NCP1835

Integrated Li-Ion Charger

NCP1835 is an integrated linear charger specifically designed to charge 1 cell Li Ion batteries with a constant current, constant voltage (CCCV) profile. It can charge at currents of up to 1.0 A.

Its low input voltage capability, adjustable charge current, ability to maintain regulation without a battery, and its onboard thermal foldback make it versatile enough to charge from a variety of wall adapters. The NCP1835 can charge from a standard voltage source wall adapter as a CCCV charger, or from a current limited adapter to limit power dissipation in the pass device.

Features

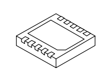
- Integrated Voltage and Current Regulation
- No External MOSFET, Sense Resistor or Blocking Diode Required
- Charge Current Thermal Foldback
- Integrated Pre charge Current for Conditioning Deeply Discharged Battery
- Integrated End of Charge (EOC) Detection
- 1% Voltage Regulation
- 4.2 V or 4.242 V Regulated Output Voltage
- Regulation Maintained without a Battery Present
- Programmable Full Charge Current 300 1000 mA
- Open Drain Charger Status and Fault Alert Flags
- 2.8 V Output for AC Present Indication and Powering Charging Subsystems
- Minimum Input Voltage of 2.4 V Allows Use of Current Limited Adapters
- Automatically Recharging if Battery Voltage Drops after Charging Cycle is Completed
- Low Profile 3x3 mm DFN Package
- Pb Free Packages are Available

Typical Applications

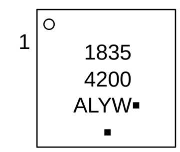
- Cellular Phones
- PDAs, MP3 Players
- Stand Alone Chargers
- Battery Operated Devices

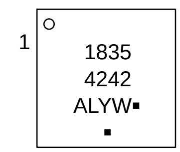
http://onsemi.com

MARKING DIAGRAMS



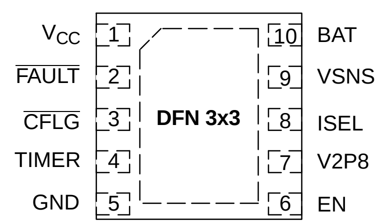
DFN 3x3
MN SUFFIX
CASE 485C





1835 = Device Code
4200 = 4.2 V
4242 = 4.242 V
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package
(Note: Microdot may be in either location)

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 15 of this data sheet.

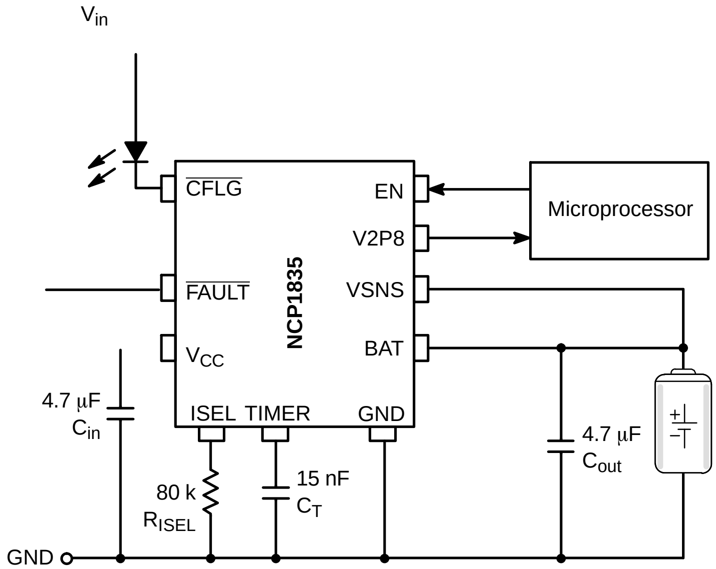


Figure 1. Typical Aa9t39 33 ta2.4 9.36 c1 07 35.476 .8(ypical 0 lS 1 0 0 1 6.24 15 0 1 6.24 15 0

