
Single-cell Li-Ion Charger IC with System Power Management

General Description

The EMC5060 is a single-cell Li-ion charger IC with system power management feature. It charges the battery and power the system simultaneously. The maximum charging current (up to 1.5A) is set by external resistor for fast charging. The output voltage for the system is regulated to a nominal value (three different versions available: 4.4V, 5V or 6V); the actual value of the output voltage depends on the input voltage from the adapter, the charging current and the system loading. With the decrease of the input voltage or the increase of the system loading current, the output voltage drops. When the output voltage drops to a predetermined value (V_{APM-REG}), the Active Power Management function is activated and tries to maintain the output voltage at V_{APM-REG}; the EMC5060 will suffice the system loading with first priority and reduce the charging current temporarily, i.e. under heavy load condition, the EMC5060 charges the battery with the remaining available current to keep the output voltage at V_{APM}. In this manner, the charge and discharge cycle of the battery can be reduced.

It is possible that the EMC5060 fails to maintain the output voltage at V_{APM-REG}; for example, when the system loading current exceeds the capability of the current-limiting AC adapter. In this scenario, the output voltage drops to the battery voltage, and the system is allowed to draw current from the battery.

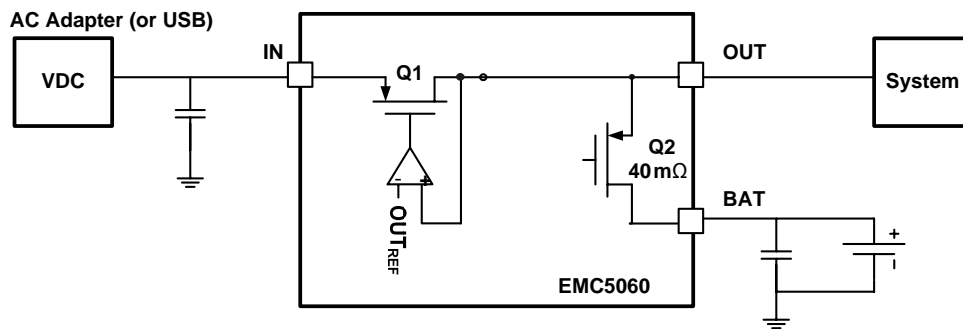
Features

- TQFN-20L Package
- Active Power Management (APM) for Simultaneously Powering the System and Charging the Battery
- Total Current Supported Up to 2 Amperes (System Loading Having Higher Priority on the Budget)
- Automatic Power Source Selection (AC Adapter or Battery)
- 40mΩ Power Path for the Battery to Supply the System Power Efficiently
- Junction Temperature Detection and Thermal Regulation During Charging Process
- External LED Indicating Charger and Power Good Status as well as Fault Condition
- Thermal, Short-Circuit, and Reverse Current Protection
- Short-Circuit Protection in the Low Power Consumption Sleep Mode
- SYSOFF Function to Cut Off the Path between the System and the Battery
- 6V (V_{OUT} = 4.4V) Maximum Input Operating

Applications

- Battery-Powered Devices or Equipment
- Mobile Phones, Digital Cameras and MP3 Players
- Radios, other Hand-Held Games and Instruments
- Solar Power System

Power Flow



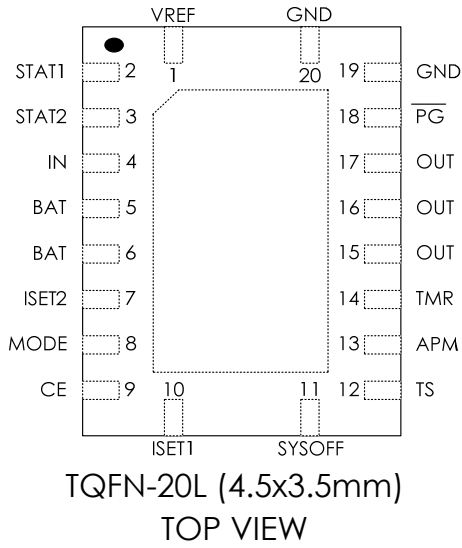
The EMC5060 selects the power source automatically. In the absence of the input source (AC adapter or USB), the battery is chosen to power the system. Under this circumstance, the EMC5060 consumes less than 5uA; the power path resistance from the battery to the system is only 40mΩ; all these guarantee a high efficiency and elongate the battery discharge time. With this stringent sleep current budget (< 5uA), the EMC5060 is still able to detect an output short condition and cuts off the power path between the battery and the system under short condition.

With the input power present, the mode pin sets the EMC5060 in adapter mode or USB mode. In adapter mode, EMC5060 does not limit the total current directly, current limiting phenomenon occurs through Adaptive Power Management in response to the output voltage drop. The resistor connected to ISET1 pin sets the maximum charging current. This maximum charging current can be halved by pulling down the ISET2 pin. In USB mode, the EMC5060 will limit the total current within 450mA (ISET2=1) or 90mA (ISET2=0). The maximum charging current is still set by the resistor connected to ISET1 pin; however, because of this current limiting feature, the actual charging current is usually less than 450mA (or 90mA).

Power Source Selection and Charge Current Setting

MODE Pin Level	AC Adapter	Loading Power Source	Charge Current Setting
Low	Yes	USB	ISET1, limitation depends on ISET2 setting
	No	Battery	N/A
High	Yes	AC Adapter	ISET1, half charging rate by setting ISET2 to low
	No	Battery	N/A

Package Configuration



EMC5060-XXHG20NRR

XX Output Voltage

HG20 TQFN-20L (4.5x3.5mm) Package

NRR RoHS & Halogen free package

Commercial Grade Temperature

Rating: -40 to 85°C

Package in Tape & Reel

Order, Mark & Packing information

Package	V _{out} (V)	Product ID	Marking	Packing
TQFN-20L (4.5x3.5mm)	4.4V	EMC5060-44HG20NRR		Tape & Reel 3K units
	5.0V	EMC5060-50HG20NRR		
	6.0V	EMC5060-60HG20NRR		

Pin Functions

Pin No.	I/O	Pin Name	Pin Function
1	O	VREF	Internal reference; VREF output capacitor not required, but one with a value of 0.1 μ F is recommended.
2	O	STAT1	Charge status flag 1 (open-drain)
3	O	STAT2	Charge status flag 2 (open-drain)
4	I	IN	Chip input voltage
5, 6	I/O	BAT	Battery connection; charging or discharging all through this pin
7	I	ISET2	USB mode total current selection (High = 450mA, Low = 90mA) and AC mode charge current selection (High = Full current, Low = half current)
8	I	MODE	Set EMC5060 in AC(High) or USB(Low) mode
9	I	CE	Chip enable (active high)
10	I/O	ISET1	Set the maximum charging current
11	I	YSOFF	Cut off the power path between the battery and the output pin
12	I/O	TS	Battery Temperature sensing
13	I	APM	Active Power Management set point ※ no need for capacitors
14	I/O	TMR	Timer program by external resistor connected to this pin. Tying TMR and VREF together to disable the safety timer
15, 16, 17	O	OUT	System output
18	O	\overline{PG}	Power-good status flag (open-drain)
19, 20	I	GND	Chip Ground

