CONSONANCE

2A, Single-Cell Li-ion Battery Charger IC
CN3798

General Descriptions:

The CN3798 is a highly-integrated switch-mode single-cell lithium ion and lithium polymer battery charger IC that can be powered by photovoltaic cell with few external components.

The CN3798 charges battery with constant current and constant voltage mode. Deeply discharged batteries are automatically trickle charged until the cell voltage exceeds 2.45V. After battery voltage rises above 2.45V, CN3798 enters constant current mode, in which the constant charge current is internally fixed at 2A. In constant voltage mode, the regulation voltage is fixed at 4.2V with ±1% accuracy.

The charge cycle is terminated once the charge current drops to 200mA, and a new charge cycle automatically restarts if the battery voltage falls below 4.06V.

CN3798 will automatically enter sleep mode when input voltage is lower than battery voltage.

Other features include JEITA-compliant battery temperature monitoring, short battery protection, battery over voltage protection, junction over temperature protection and 2 status indications, etc.

CN3798 is available in thermally-enhanced 8-pin SOP package.

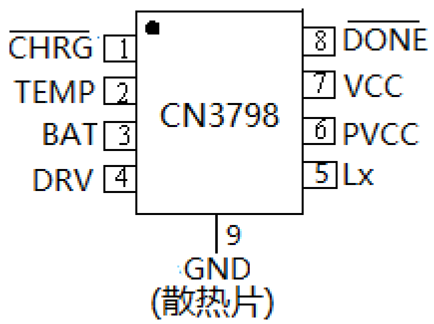
Applications:

- Power Bank
- Hand-held Equipment
- E-Cigarette
- Portable Industrial and Medical Equipment
- Standalone Battery Chargers

Features:

- Input Voltage Range: 4.55V to 6.5V
- Complete Charger IC for single-cell Li-ion and Li-Polymer Battery
- PFM Operation Mode
- Regulation Voltage: 4.2V±1%
- Fixed Charge Current: 2A
- Automatic Charge Current Adjustment according to Loading Capability of Input Supply
- Automatic Conditioning of Deeply Discharged Batteries
- Automatic Recharge
- JEITA-Compliant Battery Temperature Monitoring
- Short Battery Protection
- Battery Over voltage Protection
- 2 Charging Status Indications
- Junction Over Temperature Protection
- Operating Ambient Temperature −40℃ to +85℃
- Available in 8 Pin eSOP Package
- Pb-free, Rohs-Compliant, Halogen Free

Pin Assignment:



Typical Application Circuit:

