AC/DC Drivers

Quasi-Resonant Control type
DC/DC Converter IC

BM1Q021FJ /BM1Q041FJ

General Description
The quasi-resonant controller typed AC/DC converter IC BM1Q021FJ/BM1Q041FJ provides an optimum system for all products that include an electrical outlet. Quasi-resonant operation enables soft switching and helps to keep EMI low.

With MOSFET for switching and current detection resistors as external devices, a higher degree of design freedom is achieved.

As BM1Q021FJ/BM1Q041FJ built in HV starter circuit, it contributes to low consumption power and high speed start. Because the built-in burst mode is reduced switching loss and IC consumption current is low, Stand-by power is very low.

Because BM1Q021FJ/BM1Q041FJ built-in soft-start, burst mode, over current limiter which is cycle-by-cycle, over load protection, over voltage protection, CS open protection and so on, BM1Q021FJ/BM1Q041FJ are highly safety.

Key Specifications
- Operating Power Supply Voltage Range:
  - VCC : 8.9V to 26.0V
  - VH : to 600V

- Operating Current:
  - Normal : 0.60mA (Typ.)
  - Burst : 0.35mA (Typ.)

- Max frequency: 120kHz (Typ.)
- Operate temperature range: -40°C to +105°C

Features
- Quasi-resonant method
- Built-in 650V tolerate start circuit
- Low power when load is light ( Burst operation)
- Maximum frequency control (120kHz)
- Frequency reduction function
- AC voltage correction function
- VCC pin : under voltage protection
- VCC pin : overvoltage protection
- Over-current protection (cycle-by-cycle)
- OUT pin : H voltage 12V clamp
- Soft start
- ZT trigger mask function
- ZT Over voltage protection[BM1Q021 Auto-restart]
- FB Over Load protection [Auto-restart]
- CS pin open protection [Auto-restart]

Package
SOP-J8 4.90mm × 6.00mm × 1.65mm
(Typ.) (Typ.) (Max.)

Applications
AC adapters and household appliances (printer, TV, vacuum cleaners, air cleaners, air conditioners, IH cooking heaters etc.)

Line Up

<table>
<thead>
<tr>
<th>IC</th>
<th>ZT OVP</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM1Q021FJ</td>
<td>Auto-restart</td>
</tr>
<tr>
<td>BM1Q041FJ</td>
<td>None</td>
</tr>
</tbody>
</table>

Figure 1. Application Circuit
Absolute Maximum Ratings (Ta=25°C)

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage range 1</td>
<td>Vmax1</td>
<td>-0.3 ~ 30</td>
<td>V</td>
<td>VCC</td>
</tr>
<tr>
<td>Input voltage range 2</td>
<td>Vmax2</td>
<td>-0.3 ~ 6.5</td>
<td>V</td>
<td>CS, FB</td>
</tr>
<tr>
<td>Input voltage range 3</td>
<td>Vmax3</td>
<td>-0.3 ~ 7.0</td>
<td>V</td>
<td>ZT</td>
</tr>
<tr>
<td>Input voltage range 4</td>
<td>Vmax4</td>
<td>-0.3 ~ 15</td>
<td>V</td>
<td>OUT</td>
</tr>
<tr>
<td>Input voltage range 5</td>
<td>Vmax5</td>
<td>-0.3 ~ 650</td>
<td>V</td>
<td>VH</td>
</tr>
<tr>
<td>OUT pin out peak current1</td>
<td>ICH</td>
<td>-0.5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>OUT pin out peak current2</td>
<td>IOL</td>
<td>1.0</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>ZT pin current1</td>
<td>ISZT1</td>
<td>-3.0</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>ZT pin current2</td>
<td>ISZT2</td>
<td>3.0</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Allowable dissipation</td>
<td>Pd</td>
<td>0.67(Note1)</td>
<td>W</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>Topr</td>
<td>-40 ~ +105</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Max junction temperature</td>
<td>Tjmax</td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Storage temperature range</td>
<td>Tstr</td>
<td>-55 ~ +150</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

(Note1) When mounted (on 70 mm × 70 mm, 1.6 mm thick, glass epoxy on single-layer substrate). Reduce to 5.4 mW/°C when Ta = 25°C or above.