Functional Block Diagram

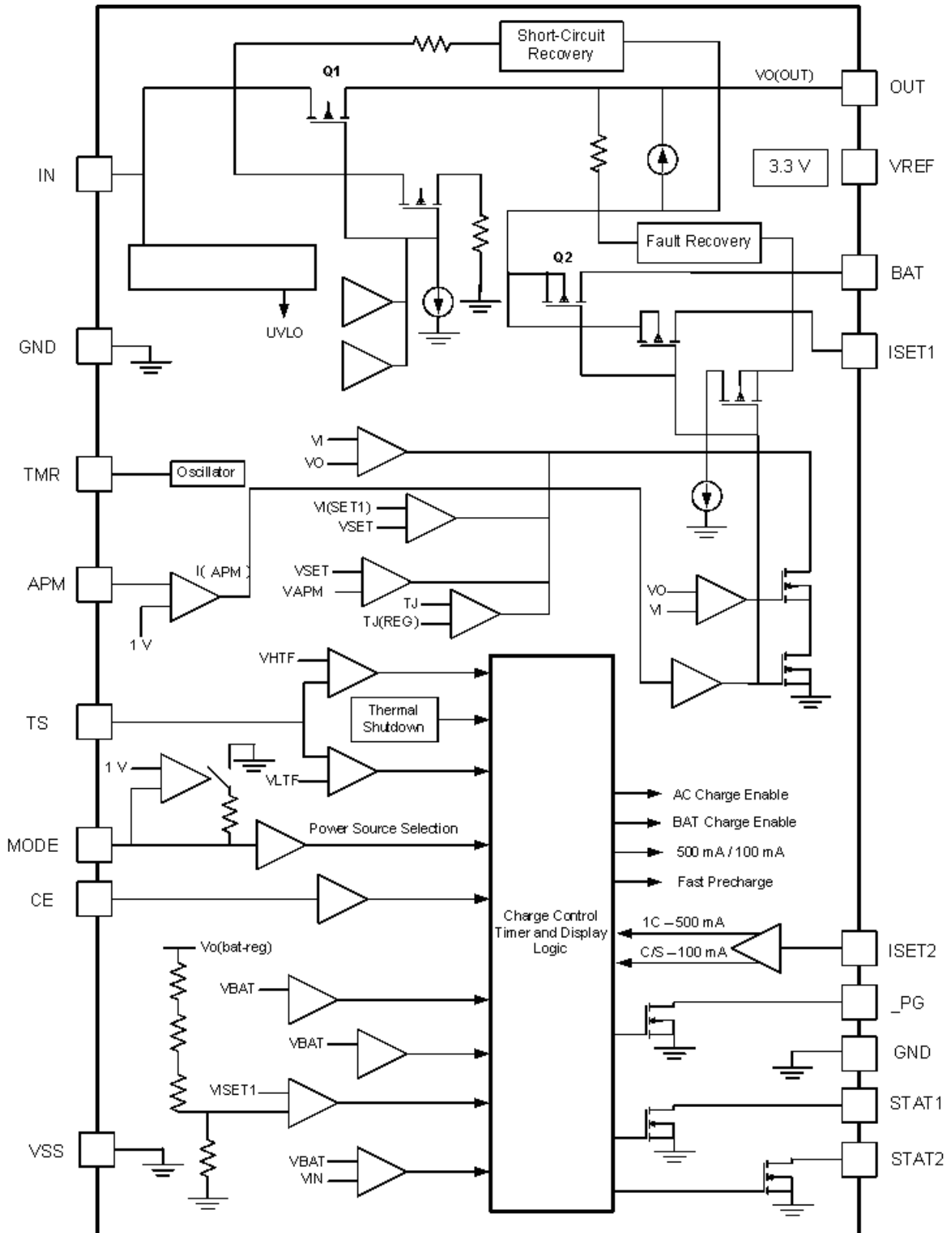


Fig. 2

Absolute Maximum Ratings

Devices are subjected to fail if they stay above absolute maximum ratings.

IN	0.3V to 18V	Output Sink Current (\overline{PG} , STAT1, STAT2)	15mA
BAT, CE, APM, \overline{PG} , MODE, OUT, TS	0.3V to 7V	Lead Temperature (Soldering, 10 sec)	260°C
ISET1, ISET2, STAT1, STAT2	0.3V to 7V	Operating Temperature Range	-40°C to 85°C
VREF, TMR	-0.3V to (VIN + 0.3V)	Junction Temperature (Note 1)	150°C
Input Current	3.5A	Storage Temperature Range	-65°C to 150°C
I _{OUT} Output Current	4.0A	ESD Susceptibility HBM	2KV
I _{BAT} Output Current	-4.0A to 3.5A	MM	200V
Output Source Current (Regulation at 3.3V)	30mA		

Operating Ratings

V _{IN} Supply Voltage	4.35V to 6V for V _{OUT} = 4.4V	Operating Junction Temperature Range	125°C
I _{AC} Input Current	2.0A		

Thermal data

Package	Thermal resistance	Parameter	Value
TQFN-20L (4.5x3.5mm)	θ_{JA} (Note 2)	Junction-ambient	52°C/W
	θ_{JC} (Note 3)	Junction-case	10°C/W

Note 1: T_J is a function of the ambient temperature T_A and power dissipation P_D (T_J = T_A + (P_D) * θ_{JA}).

Note 2: θ_{JA} is measured in the natural convection at T_A=25°C on a highly effective thermal conductivity test board (2 layers, 2SOP) according to the JEDEC 51-7 thermal measurement standard.

Note 3: θ_{JC} represents the heat resistance between the chip and the package top case.