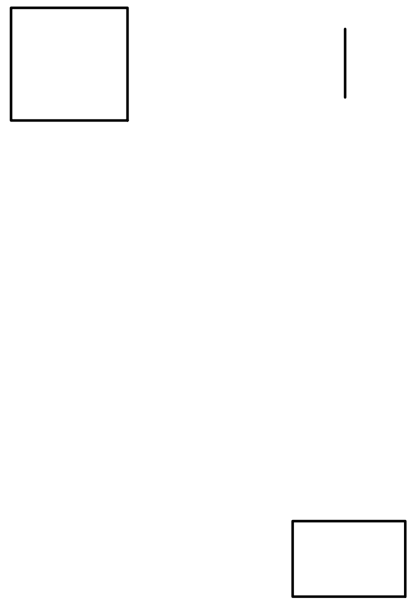


Figure 2. Detailed Block Diagram

ELECTRICAL CHARACTERISTICS (Typical values are tested at V_{CC} = 5.0 V and room temperature, maximum and minimum values are guaranteed over 0°C to 70°C with a supply voltage in the range of 4.3 V to 6.5 V, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
V_{CC} SUPPLY					
Operating Supply Range	V_{CC}	2.8	–	6.5	V
Rising V_{CC} Threshold	V_{RISE}	3.0	3.4	3.95	V
Falling V_{CC} Lockout Threshold	V_{FALL}	2.0	2.4	2.8	V
Quiescent V_{CC} Pin Supply Current Shutdown (EN = Low) Normal Operation (EN = High)	 I_{VCC} I_{VCC}	 – –	 30 1.0	 – –	 μA mA
Battery Drain Current Manual Shutdown (V_{CC} = 5.0 V, VSNS = 4.0 V, EN = Low)	I_{BMS}	–	–	3.0	μA
CHARGING PERFORMANCE					
Regulated Output Voltage in Constant Voltage (CV) Mode 4.2 V Version, I_{CHG} = 10 mA 4.242 V Version, I_{CHG} = 10 mA					

