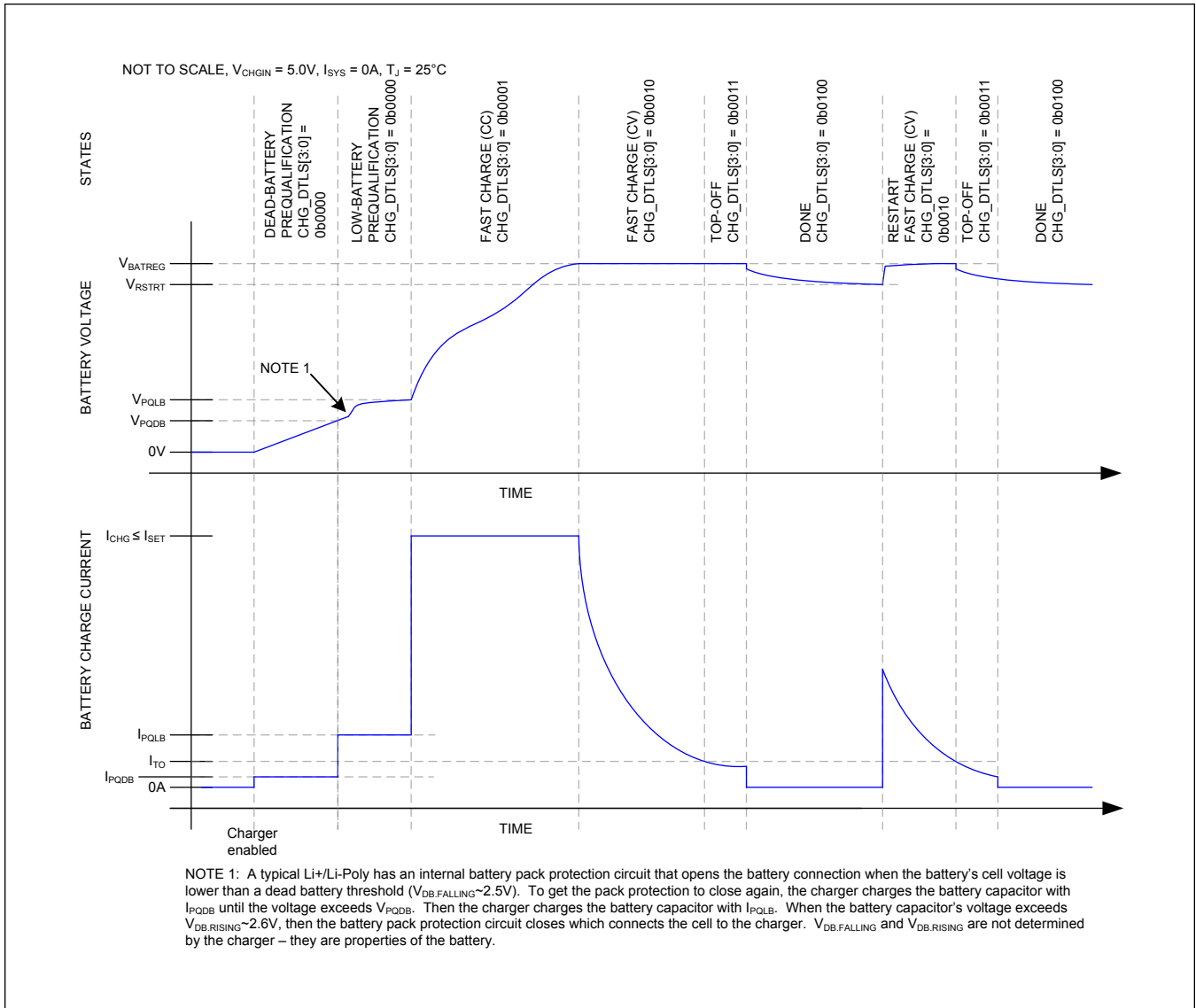


Figure 4. Li+/Li-Poly Charge Profile

Dead-Battery Prequalification State

As shown in [Figure 3](#), the dead-battery prequalification state occurs when the main-battery voltage is less than V_{PQDB} . After being in this state for t_{SCIDG} , a CHG_I interrupt is generated, CHG_OK is set, and CHG_DTLS is set to 0x00. In the dead-battery prequalification state, charge current into the battery is I_{PQDB} .

The following events cause the state machine to exit this state:

- Main battery voltage rises above V_{PQDB} and the charger enters the “Low-Battery Prequalification” state.
- If the battery charger remains in this state for longer than t_{PQ} , the charger state machine transitions to the “Timer Fault” state.
- If the watchdog timer is not serviced, the charger state machine transitions to the “Watchdog Suspend” state.

Note that the dead-battery prequalification state works with battery voltages down to zero volts. The low zero volt operation typically allows this battery charger to recover batteries that have an “open” internal pack protector. Typically, a pack's internal protection circuit opens if the battery has experienced an overcurrent, undervoltage, or overvoltage event. When a battery with an “open” internal pack protector is used with this charger, the low-battery prequalification mode current flows into the 0V battery. This current raises the pack's terminal voltage to the point where the internal pack protection switch closes.

Note that a normal battery typically stays in the low-battery prequalification state for several minutes or less. Therefore, a battery that stays in low-battery prequalification state for longer than t_{PQ} might be experiencing a problem.

Fast-Charge Constant Current State

As shown in [Figure 3](#), the fast-charge constant current (CC) state occurs when the main-battery voltage is greater than the low-battery prequalification threshold and less than the battery regulation threshold ($V_{PQLB} < V_{BATT} < V_{BATREG}$). After being in the fast-charge CC state for t_{SCIDG} , a CHG_I interrupt is generated, CHG_OK is set, and CHG_DTLS = 0x01.

In the fast-charge CC state, the current into the battery is less than or equal to I_{FC} . Charge current can be less than I_{FC} for any of the following reasons:

- The charger input is in input current limit.
- The charger input voltage is low.
- The charger is in thermal foldback.
- The system load is consuming adapter current. Note that the system load always gets priority over the battery charge current.

The following events cause the state machine to exit this state:

- When the main battery voltage rises above V_{BATREG} , the charger enters the “Fast Charge (CV)” state.
- If the battery charger remains in this state for longer than t_{FC} , the charger state machine transitions to the “Timer Fault” state.
- If the watchdog timer is not serviced, the charger state machine transitions to the “Watchdog Suspend” state.

The battery charger 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.

Topoff State

As shown in [Figure 3](#), the topoff state can only be entered from the fast-charge CV state when the charger current decreases below I_{TO} for t_{TERM} . After being in the topoff state for t_{SCIDG} , a CHG_I interrupt is generated, CHG_OK is set, and CHG_DTLS = 0x03. In the topoff state, the battery charger tries to maintain V_{BATREG} across the battery and typically the charge current is less than or equal to I_{TO} .

The smart power selector control circuitry may reduce the charge current lower than the battery may otherwise consume for any of the following reasons:

- The charger input is in input current limit.
- The charger input voltage is low.

- The charger is in thermal foldback.
- The system load is consuming adapter current. Note that the system load always gets priority over the battery charge current.

The following events cause the state machine to exit this state:

- After being in this state for the toff time (t_{TO}), the charger enters the "Done" state.
- If $V_{BATT} < V_{BATREG} - V_{RSTRT}$, the charger goes back to the "Fast-Charge (CC)" state.
- If the watchdog timer is not serviced, the charger state machine transitions to the "Watchdog Suspend" state.

Done State

As shown in [Figure 3](#), the battery charger enters its done state after the charger has been in the toff state for t_{TO} . After being in this state for t_{SCIDG} , a CHG_I interrupt is generated, CHG_OK is cleared, and CHG_DTLS = 0x04.

The following events cause the state machine to exit this state:

- If $V_{BATT} < V_{BATREG} - V_{RSTRT}$, the charger goes back to the "Fast-Charge (CC)" state.
- If the watchdog timer is not serviced, the charger state machine transitions to the "Watchdog Suspend" state.

In the done state, the charge current into the battery (I_{CHG}) is 0A. In the done state, the charger presents a very low load (I_{MBDN}) to the battery. If the system load presented to the battery is low ($\ll 100\mu A$), 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_{RSTRT}) and the charger state machine transitions back into the fast-charge CV state. There is no soft-start (di/dt limiting) during the done to fast-charge state transition.

Timer Fault State

The battery charger provides both a charge timer and a watchdog timer to ensure safe charging. As shown in [Figure 3](#), the charge timer prevents the battery from charging indefinitely. The time that the charger is allowed to remain in each of its prequalification states is t_{PQ} . The time that the charger is allowed to remain in the fast-charge CC and CV states is t_{FC} , which is programmable with FCHGTIME. Finally, the time that the charger is in the toff state is t_{TO} , which is programmable with TO_TIME. Upon entering the timer fault state, a CHG_I interrupt is generated without a delay, CHG_OK is cleared, and CHG_DTLS = 0x06.

In the timer fault state, the charger is off. The charger can exit the timer fault state by programming the charger to be off and then programming it to be on again through the MODE bits. Alternatively, the charger input can be removed and reinserted to exit the timer fault state (see the "ANY STATE" bubble in the upper right of [Figure 3](#)).

The IC provides seven (7) power states and one (1) no power state (see register description CHG_CNFG_00 [3:0]). Under power limited conditions, the power path feature maintains SYS and USB-OTG loads at the expense of battery charge current. In addition, the battery supplements the input power when required. Transitions between power states are initiated by detection/removal of valid power sources, OTG events, and undervoltage conditions. Details of the BVP and SYS voltages are provided for each state.

1. NO INPUT POWER, MODE = undefined. No input adapter or battery is detected. The charger and system is off. Battery is disconnected and charger is off.
2. BATTERY-ONLY, MODE = 0x00. Adapter input is invalid, outside the input voltage operating range (Q_{CHGIN} = off). Battery is connected to power the SYS load (Q_{BAT} = on), and boost is ready to power OTG (boost = standby), see [Figure 5](#).

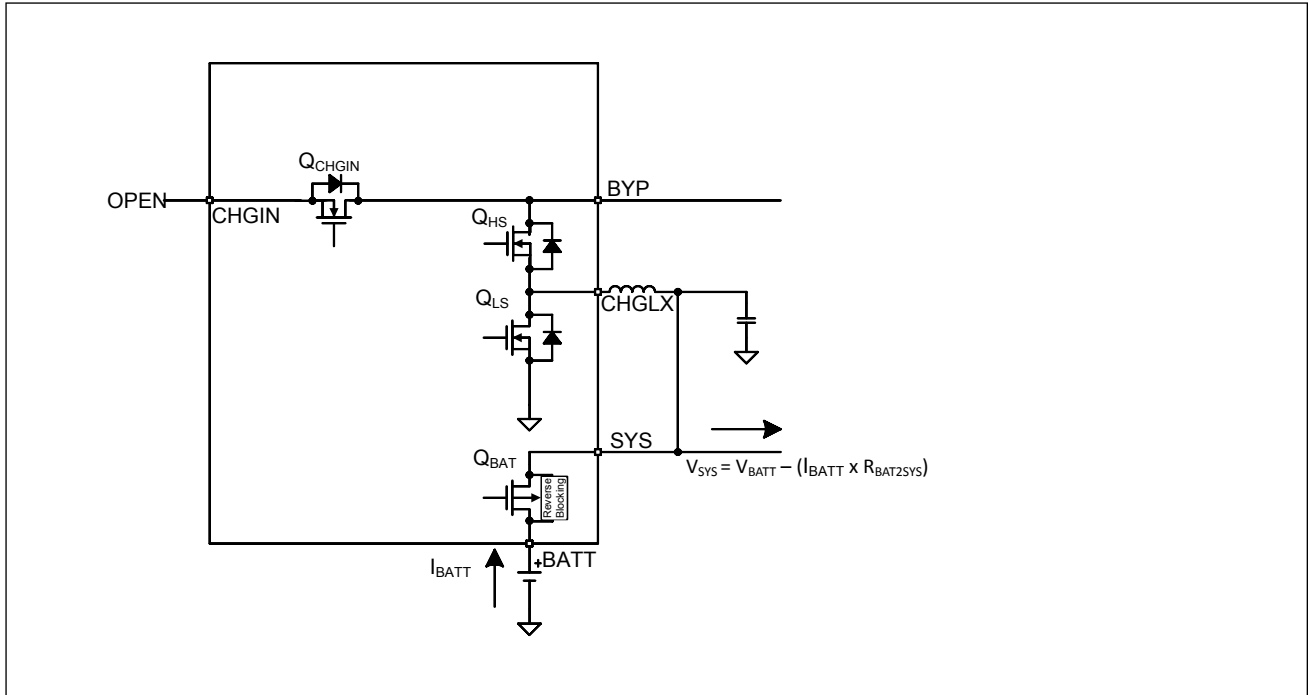


Figure 5. Battery Only

3. BATTERY-BOOST, MODE = 0x08: Adapter input is invalid outside the input voltage operating range ($Q_{CHGIN} = \text{off}$). Battery is connected to power the SYS load ($Q_{BAT} = \text{on}$) and charger is operating in boost mode (boost = on), see [Figure 6](#).

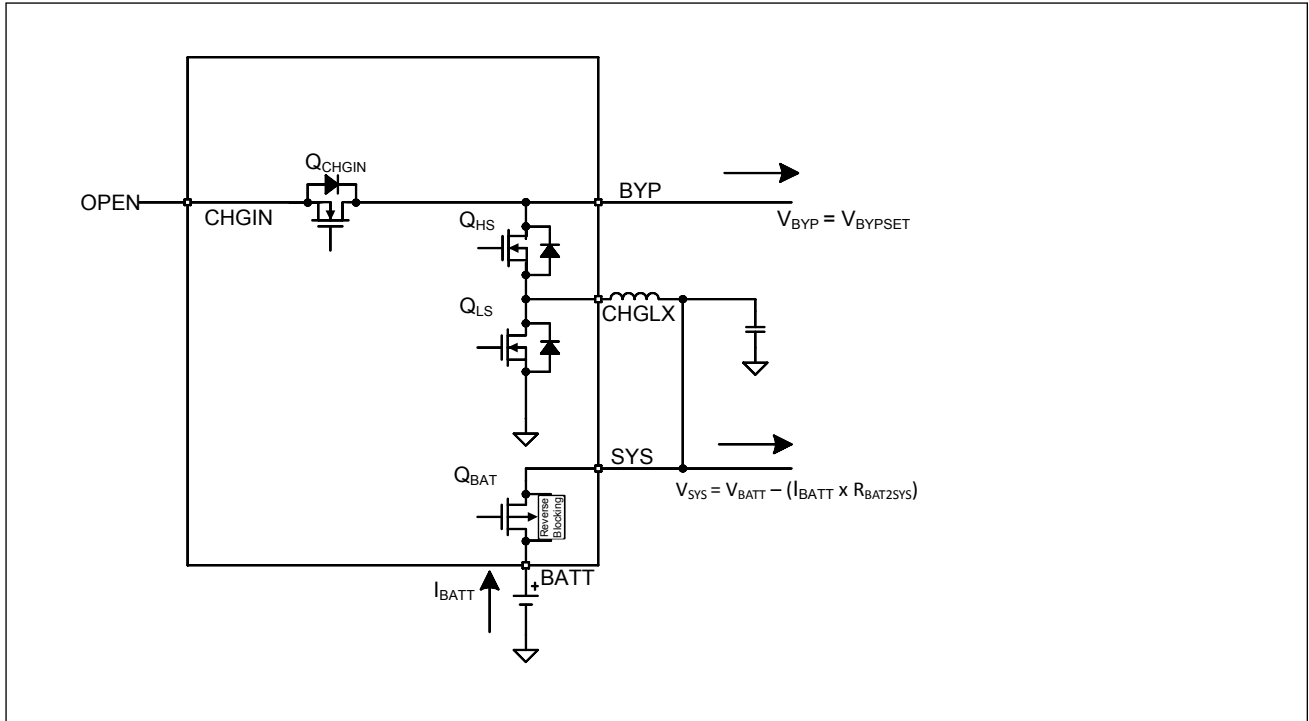


Figure 6. Battery-Boost

4. BATTERY-BOOST (OTG), MODE = 0x0A: OTG is active ($Q_{CHGIN} = \text{on}$). Battery is connected to support SYS and OTG loads ($Q_{BAT} = \text{on}$) and charger is operating in boost mode (boost = on), see [Figure 7](#).