Caution: Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

Operating Conditions (Ta=25°C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply voltage range 1</td>
<td>VCC</td>
<td>8.9~26.0</td>
<td>V</td>
<td>VCC</td>
</tr>
<tr>
<td>Power supply voltage range 2</td>
<td>VH</td>
<td>80~600</td>
<td>V</td>
<td>VH</td>
</tr>
</tbody>
</table>

Electrical Characteristics (Unless otherwise noted, Ta = 25°C, VCC = 15 V)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Specifications</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Circuit current]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit current (ON)1</td>
<td>ION1</td>
<td>-</td>
<td>600</td>
<td>1000</td>
</tr>
<tr>
<td>Circuit current (ON)2</td>
<td>ION2</td>
<td>-</td>
<td>350</td>
<td>450</td>
</tr>
<tr>
<td>Circuit current (OFF)</td>
<td>IOFF</td>
<td>-</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>[VH pin starter]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VH Start current1</td>
<td>ISTART1</td>
<td>0.400</td>
<td>0.700</td>
<td>1.000</td>
</tr>
<tr>
<td>VH Start current2</td>
<td>ISTART2</td>
<td>1.00</td>
<td>3.00</td>
<td>6.00</td>
</tr>
<tr>
<td>VH OFF current</td>
<td>ISTART3</td>
<td>-</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>VH start current switched voltage</td>
<td>VSC</td>
<td>0.400</td>
<td>0.800</td>
<td>1.400</td>
</tr>
<tr>
<td>[VCC UVLO protection]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCC UVLO voltage1</td>
<td>UVLO1</td>
<td>12.50</td>
<td>13.50</td>
<td>14.50</td>
</tr>
<tr>
<td>VCC UVLO voltage2</td>
<td>UVLO2</td>
<td>7.50</td>
<td>8.20</td>
<td>8.90</td>
</tr>
<tr>
<td>VCC UVLO hysteresis</td>
<td>UVLO3</td>
<td>-</td>
<td>5.30</td>
<td>-</td>
</tr>
<tr>
<td>VCC charge start voltage</td>
<td>CHG1</td>
<td>7.70</td>
<td>8.70</td>
<td>9.70</td>
</tr>
<tr>
<td>VCC charge end voltage</td>
<td>CHG2</td>
<td>12.00</td>
<td>13.00</td>
<td>14.00</td>
</tr>
<tr>
<td>VCC OVP voltage1</td>
<td>OVP1</td>
<td>26.00</td>
<td>27.50</td>
<td>29.00</td>
</tr>
<tr>
<td>VCC OVP voltage2</td>
<td>OVP2</td>
<td>23.50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VCC OVP hysteresis</td>
<td>OVP3</td>
<td>4.00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>[OUT pin]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUT pin H voltage</td>
<td>VOUTH</td>
<td>10.5</td>
<td>12.5</td>
<td>14.5</td>
</tr>
<tr>
<td>OUT pin L voltage</td>
<td>VOUTL</td>
<td>-</td>
<td>-</td>
<td>0.30</td>
</tr>
<tr>
<td>OUT pin Pull-down resistor</td>
<td>RPDOUT</td>
<td>75</td>
<td>100</td>
<td>125</td>
</tr>
</tbody>
</table>
### IC control unit Electrical Characteristics