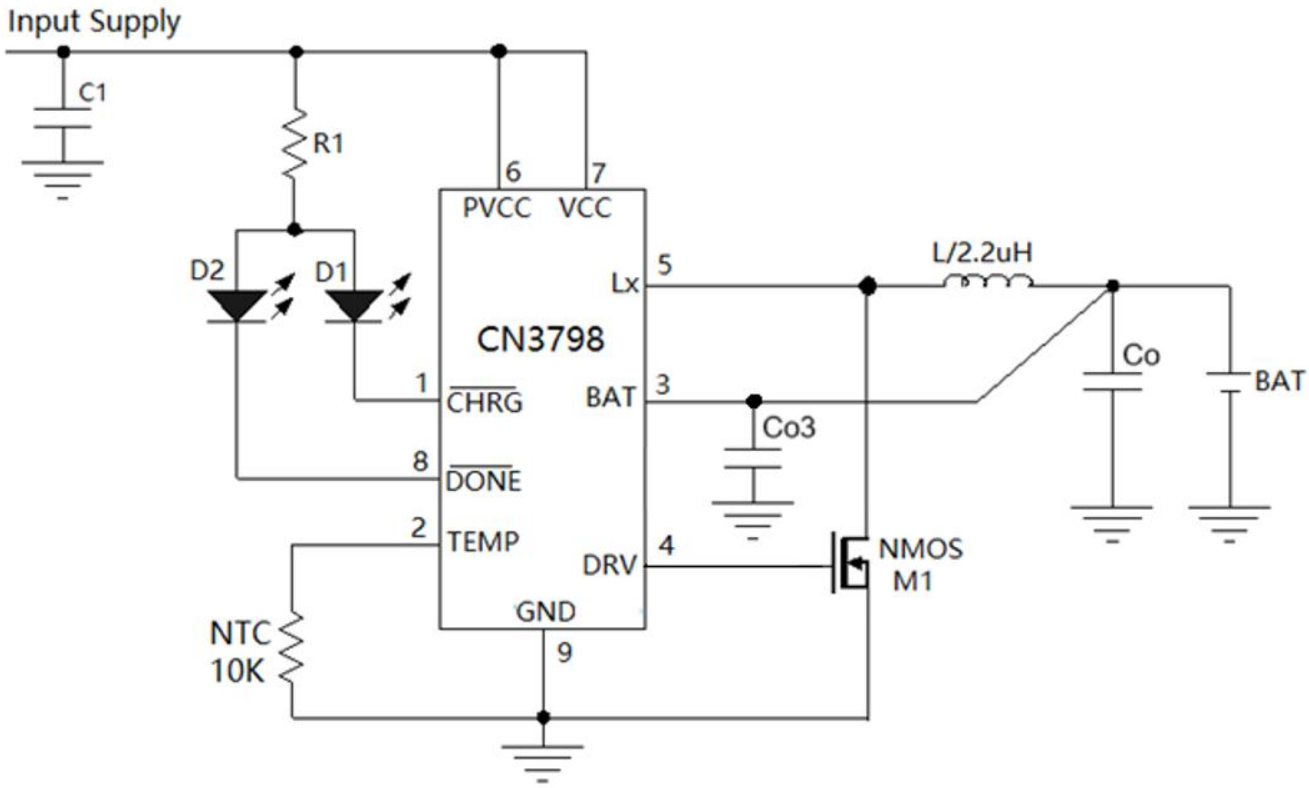


Figure 1　Typical Application Circuit

Ordering Information

Part No.	Package	Top Marking	Shipment	Operating Ambient Temperature
CN3798	eSOP8	CN3798	Tape and Reel, 4000/Reel	－40℃ to ＋85℃

Pin Description:

Pin No.	Name	Descriptions
1	$\overline{\text{CHRG}}$	**Open-Drain Charge Status Output.** When the battery is being charged, this pin is pulled low by an internal switch. Otherwise this pin is in high impedance state.
2	TEMP	**Battery Temperature Monitoring Input.** Connecting a 10KΩ NTC thermistor between TEMP pin and GND. ● If TEMP pin's voltage is below 0.1V or above 0.85V, which means battery is too hot or too cold, charging is suspended. ● If TEMP's voltage is between 0.1V and 0.135V, which means battery is warm, charge current is reduced to 50% of full-scale current and regulation voltage is reduced to 4.06V. ● If TEMP's voltage is between 0.135V and 0.55V, CN3798 functions normally. ● If TEMP's voltage is between 0.55V and 0.85V, which means battery is cool, charge current is reduced to 33% of constant current. If battery temperature monitoring function is not needed, connect a fixed 10K ohm resistor from TEMP pin to GND.
3	BAT	**Positive Terminal of Battery.** Battery voltage is sensed through BAT pin, connect BAT pin to the positive terminal of battery.
4	DRV	**Gate Drive Pin for External N-channel MOSFET.** Connect DRV pin to the gate of external N-channel MOSFET。
5	Lx	**Inductor Connection Pin.** The Lx pin should be connected to inductor input terminal. The charge current flows out of CN3798 from this pin. Internally a high-side power MOSFET is placed between PVCC pin and Lx pin.
6	PVCC	**Power DC Power Supply Input.** PVCC is connected to the high-side power switch internally. The charge current flows into CN3798 during the period of on-time of high-side power switch. Connect at least a 10uF ceramic bypassing capacitor from PVCC to GND and place the capacitor as close as possible to CN3798.
7	VCC	**Analog DC Power Supply Input.** VCC is the power supply for internal circuit. Bypass this pin with a 10uF ceramic capacitor.
8	$\overline{\text{DONE}}$	**Open-Drain Charge Termination Output.** When the charging is terminated, this pin is pulled low by an internal switch. Otherwise this pin is in high impedance state.
9	GND	**Exposed Thermal PAD.** The ground of the CN3798, always solder the exposed thermal PAD on the backside of the IC to ground in PCB.