TYPICAL OPERATING CHARACTERISTICS

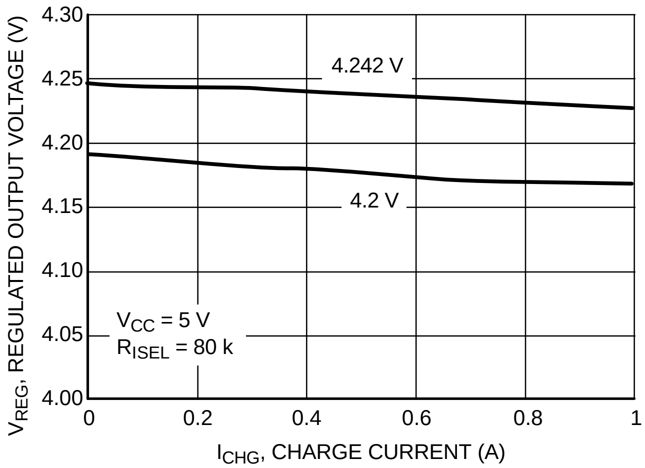


Figure 3. Regulated Output Voltage vs. Charge Current

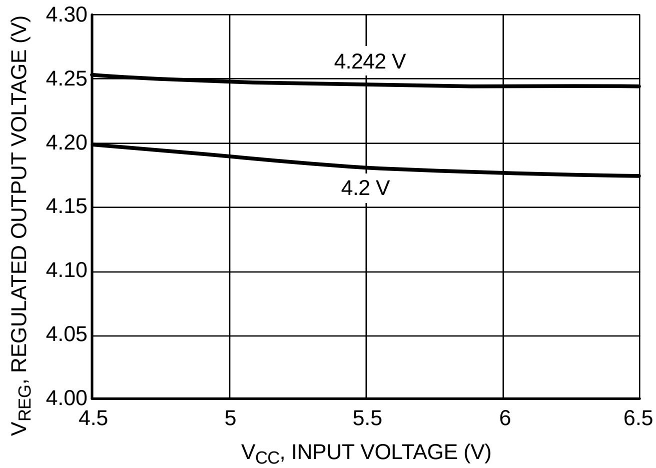


Figure 4. Regulated Output Voltage (floating) vs. Input Voltage

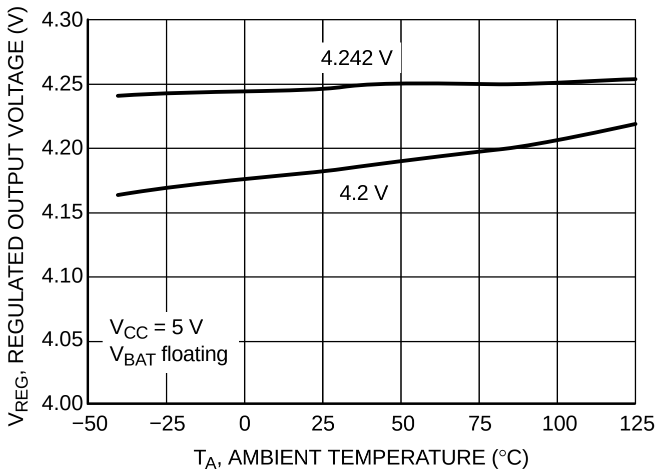


Figure 5. Regulated Output Voltage vs. Temperature

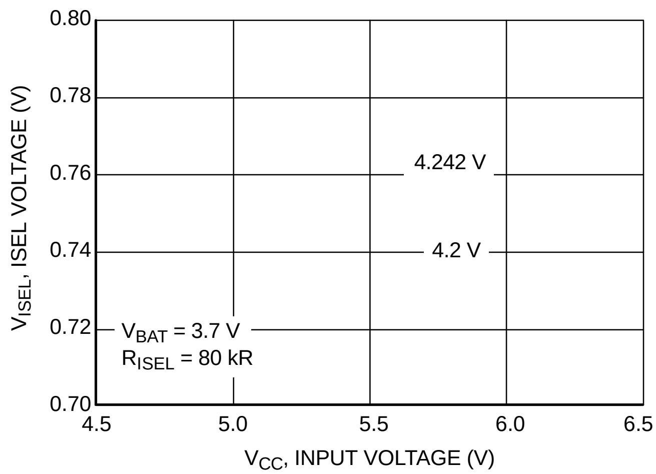


Figure 6. ISEL Voltage vs. Input Voltage

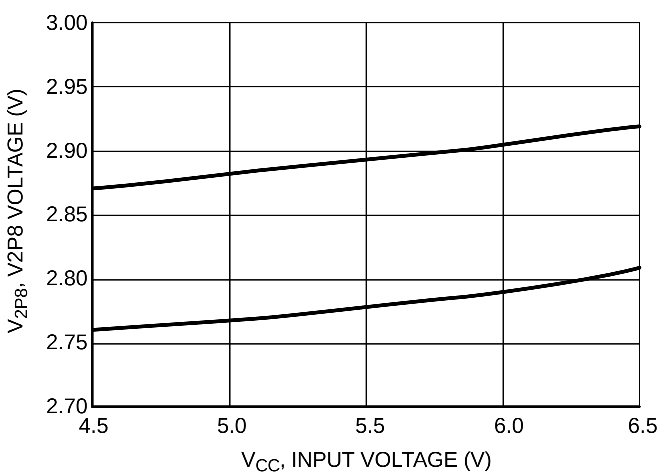
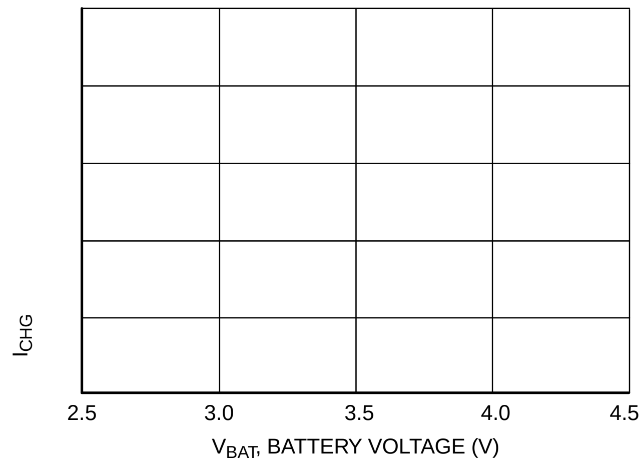