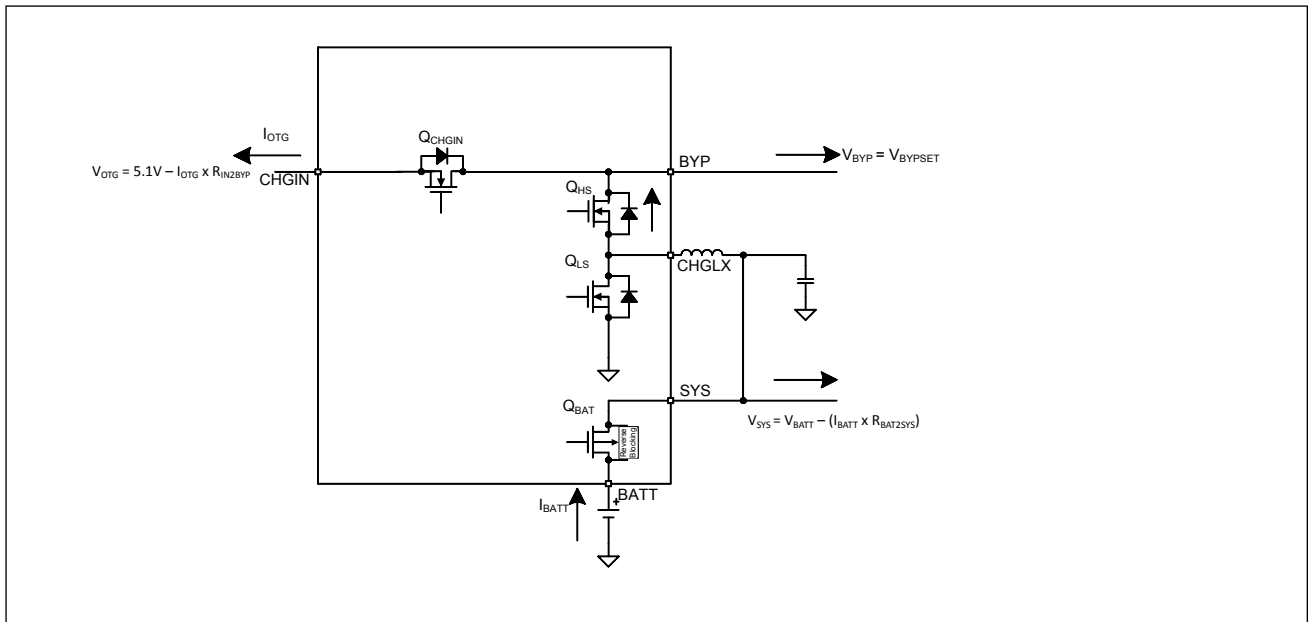


Figure 7. Battery-Boost (OTG)

- 5. NO CHARGE-BUCK, MODE = 0x0C: Adapter is detected within the input voltage operating range ($Q_{CHGIN} = \text{on}$). Battery is disconnected ($Q_{BAT} = \text{off}$) and charger is operating in buck mode powering SYS node, see [Figure 8](#).

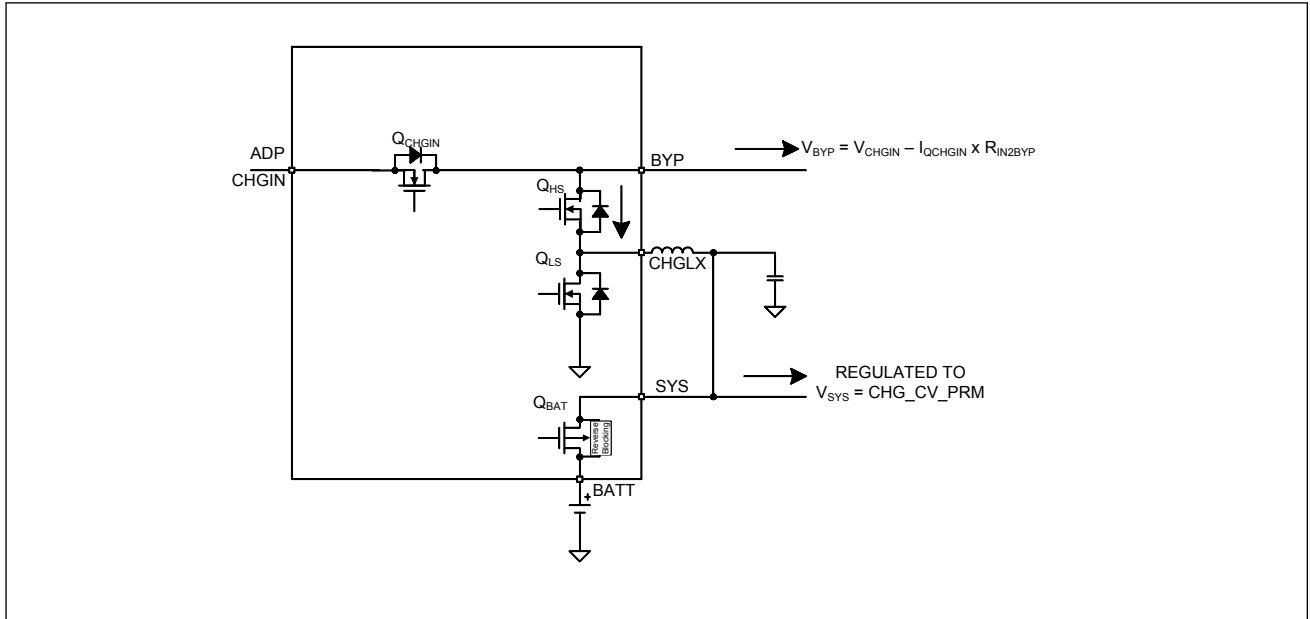


Figure 8. No Charge-Buck

- 6. CHARGE-BUCK, MODE = 0x0D: Adapter is detected within the input voltage operating range ($Q_{CHGIN} = \text{on}$). Battery is connected in charge mode ($Q_{BAT} = \text{on}$) and charger is operating in buck mode, see [Figure 9](#).

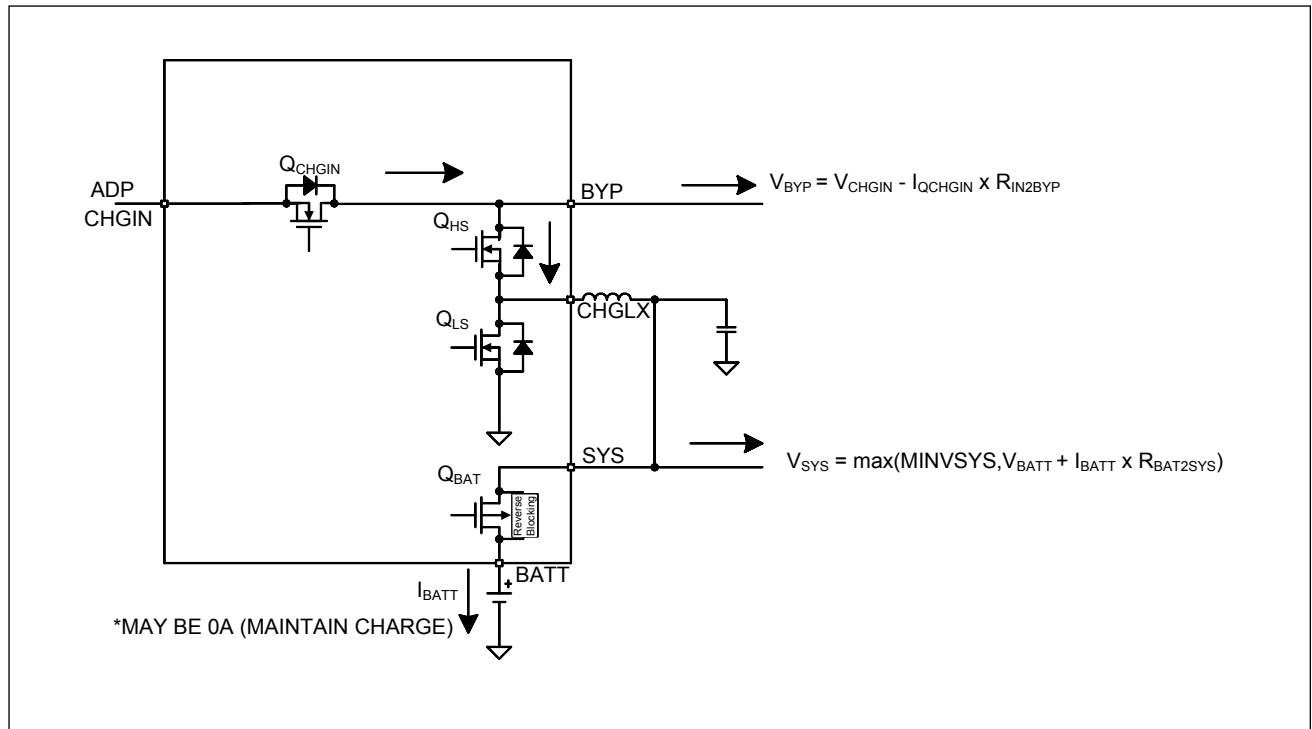


Figure 9. Charge-Buck

Watchdog Timer

The battery charger provides both a charge timer and a watchdog timer to ensure safe charging. As shown in [Figure 3](#), the watchdog timer protects the battery from charging indefinitely in the event that the host hangs or otherwise cannot communicate correctly. The watchdog timer is disabled by default with $WDTEN = 0$. To use the watchdog timer feature, enable the feature by setting $WDTEN$. While enabled, the system controller must reset the watchdog timer within the timer period (t_{WD}) for the charger to operate normally. Reset the watchdog timer by programming $WDTCLR = 0x01$.

If the watchdog timer expires while the charger is in dead-battery prequalification, low-battery prequalification, fast charge CC or CV, toff, done, or timer fault, the charging stops, a CHG_I interrupt is generated without a delay, CHG_OK is cleared, and CHG_DTLS indicates that the charger is off because the watchdog timer expired. Once the watchdog timer has expired, the charger may be restarted by programming $WDTCLR = 0x01$. The SYS node can be supported by the battery and/or the adapter through the DC-DC buck while the watchdog timer has expired.

Thermal Shutdown State

In the IC, the thermistor is monitored to turn off the charger during battery temperature fault events. The battery regulation voltage and current limits are not adjusted. As shown in [Figure 3](#), the thermal shutdown state occurs when the battery charger is in any state and the junction temperature (T_J) is higher than the device's thermal shutdown threshold (T_{SHDN}) or below 0°C . When T_J is close to T_{SHDN} , the charger folds back the input current limit to 0A so the charger and inputs are effectively off as shown in [Figure 10](#). Upon entering this state, CHG_I interrupt is generated without a delay, CHG_OK is cleared, and CHG_DTLS = $0x0A$.

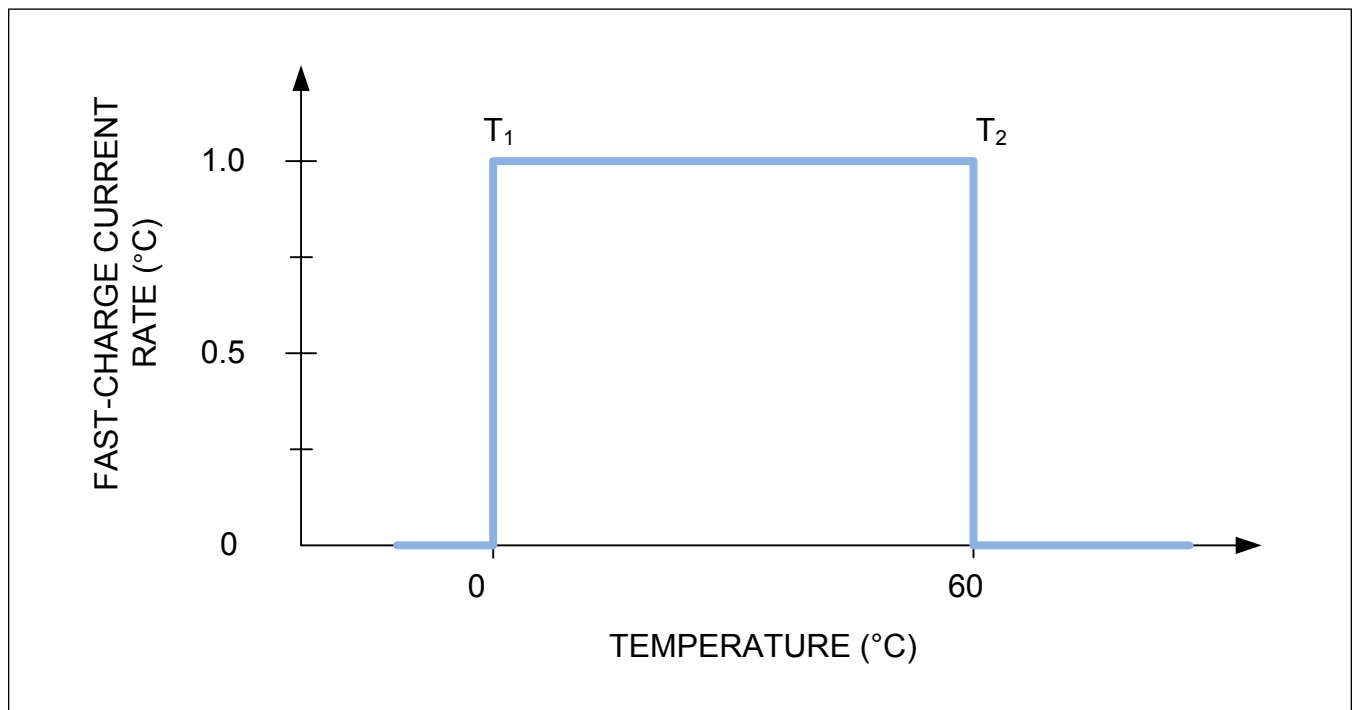


Figure 10. Thermal Shutdown Regions

In the thermal shutdown state, the charger is off and timers are suspended. The charger exits the temperature suspend state and returns to the state it came from once the die temperature has cooled. The timers resume once the charger exits this state.

Main Battery Differential Voltage Sense

As shown in [Figure 11](#), BAT_SP and BAT_SN are differential remote sense lines for the main battery. To improve accuracy and decrease charging times, the battery charger voltage sense is based on the differential voltage between BAT_SP and BAT_SN.

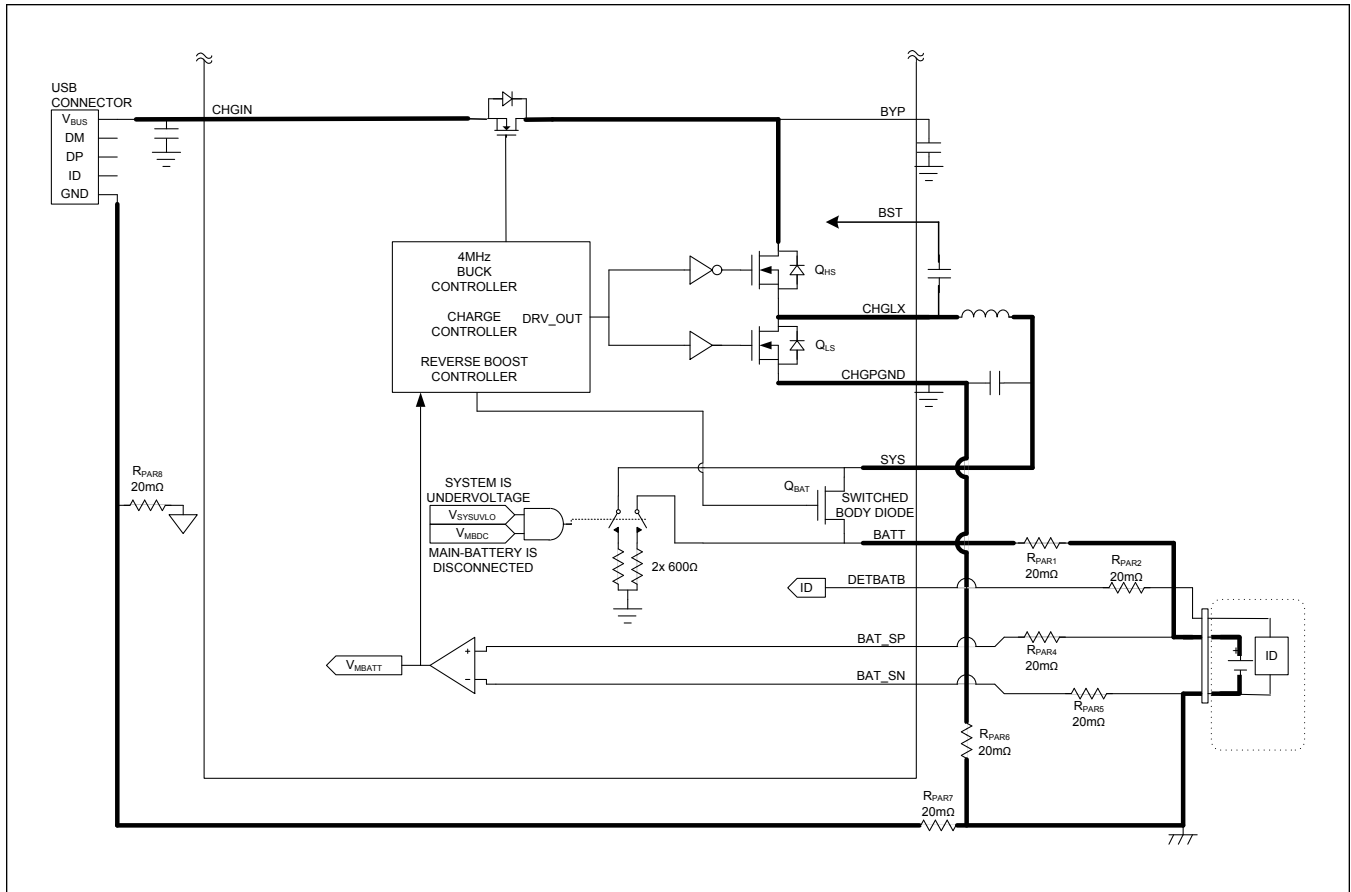


Figure 11. Schematic with Parasitic Capacitances

Figure 11 shows the high-current paths of the battery charger along with some example parasitic resistances. A Maxim battery charger without the remote sensing function would typically measure the battery voltage between BATT and GND. In the case of Figure 11, a charge current of 1A measuring from BATT to GND leads to a V_{BATT} that is 40mV higher than the real voltage because of R_{PAR1} and R_{PAR7} ($I_{CHG} \times (R_{PAR1} + R_{PAR7}) = 1A \times 40m\Omega = 40mV$). Since the charger thinks the battery voltage is higher than it actually is, it enters fast-charge CV state sooner and the effective charge time may be extended by 10 minutes (based on real lab measurements). This charger with differential remote sensing does not experience this type of problem because BAT_SP and BAT_SN sense the battery voltage directly. To get the maximum benefit from these sense lines, connect them as close as possible to the main battery connector.