Absolute Maximum Ratings

VCC, PVCC Voltage…..…………..…−0.3V to 7V
TEMP, BAT Voltage……… −0.3V to VCC+0.3V
Lx…………………………. −0.3V to VCC+0.3V
$\overline{CHRG}$ and $\overline{DONE}$ Voltage……..…. −0.3V to 7V
DRV Voltage..........................−0.3V to VCC+0.3V

Storage Temperature…...............−65℃ to 150℃
Operating Temperature………’....−40℃ to 85℃
Lead Temperature(Soldering, 10s)…..…......260℃
Thermal Resistance (eSOP8)……………100℃/W

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 above 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.

Electrical Characteristics:

(VCC＝5V, T_A＝−40℃ to 85℃, Typical values are at T_A＝+25°C, unless otherwise noted)

Parameters	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	VCC		4.55		6.5	V
Under Voltage Lockout Threshold	V_{UVLO}		2.5	3.0	3.5	V
Operating Current	I_{VCC}	V_{BAT}＝4.3V, No Switching	385	510	635	uA
Regulation Voltage (Constant Voltage Mode)	V_{REG}	Normal Battery Temperature	4.161	4.2	4.242	V
		Battery Warm	4.02	4.06	4.1	
Constant Charge Current	I_{CC}	$V_{PRE}<V_{BAT}<4.2V$	1.6	2	2.4	A
BAT Pin Current		Termination, V_{BAT}＝4.3V	5	9	13	uA
	I_{SLP}	Sleep Mode, V_{BAT}＝4.2V			3	
Trickle Charge Mode						
Precharge Threshold	V_{PRE}	BAT voltage rises	2.35	2.45	2.55	V
Precharge Hysteresis	H_{PRE}	BAT voltage falls		0.14		V
Trickle Charge Current	I_{PRE}	$V_{SRT}<V_{BAT}<V_{PRE}$	80	150	220	mA
Charge Termination						
Termination Threshold	I_{term}	Charge current falls	125	200	280	mA
Recharge						
Recharge Threshold (BAT Voltage Falls)	V_{RECH}	Normal Battery Temperature	3.98	4.06	4.14	V
		Battery Warm	3.77	3.85	3.93	
Battery Short Protection						
Battery Short Threshold	V_{SRT}		0.5	0.9	1.3	V
Battery Short Current	I_{SRT}	V_{BAT}＝0.5V	35	65	95	mA
Battery Over Voltage Protection						
Over Voltage Threshold	Vov	BAT voltage rises	4.29	4.46	4.63	V
Over Voltage Release Threshold	Vclr	BAT voltage falls	4.13	4.29	4.45	

(Continued from last page)

