2A Li-ion/Li Polymer Battery Charger

General Description

The EMC5051 is a highly-integrated battery charger for single-cell Li-ion or Li-polymer batteries capable of operating with an input voltage reached 2.5V.   It is a complete charger device designed to work with an USB port or 5V output AC adapter.

The EMC5051 operates with CC (constant current) mode and CV (constant voltage) mode profiles.   A low-current preconditioning charge mode is also provided as a trickle charging operation. The charge current is programmable up to 2A with an external resistor or a logic input. The charge voltage is 1% accurate over the full application range.

When operating with a current-limited adapter, the charger minimizes the thermal dissipation with pulsed operations to prevent overheat conditions that is commonly occurred with conventional linear chargers. The EMC5051 reduces charge current for thermal fold-back to ensure product safe operation. The charger automatically re-charges the battery when the battery voltage drops blow a recharge threshold. The chip includes a safety timer for setting the fast charge time limit in case of charging a dead battery.

Additional features include preconditioning of an over-discharged battery and charging the battery in a safe temperature range with an NTC thermistor interface. The thermally enhanced TQFN packages are offered for space limited handheld applications.

Features

- Complete Charger for Single-Cell Li-ion Batteries
- Charges from either AC Adapter or USB Port
- Integrated Power Pass Device with Current Sensing
- No External Blocking Diode Required
- Pre-charge Condition with Safety Timing
- 1% Charger Voltage Accuracy
- Programmable Current Limit up to 2A
- Programmable End-of-Charge Current
- Sleep Mode for Power Saving
- Charge Current Thermal Fold-back
- NTC Thermistor Interface for Battery Temperature
- Monitor
- Stand-Alone or Integrated Charger
- Ambient Temperature Range: -40°C to +85°C
- Thermally-Enhanced TQFN-16L 4mmx4mm Packages
- Pb-Free Plus Anneal Available (RoHS Compliant

Applications

- PDAs, Cell Phones and Smart Phones
- Digital Camera, MP3 and Handheld Gamming
- Portable Instruments including Medical Handhelds
- Self-Charging Battery Packs
- Stand-Alone Chargers or USB Port Chargers
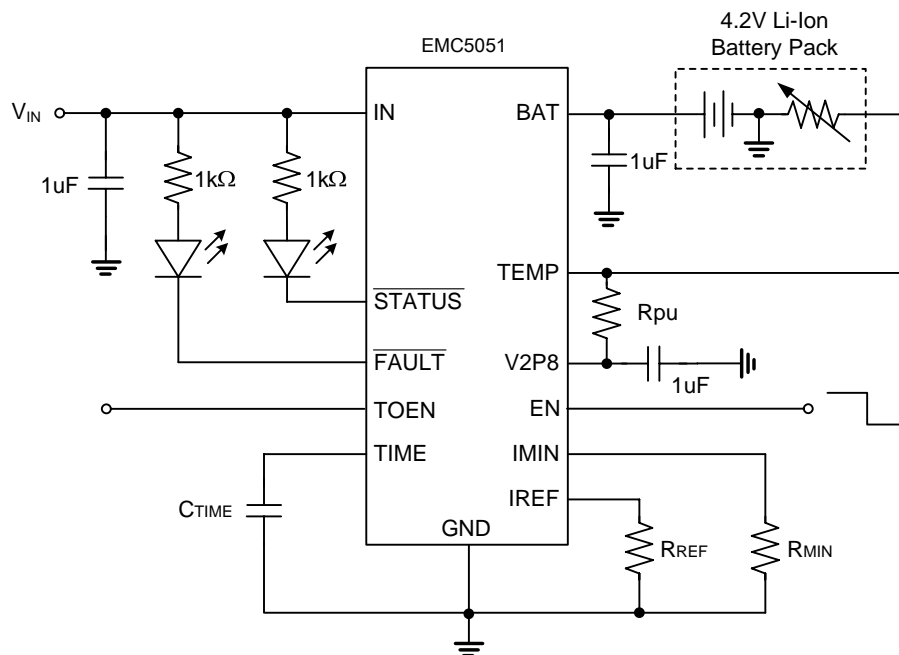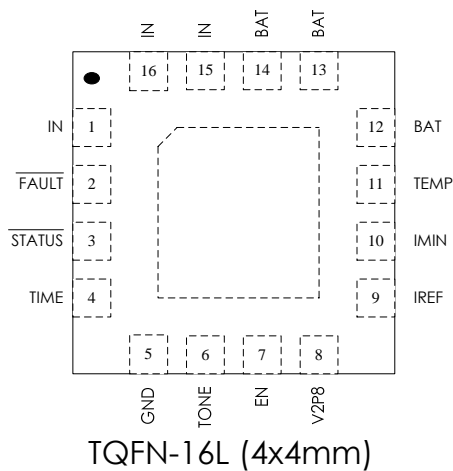
Typical Application