OTG Mode

The DC-DC converter topology of the IC allows it to operate as a forward buck converter or reverse boost converter. The modes of the DC-DC converter are controlled with MODE, and DIS_CD_CTRL (BIT7 of CHG_CFG_00) has to be enabled. When MODE = 0x09 or 0x0A, the DC-DC converter operates in reverse boost mode allowing it to source current to CHGIN. The two modes allow current to be sourced from CHGIN and are commonly referred to as OTG modes (the term OTG is based off of the Universal Serial Bus's on-the-go concept).

When MODE = 0x09 or 0x0A, the DC-DC converter operates in reverse boost mode, regulates V_{BYP} to V_{BYP_OTG} (5.1V, typ), and the switch from BYP to CHGIN is closed. The current through the BYP to CHGIN switch is limited to the value programmed by OTG_ILIM. The four OTG_ILIM options allow for supplying 500mA or 1500mA to an external load. When the OTG mode is selected, the unipolar CHGIN transfer function measures current going out of CHGIN. When OTG mode is not selected, the unipolar CHGIN transfer function measures current going into CHGIN.

If the external OTG load at CHGIN exceeds $I_{CHGIN.OTG.LIM}$, then a `BYP_I` interrupt is generated, `BYP_OK = 0`, and `BYP_DTLS = 0bxxx1`. In response to an overload at CHGIN during OTG mode operation, the `BYP` to CHGIN switch is latched off. The `BYP` to CHGIN switches automatically retry in $\sim 468\text{ms}$. If the overload at CHGIN persists, then the switch toggles on and off with $\sim 52\text{ms}$ on and $\sim 416\text{ms}$ off. Hence, the OTG has an ON duty cycle $\sim 11\%$.

In the IC, the OTG ON duty cycle can be optionally changed to $\sim 1.57\%$ with 1.67ms ON time and 104ms OFF time. This option is enabled by `OTG_DC` in BIT5 of `CHG_CNFG_06`.

Master-Slave Charging

The IC is designed to support two additional slave chargers making it capable of providing a combined charging current of 9A (3A from MAX77860 and 3A from each slave). The slave charger(s) are only enabled during the `CC/CV` portion, and are disabled during other modes.

The user is able to set slave charging current by accessing the `SLAVE_CC` register in the IC using `I2C`. The IC eventually controls the slave charger using the `S-Wire_I` interface.

The IC protects the battery by choosing the minimum current between `SLAVE_CC` and charging current commanded by `MAXCHARGE`. To disable this protection feature, the user may set `Dis_Slave_AutoUpdate` to overwrite slave charging current according to `SLAVE_CC`.

The IC also gives two options to sense battery current for fuel gauge usage. The user may indicate their option using the slave pin.

1. Internal sense using internal FET.
 - Connect slave pin to GND.
 - This method should be used when no slave charger is required.
 - Saves cost of 1 external R_{SENSE} .
2. External sense using external R_{SENSE} .
3. Connect the slave pin to SYS.

This method should be used when slave charger(s) are required.

S-Wire I Timing

[Figure 12](#) shows the timing of S-Wire transfer on SWI.

1. SWI goes high to indicate the start of `S-WIRE_I` transmission.
2. T_{wait_int} is the enable delay for `S-Wire_I` commands after SWI goes high, also indicates slave to turn ON.
3. A collection of pulses is transferred as a programming command for any of the three converters.
 - a) A low pulse is defined by T_{sL} .
 - b) A high pulse is defined by T_{sH} .
 - c) The desired programming command depends on the number of pulses.
 - d) The number of pulses is determined by the number of rising edge.
4. Holding SWI high for T_{stop} to indicate the end of current programming command.
5. Multiple programming commands can be repeated at any time after T_{wait_int} .
6. Holding SWI low for T_{off_dly} to indicate the end of S-WIRE transmission, also indicates slave to turn OFF.
7. SWI1 and SWI2 transmission is purposefully staggered to avoid having both slave chargers turn ON at the same time ([Figure 13](#)).

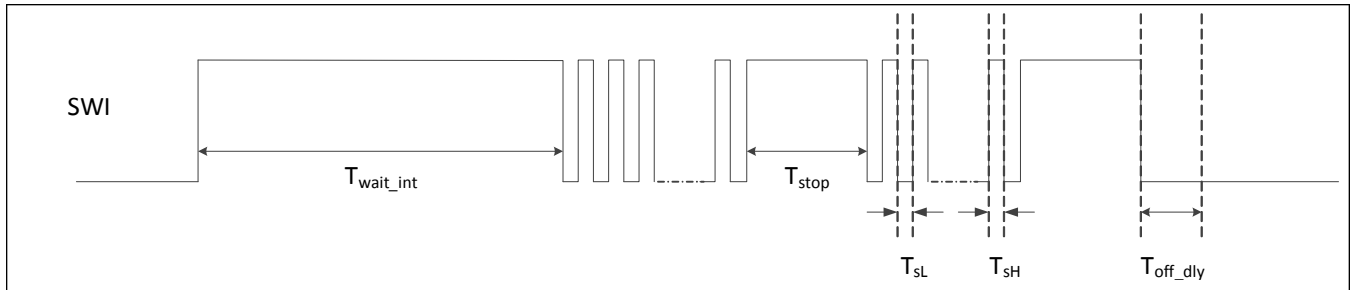


Figure 12. S-Wire Timing Diagram

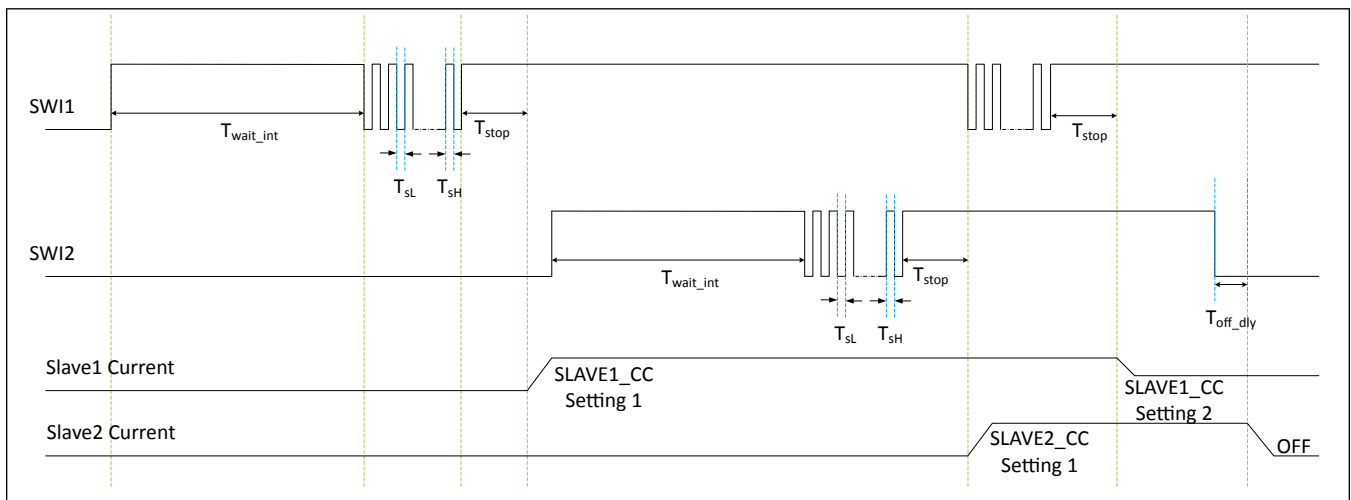


Figure 13. SW1 and SW2 Transmission

S-Wire Interrupt (Slave Fault Detection)

When a fault condition occurs at slave charger, the fault is reported to the IC and the IC interrupts the AP for slave charger fault condition. The following IC registers are for slave charger faults.

Interrupt Registers

Table 2. Top Level Interrupt

I ² C SLAVE ADDRESS (WRITE)	REGISTER ADDRESS (HEX)	REGISTER NAME	RESET VALUE	BIT7	BIT6	BIT5	BIT4
0xCC	0x22	INTSRC	0x00	RSVD	SLAVE_INT	B2SOVRC_INT	FLED_INT
0xCC	0x23	INTSRCMASK	0xFF	RSVD	SLAVE_INT_MASK	B2SOVRC_INT_MASK	FLED_INT_MASK
BIT3		BIT2		BIT1		BIT0	
CHGRDET_INT		FG_INT		TOP_INT		CHGR_INT	
CHGRDET_INT_MASK		FG_INT_MASK		TOP_INT_MASK		CHGR_INT_MASK	

Table 3. Functional Register

I ² C SLAVE ADDRESS (WRITE)	REGISTER ADDRESS (HEX)	REGISTER NAME	RESET VALUE	BIT7	BIT6	BIT5	BIT4
0xD2	0x80	SWI_INT	0x00	RSVD	RSVD	RSVD	RSVD
0xD2	0x81	SWI_INT_MASK	0xFF	RSVD	RSVD	RSVD	RSVD

Table 3. Functional Register (continued)

BIT3	BIT2	BIT1	BIT0
RSVD	CV_I	SLAVE2_I	SLAVE1_I
RSVD	CV_M	SLAVE2_M	SLAVE1_M

Programming the SLAVE Charging Current

The slave charging current is programmable through the S-Wire_I interface in 64-steps of 25mA per step. Slave current should respond only after Tstop completed.

The IC has two pins, e.g., SWI1 and SWI2 to cater to two slaves. SWI1 and SWI2 commands are staggered to avoid both slaves from turning ON at the same time to avoid causing excessively high in-rush current.

ONKEY

ONKEY is an active-low signal with default 1s debounce timer ONKEYTDEB for ship mode release. When no charging source is available at CHGIN, enable DISQIBS bit (DISIBS = 1) with I²C to set the device in ship mode. Q_{BAT} switch is disabled and SYS is isolated from BAT. With a healthy battery, pressing the ONKEY for longer than ONKEYTDEB re-enables the Q_{BAT} switch and the device exits ship mode.

When the charging source is available at CHGIN, pressing the ONKEY longer than ONKEYTD_long resets V_{SYS} rail. The IC enters buck-off and Q_{BAT} off mode for around 1s (system OFF). After that, Q_{BAT} is automatically turned on and then buck on (system ON). The details are shown in [Figure 14](#).

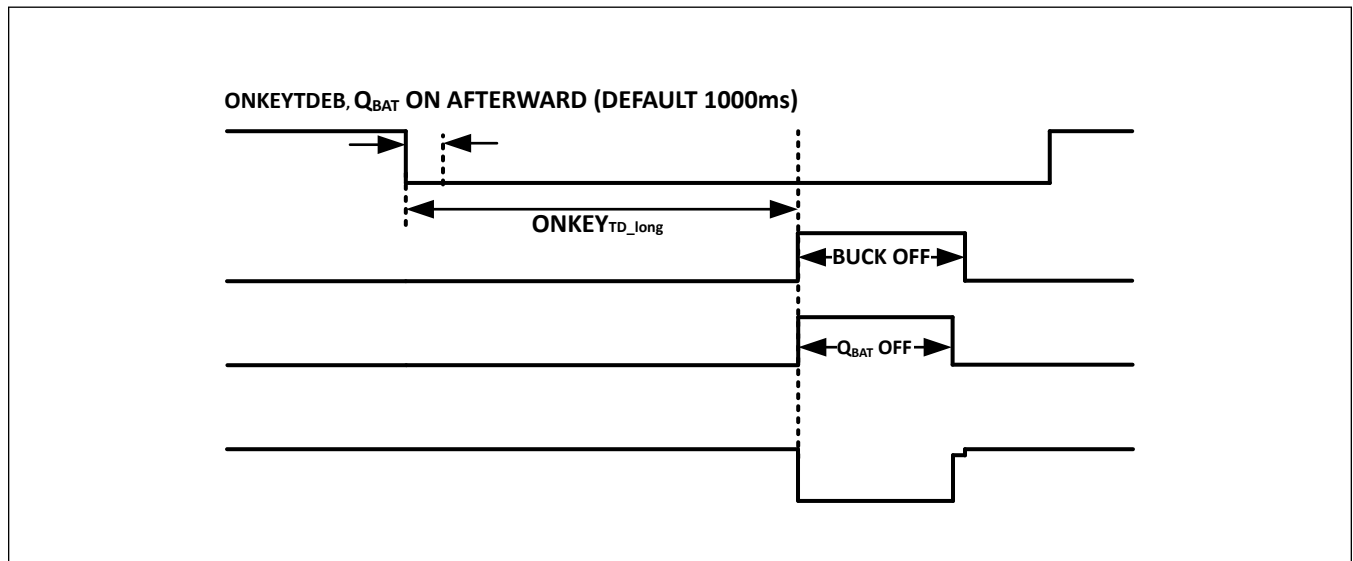


Figure 14. ONKEY Timing Diagram

Main Battery Overcurrent Protection Due to Fault

The IC protects itself, the battery, and the system from potential damage due to excessive battery discharge current. Excessive battery discharge current may occur in a smartphone for several reasons such as exposure to moisture, a software problem, an IC failure, a component failure, or a mechanical failure that causes a short circuit. The main battery overcurrent protection feature is enabled with B2SOVRC. Disabling this feature reduces the main battery current consumption by I_{MBOVRC}.

When the main battery (BATT) to system (SYS) discharge current (I_{BATT}) exceeds the programmed overcurrent threshold for at least t_{MBOVRC}, a BAT_I interrupt is generated, BAT_OK is cleared, and BAT_DTLS reports and overcurrent condition. Typically, when the system’s processor detects this overcurrent interrupt it executes a

housekeeping routine that tries to mitigate the overcurrent situation. If the processor cannot correct the overcurrent, then it can disable the BATT to SYS discharge path (B2S switch) by driving DISIBS bit to a logic high.

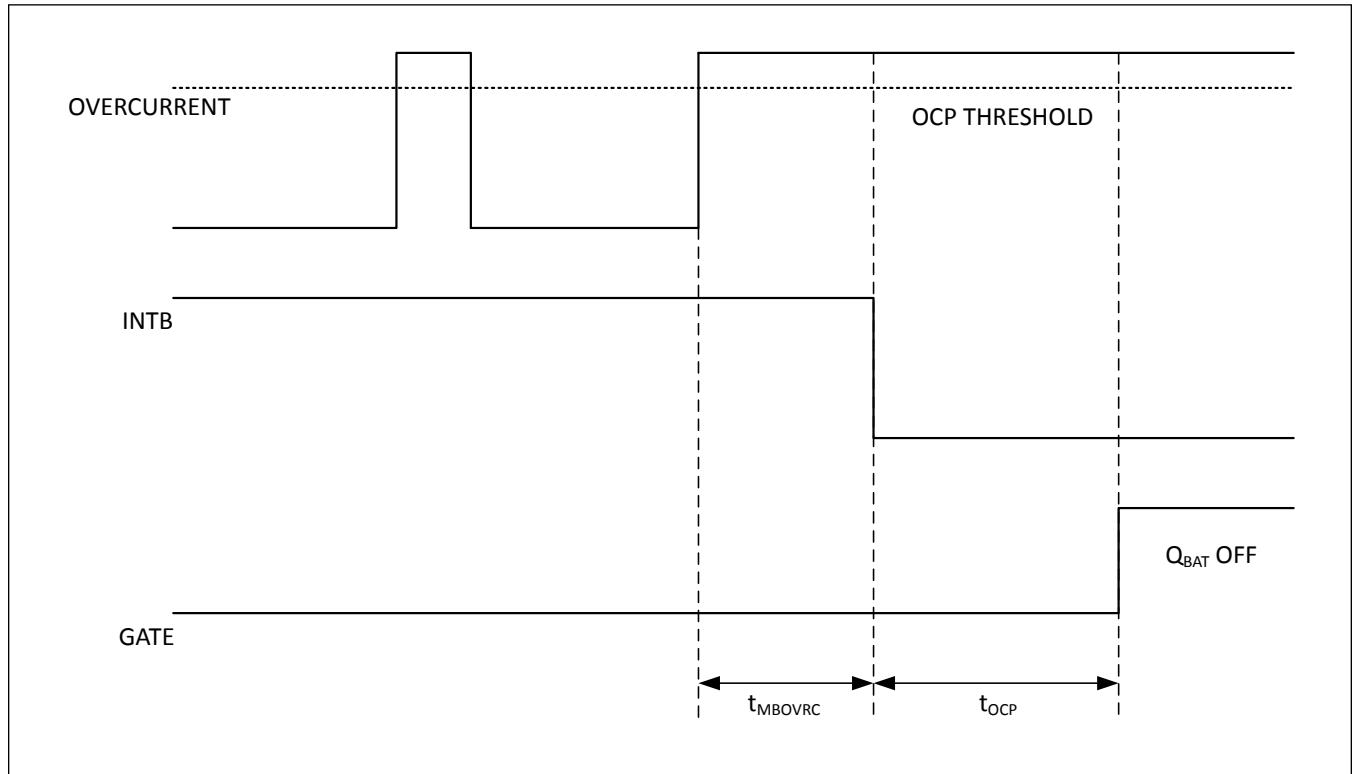


Figure 15. Overcurrent Protection Timing Diagram

There are three different scenarios of how the IC responds to setting the DISIBS bit high depending on the available power source and the state of the charger.