Parameters	Symbol	Test Conditions	Min	Typ	Max	Unit
Junction Over Temperature Protection						
Over Temperature Threshold		Junction Temperature rises		145		℃
Over Temperature		Junction Temperature falls		125		℃
TEMP Pin						
TEMP Current	I_{TEMP}		27	30	33	uA
Cold Threshold	V_{COLD}	V_{TEMP} rises, cool to cold	800	850	900	mV
Cold Release Threshold	V_{COLDR}	V_{TENP} falls, cold to cool	755	805	855	mV
Cool Threshold	V_{COOL}	V_{TEMP} rises, normal to cool	510	550	590	mV
Cool Release Threshold	V_{COOLR}	V_{TENP} falls, cool to normal	465	505	545	mV
Warm Threshold	V_{WARM}	V_{TENP} falls, normal to warm	120	135	150	mV
Warm Release Threshold	V_{WARMR}	V_{TEMP} rises, warm to normal	138	155	172	mV
Hot Threshold	V_{HOT}	V_{TENP} falls, warm to hot	85	100	115	mV
Hot Release Threshold	V_{HOTR}	V_{TEMP} rises, hot to warm	105	120	135	mV
$\overline{\text{CHRG}}$ Pin						
$\overline{\text{CHRG}}$ Sink Current	I_{CHRG}	V_{CHRG}＝1V,Charging status	7	12	18	mA
$\overline{\text{CHRG}}$ Leakage Current	I_{LK1}	V_{CHRG}＝6.5V, Termination			1	uA
$\overline{\text{DONE}}$ Pin						
$\overline{\text{DONE}}$ Sink Current	I_{DONE}	V_{DONE}＝1V, Termination	7	12	18	mA
$\overline{\text{DONE}}$ Leakage Current	I_{LK2}	V_{DONE}＝6.5V, charge mode			1	uA
Sleep Mode						
Sleep Mode Threshold	V_{SLP}	VCC falls, Test VCC－V_{BAT}	0.01	0.03	0.05	V
Sleep Mode Release Threshold	V_{SLPR}	VCC rises, Test VCC－V_{BAT}	0.04	0.075	0.11	V

Detailed Description:

The CN3798 is a highly-integrated constant current, constant voltage single-cell Li-ion and Li-polymer battery charger IC that can be powered by the photovoltaic cell. The device adopts PFM step-down (buck) switching architecture. The charge current is internally fixed at 2A. The final battery regulation voltage in constant voltage mode is set at 4.2V typical with 1% accuracy.

A charge cycle begins when the voltage at the VCC pin meets the following 3 conditions:

- VCC rises above V_{UVLO}
- VCC is higher than battery voltage by V_{SLPR}
- VCC is no less than 4.55V

At the beginning of the charge cycle, if the battery voltage is less than precharge threshold (2.45V typical), the charger goes into trickle charge mode. The trickle charge current is internally set to 150mA, and will be further reduced to 65mA if battery voltage is below 0.9V typical, which is considered as short battery. When the battery voltage exceeds precharge threshold, the charger goes into the full-scale constant current charge mode. When the battery voltage approaches the regulation voltage, the charger goes into constant voltage mode, and the charge current will start to decrease. When the charge current drops to termination threshold (200mA typical), the charge cycle is terminated, and $\overline{\text{CHRG}}$ pin outputs high impedance, $\overline{\text{DONE}}$ pin outputs logic low to indicate termination status.

To restart the charge cycle, just remove and reapply the input supply. Also, a new charge cycle will begin if the battery voltage drops below the recharge threshold (4.06V typical).

When the input supply is not present, the charger automatically enters sleep mode.

To prevent the chip from being damaged by thermal run-away, junction over temperature protection is included. If the junction temperature is over 145℃, the internal power switches are turned off, no current flows to battery. The over temperature protection mode will not be released until the junction temperature falls below 125℃.

An overvoltage protection guards against battery voltage transient overshoot. In this case, the internal high-side switch is turned off until the over-voltage condition is cleared. This feature is useful for battery load dump or sudden removal of battery.

The charging profile is shown in Figure 2.