Electrical Characteristics

Ambient temperature $T_A = 25^\circ\text{C}$ and the recommended V_{IN} range (unless otherwise noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Active supply current	$I_{CC(SPLY)}$	$V_{IN} > 4.35\text{V}$		1.1	2	mA
Sleep mode Current (flow into BAT pin)	$I_{CC(SLP)}$	$V_{IN} < V_{BAT}$ $2.6\text{V} < V_{BAT} < V_{O(OUT-REG)}$ No load at the OUT pin		2.5	5	μA
Input pin standby current	$I_{CC(IN-STDBY)}$	$V_{IN} < 6\text{V}$, Total current flow into IN pin with CE pin low; no load			200	μA
BAT pin standby current	$I_{CC(BAT-STDBY)}$	Total current flow into BAT pin with input source present and CE pin low		45	65	μA
Charge done current, BAT	$I_{B(BAT)}$	Current into to the battery after the termination of the charging process		1	5	μA
VOLTAGE REGULATION						
Regulation V_{OUT} EMC5060-44HG20NRR	$V_{O(OUT-REG)}$	$V_{IN} > 4.4\text{V} + V_{ACDO}$ V_{ACDO} : In to OUT dropout voltage		4.4	4.5	V
Regulation V_{OUT} EMC5060-50HG20NRR	$V_{O(OUT-REG)}$	$V_{IN} > 5\text{V} + V_{ACDO}$ V_{ACDO} : In to OUT dropout voltage		5	5.2	V
Regulation V_{OUT} EMC5060-60HG20NRR	$V_{O(OUT-REG)}$	$V_{IN} > 6\text{V} + V_{ACDO}$ V_{ACDO} : In to OUT dropout voltage		6	6.3	V
APM REGULATION						
APM set point	$V_{(APM-SET)}$	$V_{APM-SET} < V_{OUT}$	2.6		3.8	V
APM current source	$I_{(APM-SET)}$	Input present	95	100	105	μA
APM scale factor	SF	$V_{APM-REG} = V_{APM-SET} \times SF$	1.139	1.15	1.162	
Q1,Q2 DROP-OUT VOLTAGE						
IN to OUT dropout voltage	$V_{(ACDO)}$	Mode = High , $I_{IN} = 1\text{A}$		300	475	mV
BAT to OUT dropout voltage	$V_{(BATDO)}$	$V_{(BAT)} > 4\text{V}$, $I_{(BAT)} = 1\text{A}$		40	100	mV
BATTERY SUPPLEMENT MODE						
Run battery supplement mode	V_{BSUP1}	$V_{(BAT)} > 2\text{V}$		$V_{(OUT)} < V_{(BAT)} - 60\text{mV}$		V
Escape battery supplement mode	V_{BSUP2}	$V_{(BAT)} > 2\text{V}$		$V_{(OUT)} > V_{(BAT)} - 20\text{mV}$		V
SHORT CIRCUIT PROTECTION						
Short-circuit recovery between BAT to OUT	I_{OSH1}	Pull-up source from BAT to OUT for short-circuit recovery $V_{(OUT)} < V_{(BAT)} - 200\text{mV}$		10		mA
IN to OUT short-circuit protection	R_{SHAC}	$V_{(OUT)} < 1\text{V}$		500		Ω

Electrical Characteristics (continued)

Ambient temperature $T_A = 25^\circ\text{C}$ and the recommended V_{IN} range (unless otherwise noted)

CHARGING-PRECHARGE						
Precharge to fast-charge transition voltage	$V_{(LOWV)}$	Voltage on BAT	2.9	3	3.1	V
Precharge current range	$I_{O(PRECHG)}$		10		150	mA
Precharge set voltage	$V_{(PRECHG)}$		225	250	275	mV
De-glitch time between fast charge and precharge transition	$T_{(DGLF)}$	$t_{FALL} = 100 \text{ ns}$, 10mV overdrive, $V_{(BAT)}$ decreasing below threshold		22.5		ms
CHARGING-CURRENT REGULATION						
Fast charge current range	$I_{O(BAT)}$	$V_{(BAT)} > V_{(LOWV)}$, Mode = High	100	1000	1500	mA
BAT to OUT pull-up	R_{PBAT}	$V_{(BAT)} < 1 \text{ V}$		1000		Ω
Battery charge current set voltage(1)	$V_{(SET)}$	Voltage on ISET1	2.47	2.5	2.53	V
Charge current set factor	$K_{(SET)}$	$100 \text{ mA} < I_{O(BAT)} < 1.5 \text{ A}$	375	425	450	
		$10 \text{ mA} < I_{O(BAT)} < 100 \text{ mA}$	300	450	600	
USB MODE INPUT CURRENT LIMIT						
USB input current range	$I_{(USB)}$	ISET2 = High	400		500	mA
		ISET2 = Low	80	90	100	
CHARGING VOLTAGE REGULATION, $V_{O(DO-MAX)} < V_{CC}$, $I_{TERM} < I_{BAT(OUT)} < 1 \text{ A}$						
Battery-charge-voltage	$V_{O(BAT-REG)}$			4.2		V
Battery charge voltage		$T_A = 25^\circ\text{C}$	-0.5%		0.5%	
Regulation accuracy			-1%		1%	
CHARGE TERMINATION DETECTION						
Charge done detection current	$I_{(TERM)}$	$V_{(BAT)} > V_{(RCH)}$, $I_{(TERM)} = (K_{(SET)} \times V_{(TERM)}) / R_{SET}$	10		150	mA
Charge done set voltage, measured on ISET1	$V_{(TERM)}$	$V_{(BAT)} > V_{(RCH)}$, Mode = High	230	250	270	mV
		$V_{(BAT)} > V_{(RCH)}$, Mode = Low	95	100	130	
TEMPERATURE SENSE COMPARATORS						
High voltage, low temperature threshold	V_{LTF}	Temp fault at $V_{(TS)} > V_{LTF}$		2.5		V
Low voltage, high temperature threshold	V_{HIF}	Temp fault at $V_{(TS)} < V_{HIF}$		0.5		V
Current source for temperature sense	I_{TS}		95	100	105	μA
BATTERY RECHARGE THRESHOLD						
Recharge threshold voltage	V_{RCH}		$V_{O(BAT-RE G)} - 0.075$	$V_{O(BAT-RE G)} - 0.1$	$V_{O(BAT-RE G)} - 0.125$	V
STAT1, STAT2, AND $\overline{\text{PG}}$						
Low-level output saturation voltage	V_{OL}	$I_{OL} = 5 \text{ mA}$, requiring an external pull-up resistor $> 1 \text{ K}$			0.25	V
Input leakage current	I_{LKG}			1	5	μA

Electrical Characteristics (continued)