(Unless otherwise noted, \( T_a = 25^\circ C\), \( V_{CC} = 15\) V)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Specifications</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>TYP</td>
<td>MAX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[ DC/DC converter unit ] (Turn-off)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pull-up resistor of FB pin</td>
<td>( R_{FB} )</td>
<td>22.5</td>
<td>30.0</td>
<td>37.5</td>
</tr>
<tr>
<td>CS over current voltage 1A</td>
<td>( V_{lim1A} )</td>
<td>0.475</td>
<td>0.500</td>
<td>0.525</td>
</tr>
<tr>
<td>CS over current voltage 1B</td>
<td>( V_{lim1B} )</td>
<td>0.310</td>
<td>0.350</td>
<td>0.390</td>
</tr>
<tr>
<td>CS over current voltage 2A</td>
<td>( V_{lim2A} )</td>
<td>0.100</td>
<td>0.125</td>
<td>0.150</td>
</tr>
<tr>
<td>CS over current voltage 2B</td>
<td>( V_{lim2B} )</td>
<td>0.062</td>
<td>0.088</td>
<td>0.113</td>
</tr>
<tr>
<td>Voltage gain1 (( ΔV_{FB}/ΔV_{CS} ))</td>
<td>( AV_{CS1} )</td>
<td>3.40</td>
<td>4.00</td>
<td>4.60</td>
</tr>
<tr>
<td>Voltage gain2 (( ΔV_{FB}/ΔV_{CS} ))</td>
<td>( AV_{CS2} )</td>
<td>4.86</td>
<td>5.71</td>
<td>6.57</td>
</tr>
<tr>
<td>ZT current switched CS 1</td>
<td>( I_{ZT1} )</td>
<td>0.93</td>
<td>1.00</td>
<td>1.07</td>
</tr>
<tr>
<td>ZT current switched CS 2</td>
<td>( I_{ZT2} )</td>
<td>0.82</td>
<td>0.90</td>
<td>0.98</td>
</tr>
<tr>
<td>ZT current hysteresis switched CS voltage</td>
<td>( I_{ZTHYS} )</td>
<td>-</td>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>CS Leading Edge Blanking</td>
<td>( T_{LEB} )</td>
<td>-</td>
<td>0.250</td>
<td>-</td>
</tr>
<tr>
<td>Turn-off time</td>
<td>( T_{OFF} )</td>
<td>-</td>
<td>0.150</td>
<td>-</td>
</tr>
<tr>
<td>At applying PULSE to the CS pin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum ON width</td>
<td>( T_{min} )</td>
<td>-</td>
<td>0.400</td>
<td>-</td>
</tr>
<tr>
<td>Maximum ON width</td>
<td>( T_{max} )</td>
<td>30.0</td>
<td>39.0</td>
<td>50.7</td>
</tr>
<tr>
<td>[ DC/DC converter unit ] (Turn-on)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZT input current 1</td>
<td>( I_{ZT1} )</td>
<td>4</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>ZT input current 2</td>
<td>( I_{ZT2} )</td>
<td>6</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>ZT input current 3</td>
<td>( I_{ZT3} )</td>
<td>8</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>Max frequency 1</td>
<td>( F_{SW1} )</td>
<td>108</td>
<td>120</td>
<td>132</td>
</tr>
<tr>
<td>Max frequency 2</td>
<td>( F_{SW2} )</td>
<td>20</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Frequency reduction start voltage</td>
<td>( V_{FBSW1} )</td>
<td>1.10</td>
<td>1.25</td>
<td>1.40</td>
</tr>
<tr>
<td>Frequency reduction end voltage</td>
<td>( V_{FBSW2} )</td>
<td>0.42</td>
<td>0.50</td>
<td>0.58</td>
</tr>
<tr>
<td>ZT comparator voltage1</td>
<td>( V_{CT1} )</td>
<td>60</td>
<td>100</td>
<td>140</td>
</tr>
<tr>
<td>ZT comparator voltage2</td>
<td>( V_{CT2} )</td>
<td>120</td>
<td>200</td>
<td>280</td>
</tr>
<tr>
<td>ZT trigger mask time</td>
<td>( T_{ZTMASK} )</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td>ZT trigger Timeout1</td>
<td>( T_{ZTOUT1} )</td>
<td>10.5</td>
<td>15.0</td>
<td>19.5</td>
</tr>
<tr>
<td>ZT trigger Timeout2</td>
<td>( T_{ZTOUT2} )</td>
<td>3.5</td>
<td>5.0</td>
<td>6.5</td>
</tr>
<tr>
<td>[ DC/DC protection ]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft start time1</td>
<td>( T_{SS1} )</td>
<td>0.35</td>
<td>0.50</td>
<td>0.65</td>
</tr>
<tr>
<td>Soft start time 2</td>
<td>( T_{SS2} )</td>
<td>0.70</td>
<td>1.00</td>
<td>1.30</td>
</tr>
<tr>
<td>Soft start time 3</td>
<td>( T_{SS3} )</td>
<td>1.40</td>
<td>2.00</td>
<td>2.60</td>
</tr>
<tr>
<td>Soft start time 4</td>
<td>( T_{SS4} )</td>
<td>2.80</td>
<td>4.00</td>
<td>5.20</td>
</tr>
<tr>
<td>FB Burst voltage</td>
<td>( V_{BURST} )</td>
<td>0.42</td>
<td>0.50</td>
<td>0.58</td>
</tr>
<tr>
<td>FB OLP voltage a</td>
<td>( V_{FOLP1A} )</td>
<td>2.6</td>
<td>2.8</td>
<td>3.0</td>
</tr>
<tr>
<td>FB OLP voltage b</td>
<td>( V_{FOLP1B} )</td>
<td>-</td>
<td>2.6</td>
<td>-</td>
</tr>
<tr>
<td>FB OLP delay timer</td>
<td>( T_{FOLP} )</td>
<td>44.8</td>
<td>64</td>
<td>83.2</td>
</tr>
<tr>
<td>FBOLP stop timer</td>
<td>( T_{OLPST} )</td>
<td>358</td>
<td>512</td>
<td>666</td>
</tr>
<tr>
<td>Protection mask time</td>
<td>( T_{mask} )</td>
<td>50</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>ZT OVP voltage</td>
<td>( V_{ZTL} )</td>
<td>4.65</td>
<td>5.00</td>
<td>5.35</td>
</tr>
<tr>
<td>ZTOVP stop timer</td>
<td>( V_{ZTOVP} )</td>
<td>358</td>
<td>512</td>
<td>666</td>
</tr>
</tbody>
</table>

* Definition of ACSNS (L : ZT current < \( I_{ZT1} \), H : ZT current > \( I_{ZT1} \))
Pin Configuration