Figure 7. V2P8 Voltage vs. Input Voltage

TYPICAL OPERATING CHARACTERISTICS



DETAILED OPERATING DESCRIPTION

Overview

Rechargeable Li Ion/Polymer batteries are normally charged with a constant current (CC) until the terminal voltage reaches a fixed voltage threshold, at which point a constant voltage (CV) is applied and the current drawn by the battery decays. The charging rate is determined by the specific rating of the battery. For example, if the battery is rated at 800 mA hours, then the recommended maximum charge rate is 800 mA. For a severely discharged cell, it takes approximately 2.5 3.5 hours to recharge the battery at the maximum rate. So, when one charges at less than the maximum charge rate, the recharge time increases. Also, the battery should not be continuously charged or the battery could age faster than necessary. Because of this, Li Ion charging systems need to stop charging within a prescribed time limit regardless of the charge rate.

The NCP1835 is a fully integrated, stand alone 1 cell Li Ion charger which performs the primary battery charging functions and includes a timer which will terminate charging if the battery has not completed charging within a prescribed time period. The charging rate is user programmable up to 1.0 A and the end of charge timer is also programmable. The NCP1835 has a thermal foldback loop which reduces the charge rate if the junction temperature is exceeded. The device also includes several outputs which can be used to drive LED indicators or interface to a microprocessor to provide status information. The adapter providing power to the charger can be a standard fixed output voltage such as a 5.0 V wall adapter or it can be a simple current limited adapter.

The NCP1835 comes in two versions with output voltage regulation thresholds of 4.2 or 4.242 V depending on the requirements of the specific battery pack being used. The user determines the charge current by selecting the resistor R_{ISEL} and determines the length of the end of charge timeout timer by selecting the capacitor, C_{TIME}.

