# DC/DC Converter IC for Lithium-Ion Battery Charging: MB3887

This Pulse-Width Modulation (PWM) DC/DC converter can dynamically control the secondary battery charging current by detecting drops in AC adapter voltage.

Features

- **Dynamically controlled charging mode**

- **Supports charging from one- to four-cell batteries**

- **External resistor to set output voltage**

- **Soft-start function**

- **Under-voltage lockout circuit**

- **Low-power standby mode**

Photo 1.   MB3887 External View
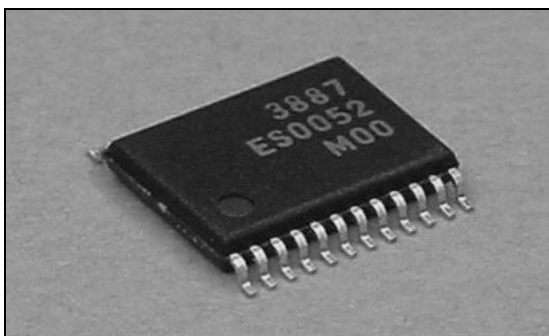
Product Overview

FUJITSU has developed many types of power supply ICs for notebook computer charging. FUJITSU models that can dynamically control charging of lithium-ion batteries for notebook computers include:

- MB3874 for three-cell parallel charging

- MB3875 for three-cell batteries

- MB3876 for four-cell parallel charging

- MB3877 for four-cell batteries

- MB3878 for one- to four-cell batteries

Now, FUJITSU is proud to announce the development of a new IC product for battery charging: the MB3887 DC/DC converter IC with Pulse-Width Modulation (PWM) to enable setting of any desired output voltage level, supporting one to four cells.

In recent years, AC adapters used with notebook computers have continued to become smaller and

lighter. Notebook computers require charge control ICs capable of rapid charging while the computer is operating, even with low-capacity AC adapters.

The MB3887, like the MB3874 through MB3878 models, can detect voltage drops in the AC adapter and dynamically control the charging current to the secondary battery to maintain constant power (dynamically controlled charging). This operation enables rapid charging while the notebook computer is operating, only limited by the capacity of the AC adapter. Charging current accuracy is increased from ±10% on previous models to ±5%. This improves charging time accuracy and reduces the load on the battery.

"... can detect voltage drops in the AC adapter and dynamically control the charging current ..."

In addition, the MB3887 uses an external output voltage setting resistor that allows the output voltage to be set to any desired level for charging one to four cells. Protective features include a soft-start function to prevent damage or abnormal operation when power to the chip set is applied. Other features include a wide supply voltage range, low standby current, and high efficiency.