Table 1 Input-Output PIN Function

<table>
<thead>
<tr>
<th>NO.</th>
<th>Pin Name</th>
<th>I/O</th>
<th>Function</th>
<th>ESD Diode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ZT</td>
<td>I</td>
<td>Zero current detect pin</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>FB</td>
<td>I</td>
<td>Feedback signal input pin</td>
<td>○</td>
</tr>
<tr>
<td>3</td>
<td>CS</td>
<td>I</td>
<td>Primary current sensing pin</td>
<td>○</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>I/O</td>
<td>GND pin</td>
<td>○</td>
</tr>
<tr>
<td>5</td>
<td>OUT</td>
<td>O</td>
<td>External MOS drive pin</td>
<td>○</td>
</tr>
<tr>
<td>6</td>
<td>VCC</td>
<td>I/O</td>
<td>Power supply pin</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>N.C.</td>
<td>-</td>
<td>Non Connection</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>VH</td>
<td>I</td>
<td>Starter circuit pin</td>
<td>-</td>
</tr>
</tbody>
</table>

External Dimensions

![External Dimensions Diagram](image)

I/O Equivalent Circuit Diagram

![I/O Equivalent Circuit Diagram](image)
Figure-4 Block Diagram
Description of Blocks

(1-1) Starter Circuit VH pin(8pin)
IC builds in starter circuit (tolerates 650V) to VH pin (8pin). It enables to be low standby power and high speed starting.
The operating current is shown in Figure-6. After starting IC, consumption power is decided by multiplied idling current \( I_{\text{START3}} \) (typ=10uA) with VH voltage. The loss by the idling current is below.

ex) power consumption of starter circuit only

\[
\text{Vac}=100V \quad \text{Power}=100V \times \sqrt{2} \times 10\mu A=1.41mW \\
\text{Vac}=240V \quad \text{Power}=240V \times \sqrt{2} \times 10\mu A=3.38mW
\]

Start time is decided by VH current and VCC pin capacitor.
The reference value of start time is shown in Figure 7. For example, VCC capacitor is charged within 0.1s in \( C_{\text{VCC}}=10\mu F \) When VH pin is shorted to GND, current of "I\(_{\text{START1}}\)" flows. (Figure-6)
When VH pin is shorted to GND, large current flows from VH line to GND. To prevent it, need to insert resistor (5kΩ~60kΩ) of "RVH" to limit current between VH line and VH pin.
When VH pin is shorted to GND, the power of \( V_{\text{H}}^2/R_{\text{VH}} \) is applied. For that, please decide resistor size to confirm power dissipation. When it does not satisfy power dissipation by one resistor, please use more than two resistors.

![Figure-5 Starter Block Diagram](image)

![Figure-6 Start-up Current vs VCC Voltage](image)

*The start up current is flown from VH pin(8Pin).

![Figure-7 Start-up Time (example)](image)

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TSZ22111・15・001
6/27
TSZ02201-0F1F0A200280-1-2
27.Sep.2016 Rev.001
It shows operation waveform of start-up in Figure-8.

A: By inserting to outlet, VH voltage applies. From the time, charging to VCC pin starts from VH pin through starter circuit. At the time, due to VCC < V<sub>SC</sub> (typ=0.8V), VH input current is limited to I<sub>START1</sub> by VCC pin short protection.

B: Because of VCC voltage > V<sub>SC</sub> (typ=0.8V), VCC short protection is released, the current flows from VH pin.

C: Because of VCC voltage > V<sub>UVLO1</sub> (typ=13.5V), the start-up stops, and VH input current is limited to I<sub>START3</sub> (typ=10uA) Furthermore, because switching operation starts, Secondary output rises. However, because Secondary output is low, VCC pin voltage is decreased. The falling rate of VCC is determined by VCC pin capacitance, the consumption current of IC and the load current that flows from the VCC pin. (V/t = CVCC/Icc )

D: Because secondary output has risen to specific voltage, VCC pin voltage is applied from the auxiliary winding and VCC voltage is stabilized.
(1-2) In Case of Useless VH pin (8pin)

This IC is also possible to start by connecting the start-up resistor to the VCC pin in the open the start-up circuit (650V breakdown voltage) of the VH pin. The structure that do not use the recharge function is shown in Figure- 9.

At start-up (before VCC VULO releasing), please be careful to set the start-up resistor shown in blue because the consumption current $I_{OFF}$ (Max=25uA) flows from VCC pin(6pin). Also, in case of not to use recharge function, the same circuit is used.

![Figure-9 Application Circuit not to use VH Pin (8pin)](image)

- How to set the start-up resistance

Start-up resistor $R_{start}$ shown in Figure-9 in blue, is necessary for the IC to start if you do not use the VH pin. If you reduce $R_{start}$ value, standby power is increased, start-up time is shorter.

If you increase $R_{start}$ on the contrary, standby power is reduced, start-up time will be longer.