Charging Operation

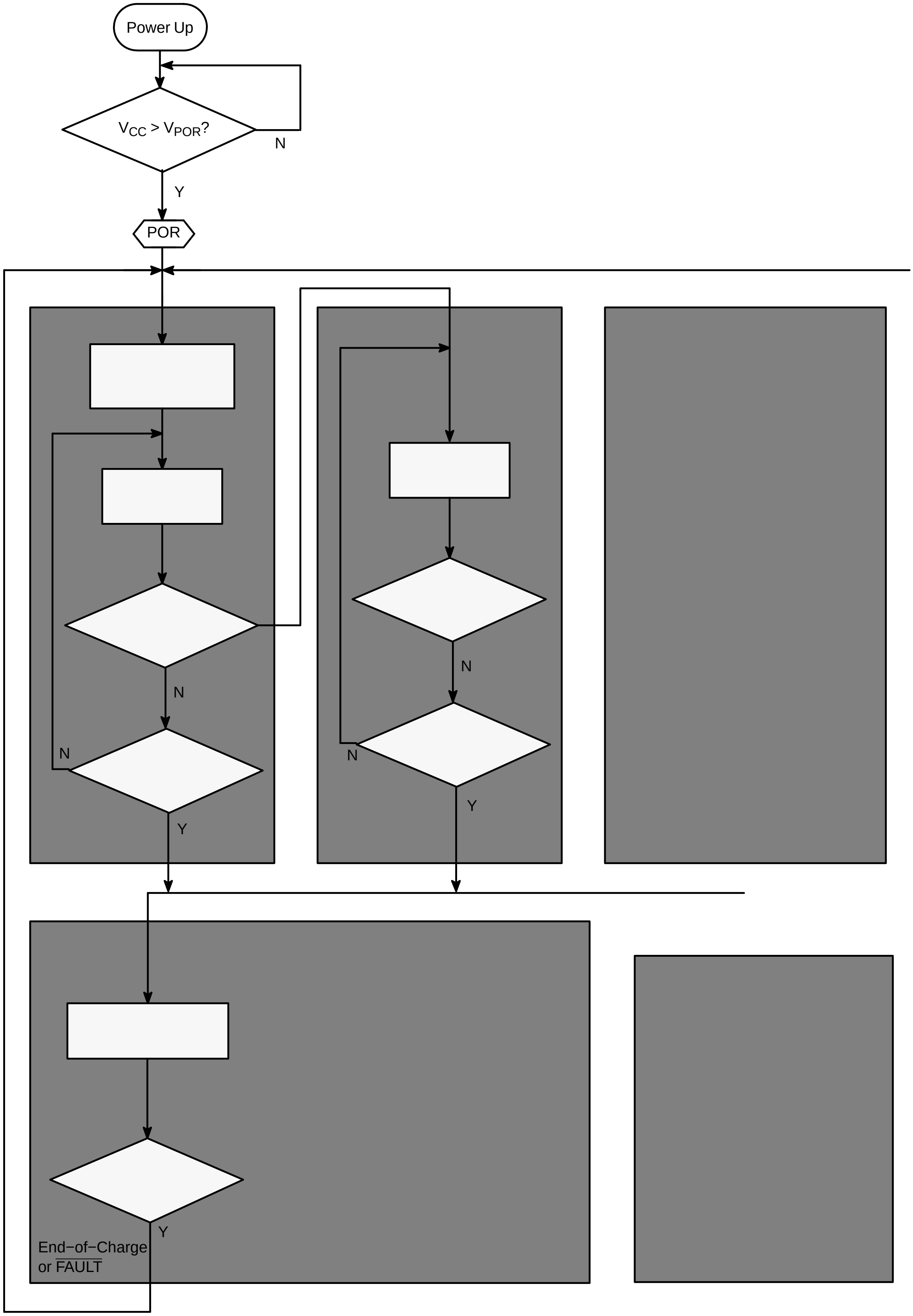
Figure 13 outlines the charging algorithm of the NCP1835 and Figure 14 graphically illustrates this. When the charger is powered up and the input voltage rises above the power on, rising threshold (nominally 3.4 V), the charger initiates the charging cycle.

The NCP1835 first determines the cell voltage. If it is less than the pre charge threshold (2.8 V), the IC recognizes the battery as severely discharged. In this state, the NCP1835 pre conditions (trickle charges) the battery by charging it at 10% of the full charge rate (I_{PC}). This slow charge prevents the battery from being damaged from high fast charge currents when it is in a deeply discharged state. The battery voltage should be trickle charged up to 2.8 V before 1/8 of the preset end of charge time is expired. If it cannot reach this voltage, than the battery is possibly shorted or damaged. Therefore, the NCP1835 stops charging and the pre charge timeout signal asserts the $\overline{\text{FAULT}}$ flag.

Once the cell voltage crosses the pre charge threshold, the device will transition to normal (full rate) charging at 100% of the programmed full rate charge current (I_{FCHG}). As the NCP1835 charges the battery, the cell voltage rises until it reaches the V_{REG} threshold, (4.2 or 4.242 V). At the maximum charge rate, it normally takes about 1 hour to reach this point from a fully discharged state, and the battery will be approximately 70 80% recharged. At this point, the charge transitions to constant voltage mode where the IC forces the battery to remain at a constant voltage, V_{REG}. During this constant voltage state, the current required to maintain V_{REG} steadily decreases as the battery approaches full charge. Charge current eventually falls to a very low value as the battery approaches a fully charged condition.