- 1) The IC is only powered from BATT and DISIBS bit is set.
 1. Q_{BAT} switch opens.
 2. SYS collapses and is allowed to go to 0V.
 3. DISIBS holds state.
 4. To exit from this state, the user has to plug in a valid input charger, then SYS is powered up and the system wakes up.
- 2) The IC is powered from BATT and CHGIN, the charger buck is not switching, and DISIBS bit is set.
 1. Same as above.
 2. To exit from this state, the user has to plug in a valid input charger, then SYS is powered up and the system wakes up.
- 3) The IC is powered from BATT and CHGIN, the charger buck is switching, and DISIBS bit is set.
 1. DISIBS bit is ignored.

SAFEOUT LDO

The SAFEOUT LDO is a linear regulator that provides programmable output voltages of 3.3V, 4.85V, 4.9V, and 4.95V through I²C register. It can be used to supply low voltage rated USB systems. The SAFEOUT linear regulator turns on when CHGIN \geq 3.2V regardless if charger is enabled or disabled. SAFEOUT is disabled when CHGIN is greater than the

overvoltage threshold. The SAFEOUT LDO integrates 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.

On-Chip ADC

Features

- In normal operating mode, ADC is used to convert voltage, current, and temperature to a digital code.
- Programmable single conversion or continuous conversion (every 1s).
- Optional averaging filter for each channel (channel 0 to 5) with fixed sampling conversion = 3.9kHz, and 2-bit selection to have 2, 4, 8, or 16 points averaging uniform for all channels.
- Optional offset compensation for channel 1 (V_{BUS} current), channel 3 (V_{BATT} current), and channel 4 (I_{REXT} current).

All settings should be programmed before ADC is enabled. Should user need to change the setting, ADC should be disabled first, change the settings and re-enabled back ADC.

Channels available for ADC conversion:

- Channel 0: V_{BUS} voltage, catered for two different voltage ranges programmable by bit $V_{BUS_HV_RANGE}$
 - $V_{BUS_HV_RANGE} = 0$: Range = 2.7V to 6.3V, with LSB = 14mV
 - $V_{BUS_HV_RANGE} = 1$: Range = 6.3V to 14.7V, with LSB = 33mV
- Channel 1: V_{BUS} current
 - Range = 0A to 4.1A, with LSB = 16mA
- Channel 2: V_{BATT} voltage
 - Range = 2.1V to 4.9V, with LSB = 11mV
- Channel 3: V_{BATT} current
 - Range = 0A to 3.1A, with LSB = 12mA
- Channel 4: I_{REXT} current
 - Range = -10A to +10A, with LSB = 78mA (2's complement)
- Channel 5: Temperature sensing in terms of (THMV/THMB) ratio
 - Range = 20% to 80%, with LSB = 0.24%

Single Mode and Continuous Mode

When turning on ADC, choose either of these two modes:

1. Single mode: ADC turns on only once. When finished converting the required channels, it shuts down automatically and waits for user input to turn on.
2. Continuous mode: ADC turns on every 1s to convert the required channels. After it finishes converting, analog circuits are turned off. The digital controller still requests CLK to count for 1s, then turns on the ADC again to do the next conversion.

Averaging Filter

To improve noise immunity for the ADC, the averaging filter function is added. The user is able to choose between 0, 2, 4, 8, and 16 points of averaging. Once the number of points is selected, it is applied to all the channels with filter function enabled. Averaging filters of CH0~CH7 can be enabled or disabled independently. When enabled, ADC turns on every 256 μ s to take measurement of the filter-enabled channel(s) until 2, 4, 8, or 16 points are done.

USB Type-C

The IC implements USB Type-C and USB BC 1.2 detection. The Type-C block implements a spec compliant DRP with V_{CONN} support allowing easy integration with an external USB PD solution. The BC 1.2 block is integrated into the Type-C state machine such that the BC 1.2 is subordinate to Type-C detection thus solving any possible interaction issues during separate block operations.

Benefits and Features

Supports full USB Battery Charging rev1.2 detection with the following features:

- Data Contact Detection (DCD)
- Detects all USB defined sources:
 - Standard USB port
 - Charging downstream port
 - Dedicated charging port
- Detects Apple power adaptors
- Samsung 2A
- New 3A DCP (requires a compatible power adapter)
- Manual restart of charger detection

Supports full USB Type-C Release1.1 with the following features:

- USB Type-C
 - Dual role port (DRP)
 - Supports standalone operation
 - Supports USB PD V_{CONN} swap
 - Supports USB PD power role swap
 - Disable mode
 - Error mode
- Integrated V_{CONN} Switch
 - 0.75Ω to either CC1 or CC2
 - External V_{CONN} source up to 5.5V
 - Bidirectional blocking
- CC Pin
 - Supports 20V pull (through 10k min ext resistor) source requirement
 - Dead battery clamp allowing for unpowered UFP identification

Register Layout Specifications**Register Map and Detailed Descriptions**

The IC has a total of three slave addresses. The slave addresses for top, charger, master/slave, ADC and USB Type-C are listed below. The least significant bit is the read/write indicator (1 for read, 0 for write).

Slave Address of MAX77860:

- Clogic, SAFEOUT LDO (0xCCh/0xCDh)
- Charger, master/slave, ADC (0xD2h/0xD3h)
- USB Type-C (0x4Ah/0x4Bh)

Register Reset Conditions in R Column:

- Type S: Registers are reset each time when $SYS < POR$ (1.55V, typ)
- Type O: Registers are reset each time when $SYS < SYS\ UVLO$ (2.55V, max), or $SYS > SYS\ OVLO$, or die temp $> +165^{\circ}C$ (or IC transitions from on to off state)

Note: "RSVD" or "Reserved" means reserved: The bit is reserved for future usage.

Top Level I²C Register

Table 4. PMIC Register (0x20)

NAME		FUNCTION	ADDR	TYPE	RESET
PMIC ID		PMIC ID	0x00	O	0x60
BIT	MODE	NAME	RESET	DESCRIPTION	
7:4	R	ID	0110	ID of MAX77860	
3:0	R	ID	0000		

Table 5. Interrupt Source (0x22)

NAME		FUNCTION	ADDR	TYPE	RESET
INTSRC		Interrupt Source	0x22	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R	RSVD	0	Reserved	
6	R	SLAVE_INT	0	Slave Interrupt 0 = No slave interrupt 1 = Slave interrupt detected	
5	R	B2SOVRC_INT	0	Battery to SYS Overcurrent Interrupt 0 = No B2SOVRC interrupt 1 = B2SOVRC interrupt detected	
4	R	RSVD	1	Reserved	
3	R	USBC_INT	0	USB Type-C Interrupt 0 = No interrupt detected in USB Type-C block 1 = Interrupt detected in USB Type-C block	
2	R	RSVD	0	Reserved	
1	R	SYS_INT	0	SYS Interrupt 0 = No SYS interrupt detected 1 = SYS interrupt detected	
0	R	CHGR_INT	0	Charger Interrupt 0 = No interrupt detected in charger block 1 = Interrupt detected in charger block	

Table 6. Interrupt Source Mask (0x23)

NAME		FUNCTION	ADDR	TYPE	RESET
INTSRCMASK		Interrupt Source Mask	0x23	S	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	RSVD	1	Reserved	
6	R/W	SLAVE_INT_MASK	1	Slave Interrupt Mask 0 = Slave interrupt is not masked 1 = Slave interrupt is masked	
5	R/W	B2SOVRC_INT_MASK	1	Battery to SYS Overcurrent Interrupt Mask 0 = B2SOVRC interrupt is not masked 1 = B2SOVRC interrupt is masked	
4	R/W	RSVD	1	Reserved	
3	R/W	USBC_INT_MASK	1	USB Type-C Interrupt Mask 0 = USB Type-C interrupt is not masked 1 = USB Type-C interrupt is masked	
2	R/W	RSVD	1	Reserved	

Table 6. Interrupt Source Mask (0x23) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
INTSRCMASK		Interrupt Source Mask	0x23	S	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
1	R/W	SYS_INT_MASK	1	SYS Interrupt Mask 0 = SYS interrupt is not masked 1 = SYS interrupt is masked	
0	R/W	CHGR_INT_MASK	1	Charger Interrupt 0 = Charger interrupt is not masked 1 = Charger interrupt is masked	

Table 7. SYSTEM Interrupt (0x24)

NAME		FUNCTION	ADDR	TYPE	RESET
SYSINTSRC		SYS Interrupt Source	0x24	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/C	RSVD	0	Reserved	
6	R/C	TSHDN_INT	0	Temp Shutdown Interrupt 0 = No T _{SHDN} interrupt; 1 = T _{SHDN} interrupt is detected	
5	R/C	YSOVLO_INT	0	SYS OVLO Interrupt 0 = No SYSOVLO interrupt 1 = SYSOVLO interrupt is detected	
4	R/C	SYSUVLO_INT	0	SYS UVLO Interrupt 0 = No SYSUVLO interrupt 1 = SYSUVLO interrupt is detected	
3	R/C	LOWSYS_INT	0	LOWSYS Interrupt 0 = No LOWSYS interrupt 1 = LOWSYS interrupt is detected	
2	R/C	RSVD	0	Reserved	
1	R/C	T140C_INT	0	+140°C Interrupt 0 = No +140°C interrupt 1 = +140°C interrupt is detected; die temp > +140°C	
0	R/C	T120C_INT	0	+120°C Interrupt 0 = No +120°C interrupt 1 = +120°C interrupt is detected; die temp > +120°C	

Table 8. SYSTEM Interrupt Source Mask (0x26)

NAME		FUNCTION	ADDR	TYPE	RESET
SYSINTMASK		System Interrupt mask	0x26	S	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	RSVD	1	Reserved	
6	R/W	TSHDN_INT_MASK	1	Temp Shutdown Interrupt Mask 0 = T _{SHDN} interrupt is not masked 1 = T _{SHDN} interrupt is masked	
5	R/W	YSOVLO_INT_MASK	1	SYS OVLO Interrupt Mask 0 = SYSOVLO interrupt is not masked 1 = SYSOVLO interrupt is masked	
4	R/W	SYSUVLO_INT_MASK	1	SYS UVLO Interrupt Mask 0 = SYSUVLO interrupt is not masked 1 = SYSUVLO interrupt is masked	

Table 8. SYSTEM Interrupt Source Mask (0x26) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
SYSINTMASK		System Interrupt mask	0x26	S	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
3	R/W	LOWSYS_INT_MASK	1	LOWSYS Interrupt Mask 0 = LOWSYS interrupt is not masked 1 = LOWSYS interrupt is masked	
2	R/W	RSVD	1	Reserved	
1	R/W	T140C_INT_MASK	1	+140°C Interrupt Mask 0 = T140C interrupt is not masked 1 = T140C interrupt is masked	
0	R/W	T120C_INT_MASK	1	120°C Interrupt Mask 0 = T120C interrupt is not masked 1 = T120C interrupt is masked	

Table 9. SAFEOUT Control Register (0xC6)

NAME		FUNCTION	ADDR	TYPE	RESET
SAFEOUTCTRL		SAFEOUT Linear regulator control	0xC6	O	0x75
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	INT_LDO_EN	0	Internal 2.5V LDO Enable Bit 0 = Disable internal 2.5V LDO 1 = Enable internal 2.5V LDO	
6	R/W	ENSAFEOUT	1	SAFEOUTLDO Enable Bit 0 = Disable SAFEOUT LDO 1 = Enable SAFEOUT LDO	
5	R/W	RSVD	1	Reserved	
4	R/W	ACTDISSAFEO	1	SAFEOUTLDO Active Discharge Enable bit 0 = No active discharge 1 = Active discharge	
3:2	R/W	RSVD	01	Reserved	
1:0	R/W	SAFEOUT[1:0]	01	SAFEOUTLDO Output Voltage Setting 00 = 4.85V; 01 = 4.90V (Default) 10 = 4.95V; 11 = 3.30V	

Charger Registers

Charger Register Details

The IC's charger has convenient default register settings and a complete charger state machine that allows it to be used with minimal software interaction. Software interaction with the register map enhances the charger by allowing a high degree of configurability. An easy-to-navigate interrupt structure and in-depth status reporting allows software to quickly track the changes in the charger's status.

Register Protection

The CHG_CNFG_01, CHG_CNFG_02, CHG_CNFG_03, CHG_CNFG_04, CHG_CNFG_05, and CHG_CNFG07 registers contain settings for static parameters that are associated with a particular system and battery. These "static" settings are typically set once each time the system's microprocessor runs its boot-up initialization code, then they are not changed again until the microprocessor reboots. CHGPROT allows for blocking the "write" access to these "static" settings to protect them from being changed unintentionally. This protection is particularly useful for critical parameters such as the battery charge current CHG_CC and the battery charge voltage CHG_CV_PRM.

Determine the following registers bit settings by considering the characteristics of the battery. Maxim recommends that CHG_CC be set to the maximum acceptable charge rate for your battery. Typically, there is no need to actively adjust the CHG_CC setting based on the capabilities of the source at CHGIN, system load, or thermal limitations of the PCB. The smart power selector intelligently manages all these parameters to optimize the power distribution:

- Charger Restart Threshold (CHG_RSTRT)
- Fast-Charge Timer (t_{FC}) (FCHGTIME)
- Fast-Charge Current (CHG_CC)
- Topoff Time (TO_TIME)
- Topoff Current (TO_ITH)
- Battery Regulation Voltage (CHG_CV_PRM)

Determine the following register bit settings by considering the characteristics of the system:

- Low-Battery Prequalification Enable (PQEN)
- Minimum System Regulation Voltage (MINVSYS)
- Junction Temperature Thermal Regulation Loop Setpoint (REGTEMP)

Interrupt, Mask, Okay, and Detail Registers

The battery charger section of the IC provides detailed interrupt generation and status for the following subblocks:

- Charger Input
- Charger State Machine
- Battery
- Bypass Node

State changes on any subblock report interrupts through the CHG_INT register. Interrupt sources are masked from affecting the hardware interrupt pin when bits in the CHG_INT_MASK register are set. The CHG_INT_OK register provides a single-bit status indication of whether the interrupt generating subblock is okay or not. The full status of interrupt generating subblock is provided in the CHG_DETAILS_00, CHG_DETAILS_01, CHG_DETAILS_02, and CHG_DETAILS_03 registers. Note that CHG_INT, CHG_INT_MASK, and CHG_INT_OK use the same bit position for each interrupt generating block to simplify software development.

Interrupt bits are automatically cleared upon reading a given interrupt register. When all pending CHG_INT interrupts are cleared, the top level interrupt bit is deasserted.

Table 10. Charger Interrupt (0xB0)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_INT		Charger interrupt	0xB0	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
0	R/C	BYP_I	0	Bypass Node Interrupt 0 = The BYP_OK bit has not changed since the last time this bit was read. 1 = The BYP_OK bit has changed since the last time this bit was read.	
1	R/C	BAT2SOC_I	0	BAT to SYS Overcurrent Interrupt 0 = The BAT2SOC_OK bit has not changed since the last time this bit was read. 1 = The BAT2SOC_OK bit has changed since the last time this bit was read.	
2	R/C	BATP_I	0	Battery Presence Interrupt 0 = The BATP_OK bit has not changed since the last time this bit was read. 1 = The BATP_OK bit has changed since the last time this bit was read.	

Table 10. Charger Interrupt (0xB0) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_INT		Charger interrupt	0xB0	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
3	R/C	BAT_I	0	Battery Interrupt 0 = The BAT_OK bit has not changed since the last time this bit was read. 1 = The BAT_OK bit has changed since the last time this bit was read.	
4	R/C	CHG_I	0	Charger Interrupt 0 = The CHG_OK bit has not changed since the last time this bit was read. 1 = The CHG_OK bit has changed since the last time this bit was read.	
5	R/C	TOPOFF_I	0	TOPOFF Interrupt 0 = The TOPOFF_OK bit has not changed since the last time this bit was read. 1 = The TOPOFF_OK bit has changed since the last time this bit was read.	
6	R/C	CHGIN_I	0	CHGIN Interrupt 0 = The CHGIN_OK bit has not changed since the last time this bit was read. 1 = The CHGIN_OK bit has changed since the last time this bit was read.	
7	R/C	AICL_CHGIN_I	0	AICL_CHGIN_I Interrupt 0 = The AICL_CHGIN_I_OK bit has not changed since the last time this bit was read. 1 = The AICL_CHGIN_I_OK bit has changed since the last time this bit was read.	