When the voltage VCC=12V, standby current $I_{OFF}$ is 25μA (max), VCC UVLO voltage $V_{UVLO1}$ is 14.5V (max).

ex) The example of start-up resistor $R_{start}$ setting

$$R_{start} = \frac{(V_{min} - V_{UVLO1}(max))}{I_{OFF}(max)}$$

In Vac=100V, if margin is -30%, $V_{Hmin}$=100×$\sqrt{2}$×0.7=99V

$V_{UVLO1}(max)$=14.5V, so

$$R_{start} = \frac{(99-14.5)}{25μA} = 3.38MΩ$$

For an example, with a sufficient margin to 3.38MΩ, and the $R_{start}$ is 2.0MΩ.

For AC100V, Power consumption in $R_{start}$ is below.

$$P_d (R_{start}) = \frac{(V_{H}-V_{CC})^2}{R_{start}} = \frac{(141V-14.5V)^2}{2.0M} = 8.00mW$$

$P_d$ in using start-up resistor is more than in using VH pin.

However for VCC pin capacitance value and VCC start-up resistor, please confirm by performing the evaluation of the actual application.
(2) Start Sequence (Soft start, Light load operation, Auto recovery in over load protection)

The start sequence of IC is shown in Figure-10. About each detail, explain in each section.

A: Input voltage from AC line is supplied to VH pin(8Pin).

B: VCC pin(6Pin) voltage is rise, when VCC>VUVLO1 (typ=13.5V), IC starts operating.
   In case of protection function is no active, IC starts to switching operation.
   Then VCC pin voltage is dropped in cause of VCC (6pin) consumption current.
   In case of VCC< VCHG1 (typ=8.7V), starter circuit is operated, IC starts to charge VCC pin. After starting of charge, IC continues to charge until VCC> VCHG2 (typ=13.0V).

C: There is a soft start function which regulates the voltage level at the CS pin to prevent a rise in voltage and current.

D: When the switching operation starts, VOUT rises.

E: Once the output voltage starts-up, set to stable the output voltage to within the TFOLP (min=44.8ms) period

F: When it is light load, burst operation is used to keep power consumption down.

G: When the FB pin(2pin) voltage keeps VFOLP1A (typ=2.8V) at or above TFOLP (64ms typ), switching is stopped by the over load protection for TOLPST (typ=512ms).
   When the FB pin(2pin) voltage does not keep VFOLP1B (typ=2.6V) at TFOLP (64ms typ), the timer of TFOLP (typ=64ms) is reset.

H: When VCC voltage(6pin) is VCHG1 (typ=8.7V) or less, starter circuit starts to charge VCC pin(6pin) to operate starter circuit.

I: When VCC voltage(6pin) is over than VCHG2 (typ=13.0V), starter circuit stops to charge VCC pin(6pin).

J: The same as F.

K: The same as G.
(3) VCC pin(6pin) Protection Function
IC built in VCC UVLO (Under Voltage Lock Out) function and VCC OVP (Over Voltage Protection) function and VCC charge function.
VCC UVLO function is the protection for VCC (pin) voltage is low. VCC OVP function is the protection for VCC (6pin) voltage is high. They are for preventing MOSFET from destroying for switching in VCC voltage low or high.
VCC charge function is stable for output voltage in VCC pin voltage low, because starter circuit charge VCC pin from VH line.

(3-1) VCC UVLO / VCC OVP Function
VCCUVLO is an auto recovery type that has voltage hysteresis. VCCOVP is an auto recovery type that has voltage hysteresis. When VCC pin voltage is larger than $V_{OVP1}$ (typ=27.5V), switching stops until VCC pin voltage is smaller than $V_{OVP2}$ (typ=23.5V).

![VCC UVLO / OVP Timing Chart](image)

Figure-11 VCC UVLO / OVP Timing Chart

A: VH (8pin) voltage input, VCC (6pin) voltage starts rising.
B: VCC pin voltage $>$ $V_{UVP1}$, releases the VCC UVLO function and DC/DC operation starts.
C: VCC pin voltage $>$ $V_{OVP1}$, VCCOVP detects the over-voltage.
D: VCC pin voltage $<$ $V_{OVP2}$, VCCOVP release and switching restart.
E: VH line voltage is down.
J: VCC $<$ $V_{UVLO2}$, VCC UVLO function starts to operate.
- For Capacitor Value of VCC pin

For stable operation of the IC, please set the 1uF or higher capacitor value of VCC pin. When the VCC capacitor terminal is too large, response of the VCC pin to the Secondary output is slows down. Please be careful. If the degree of the transformer coupling is low, since a large surge occurs to the VCC pin, the IC may be destroyed. In this case, please attach a resistor which is from 10Ω to 100Ω to the path between the capacitor and diode at the back of the auxiliary winding. Please set the resistance value in order that surge of VCC pin does not exceed the absolute maximum rating of the VCC pin by performing the waveform evaluation of VCC pin.