The NCP1835 monitors the current into the battery until it drops to 10% of the full charge rate. This is the End of Charge (EOC) threshold. Normally it takes 1.5 2.5 hours to reach this point. Once the NCP1835 reaches end of charge it opens the $\overline{\text{CFLG}}$ pin and enters the EOC state. The IC continues to charge the battery until it reaches TIMEOUT. At that point, the NCP1835 stops charging. If the system does not reach EOC during the TIMEOUT period, the NCP1835 views this as a system fault and asserts the $\overline{\text{FAULT}}$ flag. If the battery voltage drops below the recharge threshold (which can occur if the battery is loaded), the IC reinitializes the charging sequence and begins a new charge cycle. The recharge voltage threshold, V_{RECH}, is nominally 4.03 V.

In the inhibit state, the NCP1835 continues to monitor the battery voltage, but does not charge the battery. Again, if the battery voltage drops below the recharge threshold the IC reinitializes the charging sequence and begins a new charge cycle.


Power Up
$V_{CC} > V_{POR}$?
N
Y
POR
N
N
Y
N
N
Y
Y
End−of−Charge
or $\overline{FAULT}$

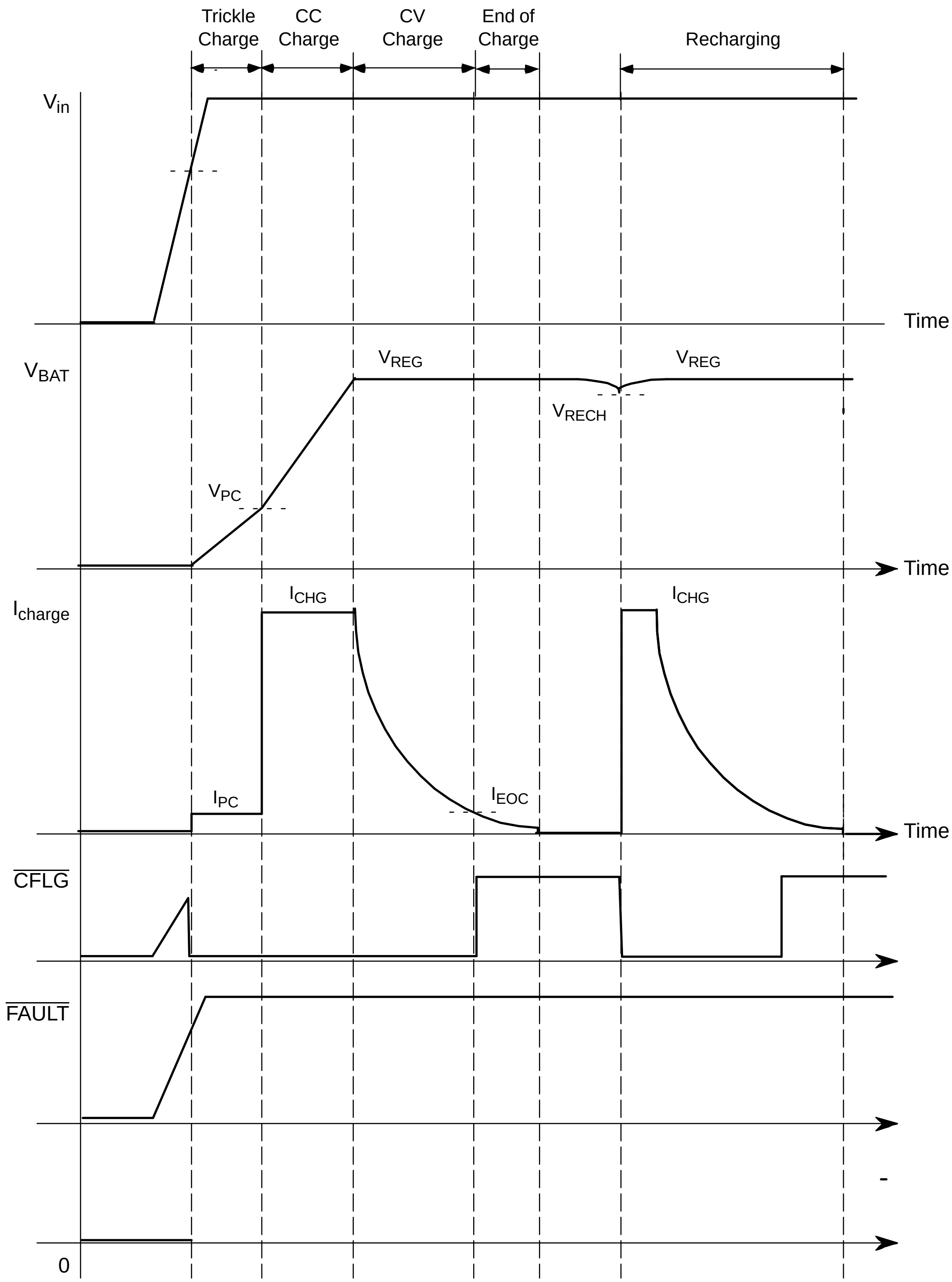


Figure 15. Typical Charging Diagram

Charge Status Indicator ($\overline{\text{CFLG}}$)

$\overline{\text{CFLG}}$ is an open drain output that indicates battery charging or End of Charge (EOC) status. It is pulled low when charging in constant current mode and constant voltage mode. It will be forced to a high impedance state when the charge current drops to I_{EOC}. When the charger is in shutdown mode, $\overline{\text{CFLG}}$ will also stay in the high impedance state.

Fault Indicator ($\overline{\text{FAULT}}$)