The MB3887 is an ideal IC for built-in chargers, charging a battery pack of one to four lithium-ion battery cells in notebook computers.
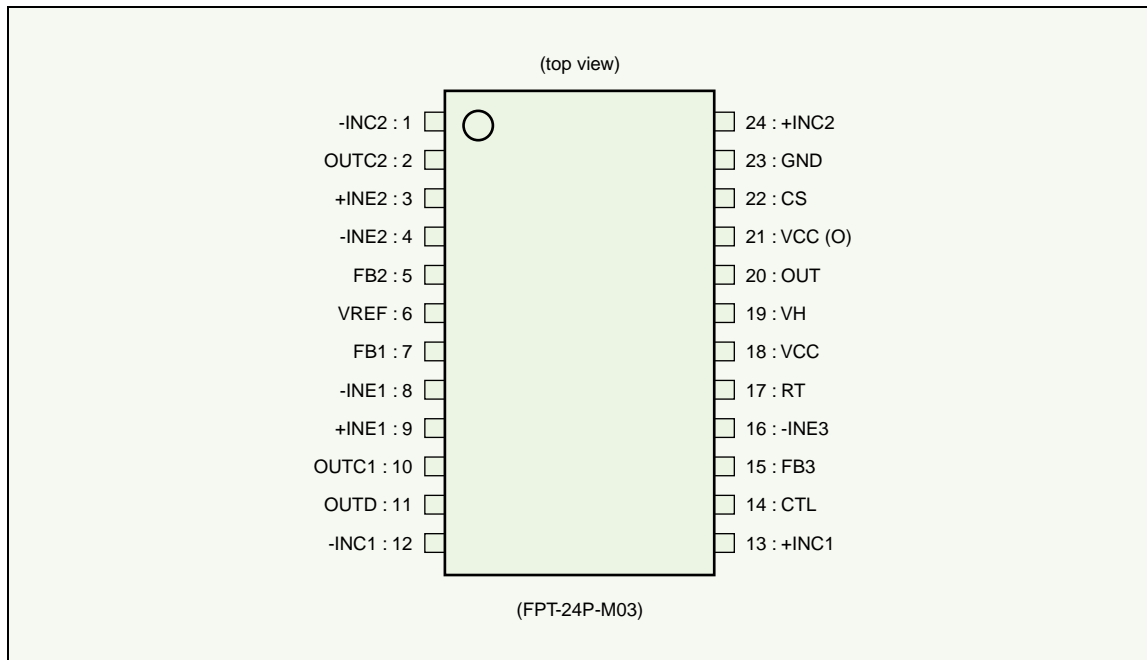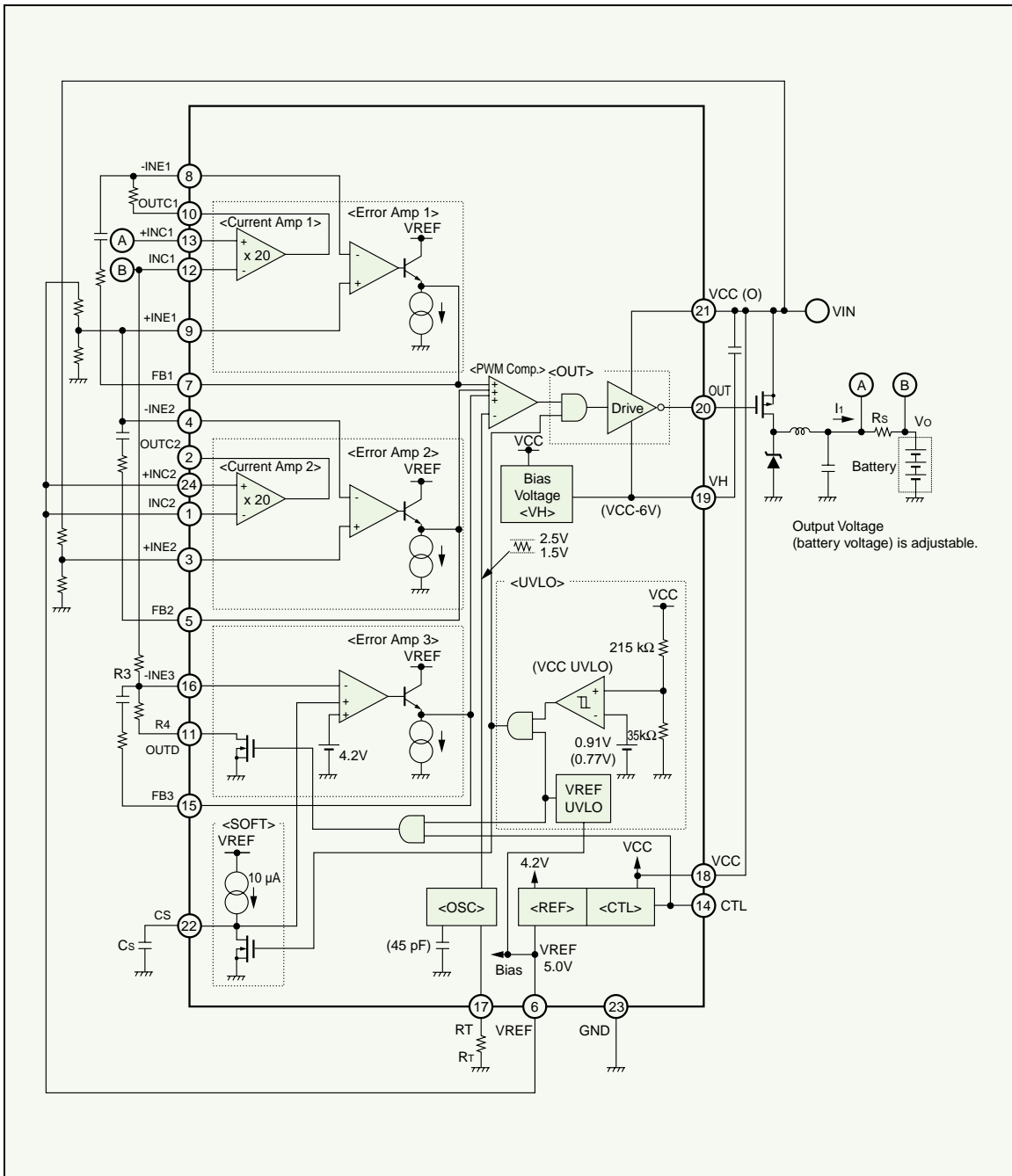
Figure 1.   MB3887 Pin Assignments