Table 11. Charger Interrupt Mask (0xB1)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_INT_MASK		Charger interrupt mask	0xB1	0	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
0	R/W	BYP_M	1	Bypass Interrupt Mask 0 = Unmasked 1 = Masked	
1	R/W	BAT2SOC_M	1	Battery to SYS Overcurrent Mask 0 = Unmasked 1 = Masked	
2	R/W	BATP_M	1	Battery Presence Interrupt Mask 0 = Unmasked 1 = Masked	
3	R/W	BAT_M	1	Battery Interrupt Mask 0 = Unmasked 1 = Masked	
4	R/W	CHG_M	1	Charger Interrupt Mask 0 = Unmasked 1 = Masked	

Table 11. Charger Interrupt Mask (0xB1) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_INT_MASK		Charger interrupt mask	0xB1	0	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
5	R/W	TOPOFF_M	1	TOPOFF Interrupt Mask 0 = Unmasked 1 = Masked	
6	R/W	CHGIN_M	1	CHGIN Interrupt Mask 0 = Unmasked 1 = Masked	
7	R/W	AICL_CHGINI_M	1	AICL_CHGINI Interrupt Mask 0 = Unmasked 1 = Masked	

Table 12. Charger Status (0xB2)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_INT_OK		Charger status	0xB2	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
0	R	BYP_OK	0	Single-Bit Bypass Status Indicator (See BYP_DTLS for more information.) 0 = Something powered by the bypass node has hit current limit, i.e., BYP_DTLS ≠ 0x00. 1 = The bypass node is okay, i.e., BYP_DTLS = 0x00.	
1	R	BAT2SOC_OK	0	Battery-to-SYS Overcurrent Status Indicator (See BAT2SOC_DTLS for more information.) 0 = Battery to SYS has not hit overcurrent limit. 1 = Battery to SYS has hit overcurrent limit.	
2	R	BATP_OK	0	BAT Present Status Indicator 0 = Main battery is not present. 1 = Main battery is present.	
3	R	BAT_OK	0	Single-Bit Battery Status Indicator (See BAT_DTLS for more information.) 0 = The battery has an issue or the charger has been suspended, i.e., BAT_DTLS ≠ 0x03 or 0x04. 1 = The battery is okay, i.e., BAT_DTLS = 0x03 or 0x04.	
4	R	CHG_OK	0	Single-Bit Charger Status Indicator (See CHG_DTLS for more information.) 0 = The charger has suspended charging or TREG = 1, i.e., CHG_DTLS ≠ 0x00 or 0x01 or 0x02 or 0x03 or 0x05 or 0x08. 1 = The charger is okay or the charger is off, i.e., CHG_DTLS = 0x00 or 0x01 or 0x02 or 0x03 or 0x05 or 0x08.	
5	R	TOPOFF_OK	0	Single-Bit TOPOFF Indicator (See CHG_DTLS for more information.) 0 = The charger is not in TOPOFF state. 1 = The charger is in TOPOFF state.	
6	R	CHGIN_OK	0	Single-Bit CHGIN Input Status Indicator (See CHGIN_DTLS for more information.) 0 = The CHGIN input is invalid, i.e., CHGIN_DTLS ≠ 0x03. 1 = The CHGIN input is valid, i.e., CHGIN_DTLS = 0x03.	
7	R	AICL_CHGINI_OK	0	AICL_CHGINI_OK 0 = AICL or/and CHGINI mode. 1 = Not in AICL mode and not in CHGINI mode.	

Table 13. Charger Details 00 (0xB3)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_DTLS_00		Charger details 00	0xB3	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
0	R	BATP_DTLS	0	Battery Detection Details 0 = Battery presence. 1 = No battery presence.	
1	R	OVPDRV_DTLS	0	OVPDRV FET Details 0 = External OVP FET off. 1 = External OVP FET on.	
2	R	VBUSDET_DTLS	0	VBUSDET Details 0 = VBUSDET above 5.8V (100mV hysteresis). 1 = VBUSDET below 5.7V.	
3	R	RSVD	0	Reserved	
4	R	RSVD	0	Reserved	
6:5	R	CHGIN_DTLS	00	CHGIN Details: <ul style="list-style-type: none"> • 0x00 = VBUS is invalid. $V_{CHGIN} < V_{CHGIN_UVLO}$ and input voltage regulation loop is not active. • 0x01 = VBUS is invalid. $V_{CHGIN} < V_{MBATT} + V_{CHGIN2SYS}$ and, $V_{CHGIN} > V_{CHGIN_UVLO}$ or input voltage regulation loop is active. • 0x02 = VBUS is invalid. $V_{CHGIN} > V_{CHGIN_OVLO}$. • 0x03 = VBUS is valid. $V_{CHGIN} > V_{CHGIN_UVLO}$ or input voltage regulation loop is active, $V_{CHGIN} > V_{MBATT} + V_{CHGIN2SYS}$. $V_{CHGIN} < V_{CHGIN_OVLO}$. 	
7	R	RSVD	0	Reserved	

Table 14. Charger Details 01 (0xB4)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_DTLS_01		Charger details 01	0xB4	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
3:0	R	CHG_DTLS	0000	Charger Details: <ul style="list-style-type: none"> • 0x00 = Charger is in dead-battery prequalification or low-battery prequalification mode, CHG_OK = 1, $V_{MBATT} < V_{PQLB}$, $T_J < T_{JSHDN}$. • 0x01 = Charger is in fast-charge constant current mode, CHG_OK = 1, $V_{MBATT} < V_{BATREG}$, $T_J < T_{JSHDN}$. • 0x02 = Charger is in fast-charge constant voltage mode, CHG_OK = 1, $V_{MBATT} = V_{BATREG}$, $T_J < T_{JSHDN}$. • 0x03 = Charger is in toff mode, CHG_OK = 1, $V_{MBATT} \geq V_{BATREG}$, $T_J < T_{JSHDN}$. • 0x04 = Charger is in done mode, CHG_OK = 0, $V_{MBATT} > V_{BATREG} - V_{RSTRT}$, $T_J < T_{JSHDN}$. • 0x05 = Reserved. • 0x06 = Charger is in timer-fault mode, CHG_OK = 0, $V_{MBATT} < V_{BATOV}$, if $BAT_DTLS = 0b001$ then $V_{MBATT} < V_{BATPQ}$, $T_J < T_{JSHDN}$. • 0x07 = Charger is in thermistor suspend mode, CHG_OK = 0, $V_{MBATT} < V_{BATOV}$. If $BAT_DTLS = 0b001$ then $V_{MBATT} < V_{PQLB}$, $T_J < T_{JSHDN}$. • 0x08 = Charger is off, charger input invalid and/or charger is disabled, CHG_OK = 1. • 0x09 = Reserved. • 0x0A = Charger is off and $T_J > T_{JSHDN}$, CHG_OK = 0. • 0x0B = Charger is off because the watchdog timer expired, CHG_OK = 0. • 0x0C-0x0F = Reserved. 	

Table 14. Charger Details 01 (0xB4) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_DTLS_01		Charger details 01	0xB4	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
6:4	R	BAT_DTLS	000	<p>Battery Details:</p> <ul style="list-style-type: none"> 0x00 = No battery and the charger is suspended. 0x01 = $V_{MBATT} < V_{PQLB}$. This condition is also reported in the CHG_DTLS as 0x00. 0x02 = The battery is taking longer than expected to charge. This could be due to high system currents, an old battery, a damaged battery, or something else. Charging has suspended and the charger is in timer fault mode. This condition is also reported in the CHG_DTLS as 0x06. 0x03 = The battery is okay and its voltage is greater than the minimum system voltage ($V_{SYSMIN} < V_{MBATT}$), Q_{BAT} is on and V_{SYS} is approximately equal to V_{MBATT}. 0x04 = The battery is okay but its voltage is low: $V_{PQLB} < V_{MBATT} < V_{SYSMIN}$. Q_{BAT} is operating like an LDO to regulate V_{SYS} to V_{SYSMIN}. 0x05 = The battery voltage is greater than the battery overvoltage flag threshold (V_{BATOVF}) or it has been greater than this threshold within the last 6ms. V_{BATOVF} is set to 240mV above the V_{BATREG} target as programmed by CHG_CV_PRM. If BATOV persists more than 56ms, charging is suspended and the DC-DC operates in buck only. Note that this flag is only generated when there is a valid input or when the DC-DC is operating as a boost. 0x06 = The battery is overcurrent or it has been overcurrent for at least 37.5ms since the last time this register has been read. 0x07 = Reserved. <p>In the event that multiple faults occur within the battery details category, overcurrent has priority followed by no-battery, then overvoltage, then timer fault, then below prequel.</p>	
7	R	TREG	0	<p>Temperature Regulation Status</p> <p>0 = The junction temperature is less than the threshold set by REGTEMP and the full charge current limit is available.</p> <p>1 = The junction temperature is greater than the threshold set by REGTEMP and the charge current limit may be folding back to reduce power dissipation.</p>	

Table 15. Charger Details 02 (0xB5)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_DTLS_02		Charger details 02	0xB5	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
2:0	R	BYP_DTLS	000	<p>Bypass Node Details. All bits in this family are independent from each other. They are grouped together only because they are all related to the health of the BYP node and any change in these bits generates a BYP_I interrupt.</p> <p>BYP_DTLS0 = OTGILIM = 0bxx1 BYP_DTLS1 = BSTILIM = 0bx1x BYP_DTLS2 = BCKNegILIM = 0b1xx *****</p> <ul style="list-style-type: none"> • 0bx00 = The bypass node is okay. • 0bxx1 = The BYP to CHGIN switch (OTG switch) current limit was reached within the last 28ms. • 0bx1x = The BYP reverse boost converter has hit its current limit—this condition persists for 28ms. • 0b1xx = The BYP buck converter has hit the max negative demand current limit—this condition persists for 446µs. 	
3	R	AICL_DTLS	0	AICL Mode Details: 0 = Not in AICL mode; 1 = In AICL mode	
4	R	CHGINI_DTLS	0	CHGINI Mode Details: 0 = Not in CHGINI mode; 1 = In CHGINI mode	
7:5	R	RSVD	000	Reserved	

Table 16. Charger Configuration 00 (0xB7)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_00		Charger configuration 00	0xB7	0	0x05
BIT	MODE	NAME	RESET	DESCRIPTION	
3:0	R/W	MODE	0101	<p>Power Selector Configuration</p> <ul style="list-style-type: none"> 0x00 = 0b0000 = charger = off, OTG = off, buck = off, boost = off. The FET_DRV switch (Q_{BAT}) is on to allow the battery to support the system. BYP may or may not be biased based on the CHGIN availability. 0x01 = 0b0001 = same as 0b0000. 0x02 = 0b0010 = same as 0b0000. 0x03 = 0b0011 = same as 0b0000. 0x04 = 0b0100 = charger = off, OTG = off, buck = on, boost = off. When there is a valid input, the buck converter regulates the system voltage to be V_{BATREG}. 0x05 = 0b0101 = charger = on, OTG = off, buck = on, boost = off. When there is a valid input, the battery is charging. V_{SYS} is the larger of V_{SYSTEMIN} and $\sim V_{MBATT} + I_{MBATT} \times R_{BAT2SYS}$. 0x06 = 0b0110 = same as 0b101. 0x07 = 0b0111 = same as 0b101. 0x08 = 0b1000 = charger = off, OTG = off, buck = off, boost = on. The FET_DRV switch (Q_{BAT}) is on to allow the battery to support the system and the charger's DC-DC operates as a boost converter. The BYP voltage is regulated to V_{BYPSET}. CHGIN to BYP FET is off. OVPDRV FET is off. 0x09 = 0b1001 = same as 0b1000. 0x0A = 0b1010 = charger = off, OTG = on, buck = off, boost = on. The FET_DRV switch (Q_{BAT}) is on to allow the battery to support the system, the charger's DC-DC operates as a boost converter. CHGIN to BYP FET is on allowing it to source current up to I_{CHGIN.OTG.MAX}. The boost target voltage is 5.1V (V_{BYP.OTG}) and V_{BYPSET} is ignored. 0x0B = reserved. 0x0C = 0b1100 = charger = off, OTG = off, buck = on, boost = on. When there is a valid input, the system is supported by that input: V_{SYS} = 4.2V. When the input is invalid, the boost is on with a target voltage equal to V_{BYPSET}. 0x0D = 0b1101 = charger = on, OTG = off, buck = on, boost = on. When there is a valid input, the system is supported by that input: V_{SYS} is the larger of V_{SYSTEMIN} and $\sim V_{MBATT} + I_{MBATT} \times R_{BAT2SYS}$. When input is invalid, the boost is on with a target voltage that is equal to V_{BYPSET}. 0x0E = 0b1110 = charger = off, OTG = on, buck = on, boost = on. V_{SYS} = 4.2V and QCHGIN is on allowing it to source current up to I_{CHGIN.OTG.MAX}. Boost is on with a target voltage of 5.1V (V_{BYP.OTG}) and V_{BYPSET} is ignored. 0x0F = 0b1111 = charger = on, OTG = on, buck = on, boost = on. V_{SYS} is the larger of V_{SYSTEMIN} and $\sim V_{MBATT} + I_{MBATT} \times R_{BAT2SYS}$. QCHGIN is on allowing it to source current up to I_{CHGIN.OTG.MAX}. Boost is on with a target voltage of 5.1V (V_{BYP.OTG}) and the V_{BYPSET} is ignored. 	

Table 16. Charger Configuration 00 (0xB7) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_00		Charger configuration 00	0xB7	0	0x05
BIT	MODE	NAME	RESET	DESCRIPTION	
4	R/W	WDTEN	0	Watchdog Timer Enable Bit. While enabled, the system controller must reset the watchdog timer within the timer period (t_{WD}) for the charger to operate normally. Reset the watchdog timer by programming WDTCLR = 0x01. 0 = Watchdog timer disabled. 1 = Watchdog timer enabled.	
5	R/W	SPREAD	0	Spread Spectrum Feature 0 = Disabled 1 = Enabled Note: Feature is operational both for 9V and 12V CHGIN input voltage. Feature is not guaranteed to be operational for 5V CHGIN input voltage. When feature is not operational, it can be kept enabled without side effects.	
6	R/W	DISIBS	0	MBATT to SYS FET Disable Control 0 = MBATT to SYS FET is controlled by the power path state machine. 1 = MBATT to SYS FET is forced off.	
7	R/W	DIS_USBC_CTRL	0	Disable USB Type-C Control Over Charger 0 = Enabled 1 = Disabled	

Table 17. Charger Configuration 01 (0xB8)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_01		Charger configuration 01	0xB8	0 R/W (protected with CHGPROT)	0xD8
BIT	MODE	NAME	RESET	DESCRIPTION	
2:0	R/W	FCHGTIME	000	Fast-Charge Timer Duration (t_{FC}) 0x00 = Disable; 0x01 = 4 hrs; 0x02 = 6 hrs; 0x03 = 8 hrs; 0x04 = 10 hrs; 0x05 = 12 hrs; 0x06 = 14 hrs; 0x07 = 16 hrs	
3	R/W	FSW	1	Switching Frequency Option 0 : 4MHz; 1 : 2MHz	
5:4	R/W	CHG_RSTRT	01	Charger Restart Threshold 0x00 = 100mV below the value programmed by CHG_CV_PRM. 0x01 = 150mV below the value programmed by CHG_CV_PRM. 0x02 = 200mV below the value programmed by CHG_CV_PRM. 0x03 = Disabled	
6	R/W	LSEL	1	Inductor Selection 0 : 0.47 μ H (for 4MHz option only) 1 : 1 μ H (for 2MHz and 4MHz options)	
7	R/W	PQEN	1	Low-Battery Prequalification Mode Enable 0 = Low-battery prequalification mode is disabled. 1 = Low-battery prequalification mode is enabled.	

Table 18. Charger Configuration 02 (0xB9)