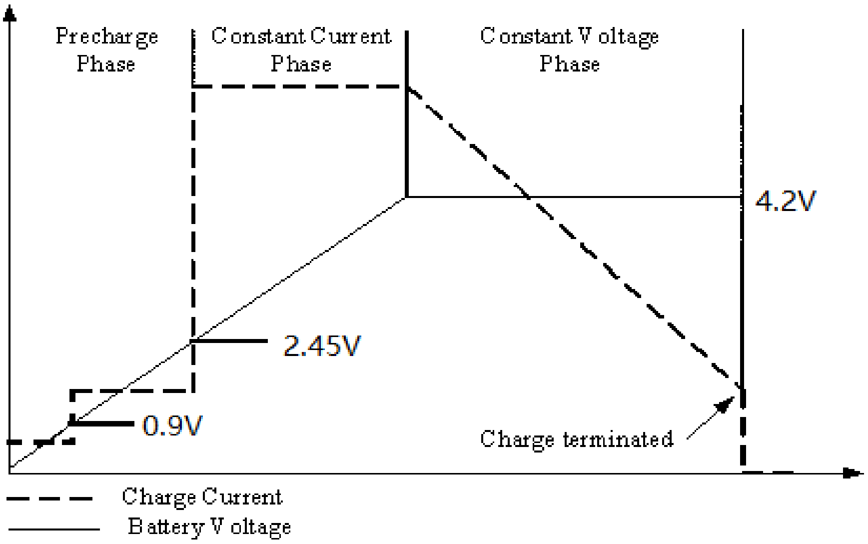


Figure 2 The Charging Profile

Application Information

Under voltage Lockout (UVLO)

An under voltage lockout circuit monitors the input supply and keeps the CN3798 off if VCC is below 3.5V.

A charge cycle will not be started unless the following 3 conditions are met simultaneously:

- VCC rises above V_{UVLO}
- VCC is higher than battery voltage by V_{SLPR}
- VCC is no less than 4.55V

Short Battery Protection

When the battery voltage is below short battery threshold (V_{SRT}), it is considered as the short battery condition, and the charge current is reduced to about 65mA as a kind of protection mechanism for battery.

Trickle Charge Mode (Precharge Mode)

At the beginning of a charge cycle, if the battery voltage is between short battery threshold (V_{SRT}) and precharge threshold (2.45V typical), the charger goes into trickle charge mode with the charge current set at about 150mA.

Constant Charge Current

When battery voltage is between precharge threshold V_{PRE} (2.45V typical) and V_{REG} (4.2V typical), CN3798 is in constant charge mode, in which charge current is internally fixed at 2A.

Automatic Charge Current Adjustment

If the loading capability of input power supply is less than the requirement of 2A charge current, then the on-chip adaptive cell will begin to function to reduce the charge current based on the loading capability of input supply. In this case, the charge current is maximized to the loading capability of input supply, the voltage at VCC pin is regulated at 4.55V maximum, which is the minimum operating voltage of CN3798.

Charge Termination

In constant voltage mode, the charge current decreases gradually. When the charge current drops below termination threshold (200mA typical), the charging is terminated, the high-side switch is turned off, no charge current is delivered to battery.

Automatic Recharge

After the charge cycle is completed and both the battery and the input supply (wall adapter) are still present, a new charge cycle will begin if the battery voltage drops below recharge threshold (4.06V typical) due to self-discharge or external loading. This will keep the battery capacity at more than 80% at all times without manually restarting the charge cycle.

Battery Over-Voltage Protection

The CN3798 will turn off the high-side switch if the battery voltage rises above over voltage threshold (4.46V typical), and the high-side switch will not be allowed to turn-on again until the battery voltage falls below 4.29V typical. This allows one-cycle response to an over-voltage condition which often occurs when the load is removed or the battery is disconnected suddenly.

Over-Temperature Protection

The CN3798 continuously monitors its junction temperature during charging process. If the junction temperature rises above 145℃, the on-chip high-side switch is turned off, and no current flows to battery. The high-side switch will not be allowed to turn on again until the junction temperature falls below 125℃.

Sleep Mode

If the voltage at VCC pin drops below $V_{BAT}+V_{SLP}$, the CN3798 will enter sleep mode. In sleep mode, the whole chip is shut down, the current consumption from battery is 3uA (Max.). The CN3798 will not come out of sleep mode until the voltage at VCC pin rises above $V_{BAT}+V_{SLPR}$.