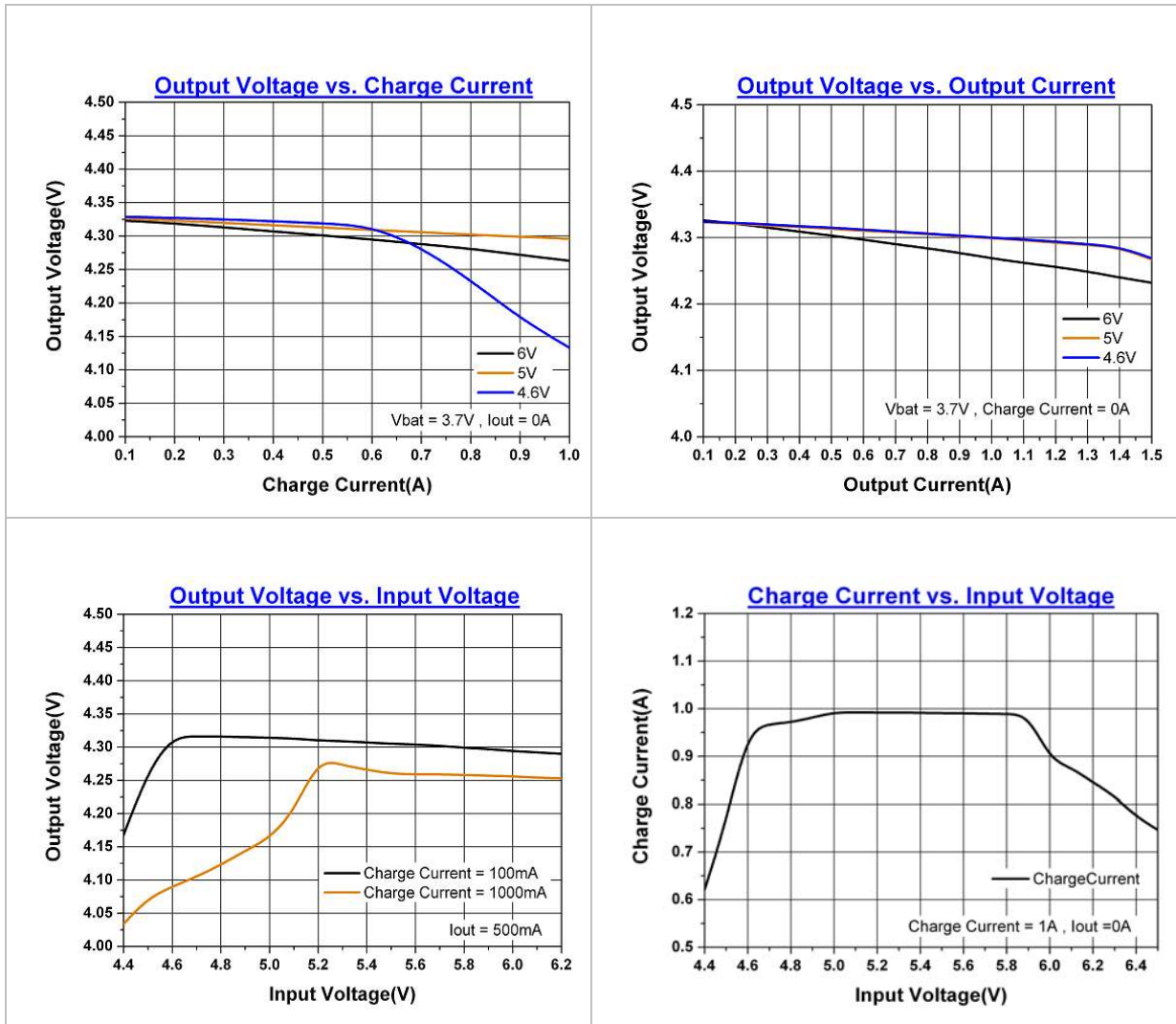
Ambient temperature $T_A = 25^\circ\text{C}$ and the recommended V_{IN} range (unless otherwise noted)

ISET2, CE						
CE pin Hold-off time	$t_{(CE-HLDOFF)}$	CE fall low only	4		6	ms
Low-level input voltage	V_{IL}		0		1.1	V
High-level input voltage	V_{IH}		1.5			
CE pin Low-level input current	I_{IL}		-1			μA
CE pin High-level input current	I_{IH}				1	
ISET2 pin Low-level input current	I_{IL}	$V_{ISET2} = 0.4\text{ V}$	-20			
ISET2 pin High-level input current	I_{IH}	$V_{ISET2} = V_{IN}$			40	
MODE						
Low-level input voltage	V_{IL}	Falling Hi→Low ; 280K \pm 10% applied when low	0.975	1	1.025	V
High-level input voltage	V_{IH}	Input RMode sets external hysteresis	$V_{IL} + 0.01$		$V_{IL} + 0.024$	V
Low-level input current, Mode	I_{IL}		-1			μA
TIMERS						
Timer set factor	$K_{(TMR)}$	$t_{(CHG)} = K_{(TMR)} \times R_{(TMR)}$	0.313	0.36	0.414	s/ Ω
External resistor limits	$R_{(TMR)}$		30		100	k Ω
Precharge timer	$t_{(PRECHG)}$		0.09 x $t_{(CHG)}$	0.1 x $t_{(CHG)}$	0.11 x $t_{(CHG)}$	s
Timer fault recovery pull-up from OUT to BAT	$I_{(FAULT)}$			1		k Ω
Time out extension factor1	$K_{(EXT1)}$	The actual charge current less than 50% of maximum fast charge current		2		
Time out extension factor2	$K_{(EXT2)}$	The actual charge current less than 25% of maximum fast charge current		4		
CHARGER SLEEP THRESHOLDS						
Sleep-mode entry threshold	$V_{(SLPENT)}$				$V_{IN} \leq V_{(BAT)} + 0.125$	mV
Sleep-mode exit threshold	$V_{(SLPEXIT)}$		$V_{IN} \geq V_{(BAT)} + 0.195$			
DE-GLITCH TIME						
De-glitch time for charge done detection, temperature fault, recharge and sleep mode detection	$T_{(DEG)}$			18.75		ms
START-UP CONTROL BOOT-UP						
Boot-up time	$t_{(BOOT-UP)}$	On the first application of input low	120	150	180	ms

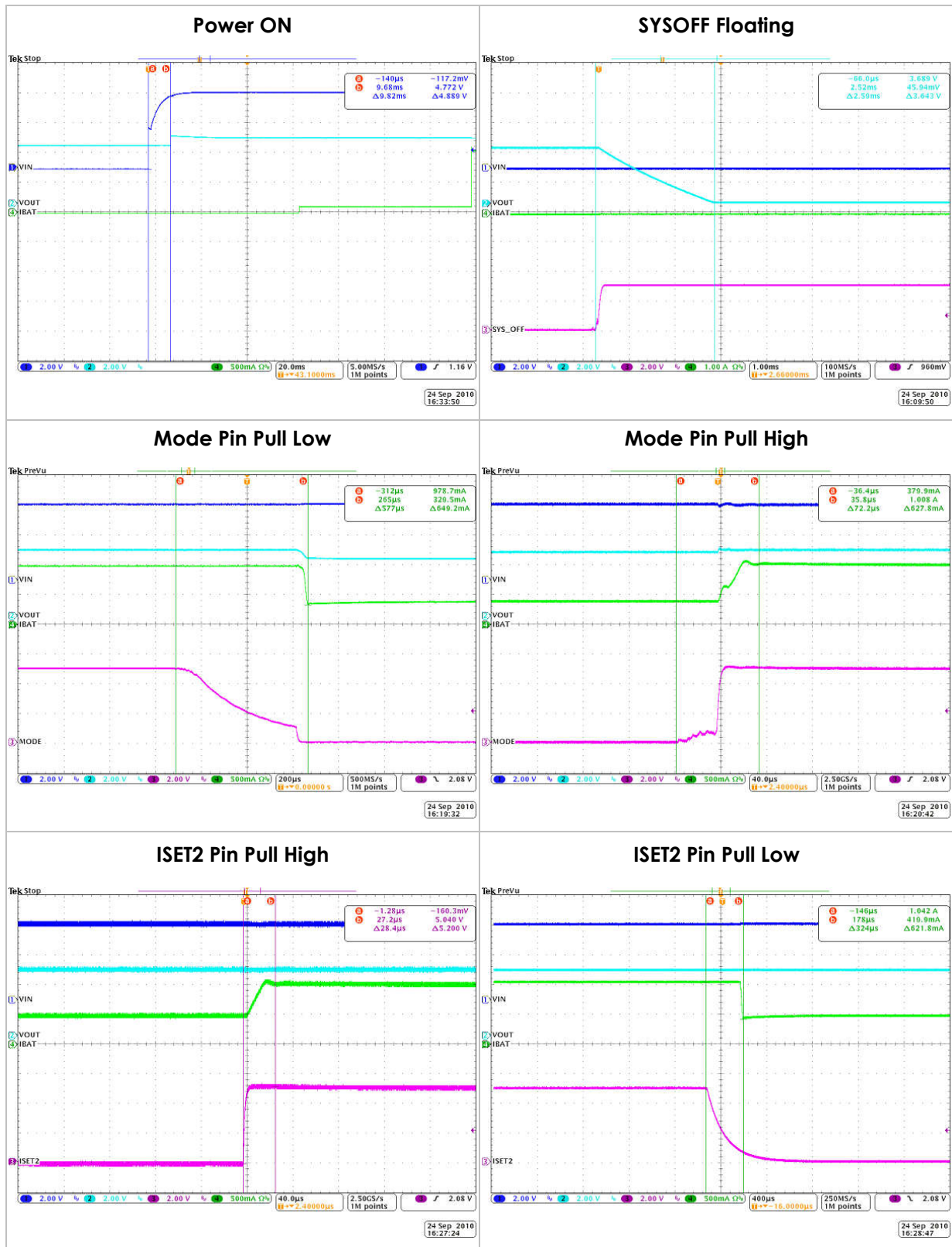
Electrical Characteristics (continued)Ambient temperature $T_A = 25^\circ\text{C}$ and the recommended V_{IN} range (unless otherwise noted)