EMC5051

4.2V Li-Ion
Battery Pack

Fig. 1

Package Configuration

TQFN-16L (4x4mm)

EMC5051-42HC16NRR

42	Output Voltage
HC16	TQFN-16L (4x4mm) Package
NRR	RoHS & Halogen free package
	Commercial Grade Temperature
	Rating: -40 to 85°C
	Package in Tape & Reel

Order, Mark & Packing information

Package	Vout(V)	Product ID	Marking	Packing
TQFN-16L (4x4mm)	4.2V	EMC5051-42HC16NRR		Tape & Reel 3K units

Pin Functions

| Pin Name	TQFN-16L	Function
1,15,16	IN	Charger Input Supply Voltage.
2	FAULT	Active-low, open-drain output, capable sinking 5mA current.
3	STATUS	Open-drain pin to show charging and Inhibit states, capable sinking of 5mA current.
4	TIME	Timing capacitor pin for connecting a capacitor to set internal clocking and charger time reference.
5	GND	Ground pin.
6	TOEN	Timeout enable control, high to enable timeout function during charge battery, low to disable TIMEOUT limit with internal 200Kohm pull-up.
7	EN	Chip enable control, high to activate the chip with internal 880Kohm pull-up.
8	V2P8	2.8V reference voltage output, capable drives up to 2mA.
9	IREF	A resistor can be connected at the pin to set the charge current.
10	IMIN	A resistor can be connected at this pin to set End-of-Charge Current.
11	TEMP	Battery Temperature input for NTC thermistor input, can be used for battery removal detection.
12, 13,14	BAT	Connection to the battery positive node.