(top view)

-INC2 : 1	24 : +INC2
OUTC2 : 2	23 : GND
+INE2 : 3	22 : CS
-INE2 : 4	21 : VCC (O)
FB2 : 5	20 : OUT
VREF : 6	19 : VH
FB1 : 7	18 : VCC
-INE1 : 8	17 : RT
+INE1 : 9	16 : -INE3
OUTC1 : 10	15 : FB3
OUTD : 11	14 : CTL
-INC1 : 12	13 : +INC1

(FPT-24P-M03)

Figure 2. MB3887 Block Diagram

Product Features

- AC adapter voltage drop detection, with dynamic control of charging current (dynamically controlled charging)

- Output voltage setting using external resistor: one cell to four cells

- High efficiency: 94%

- Wide operating supply voltage range: 8V to 25V

- Output voltage setting accuracy: ± 0.74% (T_a = −10° to 85°C)

- Charge current setting accuracy: ± 5%

- Built-in frequency setting capacitor enables frequency selection by connecting an external resistor

- Oscillator frequency range: 100 kHz to 500 kHz

- Built-in current sensing amp with common mode input voltage range: 0V to Vcc

- Output voltage setting resistor can be left open in IC standby mode to prevent inefficient current

- Standby current: 0 μA (typ.)

- Built-in soft-start function

- Built-in totem-pole-type output stage for P-ch MOSFET

- Package: SSOP-24P

Circuit Configuration

Figure 1 (see p. 41) shows the pin assignments, and Figure 2 (see p. 42) shows the block diagram. Figure 3 (see p. 44) shows the timing charts.

DC/DC Converter Functions

The MB3887 is configured with the functional blocks described in the following sections.

Reference Voltage Block (Ref)

The reference voltage block takes the voltage supplied at the Vcc pin and generates a temperature-compensated reference voltage (5.0V typ.) for the internal circuits of the IC. The reference voltage also can be output at the reference voltage VREF pin with a maximum current of 1 mA.

Triangular Wave Oscillator Block (OSC)

Built-in frequency setting capacitor can be used to generate a triangular waveform by connecting a frequency setting resistor to the RT pin. The triangular wave is input to the internal PWM comparator of the IC.

Error Amp 1 Block

The Error Amp 1 block regulates charging current by detecting the output voltage from the current detection amp (Current Amp 1), comparing this to the +INE1 pin, and amplifying the result as a PWM control signal. This block also can provide the system with stable-phase compensation by connecting a feedback resistor and capacitor between the FB1 pin and the –INE1 pin to create the desired level of loop gain.

Error Amp 2 Block

The Error Amp 2 block detects voltage drops in the AC adapter and amplifies the result as a PWM control signal. This block also can provide the system with stable phase compensation by connecting a feedback resistor and capacitor between the FB2 pin and the –INE2 pin to create the desired level of loop gain.

Error Amp Block 3

The Error Amp 3 block detects the output voltage from the DC/DC converter and produces a PWM control signal. This block also can set the output voltage for one, two, three, or four cells by connecting an external output voltage setting resistor between the –INE3 pin and OUTD pin. In addition, this block can provide the system with stable-phase compensation by connecting a feedback resistor and capacitor between the FB3 pin and the –INE3 pin to create the desired level of loop gain.

A soft-start capacitor can be connected to the CS pin to reduce in-rush current at power-on. The error amp can be used as a soft-start detector, thereby providing a constant soft-start time independent of output load.

Current Detection Amp Block (Current Amp 1)

The charging current produces a voltage drop across the ends of the output sensing resistor (Rs), which is detected in this block between the +INC pin and –INC pin, amplified 20 times and output to the next stage amplifier (Error Amp 1).