SWITCHING POWER SOURCE TIMING						
Switching power source from input to battery	$t_{\text{SW-BAT}}$	When input applied. Measure from: [$\overline{\text{PG}}$: Lo -> Hi to $I_{\text{IN}} > 5 \text{ mA}$]			50	μs
THERMAL SHUTDOWN REGULATION						
Temperature trip	T_{SHUTDOWN}	T_J (Q1 and Q3 only)		150		$^\circ\text{C}$
Thermal hysteresis		T_J (Q1 and Q3 only)		25		
Temperature regulation limit	$T_{\text{J(REG)}}$	T_J (Q2)	110		130	
UVLO						
Under-voltage lockout	V_{UVLO}	Decreasing V_{IN}	2.45	2.5	2.65	V
Hysteresis				27		mV
OVP						
Over voltage protection	V_{OVP}	Increasing V_{IN} (EMC5060-44HG20NRR)	6.2		6.8	V
VREF OUTPUT						
Output regulation voltage	$V_{\text{O(REF)}}$	Active only if ADP or USB is present		3.3		V
Regulation accuracy			-5%		+5%	
Output current	$I_{\text{O(VREF)}}$				20	mA
On resistance	$R_{\text{DS(on)}}$	OUT to VREF			50	Ω
Output capacitance	C_{OUT}				1	μF

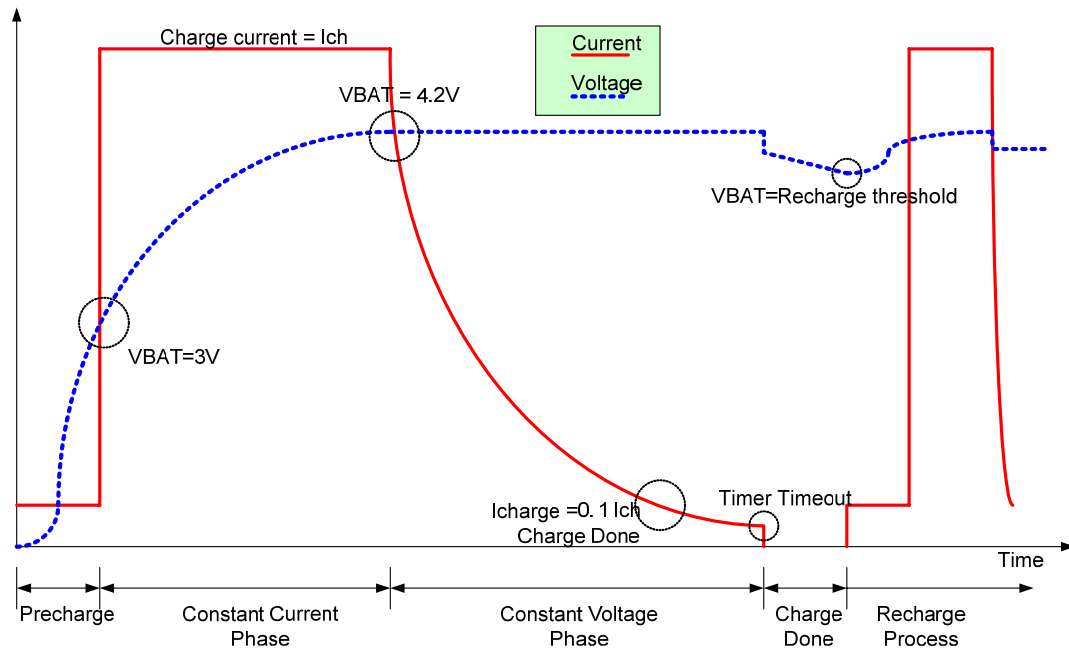
Typical Performance Characteristics



Typical Performance Characteristics (continued)



Description of Charger Operation



MODE	ISET2	Maximum Charging Current Setting	Pre-charge and Charge Done Current Setting
High	High	$I_{CH} = \frac{V_{SET} \times K_{SET}}{R_{SET}}, V_{SET,max} = 2.5$	$I_{Pre-charge} = \frac{I_{CH,max}}{10}$ $I_{Charge-done} = \frac{I_{CH,max}}{10}; AC Mode$
	Low	$I_{CH} = \frac{V_{SET} \times K_{SET}}{R_{SET}}, V_{SET,max} = 1.25$	$I_{Pre-charge} = \frac{I_{CH,max}}{5}$ $I_{Charge-done} = \frac{I_{CH,max}}{5}; AC Mode$
Low	High/Low	$I_{CH} = \frac{V_{SET} \times K_{SET}}{R_{SET}}, V_{SET,max} = 2.5$	$I_{Pre-charge} = \frac{I_{CH,max}}{10}$ $I_{Charge-done} = \frac{I_{CH,max}}{25}; USB Mode$

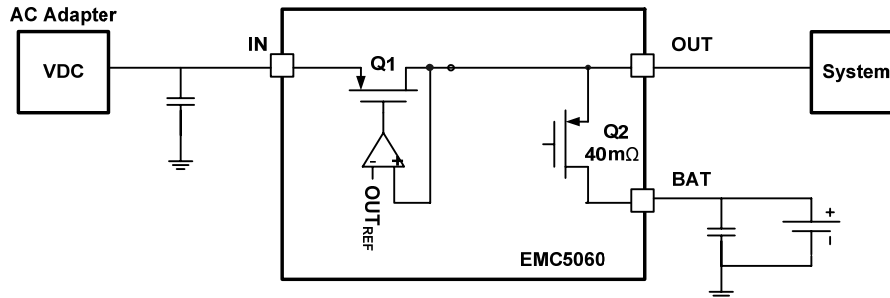
The maximum charging current, the pre-charge current and charge done current setting are given in the above table. The charging process begins with a pre-charge phase; when the battery voltage reaches the pre-charge threshold $V_{(LOW)}$, the charger enters the constant current mode. At this stage, the charger tries to charge the battery with the maximum charging current (a constant); however, the actual charging current may be lower due to Active Power Management activated by large system loading or insufficient input current capability. The thermal fold-back mechanism also reduces the actual charging current when the junction temperature is over 110° C. The battery voltage rises gradually with the constant current entering the battery.