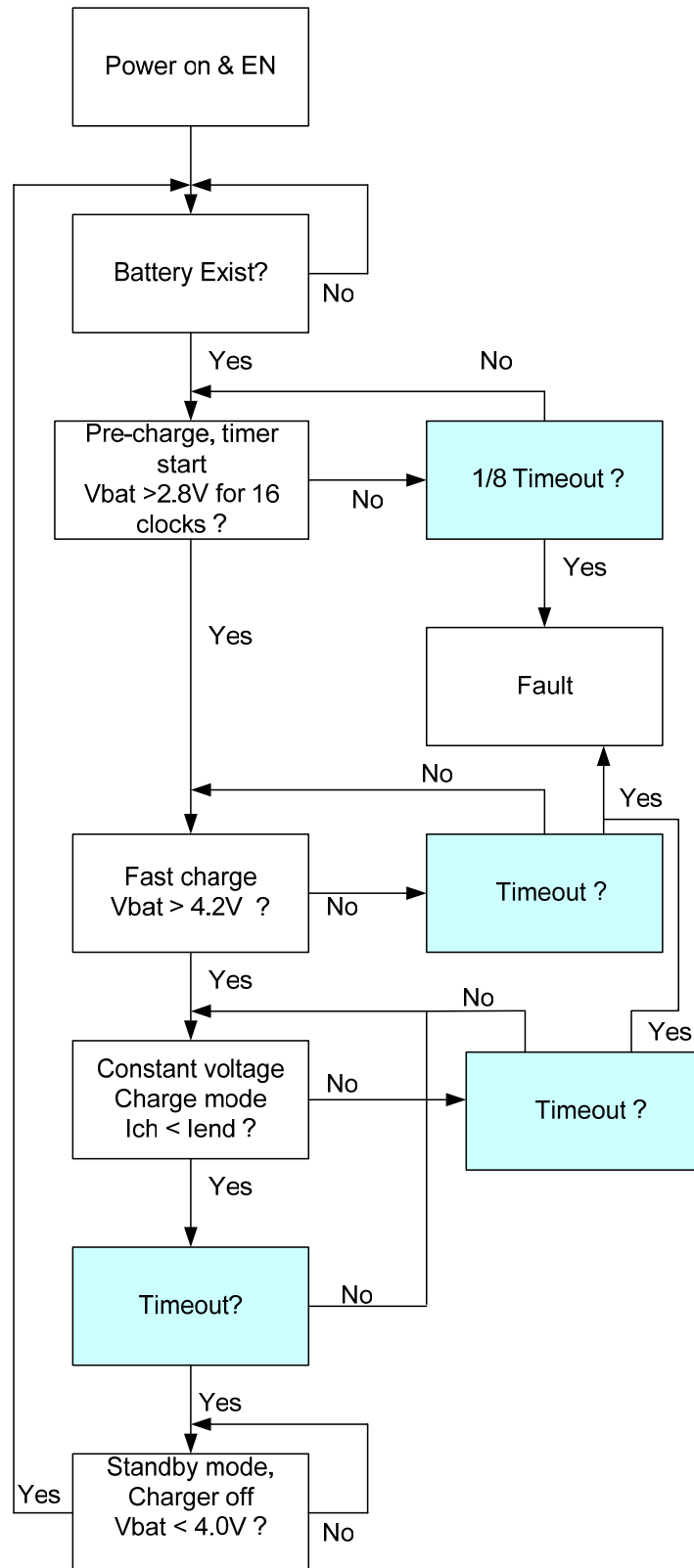## Functional Block Diagram
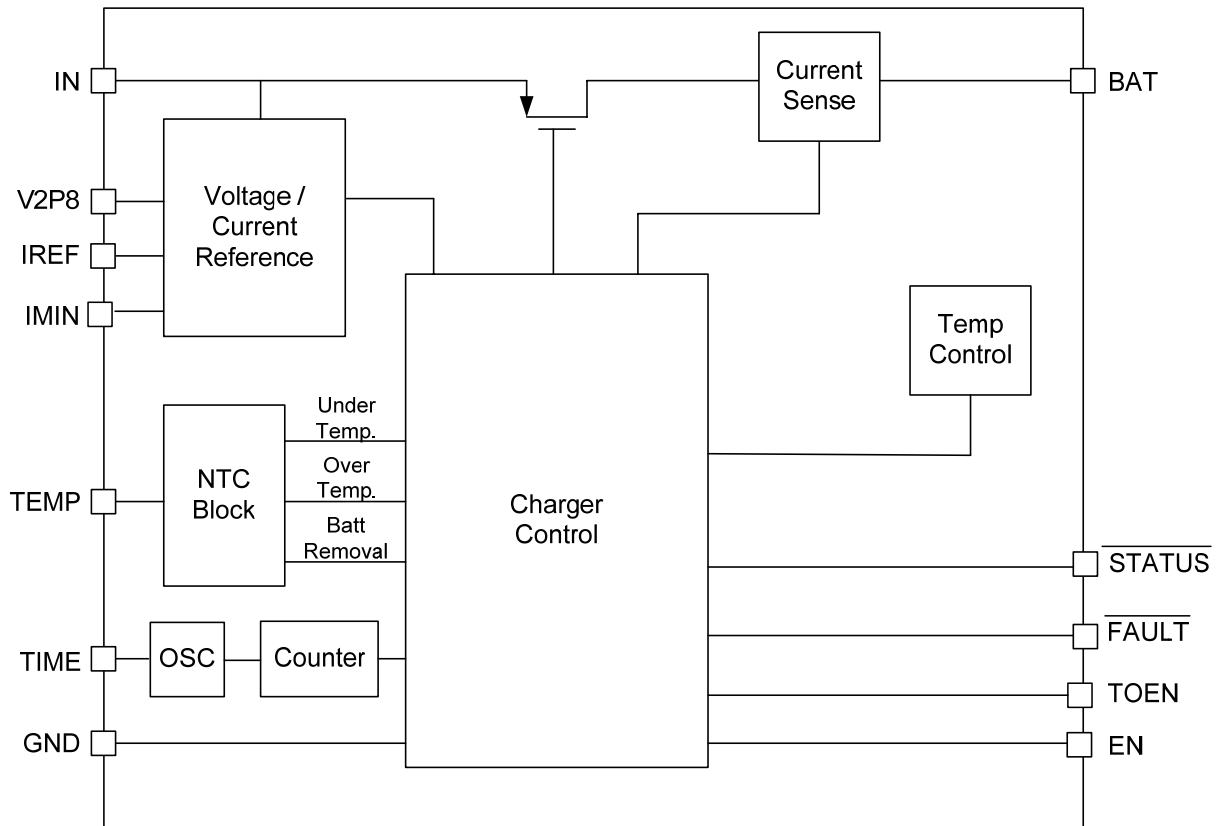
Fig. 2