PWM Comparator

The PWM comparator is a voltage pulse-width modulator that controls the output duty according to the voltage of the error amp signals. The output voltage is compared with the triangular waveform generated by the triangular wave oscillator, and used to turn on an external output transistor during the interval when the triangular waveform is lower than the error amp output voltage.

Output Block (OUT)

The output circuits have a totem-pole configuration and can drive an external P-ch MOSFET. At 'L' level output, the voltage generated by the bias voltage block (V_H) can be used to set the output amplitude to 6V (typ.). This enables better conversion efficiency and allows the use of external transistors with lower breakdown voltage levels even at wider input voltage ranges.

Bias Voltage Block (V_H)

This block produces a voltage of VCC–6V as the minimum potential for the output circuit. In standby mode, the output is the same level as VCC.

Power Control Circuit (CTL)

When the CTL pin is set to 'L' level, the IC is in standby mode (maximum standby supply current is 10 µA). When the CTL pin is set to 'H' level, an internal reference voltage is generated, and the IC goes into output operating mode.

Figure 3.   Operating Timing Chart
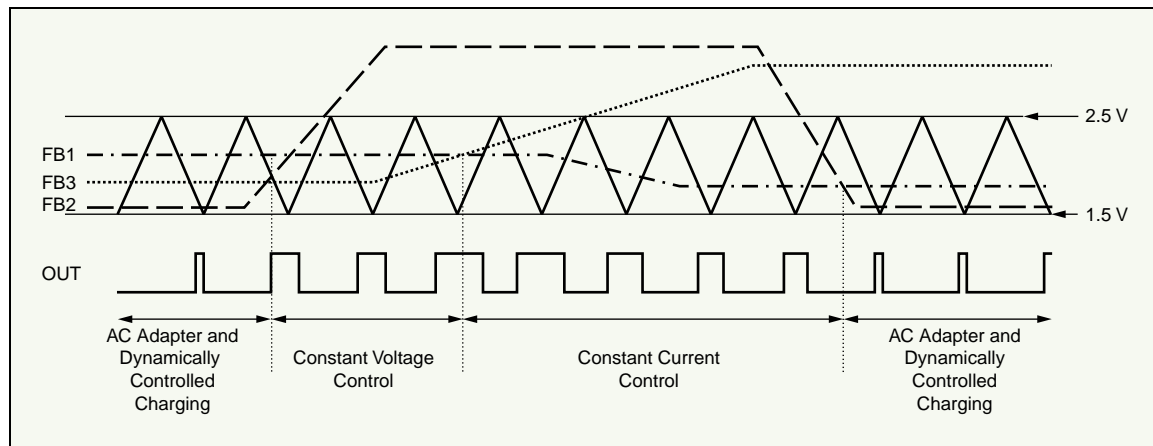
Protection Circuit Functions

The MB3887 has an Under-Voltage Lockout (UVLO) circuit that prevents abnormal operation under low Vcc conditions.

Power-on (VCC) surge states or sudden drops in supply voltage (VCC) or reference voltage (VREF) can cause a control IC to operate abnormally, leading to destruction or damage to system elements. The under-voltage lockout circuit prevents this type of abnormal operation by setting the output pin OUT at 'H' level. Operation is restored as soon as the supply voltage or internal reference voltage increases above the under voltage lockout circuit threshold voltage.

Soft-Start Function

In the soft-start block (SOFT), a capacitor can be connected to the CS pin to reduce in-rush current at power-on. By using an error amp to detect soft-start operation, the DC/DC converter can operate with a fixed soft-start time independent of output load.

Dynamically Controlled Charging

Setting the AC Adapter Detection Voltage

Figure 4 illustrates the setting of the AC adapter detection voltage.

By connecting external resistor to the +INE2 pin, when the division of the AC adapter input voltage (VCC) at point A is lower than the –INE2 pin voltage, the MB3887 goes into dynamically controlled charging mode, and the charging current is reduced to maintain the AC adapter power at a constant level.   ◆

". . . the charging current is reduced to maintain the AC adapter power at a constant level."

Figure 4.   AC Adapter Detection Voltage Setting

AC Adapter Detection Voltage Vth = (R1 + R2)/R2X - INE2

<Error Amp 2>

-INE2   4

+INE2   3

VCC   R1   A   R2