$\overline{\text{FAULT}}$ is an open drain output that indicates that a charge fault has occurred. It has two states: low or high impedance. In a normal charge cycle, it stays in a high impedance state. At fault conditions, it will be pulled low and terminate the charge cycle. A timeout fault occurs when the full charge or pre charge timeouts are violated, or if the voltage on ISEL is greater than 1.4 V or lower than 0.35 V. There are two ways to get the charger out of a fault condition and back to a normal charge cycle. One can either toggle the EN pin from GND to a floating state or reset the input power supply.

Adapter Present Indicator (V2P8)

V2P8 is an input power supply presence indicator. When the input voltage, V_{CC}, is above the power on threshold (V_{RISE}, nominally 3.4 V) and is also 100 mV above the battery voltage, it provides a 2.8 V reference voltage that can source up to 2.0 mA. This voltage can also be used to power a microprocessor I/O.

Enable/Disable (EN)

Pulling the EN pin to GND disables the NCP1835. In shutdown mode, the internal reference, oscillator, and control circuits are all turned off. This reduces the battery drain current to less than 3.0 μA and the input supply current to 30 μA. Floating the EN pin enables the charger.

Thermal Foldback

An internal thermal foldback loop reduces the programmed charge current proportionally if the die temperature rises above the preset thermal limit (nominally 100°C). This feature provides the charger protection from over heating or thermal damage. Figure 16 shows the full charge current reduction due to die temperature increase across the thermal foldback limit. For a charger with a 1.0 A constant charge current, the charge current starts

APPLICATION INFORMATION

Input and Output Capacitor Selection

A 4.7 μF or higher value ceramic capacitor is recommended for the input bypass capacitor. For the output capacitor, when there is no battery inserted and the NCP1835 is used as an LDO with 4.2 V or 4.242 V output voltage, a 4.7 μF or higher value tantalum capacitor is

The following Table 3 shows the desired TIMEOUT vs. C_{TIME} sizes. The C_{TIME} is required for proper device operation.