Charge State Flow Chart

```
                    ┌──────────────────┐
                    │   Power on & EN   │
                    └──────────────────┘
                             │
         ┌───────────────────▼──────────────┐
         │          ┌──────────────────┐     │
         │          │  Battery Exist?  │─────┘
         │          └──────────────────┘   No
         │                   │ Yes
         │                                           No
         │          ┌──────────────────┐     ◄──────────────┐
         │          │ Pre-charge, timer│                     │
         │          │      start       │      ┌──────────────────┐
         │          │ Vbat >2.8V for 16│──────│  1/8 Timeout ?   │
         │          │     clocks ?     │  No  └──────────────────┘
         │          └──────────────────┘              │ Yes
         │                   │ Yes                     ▼
         │                                    ┌──────────────────┐
         │                            No      │      Fault       │
         │          ◄────────────────────────└──────────────────┘
         │                                               ▲ Yes
         │          ┌──────────────────┐   No   ┌──────────────────┐
         │          │   Fast charge    │────────│    Timeout ?     │
         │          │  Vbat > 4.2V  ?  │        └──────────────────┘
         │          └──────────────────┘
         │                   │ Yes                  No
         │          ◄───────────────────────────────────────┐
         │          ┌──────────────────┐  No   ┌──────────────────┐
         │          │ Constant voltage │───────│                  │
         │          │   Charge mode    │       │    Timeout ?     │ Yes
         │          │   Ich < Iend ?   │       └──────────────────┘
         │          └──────────────────┘
         │                   │ Yes
         │          ┌──────────────────┐   No
         │          │    Timeout?      │────────
         │          └──────────────────┘
         │                   │ Yes
         │   Yes    ┌──────────────────┐
         └──────────│  Standby mode,   │
                    │   Charger off    │
                    │  Vbat < 4.0V ?   │  No
                    └──────────────────┘
```

Fig. 3

Absolute Maximum Ratings

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

IN -- $-0.3V$ to $6.5V$
EN -- $-0.3V$ to $V_{IN} + 0.3V$)
Other Pin Voltage -------------------- $-0.3V$ to $(V_{IN} + 0.3V)$
Charger Current --- 2A
Lead Temperature (Soldering, 10 sec)--------------- 260°C

Operating Temperature Range ---------- -40°C to 85°C
Junction Temperature (Note 1) ----------------------- 150°C
Storage Temperature Range ------------ -65°C to 150°C
ESD Susceptibility HBM ------------------------------- 2KV
   MM ------------------------------------ 200V

Thermal data

Package	Thermal resistance	Parameter	Value
TQFN-16L (4x4mm)	θ_{JA} (Note 2)	Junction-ambient	43°C/W
	θ_{JC} (Note 3)	Junction-case	8°C/W

Electrical Characteristics

V_{IN}=5V and T_A = 25°C for the typical values. The maximum and minimum values are over -40°C to +85°C ambient temperature with a supply voltage in the range of 4.6V to 5.5V, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
Input Operating Voltage Range	V_{IN}		4.6	5.0	5.5	V
Power-On Reset						
V_{IN} Rising Voltage			3.2	3.6	3.9	V
V_{IN} falling Voltage			2.25	2.5	2.7	V
Standby Current						
BAT Pin Sink Current	$I_{STANDBY}$	IN floating or EN = LOW	--	--	3.3	uA
IN Pin Supply Current	I_{IN}	BAT floating and EN pulled low	--	30	--	uA
IN Pin Supply Current		BAT floating and EN floating	--	--	1	mA
V_{IN}-V_{BAT} Offset Voltage						
Offset Voltage	V_{OS}	V_{BAT} = 4.2V, I_{BAT} = 20mA, use STATUS pin	--	150	--	mV
Voltage Regulation						
Output Voltage	V_{CH}	Tested at 50mA load, 5V input, and +25°C	4.158	4.2	4.242	V
Dropout Voltage		V_{BAT} = 4.0V, charge current = 0.35A	--	175	--	mV
Charge Current						
Constant Charge Current	I_{CHARGE}	R_{REF} = 100k, V_{BAT} = 3.0V ~4.0V	760	800	840	mA
Trickle Charge Current	$I_{TRICKLE}$	R_{REF} = 100k, V_{BAT} = 2.5V	--	120	--	mA
End-of-Charge Threshold	I_{MIN}	R_{MIN} = 100k	70	80	90	mA
V2P8 Pin Output						
V2P8 Pin Output Voltage	V_{V2P8}	Load current less than 1mA	2.8	2.9	3.0	V
Recharge Threshold						
Recharge Threshold	V_{RECHRG}		3.97	4.05	4.13	V
Recharge Threshold Hysteresis	$V_{RECHHYS}$		--	50	--	mV
Trickle Charge Threshold						
Trickle Threshold Voltage	V_{MIN}		2.7	2.8	2.9	V