When the battery voltage reaches $V_{O(BAT-REG)}$, the charger enters the constant voltage mode. At this stage, the charger keeps the battery voltage at $V_{O(BAT-REG)}$ with a decreasing charging current. When the charging current drops below the charge done current setting, nominally the charging process is complete (this can be observed from the external indicator). Depending on different versions, after the charge done status indicated, the charger will stop providing charging current completely or stay in constant voltage mode till time out. When the battery voltage drops below the recharge threshold, a new charge cycle begins.

Example:

With a $R_{set}=1K \Omega$, the maximum charging current is about 1A for ISET2=High and 0.5A for ISET2=Low. The pre-charge current $I_{Pre-charge}$ is 100mA. The charge done current setting is 100mA for AC mode and 40mA for USB mode. Note the absolute values of pre-charge current and charge done current setting do not vary with ISET2.

Power Source Selecting



- i. $V_{IN} < V_{BAT} : V_{OUT} = V_{BAT} - V_{(BATDO)}$
- ii. $V_{BAT} < V_{IN} < V_{O(OUT-REG)} : V_{OUT} = V_{IN} - V_{(ACDO)}$
- iii. $V_{O(OUT-REG)} + V_{(ACDO)} < V_{IN} < 6 : V_{OUT} = V_{O(OUT-REG)}$
- iv. $6 < V_{IN} : V_{OUT} = V_{BAT} - V_{(BATDO)}$

EMC5060 selects power source automatically depending on the voltage present at the input. When V_{IN} is lower than V_{BAT} , the battery is responsible to power the system. The output voltage V_{OUT} is $V_{BAT} - V_{(BATDO)}$. When the input voltage V_{IN} is higher than V_{BAT} and lower than 6V, the input source is used to supply the system power; the output voltage depends on V_{IN} . When V_{IN} is lower than $V_{O(OUT-REG)}$, the output voltage V_{OUT} is $V_{IN} - V_{(ACDO)}$; when V_{IN} is high enough ($>(V_{O(OUT-REG)} + V_{(ACDO)})$), the output voltage is regulated at $V_{O(OUT-REG)}$. When the input voltage V_{IN} is higher than 6V, the current path between IN and OUT is cut off to protect the chip; EMC5060 therefore selects the Battery as the power source; the output voltage V_{OUT} is then $V_{BAT} - V_{(BATDO)}$.

Active Power Management (APM)■ **AC MODE (MODE=HIGH)**

- i. $V_{(APM-REG)} < V_{OUT}$: Normal Mode; I_{CH} determined by R_{SET}
- ii. $V_{BAT} < V_{OUT} < V_{(APM-REG)}$: APM mode ; $I_{CH} = I_{supply, max} - I_{OUT}$
- iii. $V_{OUT} < V_{BAT}$: BAT supply mode

■ **USB 500 MODE (MODE=LOW , ISET2=HIGH)**

- i. $V_{(APM-REG)} < V_{OUT}$: Normal Mode; I_{CH} determined by R_{SET}
- ii. $V_{BAT} < V_{OUT} < V_{(APM-REG)}$: APM mode ; $I_{CH} = 450mA - I_{OUT}$
- iii. $V_{OUT} < V_{BAT}$: BAT supply mode

■ **USB 100 MODE (MODE=LOW , ISET2=LOW)**

- i. $V_{(APM-REG)} < V_{OUT}$: Normal Mode; I_{CH} determined by R_{SET}
- ii. $V_{BAT} < V_{OUT} < V_{(APM-REG)}$: APM mode ; $I_{CH} = 90mA - I_{OUT}$
- iii. $V_{OUT} < V_{BAT}$: BAT supply mode

The active power management feature adjusts the charging current to resist the output voltage drop due to heavy system loading or insufficient input driving capability. In the extreme situation, the charging current flow would be reversed (the battery helps to supply the system power). The active power management regulation voltage $V_{(APM-REG)}$ is given by:

$$V_{(APM-REG)} = I_{(APM-SET)} \times R_{(APM)} \times SF^{(1)}$$

When the output voltage is higher than $V_{(APM-REG)}$, the input source is capable of providing the charging current (set by R_{SET}) and output current (determined by system loading) simultaneously. When the output voltage goes down and reaches $V_{(APM-REG)}$ due to an increasing loading, EMC5060 starts to reduce the charging current and tries to keep the output voltage at $V_{(APM-REG)}$. Because EMC5060 uses the remaining available current to charge the battery, the charging current can be estimated as $I_{supply max} - I_{OUT}$. In AC mode, the $I_{supply max}$ is determined by the driving capability of the AC adapter and EMC5060 itself (Usually the limiting factor is the EMC5060, and $I_{supply max}$ is about 2A). The $I_{supply max}$ is determined by the ISET2 setting in USB mode ($I_{supply max}$ is about 450mA with ISET2 high, and $I_{supply max}$ is about 90mA with ISET2 low).

When the loading current keeps increasing and exceeds $I_{supply max}$, EMC5060 can not prevent the output voltage dropping below $V_{(APM-REG)}$ even the charging current is reduced to zero. When the output voltage drops below the battery voltage, the battery helps to supply the loading current and keeps the output voltage roughly at V_{BAT} . At this situation, we have:

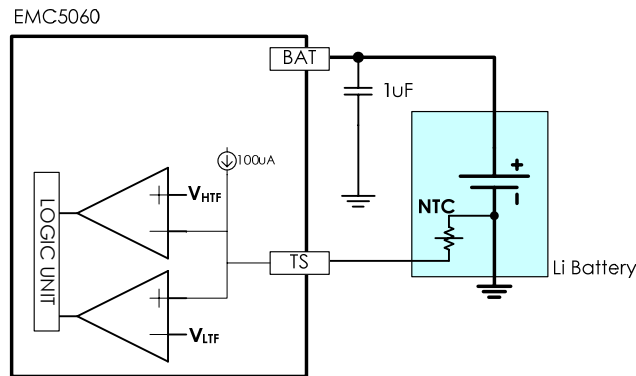
$$I_{OUT} = I_{supply max} + I_{BAT}^{(2)}$$

$$(1) \quad R_{(APM)} < 38K\Omega : V_{(APM-REG)} = I_{(APM-SET)} \times R_{(APM)} \times SF$$

$R_{(APM)} > 41K\Omega$: The $V_{(APM-REG)}$ is set to a predetermined fixed value (4.26V)

$$(2) \quad I_{BAT} = (V_{BAT} - V_{OUT}) / (40m\Omega \text{ Power Path Resistance})$$

Battery temperature Protection



EMC5060 interrupts the charging process when the battery temperature is out of normal range. EMC5060 provides an 100uA sensing current to the negative-temperature coefficient resistor (on the battery side) through the TS pin. The battery protection is achieved by constantly monitoring the voltage at the TS pin. When this voltage is higher than V_{LTF} (nominally 2.5V) or lower than V_{HTF} (nominally 0.5V), an under-temperature or over-temperature condition is detected. For a usual 103AT-type NTC resistor, the corresponding temperature range is between 0° C and 45° C. The normal battery temperature range can be modified by adjusting the NTC resistor or by adding extra resistor network between the TS pin and the negative-temperature coefficient resistor. The charging process would resume after the battery temperature goes back within the normal range.