NAME		FUNCTION	ADDR	TYPE	RESET																																																																																																																																								
CHG_CNFG_02		Charger configuration 02	0xB9	0 R/W (protected with CHGPROT)	0x09																																																																																																																																								
BIT	MODE	NAME	RESET	DESCRIPTION																																																																																																																																									
5:0	R/W	CHG_CC	001001 (450mA)	<p>Fast Charge Current Selection. When the charger is enabled, the charge current limit is set by these bits. These bits range from 0.10A (0x00) to 3.0A (0x3C) in 50mA step.</p> <p>Note: The first three codes are all 100mA.</p> <table border="1"> <thead> <tr> <th>Bits</th> <th>(mA)</th> <th>Bits</th> <th>(mA)</th> <th>Bits</th> <th>(mA)</th> <th>Bits</th> <th>(mA)</th> </tr> </thead> <tbody> <tr><td>0x00</td><td>100</td><td>0x10</td><td>800</td><td>0x20</td><td>1600</td><td>0x30</td><td>2400</td></tr> <tr><td>0x01</td><td>100</td><td>0x11</td><td>850</td><td>0x21</td><td>1650</td><td>0x31</td><td>2450</td></tr> <tr><td>0x02</td><td>100</td><td>0x12</td><td>900</td><td>0x22</td><td>1700</td><td>0x32</td><td>2500</td></tr> <tr><td>0x03</td><td>150</td><td>0x13</td><td>950</td><td>0x23</td><td>1750</td><td>0x33</td><td>2550</td></tr> <tr><td>0x04</td><td>200</td><td>0x14</td><td>1000</td><td>0x24</td><td>1800</td><td>0x34</td><td>2600</td></tr> <tr><td>0x05</td><td>250</td><td>0x15</td><td>1050</td><td>0x25</td><td>1850</td><td>0x35</td><td>2650</td></tr> <tr><td>0x06</td><td>300</td><td>0x16</td><td>1100</td><td>0x26</td><td>1900</td><td>0x36</td><td>2700</td></tr> <tr><td>0x07</td><td>350</td><td>0x17</td><td>1150</td><td>0x27</td><td>1950</td><td>0x37</td><td>2750</td></tr> <tr><td>0x08</td><td>400</td><td>0x18</td><td>1200</td><td>0x28</td><td>2000</td><td>0x38</td><td>2800</td></tr> <tr><td>0x09</td><td>450</td><td>0x19</td><td>1250</td><td>0x29</td><td>2050</td><td>0x39</td><td>2850</td></tr> <tr><td>0x0A</td><td>500</td><td>0x1A</td><td>1300</td><td>0x2A</td><td>2100</td><td>0x3A</td><td>2900</td></tr> <tr><td>0x0B</td><td>550</td><td>0x1B</td><td>1350</td><td>0x2B</td><td>2150</td><td>0x3B</td><td>2950</td></tr> <tr><td>0x0C</td><td>600</td><td>0x1C</td><td>1400</td><td>0x2C</td><td>2200</td><td>0x3C</td><td>3000</td></tr> <tr><td>0x0D</td><td>650</td><td>0x1D</td><td>1450</td><td>0x2D</td><td>2250</td><td>0x3D</td><td>3050</td></tr> <tr><td>0x0E</td><td>700</td><td>0x1E</td><td>1500</td><td>0x2E</td><td>2300</td><td>0x3E</td><td>3100</td></tr> <tr><td>0x0F</td><td>750</td><td>0x1F</td><td>1550</td><td>0x2F</td><td>2350</td><td>0x3F</td><td>3150</td></tr> </tbody> </table> <p>Note: The thermal foldback loop can reduce the battery charger's target current by ATJREG.</p>		Bits	(mA)	Bits	(mA)	Bits	(mA)	Bits	(mA)	0x00	100	0x10	800	0x20	1600	0x30	2400	0x01	100	0x11	850	0x21	1650	0x31	2450	0x02	100	0x12	900	0x22	1700	0x32	2500	0x03	150	0x13	950	0x23	1750	0x33	2550	0x04	200	0x14	1000	0x24	1800	0x34	2600	0x05	250	0x15	1050	0x25	1850	0x35	2650	0x06	300	0x16	1100	0x26	1900	0x36	2700	0x07	350	0x17	1150	0x27	1950	0x37	2750	0x08	400	0x18	1200	0x28	2000	0x38	2800	0x09	450	0x19	1250	0x29	2050	0x39	2850	0x0A	500	0x1A	1300	0x2A	2100	0x3A	2900	0x0B	550	0x1B	1350	0x2B	2150	0x3B	2950	0x0C	600	0x1C	1400	0x2C	2200	0x3C	3000	0x0D	650	0x1D	1450	0x2D	2250	0x3D	3050	0x0E	700	0x1E	1500	0x2E	2300	0x3E	3100	0x0F	750	0x1F	1550	0x2F	2350	0x3F	3150
Bits	(mA)	Bits	(mA)	Bits	(mA)	Bits	(mA)																																																																																																																																						
0x00	100	0x10	800	0x20	1600	0x30	2400																																																																																																																																						
0x01	100	0x11	850	0x21	1650	0x31	2450																																																																																																																																						
0x02	100	0x12	900	0x22	1700	0x32	2500																																																																																																																																						
0x03	150	0x13	950	0x23	1750	0x33	2550																																																																																																																																						
0x04	200	0x14	1000	0x24	1800	0x34	2600																																																																																																																																						
0x05	250	0x15	1050	0x25	1850	0x35	2650																																																																																																																																						
0x06	300	0x16	1100	0x26	1900	0x36	2700																																																																																																																																						
0x07	350	0x17	1150	0x27	1950	0x37	2750																																																																																																																																						
0x08	400	0x18	1200	0x28	2000	0x38	2800																																																																																																																																						
0x09	450	0x19	1250	0x29	2050	0x39	2850																																																																																																																																						
0x0A	500	0x1A	1300	0x2A	2100	0x3A	2900																																																																																																																																						
0x0B	550	0x1B	1350	0x2B	2150	0x3B	2950																																																																																																																																						
0x0C	600	0x1C	1400	0x2C	2200	0x3C	3000																																																																																																																																						
0x0D	650	0x1D	1450	0x2D	2250	0x3D	3050																																																																																																																																						
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0x0F	750	0x1F	1550	0x2F	2350	0x3F	3150																																																																																																																																						
7:6	R/W	OTG_ILIM	00	<p>CHGIN Output Current Limit in OTG Mode ($I_{CHGIN.OTG.LIM}$). When MODE = 0x09 or 0x0A, the CHGIN current limit is set as follows: 00 = 500mA (default); 01 = 900mA; 10 = 1200mA; 11 = 1500mA</p>																																																																																																																																									

Table 19. Charger Configuration 03 (0xBA)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_03		Charger configuration 03	0xBA	0 R/W (protected with CHGPROT)	0xDA
BIT	MODE	NAME	RESET	DESCRIPTION	
2:0	R/W	TO_ITH	010 (150mA)	<p>Topoff Current Threshold The charger transitions from its fast-charge constant voltage mode to its topoff mode when the charger current decays to the value programmed by this register. This transition generates a CHG_I interrupt and causes the CHG_DTLS register to report topoff mode. This transition also starts the topoff time as programmed by TO_TIME. 0x00 = 100mA; 0x01 = 125mA; 0x02 = 150mA (default); 0x03 = 175mA; 0x04 = 200mA; 0x05 = 250mA; 0x06 = 300mA; 0x07 = 350mA</p>	

Table 19. Charger Configuration 03 (0xBA) (continued)

5:3	R/W	TO_TIME	011 (30min)	Topoff Timer Setting 0x00 = 0 min; 0x01 = 10 min; 0x02 = 20 min; 0x03 = 30 min 0x04 = 40 min; 0x05 = 50 min; 0x06 = 60 min; 0x07 = 70 min
7:6	R/W	ILIM	11	Program Buck Peak Current Limit 00 : Support I _{CHG} = 3.00A; 01 : Support I _{CHG} = 2.75A 10 : Support I _{CHG} = 2.50A; 11 : Support I _{CHG} = 2.25A

Table 20. Charger Configuration 04 (0xBB)

NAME		FUNCTION	ADDR	TYPE	RESET				
CHG_CNFG_04		Charger configuration 04	0xBB	0 R/W (protected with CHGPROT)	0x80				
BIT	MODE	NAME	RESET	DESCRIPTION					
5:0	R/W	CHG_CV_PRM	000000 (4.2V)	Primary Charge Termination Voltage Setting When the charger is enabled and the main battery temperature is < T3 if JEITA = "1" or < T4 if JEITA = "0", then the charger's battery regulation voltage (V _{BATREG}) is set by CHG_CV_PRM.					
				Bits	V	Bits	V	Bits	V
				0x00	4.200	0x09	4.313	0x12	4.425
				0x01	4.213	0x0A	4.325	0x13	4.438
				0x02	4.225	0x0B	4.338	0x14	4.450
				0x03	4.238	0x0C	4.350	0x15	4.463
				0x04	4.250	0x0D	4.363	0x16	4.475
				0x05	4.263	0x0E	4.375	0x17	4.488
				0x06	4.275	0x0F	4.388	0x18	4.500
				0x07	4.288	0x10	4.400		
0x08	4.300	0x11	4.413						
7:6	R/W	MINVSYS	10 (3.6V)	Minimum System Regulation Voltage (V _{SYSTEMIN}) 0x00 = 3.4V; 0x01 = 3.5V; 0x02 = 3.6V; 0x03 = 3.7V					

Table 21. Charger Configuration 05 (0xBC)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_05		Charger configuration 05	0xBC	0 R/W (protected with CHGPROT)	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
1:0	R/W	CHGIN_OVP	00 (13.7V)	OVP Threshold Selection 00 = 13.7V (default); 01 = 10.2V; 10 = 8.0V; 11 = 5.85V	
3:2	R/W	I_PREQUAL	00 (50mA)	Prequal Current Selection 00 = 50mA (default); 01 = 100mA; 10 = 200mA; 11 = 400mA	
4	R/W	CHGIN_PD_FST	0 (44kΩ)	Enable Stronger Discharge Path in CHGIN 0 : 44kΩ; 1 : 8kΩ	
5	R/W	EN_THM_PRECHG	0	Enable long debounce time to allow THM pins precharge time. This is useful when the user connects the capacitor to THMB/THMV. 0 : Disable, thermistor debounce = 448μs 1 : Enable, thermistor debounce = 12ms	
7:6	R/W	RSVD	00	Reserved	

Table 22. Charger Configuration 06 (0xBD)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_06		Charger configuration 06	0xBD	0	0x80
BIT	MODE	NAME	RESET	DESCRIPTION	
1:0	R/W	WDTCLR	00	Watchdog Timer Clear Bits. Writing "01" to these bits clears the watchdog timer when the watchdog timer is enabled. 0x00 = The watchdog timer is not cleared. 0x01 = The watchdog timer is cleared. 0x02 = The watchdog timer is not cleared. 0x03 = The watchdog timer is not cleared.	
3:2	R/W	CHGPROT	00	Charger Settings Protection Bits. Writing "11" to these bits unlocks the write capability for the registers who are "Protected with CHGPROT." Writing any value besides "11" locks these registers. 0x00 = Write capability is locked. 0x01 = Write capability is locked. 0x02 = Write capability is locked. 0x03 = Write capability is unlocked.	
4	R/W	MAXOTG_EN	0	MAXOTG Feature Enable Bit 0 = MaxOTG feature is disabled (default). 1 = MaxOTG feaure is enabled.	
5	R/W	OTG_DC	0	OTG Fault Duty Cycle Selection Bit 0 = 10% ON duty cycle when OTG hits current limit (default). 1 = 1% ON duty cycle when OTG hits current limit.	
6	R/W	EN_THM	0	Enable Thermistor Control in Charger 0 = No thermistor control in charger (default). 1 = Have thermistor control in charger. Charging is stopped when battery temp > 60deg or < 0deg.	
7	R/W	LEDEN	1	Charging Status Indicator LED Enable 0 = Charging status indicator LED is disabled. 1 = Charging status indicator LED is enabled.	

Table 23. Charger Configuration 07 (0xBE)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_07		Charger configuration 07	0xBE	0 R/W (protected with CHGPROT)	0x30
BIT	MODE	NAME	RESET	DESCRIPTION	
1:0	R/W	BOVE	00	Early Battery Overvoltage Setting to Disable Slave Chargers 00 : Disable BOVE feature 01 : BOVE = BATV regulation 10 : BOVE = 1.3% above BATV regulation 11 : BOVE = 2.6% above BATV regulation	
2	R/W	DIS_QBATOFF	0	Disable QBATOFF in case of battery overcurrent hit limit. 0 = Charger controls Q _{BAT} switch; Q _{BAT} is turned off in case battery overcurrent occurs for 6ms. 1 = Q _{BAT} is not turned off when battery overcurrent occurs	
6:3	R/W	REGTEMP	0110	Junction Temperature Thermal Regulation Loop Set Point. The charger's target current limit starts to foldback and the TREG bit is set if the junction temperature is greater than the REGTEMP setpoint. 0x00 = 85°C; 0x01 = 90°C; 0x02 = 95°C; 0x03 = 100°C; 0x04 = 105°C; 0x05 = 110°C; 0x06 = 115°C (default); 0x07 = 120°C; 0x08 = 125°C; 0x09 = 130°C	

Table 23. Charger Configuration 07 (0xBE) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_07		Charger configuration 07	0xBE	0 R/W (protected with CHGPROT)	0x30
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	WD_QBATOFF	0	0 : When watchdog timer expires, turn off only the charger. 1 : When watchdog timer expires, turn off buck, charger, and Q _{BAT} switch.	

Table 24. Charger Configuration 09 (0xC0)

NAME		FUNCTION	ADDR	TYPE	RESET						
CHG_CNFG_09		Charger configuration 09	0xC0	0	0x0F						
BIT	MODE	NAME	RESET	DESCRIPTION							
6:0	R/W	CHGIN_ILIM	0x0F (0.50A)	Maximum Input Current Limit Selection. 7-bit adjustment from 100mA to 4.0A in 33mA steps. Note: The first four codes are all 100mA.							
				Bits	Unit (mA)	Bits	Unit (mA)	Bits	Unit (mA)	Bits	Unit (mA)
				0x00	100	0x20	1067	0x40	2133	0x60	3200
				0x01	100	0x21	1100	0x41	2167	0x61	3233
				0x02	100	0x22	1133	0x42	2200	0x62	3267
				0x03	100	0x23	1167	0x43	2233	0x63	3300
				0x04	133	0x24	1200	0x44	2267	0x64	3333
				0x05	167	0x25	1233	0x45	2300	0x65	3367
				0x06	200	0x26	1267	0x46	2333	0x66	3400
				0x07	233	0x27	1300	0x47	2367	0x67	3433
				0x08	267	0x28	1333	0x48	2400	0x68	3467
				0x09	300	0x29	1367	0x49	2433	0x69	3500
				0x0A	333	0x2A	1400	0x4A	2467	0x6A	3533
				0x0B	367	0x2B	1433	0x4B	2500	0x6B	3567
				0x0C	400	0x2C	1467	0x4C	2533	0x6C	3600
				0x0D	433	0x2D	1500	0x4D	2567	0x6D	3633
				0x0E	467	0x2E	1533	0x4E	2600	0x6E	3667
				0x0F	500	0x2F	1567	0x4F	2633	0x6F	3700
				0x10	533	0x30	1600	0x50	2667	0x70	3733
				0x11	567	0x31	1633	0x51	2700	0x71	3767
0x12	600	0x32	1667	0x52	2733	0x72	3800				
0x13	633	0x33	1700	0x53	2767	0x73	3833				
0x14	667	0x34	1733	0x54	2800	0x74	3867				
0x15	700	0x35	1767	0x55	2833	0x75	3900				
0x16	733	0x36	1800	0x56	2867	0x76	3933				
0x17	767	0x37	1833	0x57	2900	0x77	3967				
0x18	800	0x38	1867	0x58	2933	0x78	4000				
0x19	833	0x39	1900	0x59	2967	0x79	4000				
0x1A	867	0x3A	1933	0x5A	3000	0x7A	4000				
0x1B	900	0x3B	1967	0x5B	3033	0x7B	4000				
0x1C	933	0x3C	2000	0x5C	3067	0x7C	4000				
0x1D	967	0x3D	2033	0x5D	3100	0x7D	4000				
0x1E	1000	0x3E	2067	0x5E	3133	0x7E	4000				
0x1F	1033	0x3F	2100	0x5F	3167	0x7F	4000				
7	R/W	OVPDRV_CTL	0	OVPDRV FET Override Software Control Bit 0 : OVPDRV FET is controlled by charger internal logic. 1 : OVPDRV is forced ON regardless of charger internal logic.							

Table 25. Charger Configuration 10 (0xC1)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_10		Charger configuration 10	0xC1	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
0	R/W	DISSKIP	0	Disable Skip Mode During Buck/Charging Mode 0 = Auto buck skip mode; 1 = Disable buck skip mode.	
1	R/W	TODEB_EN	0	Enable MAX77860 Topoff Long Debouncer 0 = MAX77860 topoff deboucer is 56ms; Slave registers are not reset when master enters topoff state. 1 = MAX77860 topoff deboucer is set by register "TODEB[1:0]"; Slave registers are reset when master CHG_CC < topoff threshold for 56ms.	
3:2	R/W	TODEB[1:0]	00	Topoff long debounce timer: 00 = 112ms; 01 = 224ms; 10 = 448ms; 10 = 896ms	
7:4	R/W	RSVD	0000	Reserved	

Table 26. Charger Configuration 11 (0xC2)

NAME		FUNCTION	ADDR	TYPE	RESET						
CHG_CNFG_11		Charger configuration 11	0xC2	0	0x00						
BIT	MODE	NAME	RESET	DESCRIPTION							
6:0	R/W	VBYPSET	0x00 (3V)	Bypass Target Output Voltage in Boost Mode. 3V (0x00) to 5.75V (0x6E) in 0.025V steps. This setting is valid for the “boost only” mode (MODE = 0x08).							
				Bits	Unit (V)	Bits	Unit (V)	Bits	Unit (V)	Bits	Unit (V)
				0x00	3.000	0x20	3.800	0x40	4.600	0x60	5.400
				0x01	3.025	0x21	3.825	0x41	4.625	0x61	5.425
				0x02	3.050	0x22	3.850	0x42	4.650	0x62	5.450
				0x03	3.075	0x23	3.875	0x43	4.675	0x63	5.475
				0x04	3.100	0x24	3.900	0x44	4.700	0x64	5.500
				0x05	3.125	0x25	3.925	0x45	4.725	0x65	5.525
				0x06	3.150	0x26	3.950	0x46	4.750	0x66	5.550
				0x07	3.175	0x27	3.975	0x47	4.775	0x67	5.575
				0x08	3.200	0x28	4.000	0x48	4.800	0x68	5.600
				0x09	3.225	0x29	4.025	0x49	4.825	0x69	5.625
				0x0A	3.250	0x2A	4.050	0x4A	4.850	0x6A	5.650
				0x0B	3.275	0x2B	4.075	0x4B	4.875	0x6B	5.675
				0x0C	3.300	0x2C	4.100	0x4C	4.900	0x6C	5.700
				0x0D	3.325	0x2D	4.125	0x4D	4.925	0x6D	5.725
				0x0E	3.350	0x2E	4.150	0x4E	4.950	0x6E	5.750
				0x0F	3.375	0x2F	4.175	0x4F	4.975		
				0x10	3.400	0x30	4.200	0x50	5.000		
				0x11	3.425	0x31	4.225	0x51	5.025		
0x12	3.450	0x32	4.250	0x52	5.050						
0x13	3.475	0x33	4.275	0x53	5.075						
0x14	3.500	0x34	4.300	0x54	5.100						
0x15	3.525	0x35	4.325	0x55	5.125						
0x16	3.550	0x36	4.350	0x56	5.150						
0x17	3.575	0x37	4.375	0x57	5.175						
0x18	3.600	0x38	4.400	0x58	5.200						
0x19	3.625	0x39	4.425	0x59	5.225						
0x1A	3.650	0x3A	4.450	0x5A	5.250						
0x1B	3.675	0x3B	4.475	0x5B	5.275						
0x1C	3.700	0x3C	4.500	0x5C	5.300						
0x1D	3.725	0x3D	4.525	0x5D	5.325						
0x1E	3.750	0x3E	4.550	0x5E	5.350						
0x1F	3.775	0x3F	4.575	0x5F	5.375						
7	R/W	RSVD	0	Reserved							

Table 27. Charger Configuration 12 (0xC3)

NAME		FUNCTION	ADDR	TYPE	RESET
CHG_CNFG_12		Charger configuration 12	0xC3	O	0x44
BIT	MODE	NAME	RESET	DESCRIPTION	
3:0	R/W	B2SOVRC	0100	BAT to SYS Overcurrent Threshold 0x00 = Disabled 0x08 = 6.5 0x01 = 3.0A 0x09 = 7.0A 0x02 = 3.5A 0x0A = 7.5A 0x03 = 4.0A 0x0B = 8.0A 0x04 = 4.5A (default) 0x0C = 8.5A 0x05 = 5.0A 0x0D = 9.0A 0x06 = 5.5A 0x0E = 9.0A 0x07 = 6.0A 0x0F = 9.0A	
5:4	R/W	VCHGIN_REG	00	CHGIN Voltage Regulation Threshold (V _{CHGIN_REG}) Adjustment The CHGIN to GND minimum turn-on threshold (V _{CHGIN_UVLO}) also scales with this adjustment. 0x00 = V _{CHGIN_REG} = 4.2V and V _{CHGIN_UVLO} = 4.5V 0x01 = V _{CHGIN_REG} = 4.6V and V _{CHGIN_UVLO} = 4.9V 0x02 = V _{CHGIN_REG} = 4.7V and V _{CHGIN_UVLO} = 5.0V 0x03 = V _{CHGIN_REG} = 4.8V and V _{CHGIN_UVLO} = 5.1V	
6	R/W	CHGINSEL	1	CHGIN/USB Input Channel Select 0 = Disabled 1 = Enabled	
7	R/W	CHG_LPM	0	Charger DC-DC Low-Power Mode 0 = Normal current capability. 1 = Set CHG_LPM to increase efficiency when the DC-DC current is less than 900mA.	