Trickle Threshold Hysteresis	V_{MINHYS}		50	100	150	mV
Temperature Monitoring						
High Voltage Threshold	V_{TMAX}	V_{V2P8} = 3.0V	--	2.0	--	V
High Voltage Threshold Hysteresis		V_{V2P8} = 3.0V	--	1.9	--	V
Low Voltage Threshold	V_{TMIN}	V_{V2P8} = 3.0V	--	1	--	V
Low Voltage Threshold Hysteresis		V_{V2P8} = 3.0V	--	1.1	--	V
Threshold Foldback Threshold	T_{FOLD}		--	107	--	°C
Oscillator						
Oscillation Frequency	f_{OSC}	C_{TIME} = 15nF	305	333	370	Hz
Logic Input and Output						
EN/TOEN Pin Logic Input High			1.5	--	--	V
EN/TOEN Pin Logic Input Low			--	--	0.8	V
EN/TOEN Pin Internal Pull-Up				880		Kohm
STATUS/FAULT Output Voltage		10 mA Current	--	--	0.8	V

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℃ on a highly effective thermal conductivity test board (2 layers , 2S0P) 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.

Typical Performance Characteristics

The test conditions for the typical operating performance are: V_{IN} = 5V, T_A = +25°C, R_{REF} = 100kΩ, V_{BAT} = 3.7V, Unless otherwise noted.

Description of Charger Operation

The EMC5051 initiates a charger operation when attached with a voltage source device or adaptor.   Fig. 4 shows a typical charge profile when the chip operates as a conventional linear charger with a constant voltage source. The charging current is set by an external resistor up to 2A. The target charging voltage is 1% accurate over the specified range.

The charger IC resets internal operational circuits when internal Power-on-reset (POR) signal becomes valid. V2P8 presents a voltage reference output source capable driving 2mA current after POR. Other indication output pins are STATUS and FAULT. The STATUS is active low as an open-drain type to indicate a charging cycle and valid till EOC. The FAULT output signal becomes low to signal any occurred fault conditions such as a charging time fault, battery temperature fault or when the battery is detached. When charge with a current-limited adapter, EMC5051 should be programmed with IREF over the upper limit of ILIM.   A typical charge profile is displayed in Fig. 5 for minimizing power dissipation during CC mode.   The worst power dissipation is often at the start of CV mode, although thermal fold-back conditions could still occur in this application case.
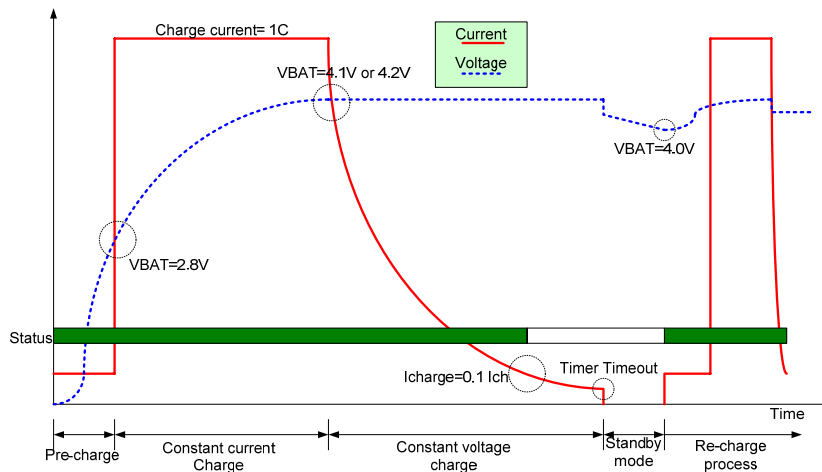
Fig. 4 A typical charger profile as a conventional linear charger
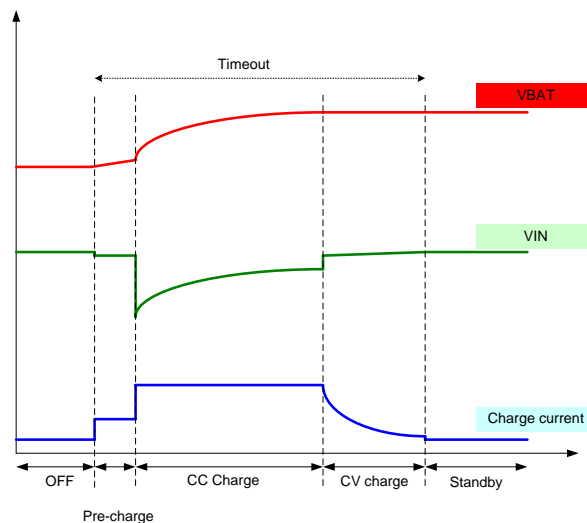
Fig. 5 A typical charge profile with a current-limited adapter