- For settings VCC OVP voltage protection when Vout (Secondary output) is increased

VCC pin voltage is determined by the transformer ratio and Vout (Secondary output). Therefore, when the Secondary output is large, it is possible to protect IC by VCCOVP. Setting VCCOVP protection is below.

\[ V_{CC} = V_{out} \times \frac{N_b}{N_s} - V_F \]  
\[ (V_{out}: \text{Secondary output}, N_b: \text{Number of auxiliary winding}, N_s: \text{Number of secondary winding}) \]

If you wish to apply protection when it becomes Secondary output × 1.3, please set the number of turns so that
\[ 1.3 \times (V_{out} \times (N_b/N_s) - V_F) > V_{OVP1} \]

VCCOVP is detected when VCC voltage is higher than the \( V_{OVP1} \) due to low degree of transformer coupling or other influences. Please confirm by performing the evaluation of the actual application.

In addition, as a protection of Secondary output, ZTOVP is also available (case BM1Q021FJ). ZTOVP is described in (6).
(3-2) VCC Recharge Function

After VCC (6pin) voltage > VUVLO1, IC start to operate. After that, when VCC pin voltage < VCHG1, VCC charge function is active. Then starter circuit operates charge VCC (6pin) from VH line. By these, IC does not occur. When the IC charge the VCC pin (6pin) and the VCC pin voltage exceeds VCHG2, the charging function is finished.

The operation is shown to Figure-13.

A: As VH pin voltage (8pin) is rising, VCC pin(6pin) is started to charge by VCC charge function.
B: VCC pin (6pin) voltage > VUVLO1, VCC UVLO function is released, VCC charge function is stopped, DC/DC operation start.
C: VCC pin (6pin) voltage is dropped for starting operation because OUTPUT voltage is low.
D: VCC pin (6pin) voltage < VCHG1, VCC pin(6pin) voltage rises to operate charge function.
E: VCC pin (6pin) voltage > VCHG2, VCC charge function stops.
F: VCC pin (6pin) voltage < VCHG1, VCC pin (6pin) voltage rises to re-operate charge function.
G: VCC pin (6pin) voltage > VCHG2, VCC charge function stops.
H: OUTPUT voltage is stable. Then, VCC pin (6pin) voltage is also stable for charging from the auxiliary winding to VCC pin(6pin).
(4) DC/DC Driver
The IC operates PFM (Pulse Frequency Modulation) mode method. By monitoring FB pin (2pin) and ZT pin (1pin), CS pin (3pin), the IC supply optimum system for DC/DC operation. The IC controls ON width (Turn Off) of external MOSFET by FB pin (2pin) and CS pin (3pin). The IC controls OFF width (Turn ON) of external MOSFET by ZT pin (1pin). The detail is shown below.

(4-1) For QR-basic Operations
The QR basic block diagram and the basic operation are shown in Figure-14,15.
For Figure-15

A: The internal oscillator outputs the SET signal, and turns ON the MOSFET. At this time, the Drain - source capacitance of the MOSFET is discharged, so noise is generated to the CS pin. This noise is called Leading Edge.
The filter for this noise is built in this IC. (It refer to (4-3)) Minimum pulse width of the IC is a 400ns (typ) by this filter and the delay time.
After that, current flows through the MOSFET, and Voltage Vcs = Rs * Ip is applied to the CS pin.

B: If CS pin voltage rises than FB pin voltage/Gain (typ = 4) or the overcurrent detection voltage Vcs, RESET signal is output, OUT turns OFF.

C: There is a delay time Tondelay from the point of B to turn OFF actually. Because of Tondelay the difference occurs in the maximum power by the AC voltage. This IC has a built-in function to reduce this difference. (It refer to (4-4))

D: The energy stored in the transformer during Ton is discharged to the secondary side, and Free vibration of the Drain voltage caused by the Cds (Drain - source capacitance) of MOSFET and Lp(transformer value) begins.

E: Since the switching frequency is determined by the IC, SET signal is output from the internal oscillator and turn ON the MOSFET by process of certain time from A.

(4 -2) Determination of ON Width(Turn OFF)
ON width is controlled by FB (2pin), CS (3pin).
By comparison between FB pin voltage divided by AVcs (typ=4) and CS pin voltage, the IC decides ON width. Besides, by comparison with Vlim1 (typ =0.5V) voltage which is generated in IC, CS comparator level is changed lineally to be shown in Figure-16(bottom). Maximum frequency also changes at this time.
CS (3pin) is shared with over current limiter circuit by pulse.
IC is changed over current limiter level and max frequency by FB (2pin) voltage.
- mode1 : Burst operation
- mode2 : Frequency reduction operation (reduce max frequency)
- mode3 : Max frequency operation (120kHz)
- mode4 : Over load operation (To detect over load state, IC is stopped switching)

Figure-16 FB pin Voltage - Over Current Limiter, Max Frequency Characteristics
The ON width of "Ton" is decided by CS Limiter level "VCS"

\[
Ton = \frac{Lp \cdot Vcs}{Vin \cdot RS}
\]

Lp: primary inductance value, Vin: voltage in Figure-14, RS: Sense resistor in Figure-14

To adjust over current limiter level, CS over current protection voltage is switched in soft-start, AC voltage. Vlim1 and Vlim2 is changed below.