USB Type-C Register**Table 28. BC_INT (0x00)**

NAME		FUNCTION	ADDR	TYPE	RESET
BC_INT		Interrupt	0x00	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/C	VBUSDet	0	0 : No change; 1 : New V _{BUSDet} status	
6	R/C	DxOVPI	0	0 : No change; 1 : New DxOVP status	
5	R/C	DNVDATREFI	0	0 : No change; 1 : New DN_VDAT_REF status	
4	R/C	ChgTypRunFI	0	Charge Detection Running Falling (ChgTypRun) Edge Interrupt 0 : No change; 1 : New ChgTypRunF status	
3	R/C	ChgTypRunRI	0	Charge Detection Running Rising (ChgTypRun) Edge Interrupt 0 : No change; 1 : New ChgTypRunR status	
2	R/C	PrChgTypI	0	0 : No change; 1 : New PrChgTyp status	
1	R/C	DCDTmol	0	0 : No change; 1 : New DCDTmo status	
0	R/C	ChgTypI	0	0 : No change; 1 : New ChgTyp status	

Note: Always read CC_INT (0x01) before reading BC_INT (0x00).

Table 29. CC_INT (0x01)

NAME		FUNCTION	ADDR	TYPE	RESET
CC_INT		Interrupt	0x01	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/C	RSVD	0	Reserved	
6	R/C	VSAFE0V_I	0	0 : No change; 1 : New V _{SAFE0V0} status	
5	R/C	DetAbtrl	0	0 : No change; 1 : New DetAbtrl status	
4	R/C	RSVD	0	Reserved	
3	R/C	CCPinStatl	0	0 : No change; 1 : New CCPinStat status	
2	R/C	CCISatI	0	0 : No change; 1 : New CCISat status	
1	R/C	CCVcnStatl	0	0 : No change; 1 : New CCVcnStat status	
0	R/C	CCStatl	0	0 : No change; 1 : New CCStat status	

Table 30. BC_INTMASK (0x02)

NAME		FUNCTION	ADDR	TYPE	RESET
BC_INTMASK		Interrupt Mask	0x02	S	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	VBUSDetM	1	0 : Mask; 1 : Unmask	
6	R/W	DxOVPM	1	0 : Mask; 1 : Unmask	
5	R/W	DNVDATREFM	1	0 : Mask; 1 : Unmask	
4	R/W	ChgTypRunFM	1	0 : Mask; 1 : Unmask	
3	R/W	ChgTypRunRM	1	0 : Mask; 1 : Unmask	
2	R/W	PrChgTypM	1	0 : Mask; 1 : Unmask	
1	R/W	DCDTmoM	1	0 : Mask; 1 : Unmask	
0	R/W	ChgTypM	1	0 : Mask; 1 : Unmask	

Table 31. CC_INTMASK (0x03)

NAME		FUNCTION	ADDR	TYPE	RESET
CC_INTMASK		Interrupt Mask	0x03	S	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	RSVD	1	Reserved	
5	R/W	VSAFE0V_M	1	0 : Mask; 1 : Unmask	
5	R/W	DetAbtrM	1	0 : Mask; 1 : Unmask	
4	R/W	RSVD	1	Reserved	
3	R/W	CCPinStatM	1	0 : Mask; 1 : Unmask	
2	R/W	CCISatM	1	0 : Mask; 1 : Unmask	
1	R/W	CCVcnStatM	1	0 : Mask; 1 : Unmask	
0	R/W	CCStatM	1	0 : Mask; 1 : Unmask	

Table 32. BC_STATUS1 (0x04)

NAME		FUNCTION	ADDR	TYPE	RESET
BC_STATUS1		Status	0x04	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R	VBUSDet	0	Status of V _{BUS} Detection 0 : V _{BUS} < V _{VBDET} ; 1 : V _{BUS} > V _{VBDET}	
6	R	ChgTypRun	0	Charger Detection Running Status 0 : Not running; 1 : Running	
5:3	R	PrChgTyp	0	Output of Proprietary Charger Detection 000 : Unknown; 001 : Samsung 2A; 010 : Apple 0.5A; 011 : Apple 1A; 100 : Apple 2A; 101 : Apple 12W; 110 : 3A DCP (if enabled); 111 : RFU	
2	R	DCDTmo	0	During charger detection, DCD detection timed out. Indicates D+/D- are open. BC1.2 detection continues as required by BC 1.2 specification but SDP most likely is found. 0 : No timeout or detection has not run. 1 : DCD timeout occurred	
1:0	R	ChgTyp	0	Output of Charger Detection 00 : Nothing attached 01 : SDP, USB cable attached. 10 : CDP, Charging downstream port. Current depends on USB operating speed. 11 : DCP, Dedicated charger. Current up to 1.5A.	

Table 33. BC_STATUS2 (0x05)

NAME		FUNCTION	ADDR	TYPE	RESET
BC_STATUS2		Status	0x05	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:2	R	RSVD	0	Reserved	
1	R	DxOVP		0 : Dn and DP < DxOVP; 1 : Dn or DP > DxOVP	
0	R	DNVDATREF	0	0 : Dn < V _{DAT_REF} debounce for t _{CDDdeb} 1 : Dn > V _{DAT_REF} debounce for t _{CDDdeb}	

Table 34. CC_STATUS1 (0x06)

NAME		FUNCTION	ADDR	TYPE	RESET
CC_STATUS1		Status	0x06	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:6	R	CCPinStat	0	Output of Active CC Pin 00 : No determination; 01 : CC1 Active 10 : CC2 Active; 11 : RFU	
5:4	R	CCISat	0	CC Pin Detected Allowed V _{BUS} Current in UFP Mode 00 : Not in UFP mode; 01 : 500mA 10 : 1.5A; 11 : 3.0A	
3	R	CCVcnStat	0	Status of V _{CONN} Output 0 : V _{CONN} disabled; 1 : V _{CONN} enabled	
2:0	R	CCStat	0	CC Pin State Machine Detection 000 : No connection; 001 : UFP 010 : DFP; 011 : Audio accessory 100 : Debug accessory; 101 : Error 110 : Disabled; 111 : RFU	

Table 35. CC_STATUS2 (0x07)

NAME		FUNCTION	ADDR	TYPE	RESET
CC_STATUS2		Status	0x07	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:4	R	RSVD	0	Reserved	
2	R	VSAFE0V_S	1	0 : $V_{BUS} < V_{SAFE0V}$ 1 : $V_{BUS} > V_{SAFE0V}$	
2	R	DetAbrt	1	0 : Charger detection runs if ChgDetEn = 1 and V_{BUS} is valid for the debounce time. 1 : Charger detection is aborted by Type-C state machine. Charger does not run if ChgDetEn = 1 and V_{BUS} is valid for the debounce time. ChgDetMan allows manual run of charger detection. If charger detection is in progress, DetAbrt = 1 immediately stops the in progress detection.	
1:0	R	RSVD	0	Reserved	

Table 36. BC_CTRL1 (0x08)

NAME		FUNCTION	ADDR	TYPE	RESET
BC_CTRL1		Control	0x08	S	0x05
BIT	MODE	NAME	RESET	DESCRIPTION	
7:6	R/W	RSVD	0	Reserved	
5	R/W	NoAutoIBUS	0	Disabling of automatic input current limit from adapter detection. '0' = Automatic determined using adapter detection. '1' = Current limit setting controlled manually through I ² C.	
4	R/W	3ADCPDet	0	Enable detection of 3A DCP (adds detection step after BC 1.2 completes to detect presence of 3A DCP – D+/D- short with 2 series diode clamp). 0 : Not enabled; 1 : Enabled	
3:2	R/W	SfOutCtrl	1	Control Over Safeout LDO 00 : Always disabled 01 : On if a valid CHGIN voltage is present. 10 : Turns on in the following conditions: <ul style="list-style-type: none"> ChgDetEn = 1 and CHGIN is valid and ChgDetRun indicates no detection running. ChgDetEn = 0 and CHGIN is valid. 11 : RFU	
1	R/W	ChgDetMan	0	Force manual run of charger detection. Bit auto resets to 0. 0 : Not enabled; 1 : Request manual run of charger detection.	
0	R/W	ChgDetEn	1	Enable Charger Detection 0 : Not enabled; 1 : Enabled (Charger detection runs every time $V_{BUS} > V_{VBDET}$.)	

Table 37. BC_CTRL2 (0x09)

NAME		FUNCTION	ADDR	TYPE	RESET
BC_CTRL2		Control	0x09	Cleared on V_{BUS} Removal	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:6	R/W	RSVD	0	Reserved	
5	R/W	DN_MON_EN	0	0 = Disabled. DNVDATREF is set to 0. 1 = Enabled	

Table 37. BC_CTRL2 (0x09) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
BC_CTRL2		Control	0x09	Cleared on V _{BUS} Removal	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
4	R/W	DPDNMan	0	0 = Resources on DP and DN are controlled by charger detection (ChgDetEn bit). 1 = Drive voltages on DP and DN according to DPDrv and DNDrv values.	
3:2	R/W	DPDrv	0	Force Voltage on DP 00 = Ground (15k resistor to GND); 01 = 0.6V 10 = 3.3V; 11 = Open	
1:0	R/W	DNDrv	0	Force Voltage on DP 00 = Ground (15k resistor to GND); 01 = 0.6V 10 = 3.3V; 11 = Open	

Table 38. CC_CTRL1 (0x0A)

NAME		FUNCTION	ADDR	TYPE	RESET
CC_CTRL1		Control	0x0A	S	0x19
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	CCSrcCurCh	0	Request new pullup value to advertise a new allowed max current value while in source downstream facing port (DFP) mode. Note: This bit resets to 0 automatically so a read always returns 0. 0 : No change request. 1 : Request value in CCSrcCur to be read.	
6:5	R/W	CCSrcCur	0	New request value for source mode pullup. Note: This value is latched in when the CCSrcCurCh bit is written to 1. Changes to the pullup value only take place if the operation state is DFP (CCStat = 010b). The pullup value is automatically returned to 0.5A when DFP mode is exited so this value may not represent the actual pullup in use. 00 : Request change to 0.5A. 01 : Request change to 1.5A. 10 : Request change to 3.0A. 11 : Reserved	
4	R/W	CCSrcSnk	1	Allow State Machine to Enter Sink Mode (UFP) Detection Note: USB PD role swap is allowed to enter sink mode. See the <i>Charger State Diagram</i> for details. 0 : Disable; 1 : Enabled	
3	R/W	CCSnkSrc	1	Allow State Machine to Enter Source Mode (DFP) Detection Note: USB PD role swap is allowed to enter source mode. See the <i>Charger State Diagram</i> for details. 0 : Disable; 1 : Enabled	
2	R/W	CCDbgEn	0	Enable Detection of Type-C Debug Adapter 0 : Disabled; 1 : Enabled	
1	R/W	CCAudEn	0	Enable Detection of Type-C Audio Adapter 0 : Disabled; 1 : Enabled	
0	R/W	CCDetEn	1	Enable CC Pin Detection. Force state machine to disabled state. 0 : Disabled; 1 : Enabled	

Table 39. CC_CTRL2 (0x0B)

NAME		FUNCTION	ADDR	TYPE	RESET
CC_CTRL2		Control	0x0B	S	0x04
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	CCForceError	0	Bit Resets to 0 After a Write (Read is always 0) 0 : No action; 1 : Force transition to ErrorRecovery state.	
6	R/W	SnkAttachedLock	0	Bit Resets to 0 After a Minimum of 1.1s 0 : Exit sink attached when $V_{BUS} < V_{BDET}$ for more than $t_{PDDebounce}$. 1 : Locked in sink attached for a minimum of 1.1s if V_{BUS} is missing.	
5	R/W	CCSnkSrcSwp	0	USB PD Power Role Swap from Sink to Source. This bit must be written to 0 once the USB PD controller completes the power role swap sequence. 0 : No swap requested; 1 : Swap requested	
4	R/W	CCSrcSnkSwp	0	USB PD Power Role Swap from Source to Sink. This bit must be written to 0 once the USB PD controller completes the power role swap sequence. 0 : No swap requested; 1 : Swap requested	
3	R/W	CCVcnSwp	0	Signal State Machine to Swap V_{CONN} roles. Bit resets to 0 after a write (read is always 0) 0 : No change in V_{CONN} role; 1 : Force change in V_{CONN}	
2	R/W	CCVcnEn	1	Force State of V_{CONN} 0 : Force V_{CONN} off (both external boost converter and V_{CONN} switch). 1 : Automatic operation based on state machine.	
1	R/W	CCSrcRst	0	Force a reset of the state machine. Immediate transition to unattached.SRC state. Bit resets to 0 after a write (read is always 0). 0 : No reset; 1 : Request reset	
0	R/W	CCSnkRst	0	Force a reset of the State Machine. Immediate transition to unattached.SNK state. Bit resets to 0 after a write (read is always 0). 0 : No reset; 1 : Request reset	

Table 40. CC_CTRL3 (0x0C)

NAME		FUNCTION	ADDR	TYPE	RESET
CC_CTRL3		Control	0x0C	S	0x03
BIT	MODE	NAME	RESET	DESCRIPTION	
7:4	R/W	RSVD	0	Reserved	
3	R/W	CCPreferSink	0	0 : Disabled 1 : Enabled	
2	R/W	CCTrySnk	0	0 : Disabled 1 : Enabled	
1:0	R/W	CCDRPPhase	3	Percent of time device is acting as unattached.SRC when $CCSNKSRCSRC = 1$ and $CCSRCSNK = 1$. 00 : 35%; 01 : 40%; 10 : 45%; 11 : 50%	

Table 41. CHGIN_ILIM1 (0x0D)

NAME		FUNCTION	ADDR	TYPE	RESET
CHGIN_ILIM1		Status	0x0D	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	

Table 41. CHGIN_ILIM1 (0x0D) (continued)

7	R	RSVD	0	Reserved
6:0	R	CHGIN_ILIM	0	Status of charger input current limit set by charger detection HW. 7 bit adjustment from 100mA to 4.0A. Setting 0x01 to 0x03 = 100mA Setting 0x04 to 0x78 = increment 33mA steps Setting 0x78 to 0x7F = 4.0A

Table 42. CHGIN_ILIM2 (0x0E)

NAME		FUNCTION	ADDR	TYPE	RESET
CHGIN_ILIM2		Status	0x0E	S	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:4	R/W	RSVD	0	Reserved	
3	R/W	CHGIN_ILIM_GATE	0	0 : No modification of CHGIN_LIM. 1 : Limit CDP to 1.5A. ChgTyp ≥ 10 (CDP) and PrChgTyp ≥ 000 (unknown) set CHGIN_LIM to 0x2D.	
2:1	R/W	SDP_MAX_CUR	0	0x0 : No modification of CHGIN_LIM. 0x1 : Limit SDP to 500mA. ChgTyp ≥ 01 (SDP) and PrChgTyp ≥ 000 (unknown) set CHGIN_LIM to 0x0F. 0x2 : Limit SDP to 1.0A. ChgTyp ≥ 01 (SDP) and PrChgTyp ≥ 000 (unknown) set CHGIN_LIM to 0x1E. 0x3 : Limit SDP to 1.5A. ChgTyp ≥ 01 (SDP) and PrChgTyp ≥ 000 (unknown) set CHGIN_LIM to 0x2D.	
0	R/W	CDP_MAX_CUR	0	0 : No gating of CHGIN_LIM setting by BC 1.2 FSM. 1 : Gate changes in CHGIN_LIM until BC 1.2 FSM completes. ChgTypRun ≥ 0	

Master Slave**Table 43. S-Wire Interrupt (0x80)**

NAME		FUNCTION	ADDR	TYPE	RESET
SWI_INT		S-Wire interrupt	0x80	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:5	R/C	RSVD	000	Reserved	
4	R/C	SLAVE2_FAULT_I	0	SLAVE2 Fault Interrupt 0 = SLAVE Charger 2 does not have fault since the last time this bit was read. 1 = SLAVE Charger 2 has fault since the last time this bit was read.	
3	R/C	SLAVE1_FAULT_I	0	SLAVE1 Fault Interrupt 0 = SLAVE Charger 1 does not have fault since the last time this bit was read. 1 = SLAVE Charger 1 has fault since the last time this bit was read.	
2	R/C	CV_I	0	CC to CV Interrupt 0 = No CV transition since the last time this bit was read. 1 = Charger transition from CC to CV since the last time this bit was read. Note: This interrupt is only enabled when FGCC = 0 (fuel gauge 0x50<3>).	
1	R/C	SLAVE2_TREG_I	0	SLAVE Charger 2 Thermal Regulation Interrupt 0 = SLAVE2_S has not changed since the last time this bit was read. 1 = SLAVE2_S has changed since the last time this bit was read.	