Application Information

One linear charging case, the EMC5051 performs either constant current (CC) and constant voltage (CV) profiles. The charging current is set by an external resistor up to 2A. The target charging voltage is 1% accurate over the specified range. EMC5051 enters a trickle mode for preconditioning operation each time when a charging cycle starts till that the minimum charging voltage is reached and verified in 15 clock cycles.

A thermal-feedback function offers thermal protection during linear charging operations. When the internal temperature EMC5051 goes up above 100 degree C, the charger automatically reduces the

charging current. TEMP pin is examined for charging temperature during the charging operation. The temperature range is determined with an external NTC thermistor. The NTC need have 7:1 for Rcold to

Rhot, once user choose a NTC, the temperature range will be fixed also, then we will have

2.0=3.0*Rcold/(Rpu+Rcold)………
1.0=3.0*Rhot/(Rpu+Rhot)………..

Using these two formulas, we can get Rpu, and also can get Rcold and Rhot refer the NTC table.

EMC5051 provides a TIMEOUT limit to prevent charging a dead battery for extensive time. Recharging is automatically started when batter voltage drop to the recharging threshold point.

EMC5051 enters the shutdown mode in case no voltage adapter is attached.

STATUS	FAULT	Condition
High	High	Power-down, charging is suspended or interrupted
Low	High	Charging
High	Low	Bad battery (Safety timer expired)

Charge current setting

$$I_{ch\arg e} = 0.8 \times \left(\frac{10^5}{R_{REF}} \right)$$ Where R_{REF} in KΩ

Charge timer setting

$$Time = 14 \times \frac{C_{TIME}}{1nF}$$ Where $Time$ in Minutes

End-of-Charge Current setting

$$I_{MIN} = \frac{8000}{R_{MIN}}$$ Where R_{MIN} in KΩ
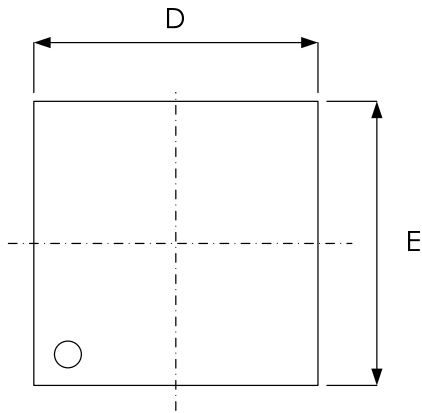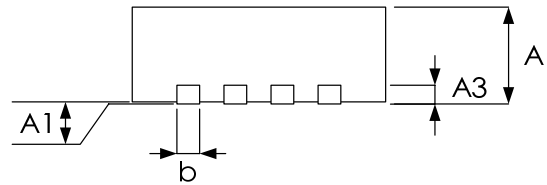
ESMT/EMP