<table>
<thead>
<tr>
<th>Soft start</th>
<th>AC=100V</th>
<th>AC=230V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vlim1</td>
<td>Vlim2</td>
</tr>
<tr>
<td>start~0.5ms</td>
<td>0.063V (12%)</td>
<td>0.016V (3%)</td>
</tr>
<tr>
<td>0.5ms~1ms</td>
<td>0.125V (25%)</td>
<td>0.032V (6%)</td>
</tr>
<tr>
<td>1ms~2ms</td>
<td>0.250V (50%)</td>
<td>0.063V (12%)</td>
</tr>
<tr>
<td>2ms~4ms</td>
<td>0.375V (75%)</td>
<td>0.094V (19%)</td>
</tr>
<tr>
<td>4ms~</td>
<td>0.500V (100%)</td>
<td>0.125V (25%)</td>
</tr>
</tbody>
</table>

* (percent) is shown comparative value with Vlim1 (typ = 0.5V) in normal operation.

The reason that distinguish between AC100V and AC230V is by CS over current protection voltage switch function which is shown to (4-4).

(4-3) LEB (Leading Edge Blanking) Function

When a MOSFET for switching is turned ON, surge current occurs in cause of capacitance or rush current. Therefore, when CS (3pin) voltage rises temporarily, over current limiter circuit may miss detections.

To prevent miss detections, the IC build-in blanking function which mask for \( T_{\text{LEB}} \) (typ=250ns) from switching OUT pin(5pin) from L to H. This blanking function enables to reduce noise filter of CS pin(3pin).

However, when CS pin noise does not converge less than 250ns, need to attach RC filter to CS pin shown in Figure-17. Then, delay time occurs to CS pin detection by RC filter.

Also, even if the filter in not attached, it is recommended that it is attached an Rcs resistor to CS pin as surge provision. Rcs recommended resistor value is about 1kΩ.

---

**Table2 Over current protection voltage Detail**

<table>
<thead>
<tr>
<th>Soft start</th>
<th>AC=100V</th>
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</tr>
<tr>
<td>4ms~</td>
<td>0.500V (100%)</td>
<td>0.125V (25%)</td>
</tr>
</tbody>
</table>

---

![Figure-17. CS pin surrounding circuit](image-url)
(4-4) CS Over Current Protection Switching Function

When input voltage (VH) is higher, ON time is short, and the operating frequency increases. As a result, maximum capable power increases for constant over current limiter. For that, monitoring input voltage (VH), IC switches over current detection of IC.

In case of high voltage (AC230V), IC changes over current comparator level to ×0.7 multiple of normal level. The detection method is that IC monitors ZT input current, then, IC switches it.

When MOSFET turns on, the voltage of “Va” has negative voltage to be affected input voltage (VH). Then, ZT (1pin) voltage is clamped near 0V by IC, ZT pin flows current to bias coil. The calculation is below. And show block figure to Figure-18, show graph to Figure-19, Figure-20.

\[
I_{zt} = \frac{(V_a - V_{zt})}{R_{zt_1}} \Rightarrow \frac{V_a}{R_{zt_1}} = VH \times \frac{Na}{Np} / R_{zt_1}
\]

Please set ZT current “Izt” to select the resistor Rzt1. And set bottom detection timing to select Czt.

About ZT current, IC builds in ZT current hysteresis I_{ZTHYS}(typ=0.1mA) to prevent VH detection changing by input voltage.

Figure-18 CS Over Current Detection Switched ZT current block diagram
**Figure-19  FB pin Voltage vs CS pin Voltage Characteristics**

**Figure-20  Izt Current vs Switched CS Voltage Characteristics**

ex) setting method (Switching between AC100V and AC220V)

AC100V: 141V±28V (±20% margin)

AC220V: 308V±62V (±20% margin)

In above case, need to switch CS over current detection voltage from 182V to 246V. For that, switching VH voltage from AC100V to AC220V may be selected in VH=214V.

Setting Np=100, Na=15

\[
\text{Va}=\text{Vin} \times \frac{\text{Na}}{\text{Np}} = 214V \times \frac{15}{100} \times (-1) = -32.1V
\]

\[
\text{Rzc} = \frac{\text{Va}}{\text{IZT}} = \frac{-32.1V}{-1mA} = 32.1k\Omega
\]

Therefore, set to \(Rzt=32K\Omega\)

**(4-5) Determination of OFF Width (Turn on)**

OFF width is controlled at the ZT pin. When OUT is Low, the power stored in the coil is supplied to the secondary-side output capacitor. When this power supply ends, there is no more current flowing to the secondary side, so the drain voltage of switching MOSFET drops. Consequently, the voltage on the auxiliary winding side also drops. A voltage that was resistance-divided by Rzt1 and Rzt2 is applied to ZT pin. When this voltage level drops to \(V_{ZT1}\) (100 mV typ) or below, MOSFET is turned ON by the ZT comparator. Since zero current status is detected at the ZT pin, time constants are generated using Czt, Rzt1, and Rzt2.