Table 43. S-Wire Interrupt (0x80) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
SWI_INT		S-Wire interrupt	0x80	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
0	R/C	SLAVE1_TREG_I	0	SLAVE Charger 1 Thermal Regulation Interrupt 0 = SLAVE1_S has not changed since the last time this bit was read. 1 = SLAVE1_S has changed since the last time this bit was read.	

Table 44. S-Wire Interrupt Mask (0x81)

NAME		FUNCTION	ADDR	TYPE	RESET
SWI_INT_MASK		S-Wire interrupt Mask	0x81	0	0xFF
BIT	MODE	NAME	RESET	DESCRIPTION	
7:5	R/W	RSVD	111	Reserved	
4	R/W	SLAVE2_FAULT_M	1	SLAVE2 Fault Interrupt Mask 0 = SLAVE Charger 2 fault interrupt is not masked. 1 = SLAVE Charger 2 fault interrupt is masked.	
3	R/W	SLAVE1_FAULT_M	1	SLAVE1 Fault Interrupt Mask 0 = SLAVE Charger 1 fault interrupt is not masked. 1 = SLAVE Charger 1 fault interrupt is masked.	
2	R/W	CV_M	1	CV Interrupt Mask 0 = CV interrupt is not masked. 1 = CV interrupt is masked.	
1	R/W	SLAVE2_TREG_M	1	SLAVE2 Thermal Regulation Interrupt Mask 0 = SLAVE Charger 2 thermal regulation interrupt is not masked. 1 = SLAVE Charger 2 thermal regulation interrupt is masked.	
0	R/W	SLAVE1_TREG_M	1	SLAVE2 Thermal Regulation Interrupt Mask 0 = SLAVE Charger 2 thermal regulation interrupt is not masked. 1 = SLAVE Charger 2 thermal regulation interrupt is masked.	

Table 45. Slave Charger 1 CC (0x82)

NAME		FUNCTION	ADDR	TYPE	RESET
SLAVE1_CC		SLAVE1_CC_Setting	0x82	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	Dis_Slave1_AutoUpdate	0	Disable Slave Charger 1 Min Selector Between Master CC Setting and Slave1 CC Setting 0 = Min selector is on; Final Slave1 CC command to Slave1 = min (Master CC, Slave1 CC) 1 = Min selector is off; Final Slave1 CC command to Slave1 = Slave1 CC	
6	R/W	RSVD	0	Reserved	

Table 45. Slave Charger 1 CC (0x82) (continued)

5:0	R/W	SLAVE1_CC[5:0]	000000	SLAVE Charger 1 Constant Current Setting 0x00h = OFF = 0 pulse 0x01h = OFF = 1 pulse 0x02h = OFF = 2 pulses 0x03h = 100mA = 3 pulses 0x04h = 150mA = 4 pulses 0x05h = 200mA = 5 pulses . . 0x3Bh = 2950mA = 59 pulses 0x3Ch = 3000mA = 60 pulses 0x3Dh = 3000mA = 61 pulses 0x3Eh = 3000mA = 62 pulses 0x3Fh = 3000mA = 63 pulses
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Table 46. Slave Charger 2 CC (0x83)

NAME		FUNCTION	ADDR	TYPE	RESET
SLAVE2_CC		SLAVE2_CC_Setting	0x83	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	Dis_Slave2_AutoUpdate	0	Disable Slave Charger 2 Min Selector Between Master CC Setting and Slave2 CC Setting 0 = Min selector is on; Final Slave2 CC command to Slave2 = min (Master CC, Slave2 CC) 1 = Min selector is off; Final Slave2 CC command to Slave2 = Slave2 CC	
6	R/W	RSVD	0	Reserved	
5:0	R/W	SLAVE2_CC[5:0]	000000	SLAVE Charger 2 Constant Current Setting 0x00h = OFF = 0 pulse 0x01h = OFF = 1 pulse 0x02h = OFF = 2 pulses 0x03h = 100mA = 3 pulses 0x04h = 150mA = 4 pulses 0x05h = 200mA = 5 pulses . . 0x3Bh = 2950mA = 59 pulses 0x3Ch = 3000mA = 60 pulses 0x3Dh = 3000mA = 61 pulses 0x3Eh = 3000mA = 62 pulses 0x3Fh = 3000mA = 63 pulses	

Table 47. S-Wire 1 Readback (0x84)

NAME		FUNCTION	ADDR	TYPE	RESET
SWI1_READBACK		SLAVE1 CC ReadBack	0x84	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R	RSVD	0	Reserved	
6	R	RSVD	0	Reserved	
5:0	R	SWI1_READBACK[5:0]	000000	SLAVE Charger 1 Actual Constant Current Setting. This is a read only register.	

Table 48. S-Wire 2 Readback (0x85)

NAME		FUNCTION	ADDR	TYPE	RESET
SWI2_READBACK		SLAVE2 CC ReadBack	0x84	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R	RSVD	0	Reserved	
6	R	RSVD	0	Reserved	
5:0	R	SWI2_READBACK[5:0]	000000	SLAVE Charger 2 Actual Constant Current Setting. This is a read only register.	

Table 49. S-Wire Status (0x86)

NAME		FUNCTION	ADDR	TYPE	RESET
SWI_STATUS		S-Wire Status	0x86	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:3	R	RSVD	00000	Reserved	
2	R	CV_S	0	MAX77860 Charger CV Status 0 = Charger is not in CV mode. 1 = Charger is in CV mode.	
1	R	SLAVE2_TREG_S	0	SLAVE2 Thermal Regulation Status 0 = SLAVE Charger 2 is not in thermal regulation. 1 = SLAVE Charger 2 is in thermal regulation.	
0	R	SLAVE1_TREG_S	0	SLAVE1 Thermal Regulation Status 0 = SLAVE Charger 1 is not in thermal regulation. 1 = SLAVE Charger 1 is in thermal regulation.	

ADC**Table 50. ADC_CONFIG1 (0x50)**

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_CONFIG1		ADC Configuration	0x50	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	V _{BUS} _HV_RANGE	0	V _{BUS} Monitoring Range (Channel 0) 0 : 2.7V–6.3V; LSB = 14mV; 1 : 6.3V–14.7V; LSB = 33mV	
6:5	R/W	ADC_Filter<1:0>	00	Averaging filter selection for all channels with filter enabled. 00: 2-Points averaging 01: 4-Points averaging 10: 8-Points averaging 11: 16-Points averaging	
4	R/W	CH4_OffsetCalEn	0	Enable offset calibration on channel 4 (R _{REXT}). 0 : Disable; 1 : Enable	
3	R/W	CH3_OffsetCalEn	0	Enable offset calibration on channel 3 (V _{BATT} current). 0 : Disable; 1 : Enable	
2	R/W	CH1_OffsetCalEn	0	Enable offset calibration on channel 1 (V _{BUS} current). 0 : Disable; 1 : Enable	
1	R/W	MEAS_ADC_CONT	0	ADC Mode 00 : Disable; 01 : Single mode; 10 : Continuous mode 11 : Continuous mode Note: MEAS_ADC_SINGLE is clear to 0 at the end of conversion.	

Table 51. ADC_CONFIG2 (0x51)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_CONFIG2		ADC Channel Enable	0X51	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	CH7_Enable	0	Channel 7 Enable (Test Channel) Range = 0.6V to 1.4V; LSB = 3.1mV 0 : Disable; 1 : Enable	
6	R/W	CH6_Enable	0	Channel 6 Enable (Reserved/VCM) Range = 0.6V to 1.4V; LSB = 3.1mV 0 : Disable; 1 : Enable	
5	R/W	CH5_Enable	0	Channel 5 Enable (Temperature in terms of THMV/THMB) Range = 20% to 80%; LSB = 0.24% 0 : Disable; 1 : Enable	
4	R/W	CH4_Enable	0	Channel 4 Enable (I _{REXT} Current) Range = (-10A) to (+10A); LSB = 78mA 0 : Disable; 1 : Enable	
3	R/W	CH3_Enable	0	Channel 3 Enable (V _{BATT} Current) Range = 0A to 3.1A; LSB = 12mA 0 : Disable; 1 : Enable	
2	R/W	CH2_Enable	0	Channel 2 Enable (V _{BATT} Voltage) Range = 2.1V to 4.9V; LSB = 11mV 0 : Disable; 1 : Enable	
1	R/W	CH1_Enable	0	Channel 1 Enable (V _{BUS} Current) Range = 0A to 4.1A; LSB = 16mA 0 : Disable; 1 : Enable	
0	R/W	CH0_Enable	0	Channel 0 Enable (V _{BUS} Voltage) V _{BUS_HV_RANGE} = 0 : Range = 2.7V to 6.3V; LSB = 14mV V _{BUS_HV_RANGE} = 1 : Range = 6.3V to 14.7V; LSB = 33mV 0 : Disable; 1 : Enable	

Table 52. ADC_CONFIG3 (0x52)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_CONFIG3		ADC Filter Enable	0X52	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7	R/W	CH7_FilterEn	0	Channel 7 Filter Enable; averaging filter point follows ADC_Filter<1:0> 0 : Disable; 1 : Enable	
6	R/W	CH6_FilterEn	0	Channel 6 Filter Enable; averaging filter point follows ADC_Filter<1:0> 0 : Disable; 1 : Enable	
5	R/W	CH5_FilterEn	0	Channel 5 Filter Enable; averaging filter point follows ADC_Filter<1:0> 0 : Disable; 1 : Enable	
4	R/W	CH4_FilterEn	0	Channel 4 Filter Enable; averaging filter point follows ADC_Filter<1:0> 0 : Disable; 1 : Enable	
3	R/W	CH3_FilterEn	0	Channel 3 Filter Enable; averaging filter point follows ADC_Filter<1:0> 0 : Disable; 1 : Enable	

Table 52. ADC_CONFIG3 (0x52) (continued)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_CONFIG3		ADC Filter Enable	0X52	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
2	R/W	CH2_FilterEn	0	Channel 2 Filter Enable; averaging filter point follows ADC_Filter<1:0> 0 : Disable; 1 : Enable	
1	R/W	CH1_FilterEn	0	Channel 1 Filter Enable; averaging filter point follows ADC_Filter<1:0> 0 : Disable; 1 : Enable	
0	R/W	CH0_FilterEn	0	Channel 0 Filter Enable; averaging filter point follows ADC_Filter<1:0> 0 : Disable; 1 : Enable	

Table 53. ADC_DATA_CH0 (0x53)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_DATA_CH0		Data for channel 0	0x53	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH0_DATA	0x00h	Channel 0 (V _{BUS} Voltage) Data V _{BUS_HV_RANGE} = 0 0x00h = 2.7V . . 0xFFh = 6.3V (step = 14mV) V _{BUS_HV_RANGE} = 1 0x00h = 6.3V . . 0xFFh = 14.7V (step = 33mV)	

Table 54. ADC_DATA_CH1 (0x54)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_DATA_CH1		Data for channel 1	0x54	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH1_DATA	0x00h	Channel 1 (V _{BUS} Current) Data 0x00h = 0.0A . . 0xFFh = 4.1A (step = 16mA)	

Table 55. ADC_DATA_CH2 (0x55)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_DATA_CH2		Data for channel 2	0x55	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH2_DATA	0x00h	Channel 2 (V _{BATT} Voltage) Data 0x00h = 2.1A . . 0xFFh = 4.9V (step = 11mV)	

Table 56. ADC_DATA_CH3 (0x56)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_DATA_CH3		Data for channel 3	0x56	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH3_DATA	0x00h	Channel 3 (V_{BATT} Current) Data 0x00h = 0.0A . . 0xFFh = 3.1A (step = 12mA)	

Table 57. ADC_DATA_CH4 (0x57)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_DATA_CH4		Data for channel 4	0x57	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH4_DATA	0x00h	Channel 4 (V_{BATT} I_{REXT} Current) Data (2's Complement) 0x00h = 0A . 0x7Fh = +10A 0x80h = -10A . 0xFFh = 0A (step = 78.125mA)	

Table 58. ADC_DATA_CH5 (0x58)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_DATA_CH5		Data for channel 5	0x58	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH5_DATA	0x00h	Channel 5 (Temperature Sensing) Data (in terms of (THMV/THMB)) 0x00h = 20% . 0xFFh = 80% (step = 0.24%)	

Table 59. ADC_DATA_CH6 (0x59)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_DATA_CH6		Data for channel 6	0x59	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH6_DATA	0x00h	Channel 6 (Reserved) Data 0x00h = 0.6V . 0xFFh = 1.4V (step = 3.1mV) Note: Channel connected to VCM signal internally.	

Table 60. ADC_DATA_CH7 (0x5A)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_DATA_CH7		Data for channel 7	0x5A	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	

Table 60. ADC_DATA_CH7 (0x5A) (continued)

7:0	R	CH7_DATA	0x00h	Channel 7 (Test) Data 0x00h = 0.6V . . 0xFFh = 1.4V (step = 3.1mV) Note: Channel connected to TEST1 during test mode.
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Table 61. ADC_OFFSET_CH1 (0x5B)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_OFFSET_CH1		Offset raw data for channel 1	0x5B	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH1_OFFSET	0x00h	Channel 1 (V _{BUS} Current) Offset Calibration. CH1_OFFSET<7:0> is the readback (raw) code. It can be converted to offset code by the following formula: Readback Code: Ideal Code = Offset Code, Ideal Code = 0x80h 0x00h to 0x80h = -128d : -2.048A . 0x7Eh to 0x80h = -2d : -0.032A 0x7Fh to 0x80h = -1d : -0.016A 0x80h to 0x80h = 0d : 0A 0x81h to 0x80h = 1d : 0.016A 0x82h to 0x80h = 2d : 0.032A . 0xFFh to 0x80h = 127d : 2.032A (step = 16mA)	

Table 62. ADC_OFFSET_CH3 (0x5C)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_OFFSET_CH3		Offset raw data for channel 3	0x5C	O	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH3_OFFSET	0x00h	Channel 3 (V _{BAT} Current) Offset Calibration. CH3_OFFSET<7:0> is the readback (raw) code. It can be converted to offset code by the following formula: Readback Code: Ideal Code = Offset Code, Ideal Code = 0x80h 0x00h to 0x80h = -128d : -1.536A . 0x7Eh to 0x80h = -2d : -0.024A 0x7Fh to 0x80h = -1d : -0.012A 0x80h to 0x80h = 0d : 0A 0x81h to 0x80h = 1d : 0.012A 0x82h to 0x80h = 2d : 0.024A . 0xFFh to 0x80h = 127d : 1.524A (step = 12mA)	

Table 63. ADC_OFFSET_CH4 (0X5D)

NAME		FUNCTION	ADDR	TYPE	RESET
ADC_OFFSET_CH4		Offset raw data for channel 4	0x5D	0	0x00
BIT	MODE	NAME	RESET	DESCRIPTION	
7:0	R	CH4_OFFSET	0x00h	<p>Channel 4 (V_{BATT} Current) Offset Calibration. CH4_OFFSET<7:0> is the readback (raw) code. It can be converted to offset code by the following formula:</p> <p>Readback Code: Ideal Code = Offset Code, Ideal Code = 0x80h</p> <p>0x00h – 0x80h = 0x00h = -128d : -10A</p> <p>.</p> <p>0x7Eh – 0x80h = 0x82h = -2d : -0.15625A</p> <p>0x7Fh – 0x80h = 0x81h = -1d : -0.078125A</p> <p>0x80h – 0x80h = 0x80h = 0d : 0A</p> <p>0x81h – 0x80h = 0x7Fh = 1d : 0.078125A</p> <p>0xh – 0x80h = 0x7Eh = 2d : 0.15625A</p> <p>.</p> <p>0x00h – 0x80h = 0x01h = 127d : 9.921875A</p> <p>(step = 78.125mA)</p>	

MAX77860

USB Type-C, 3A Switch-Mode Buck Charger with Integrated CC Detection, Reverse Boost, and ADC

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	2/19	Initial release	—
0.1		Updated cable resistance from “300mΩ to 3Ω” to “300mΩ and 3Ω” in the Input-Voltage Regulation Loop and Adaptive Input Current Limit (AICL) section	32
1	2/19	Updated SYS Input Range section in the Electrical Characteristics table, added Pin Configuration and Pin Description table	9, 28
2	6/19	Updated <i>Functional Block Diagram</i> and <i>Typical Application Circuits</i> , corrected minor errors	1, 32, 33, 71, 87

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