Status Indication

The CN3798 has 2 open-drain status outputs: $\overline{CHRG}$ and $\overline{DONE}$. $\overline{CHRG}$ pin is pulled low when the charger is in charging status, otherwise $\overline{CHRG}$ pin becomes high impedance. $\overline{DONE}$ pin is pulled low if the charger is in termination status, otherwise $\overline{DONE}$ pin becomes high impedance.

When the battery is not present, the charger charges the output capacitor to the regulation voltage or to over voltage threshold quickly depending on the output capacitance, then the BAT pin's voltage decays slowly to recharge threshold because of low leakage current at BAT pin, which results in a ripple waveform at BAT pin.

The $\overline{CHRG}$ or $\overline{DONE}$ open drain status output that is not used should be tied to ground.

The table 1 lists the two indicator status and its corresponding charging status. It is supposed that red LED is connected to $\overline{CHRG}$ pin and green LED is connected to $\overline{DONE}$ pin.

$\overline{CHRG}$ pin	$\overline{DONE}$ pin	State Description
Low(Red LED on)	High Impedance(Green LED off)	Charging
High Impedance(Red LED off)	Low(Green LED on)	Charge termination
Pulse (Red LED looks like being off)	Pulse (Green LED on or blinking)	Battery not present
High Impedance(Red LED off)	High Impedance(Green LED off)	There are 3 possible reasons: ● The voltage at the VCC pin below 4.55V or ● The voltage at the VCC pin below V_{BAT} ● Battery temperature hot or cold

Table 1 Indication Status

Battery Temperature Monitoring

To prevent the damage caused by the very high or very low temperature done to the battery, the CN3798 continuously monitor battery temperature by measuring the voltage at TEMP pin which is determined by TEMP pin's source current (30uA typical) and a 10KΩ negative temperature coefficient (NTC) thermistor connected between TEMP pin and GND as shown in Figure 1.

If battery temperature monitoring function is not needed, connect a fixed 10KΩ resistor from TEMP to GND.

The battery temperature monitoring function for CN3798 is designed to follow the JEITA standard; charge current or charge termination voltage is reduced based on battery temperature ranges.

There are totally five battery temperature ranges for CN3798:

- Hot: Above 55℃,
- Warm: 45℃ to 55℃,
- Normal: 10℃ to 45℃
- Cool: 0℃ to 10℃,
- Cold: Below 0℃.

Normal operation occurs when battery temperature is between 10℃ and 45℃, charge current and voltage will be the normal values.

When battery is in the Cool temperature range, which is between 0℃ and 10℃, the charge current is 33% of full-scale charge current and charge regulation voltage is not changed.

When the battery is in the Warm temperature range, which is between 45℃ and 55℃, the charge current is reduced to 50% of full-scale charge current and charge regulation voltage is reduced to 4.06V (Typical).

Charging is suspended if battery temperature is below Cold temperature of 0℃ or above Hot temperature of 55℃. When charging is suspended, both $\overline{CHRG}$ and $\overline{DONE}$ pin becomes high impedance state.

Once battery temperature is not in hot range and cold range, charging resumes automatically.

TEMP pin voltage is the product of its source current and NTC's resistance, so the selection of NTC should make sure TEMP pin voltage meet the requirements of hot, warm, cool and cold threshold. An NTC of nominal resistance 10KΩ at room temperature may be suitable for CN3798.

A resistor of small resistance in series with NTC thermistor and a resistor of large resistance in parallel with NTC thermistor can fine tune CN3798's temperature range.

The following table lists TEMP pin voltage, charge current and termination voltage in the above-mentioned 5 battery temperature range.