Charge Timeout Setting

The charge timeout setting is programmed by the resistor R_{TMR} connected between the TMR and ground pin. The timeout setting is given by:

$$T_{CHG} = K_{TMR} \times R_{TMR}$$

A suggested 36K Ω R_{TMR} gives a 3.6 hrs timeout setting because the nominal value of K_{TMR} is 0.36 sec/ Ω . In the actual charging process, the charging duration is elongated if the charging current can not reach the maximum current setting (again this relates to system loading and environment temperature); therefore, it is possible that the charging process is still on progress while the 3.6 hrs timeout limit has been reached. To circumvent this problem, the actual charging current is monitored and the clock rate of the timer counter is halved if the charging current is less than 50% of the maximum fast charging current. This is equivalent to modify the timeout setting temporarily by the following equation:

$$T_{CHG} = K_{EXT1} \times K_{TMR} \times R_{TMR}, \quad K_{EXT1} = 2$$

If the actual charging current is less than one fourth the maximum fast charging current, the time out counter rate is reduced to 25%. The temporary timeout setting is given by:

$$T_{CHG} = K_{EXT2} \times K_{TMR} \times R_{TMR}, \quad K_{EXT2} = 4$$

Once the abnormal condition is removed (high temperature or heavy loading), the charging current resumes the maximum values (set by R_{set}), and the time out counter will operate in normal rate.

Charge Status Indicator

If the battery is present, the open drain pins STAT1 and STAT2 provides the information about the charger status when the CE pin (chip enable) is set to high. The various charger status and the corresponding STAT1 and STAT2 levels are given in the above Table. Connect these pins to the host processor or LEDs to indicate the charger status.

Status	STAT1	STAT2
Pre-charge	ON	ON
Constant current and constant voltage charge	ON	OFF
Charge done	OFF	ON
Fault condition (time out, sleep mode, or OTP)	OFF	OFF

If the battery is absent and $I_{OUT} < 1A$, the BAT pin cycles between charge done and charging (battery recharge threshold $\sim 4.1V$).

Short Circuit Protection

EMC5060 provides short circuit protection for both the input and the battery. When V_{IN} is larger than V_{BAT} , AC adapter (or USB port) is chosen as the power source. If the output voltage is lower than 1V, a short circuit condition is detected; the power path between the input and the output will be cut off. The charging process will be interrupted. A 500Ω resistor is used to pull up the output voltage; if the load at the output is removed, the output voltage can be pulled up and the short circuit condition is dissolved.

Similarly, when the battery is chosen as the power source, an output voltage lower than the battery voltage by 200mV will trigger the short circuit protection mechanism (this corresponds to a 5A loading current). A 10mA current source is used to pull up the output and detect the removal of the short condition. The power consumption is less than 5uA under the battery supply mode; however, EMC5060 is still able to monitor the output voltage and detect a short circuit condition with this limiting current budget.

YSOFF Function

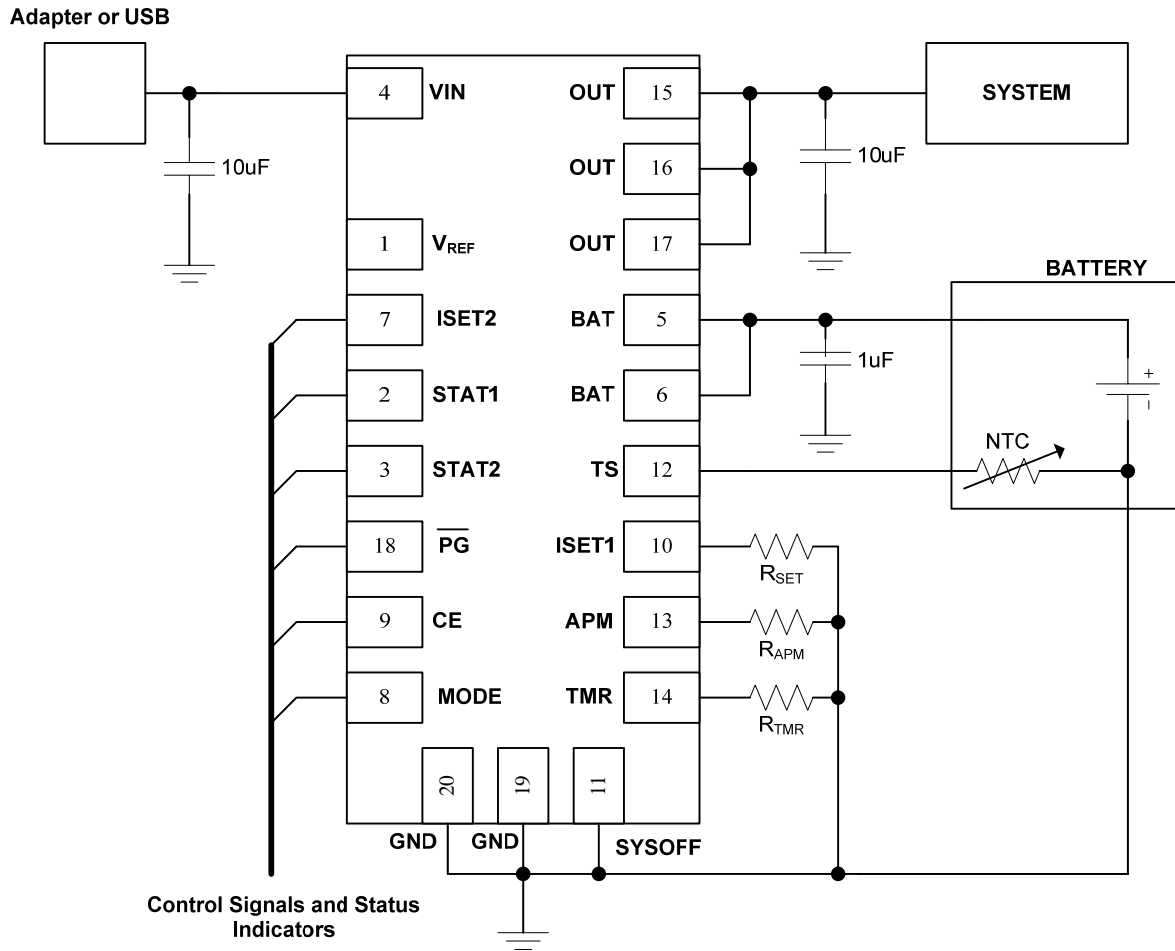
The SYSOFF function is used to cut off the power path between the battery and the output. This means the charger function can be disabled by pulling up the SYSOFF pin; in this mode, the EMC5060 is almost a regulator to power the system. Because the power path is cut off, the output voltage will drop to zero when the input source is removed, the battery will not be used to power the system. The SYSOFF pin is pulled high internally; therefore, this pin should be pulled to ground for normal operation.