Table 3. TIMEOUT vs. C_{TIME} Size

C_{TIME} (nF)	TIMEOUT (minute)
0.47	6.6
1	14
5.6	78
8.2	115
10	140
15	210
33	462
56	784

Thermal Considerations

The NCP1835 is housed in a thermally enhanced 3x3 mm DFN package. In order to deliver the maximum power dissipation under all conditions, it is very important that the user solders exposed metal pad under the package to the ground copper area and then connect this area to a ground plane through thermal vias. This can greatly reduce the thermal impedance of the device and further enhance its power dissipation capability and thus its output current capability.

Charging with Constant Voltage Adapters or Current Limited Adapters

The NCP1835 can be powered from two types of regulated adapters: a traditional constant voltage type or a

PCB Layout Recommendations

The recommended footprint for the 3x3 mm DFN package is included on the Package Dimension page. It is critical that the exposed metal pad is properly soldered to the ground copper area and then connected to a ground plane through thermal vias. The maximum recommended thermal via diameter is 12 mils (0.305 mm). Limited by the size of the pad, six thermal vias should allow for proper thermal regulation without sacrificing too much copper area within the pad. The copper pad is the primary heatsink and should be connected to as much top layer metal as possible to minimize the thermal impedance. Figure 21 illustrates graphically the recommended connection for the exposed pad with vias.

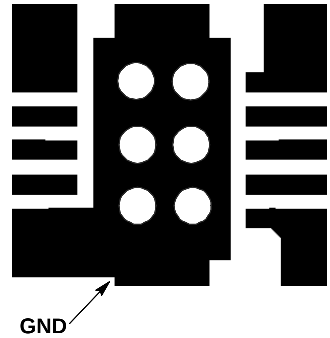


Figure 21. Recommended Footprint

The following is a NCP1835 Demo Board Schematic, Layout, and suggested Bill of Materials.

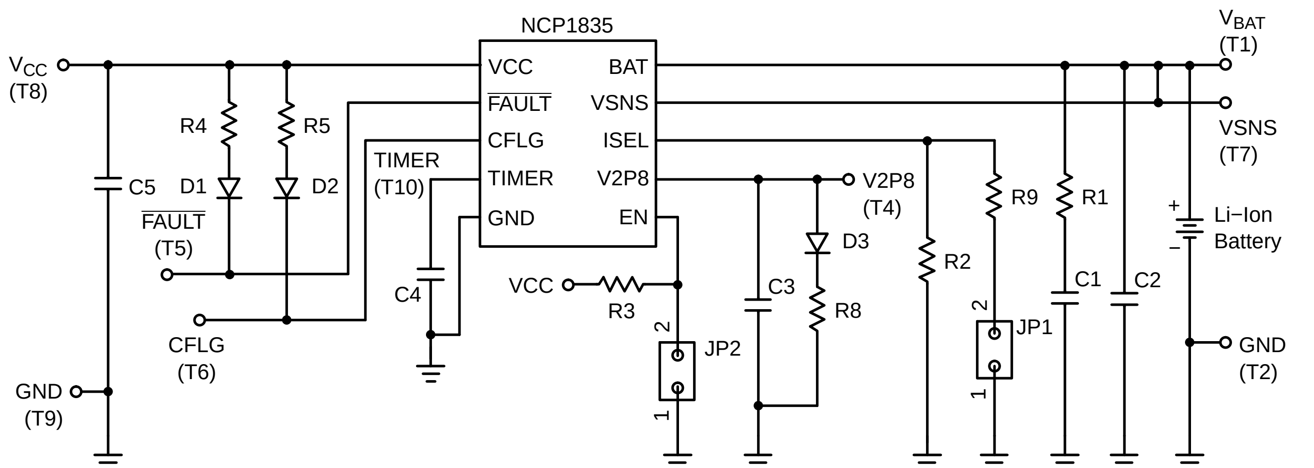


Figure 22. Demo Board Schematic

Table 4. Bill of Materials

Item	Qty.	Part Description	Designators	Suppliers