Battery Temperature Range	TEMP Pin Voltage	Charge Current	Regulation Voltage
Hot: above 55℃	V_{TEMP}<V_{HOT}	Charge Suspended	Charge Suspended
Warm: 45℃ to 55℃	V_{HOTR}<V_{TEMP}<V_{WARM}	50%*I_{CC}	4.06V
Normal: 10℃ to 45℃	V_{WARMR}<V_{TEMP}<V_{COOLR}	Normal Value	4.2V
Cool: 0℃ to 10℃	V_{COOL}<V_{TEMP}<V_{COLDR}	33%*I_{CC}	4.2V
Cold: below 0℃	V_{TEMP}>V_{COLD}	Charge Suspended	Charge Suspended

Input Capacitor

Since the input capacitor (C1 in Figure 1) is assumed to absorb all input switching ripple current in the converter, it must have an adequate ripple current rating. Worst-case RMS ripple current is approximately one-half of charge current (2A typical).

The input capacitance depends on input supply's characteristics and cable length, etc. Generally a 10uF to 22uF ceramic capacitor can meet the requirements. Cares must be taken that some ceramic capacitors exhibit large voltage coefficient, which may lead to lower capacitance when a DC voltage is applied. In this case, the capacitor value should be increased properly, and the capacitor's package should be 0805 at least.

If electrolytic capacitor is used, then a ceramic capacitor of 1uF to 10uF should be placed in parallel with the electrolytic capacitor to filter out the high-frequency noise.

Output Capacitor

To ensure CN3798's proper operation, at least 2 bypassing capacitors are needed at output.

The first capacitor is for the bypassing of CN3798's BAT pin (Pin 3), this capacitor is to ensure the correct sampling of battery voltage, C_{O3} in Figure 1 is the capacitor. A ceramic capacitor of at least 1uF for C_{O3} can meet the requirement. In PCB design, C_{O3} should be placed as close as possible to BAT pin (Pin 3).

The selection of second output capacitor (C_O in Figure 1) is primarily determined by the ESR required to minimize ripple voltage and load step transients. A low-ESR ceramic capacitor of 10uF to 22uF should be used as the output capacitor.

Cares must be taken that some ceramic capacitors exhibit large voltage coefficient, which may lead to lower capacitance when a DC voltage is applied. In this case, the capacitor value should be increased properly, and the capacitor's package should be 0805 at least.

If electrolytic capacitor is used for C_O, then a ceramic capacitor of 1uF to 10uF should be placed in parallel with the electrolytic capacitor to filter out the high-frequency noise.

Inductor Selection

Generally a 2.2uH inductor with over 3.5A I_{SAT} and less-than-40mohm DCR is suitable for most applications.

N-channel MOSFET Selection

CN3798 needs an external N-channel MOSFET (M1 in Figure 1) as rectifier power switch. The following 4 parameters should be given special considerations when selecting the N-channel MOSFET:

- Turn-on Threshold Vth
  Since CN3798's minimum operating voltage is 4.55V, the N-channel MOSFET's turn-on threshold should be low enough so that the N-channel MOSFET can be fully turned on at VCC of 4.55V.
- On-resistance Rds(on)
  The on-resistance Rds(on) of the N-channel MOSFET should be between 18mΩ and 50mΩ.
- Total Gate Charge Qg and Reverse Transfer Capacitance C_{RSS}
  On the condition that the on-resistance Rds(on) meets the above-mentioned condition, the total gate charge Qg and reverse transfer capacitance C_{RSS} should be chosen as small as possible.
- Continuous Drain Current I_D
  The continuous drain current I_D should be no less than 1.5A.

The N-channel MOSFET CN30N06 is the suitable candidate for most applications.

Hot Plug-in Consideration

During adapter hot plug-in, the parasitic inductance from the adapter cable and the input capacitor form a second order system. The transient voltage spike at the VCC pin may be beyond the IC maximum voltage rating and damage the IC.

The following 3 methods may be adopted to damping or limiting the over-voltage spike during adapter hot plug-in.

(1) An electrolytic capacitor with high ESR as input bypassing capacitor.

(2) A TVS diode is used between VCC(PVCC) and GND.

(3) Add over voltage protection circuit at VCC and PVCC

Considerations for Battery Inductive Load

If inductive load such as motor, or step-up DC-DC converter is connected to battery, the following 2 measures should be adopted to prevent CN3798 from being damaged by counter electromotive force generated when the inductive load is being turned off.

