Built-in Bypass FET Synchronous-Rectification-Type PFM/PWM Step-Down Regulator MB39C004

MB39C004 is a synchronous-rectification-type 1-channel step-down DC/DC converter IC that uses current mode. Pch MOS FET which bypasses I/O corresponding to heavy current (1A) is built in, and is best suited for built-in power supplies in portable devices such as power amplifiers in cellular phones.

Product Description

Based on the technological foundation of a variety of converter ICs, FUJITSU has recently completed “MB39C004,” built-in bypass FET synchronous-rectification-type 1-channel step-down DC/DC converter IC, an upgrade of “MB39C001” that enabled synchronous-rectification-type step-down DC/DC conversion with one channel using current mode and built-in FET switch.

Third-generation cellular phones need a DC/DC converter even for power supply to a power amplifier. Particularly for use requiring high power, it is becoming common to switch to a bypass FET. As a result, demand has increased for built-in bypass FET DC/DC converter that has low on-resistance and low loss.

This product mounts a FET switch, an oscillator, an error amplifier, a PFM/PWM controlling circuit, and a reference voltage in a single package. As such, it is possible to construct this device using only a coil and a decoupling condenser as external parts.

MB39C004 oscillates at a fixed frequency of 2MHz if there is any load current, but the conversion efficiency is enhanced since it adopts the synchronous rectification type. Under light load, it enters PFM operation so that the conversion efficiency is considerably better than that using the PWM type. If the PFM operation is not necessary, it can be used in the PWM fixed mode.

Furthermore, owing to the adoption of the current mode, the response to sudden changes in load is drastically better than that with voltage control. Phase compensation does not require an external resistor or condenser, enabling a reduced number of parts and simplified construction of the DC/DC converter. Since this product uses the current mode, it does not require protective functions such as soft-start and short-circuit protection.

Photo 1  External View
The output voltage can be set up optionally with control by DAC or a voltage divider utilizing internal reference voltage. Other built-in functions include temperature protection and UVLO.

This product is optimal for built-in power supplies in portable devices such as power amplifiers in mobile phones, DSCs, and PDAs.

**Product Features**

- High efficiency: 96% (Max.)
- Quiescent current: 30 μA (at PFM)
- Output current (DC/DC): 800 mA (Max.)
- Output current (bypass FET): 1A (Max.)
- Power-supply voltage range: 2.5V to 5.5V
- Operation frequency: 2MHz (Typ.)
- Built-in PWM operation fixation function
- Flyback diode not required
- Low dropout operation: 100% on duty
- Built-in high-precision reference voltage source: 1.24V±2%
- Current consumption at shutdown: 1μA or less
- Built-in FET switch: Pch MOS FET 0.3Ω (Typ.)
  Nch MOS FET 0.2Ω (Typ.)
- Built-in bypass FET: Pch MOS FET 0.05Ω (on wafer:Typ.)
  Pch MOS FET 0.08Ω (on package:Typ.)
- Current mode enables fast response to input/load transient
- Built-in temperature protection function
- Package: BCC10

**Circuit Configuration**

The pin assignments are shown in Figure 1, the pin functions in Table 1, and the block diagram in Figure 2.

MB39C004 is configured with the following six function blocks.

- **PFM/PWM Logic Control Circuit**
  Under normal operation, this section functions to allow a built-in Pch/Nch MOS FET to operate in synchronous rectification mode with the frequency (2MHz) set by a built-in oscillator (square wave oscillator circuit). Under light load, it operates intermittently.
  This circuit protects against penetration current caused by

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**Table 1 Pin Functions**

<table>
<thead>
<tr>
<th>Pin no.</th>
<th>Pin code</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OUT</td>
<td>I</td>
<td>Output voltage feedback terminal</td>
</tr>
<tr>
<td>2</td>
<td>VDD</td>
<td>—</td>
<td>Power-supply terminal</td>
</tr>
<tr>
<td>3</td>
<td>MODE</td>
<td>I</td>
<td>Operation mode switching terminal (L: PFM/PWM mode, H: PWM mode)</td>
</tr>
<tr>
<td>4</td>
<td>LX</td>
<td>O</td>
<td>Output terminal for inductance connection. It enters high impedance mode during shutdown.</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>—</td>
<td>Ground terminal</td>
</tr>
<tr>
<td>6</td>
<td>VREF</td>
<td>O</td>
<td>Reference voltage output terminal</td>
</tr>
<tr>
<td>7</td>
<td>CTL</td>
<td>I</td>
<td>Control input terminal (L: shutdown, H: normal operation)</td>
</tr>
<tr>
<td>8</td>
<td>VREFIN</td>
<td>I</td>
<td>Error amplifier (Error Amp) noninverted input terminal</td>
</tr>
<tr>
<td>9</td>
<td>VDD</td>
<td>—</td>
<td>Power-supply terminal</td>
</tr>
<tr>
<td>10</td>
<td>OUT</td>
<td>I</td>
<td>Output voltage feedback terminal</td>
</tr>
</tbody>
</table>
synchronous rectification and return current in discontinuous action.

■ Iout Comparator Circuit
This section detects the current (ILx) from a built-in Pch MOS FET to an external inductor.
By comparing the I/V conversion of ILx’s peak current IPK (VIDET) with the output from the error amplifier, it instructs the PFM/PWM logic control to switch the built-in Pch MOS FET off.

■ Error Amp Phase Compensation Circuit
This circuit compares the reference voltage such as VREF with the output voltage. With the incorporation of a phase compensation circuit, this product maintains optimal operation. As such, it is not necessary to introduce a phase compensation circuit or any other external device for this purpose.

■ VREF Circuit
It generates high-precision reference current with a band-gap reference (BGR) circuit. Its output voltage is 1.24V (Typ).

■ Bypass FET Circuit
It short-circuits the DC/DC power supply (VIN) and output (Vo). For this product, it stops DC/DC operation when VREFIN voltage elevates to 1.2V or higher and switches the bypass FET on.

■ Protection Circuit
This section incorporates an overcurrent protection circuit. This circuit turns the Nch/Pch FET switch off, when the temperature of the joint section reaches 135°C.
This product does not have a dedicated circuit for overcurrent protection; however, the adoption of current mode as the voltage control method enables constant monitoring and controlling of the peak current value.

Figure 2 Block Diagram

※ Output voltage can be set up as shown by the following formula by applying voltage to the VREFIN terminal from DAC.
Internal output voltage setup resistance ratio: \( R_3 + R_4 = 3 \times \frac{R_4}{R_4} \)
Vo = 3 × VREFIN
※ When the VDD voltage drops below the preset value of output voltage, the Pch-FET is fixed to on-operation.