Application Circuit
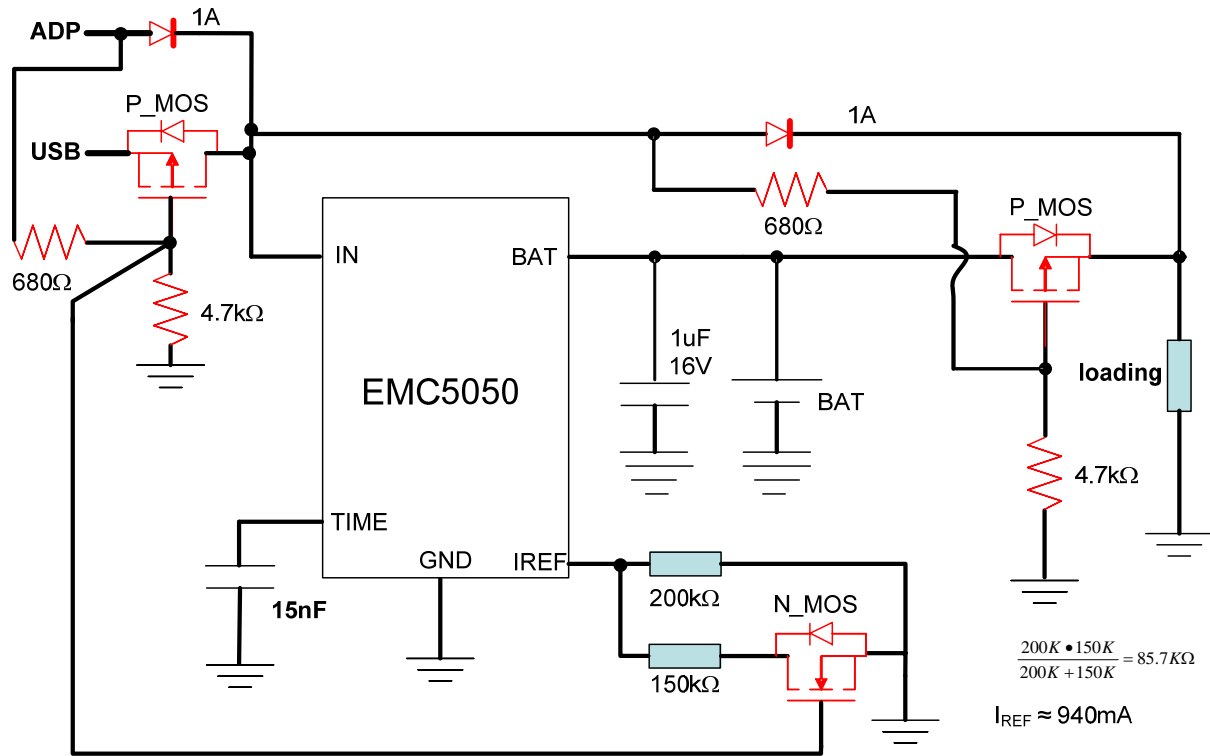
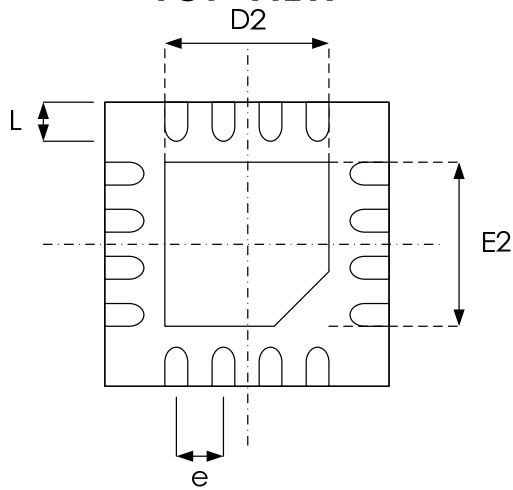
Fig. 6 External Power Path Application Circuit

ESMT/EMP

Package Outline Drawing
TQFN-16L (4x4 mm)

TOP VIEW

SIDE VIEW

BOTTOM VIEW

Symbol	Dimension in mm	
	Min	Max
A	0.70	0.85
A1	0.00	0.05
A3	0.18	0.25
b	0.25	0.35
D	3.95	4.05
E	3.95	4.05
e	0.65 BSC	
L	0.35	0.65

Exposed pad

	Dimension in mm	
	Min	Max
D2	2.00	2.20
E2	2.00	2.20

ESMT/EMP

Revision History

Revision	Date	Description
0.1	2011.05.23	Original.
0.2	2012.04.19	Revise "Package Information"

ESMT/EMP