Recharge Process and Timer Fault Elimination

If timeout occurs and the battery voltage is higher than the recharge threshold, the charger will stay in the charge done mode until the battery voltage drops below the recharge threshold. Once the battery voltage drops below the recharge threshold, a new charge cycle starts.

If timeout occurs and the battery voltage is lower than the recharge threshold, the charger will indicate a fault condition and an internal resistor between output and battery will try to pull up the battery voltage. If the internal resistor is unable to pull up the battery voltage to the recharge threshold, the charger will stay in fault condition. Once the battery voltage is higher than the recharge threshold, the charger removes the pull-up resistor, leaves the fault condition and stay in the charge done mode temporarily. The charger then waits the battery voltage to drop below the recharge threshold and starts a new charge cycle.

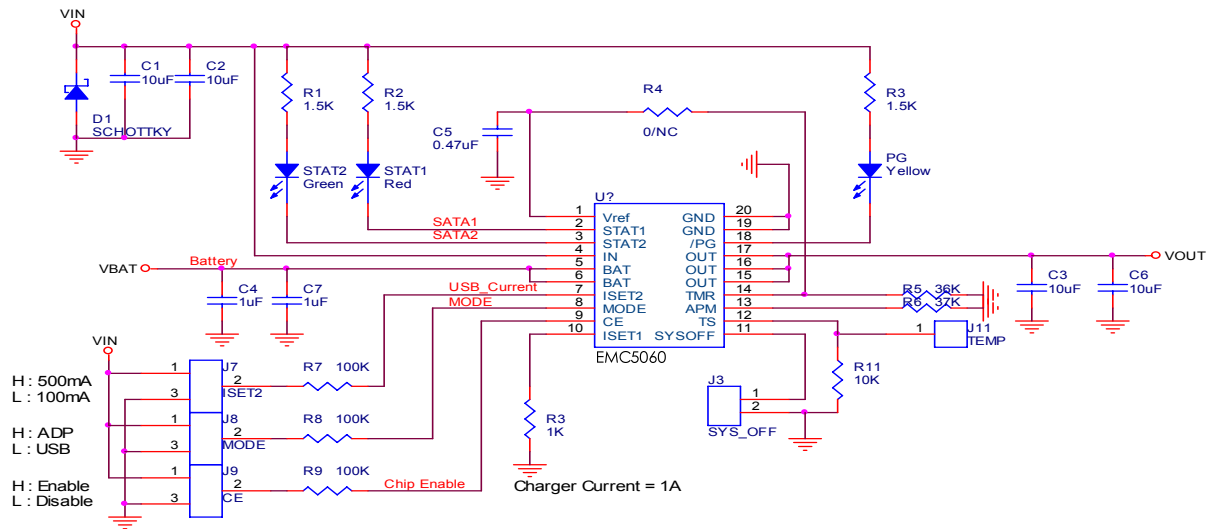
Typical Application Circuits



PCB Board Layout Considerations

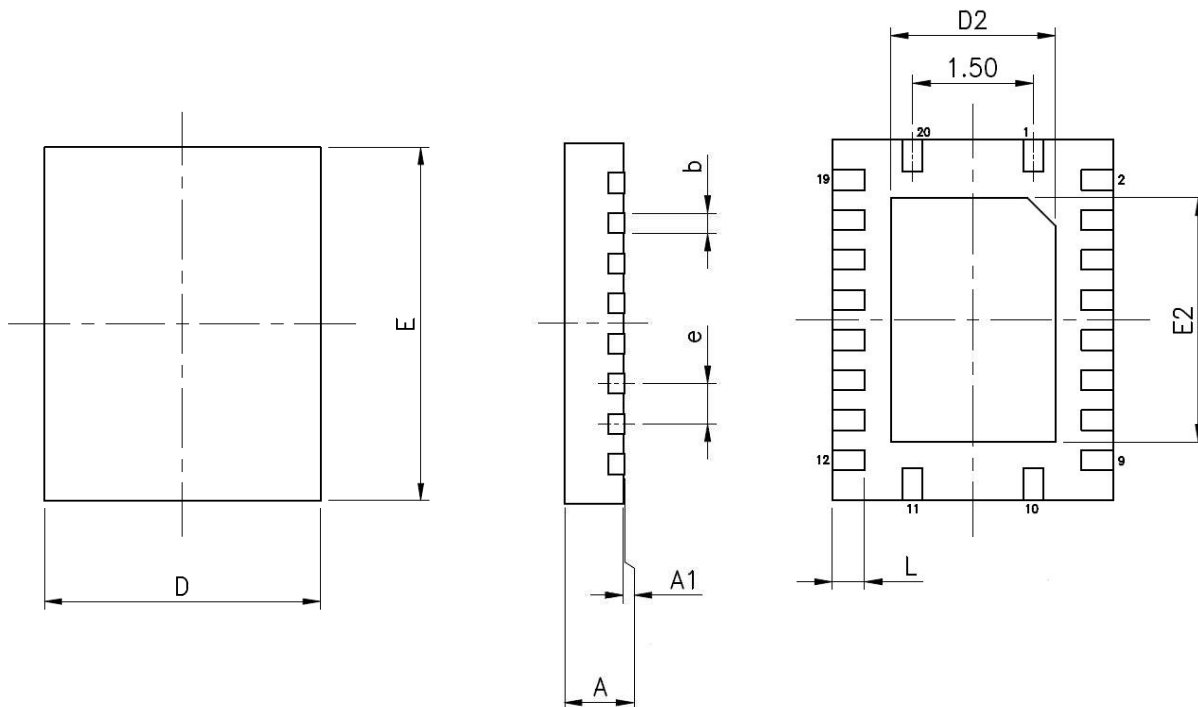
It is important to pay special attention to the PCB layout. The following provides some guidelines.

- 1) To obtain optimal performance, the decoupling capacitor from the input terminal to GND and the output filter capacitor from OUT to GND should be placed as close as possible to the EMC5060, with short trace runs to both signal and GND pins.
- 2) All low-current GND connections should be kept separate from the high-current charge or discharge paths from the battery. Use a single-point ground technique incorporating both the small signal ground path and the power ground path.
- 3) The high-current charge paths into IN and from the BAT and OUT pins must be sized appropriately for the maximum charge current in order to avoid voltage drops in these traces.



Package Information

TQFN-20L 4.5x3.5mm



SYMBOLS	DIMENSION IN MILLIMETER	
	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
b	0.18	0.3
D	3.4	3.6
D2	1.95	2.1
E	4.4	4.6
E2	2.95	3.1
e	0.50 BSC.	
L	0.30	0.50

Revision History

Revision	Date	Description
0.1	2011.07.19	Original
0.2	2011.09.15	Skip maximum & minimum values of low & high temperature sense threshold
0.3	2011.12.02	Modify Package information

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