(1) Add an 1Kohm resistor between CN3798's BAT pin and battery positive terminal.

(2) Add a schottky diode between battery positive terminal and GND. The diode's anode should be connected to GND.

PCB Layout Considerations

When laying out the printed circuit board, the following considerations should be taken to ensure proper operation of the IC.

(1) Place input bypassing capacitor as close as possible to VCC pin and PVCC pin. The traces should be as short as possible.

(2) It is critical that the exposed thermal pad on the backside of the IC package be soldered to the PCB ground. The exposed thermal pad is analog ground, and should return to system ground separately.

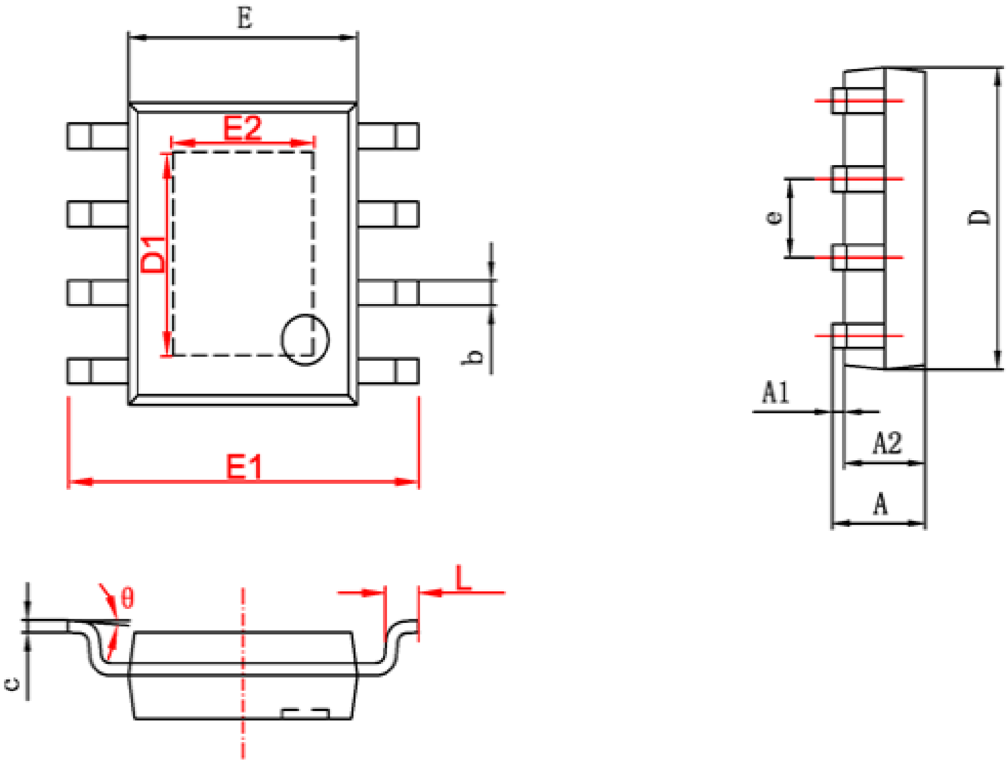
(3) The capacitor C_{O3} in Figure 1 should be placed as close as possible to BAT pin (Pin 3), its grounding terminal should be tied to analog GND.

(4) The input capacitor, inductor and output capacitor should be placed on the same layer of the PCB instead of on different layers and using vias to make this connection.

(5) Place the inductor input terminal as close as possible to the Lx pin, and place inductor's output terminal as close as possible to output capacitor. Minimize the copper area of inductor's traces to lower electrical and magnetic field radiation, but make the trace wide enough to carry the charging current. Minimize parasitic capacitance from this area to any other trace or plane.

(6) Output capacitor ground terminal and source of N-channel MOSFET need to be tied to the same copper that connects to the input capacitor ground terminal before returning to system ground separately as power ground.

Package Information (eSOP8)



字符	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Important Notice

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