However, since Rzt1 and Rzt2 setting is required in AC voltage compensation function and ZTOVP function, bottom time adjustment is set in Czt capacitor.

OFF time is calculated below equation:

\[
\text{Toff1}=Ls/(Vout+Vf) \times Is
\]

\(\text{Toff1} : \text{transformer discharge time} , Ls : \text{secondary inductance} , Vout : \text{Secondary output} , Vf : \text{secondary diode forward voltage} , Is \text{ : secondary peak current}\)

For that, switching frequency is calculated below:

\[
\text{switching frequency } = \frac{1}{(\text{transformer charge and discharge time} \times (\text{Ton+Toff1}) + (\text{bottom-1}) \times \text{resonant time})}
\]

\[
\text{resonant time } = \frac{1}{(2\times\pi\times\sqrt{Lp \times Cds})}
\]

* Lp: primary inductance , MOSFET D-S capacitor : Cds

Because frequency reduction range in light load restricts shown Figure-16, bottom detection operates by the frequency which is lower than max frequency function in Figure-16.

Additionally, a ZT trigger mask function (described in section 4-6) and a ZT timeout function (described in section 4-7) are built in IC.
(4-6) ZT Trigger Mask Function (Figure-22)
When switching is set from ON to OFF, superposition of noise may occur at the ZT pin. Then, the ZT comparator and ZTOVP comparator are masked for the $T_{ZTMASK}$ time to prevent ZT comparator operation errors.

![Figure-21 ZT Trigger Mask Function](image)

A: DC/DC OFF=>ON
B: DC/DC ON=>OFF then the surge noise occurs to ZT pin.
C: Since a noise occurs to ZT pin at B, IC masks ZT comparator and ZTOVP comparator detection for $T_{ZTMASK}$ time.

(4-7-1) ZT Timeout Function1 (Figure-23)
When ZT pin voltage is not higher than $V_{ZT2}$(typ=200mV) for $T_{ZTOUT1}$(typ=15us) such as start or low output voltage, ZT pin short, IC turns on MOSFET by force.

(4-7-2) ZT Timeout Function2 (Figure-23)
After ZT comparator detects bottom, when IC does not detect next bottom within $T_{ZTOUT2}$ (typ =5us), IC turns on MOSFET by force. After ZT comparator detects bottom at once, the function operates. For that, it does not operate at start or at low output voltage. When IC is not able to detect bottom by decreasing auxiliary winding voltage, the function operates.

![Figure-22 ZT Timeout Function](image)

A: When starting, IC starts to operate by ZT timeout function1 for ZT=0V.
B: MOSFET turns ON
C: MOSFET turns OFF
D: ZT voltage is lower than $V_{ZT2}$(typ=200mV) by ZT dump decreasing.
E: MOSFET turns ON by ZT timeout function2 after $T_{ZTOUT2}$(typ=5us) from D point.
F: ZT voltage is lower than $V_{ZT2}$(typ=200mV) by ZT dump decreasing.
G: MOSFET turns ON by ZT timeout function2 after $T_{ZTOUT2}$(typ=5us) from F point.
H: ZT pin is short to GND.
I: MOSFET turns ON by ZT timeout function1 after $T_{ZTOUT1}$(typ=15us)
(5) **Soft Start Sequence**

Normally, when AC voltage is applied, a large current flows. Then secondary output voltage and current is occurred overshoot. For preventing it, IC built in soft-start function.

When VCC pin(6pin) voltage is lower than $V_{UVLO2}$ (typ =8.2V), IC is reset. After that, when AC voltage is applied, IC operates soft-start.

The soft start function is below: ( Please refer to (4-1) turn off item about CS limiter.)

- **start ~ 0.5ms** => Set CS limiter to 12.5% of normal operation.
- **0.5ms~1ms** => Set CS limiter to 25% of normal operation.
- **1ms~2ms** => Set CS limiter to 50% of normal operation.
- **2ms~4ms** => Set CS limiter to 75% of normal operation.
- **4ms~** => normal operation

(6) **ZT pin (1pin) OVP (Over Voltage Protection : Only BM1Q021FJ)**

IC build-in OVP function to ZT (1pin). IC detect ZTOVP protection, switching is stopped for $T_{ZTOVP}$(typ=512ms). After this time, IC restart switching. ZTOVP operates by DC voltage detection and pulse detection for ZT pin.

- **DC voltage detection**
  When ZT pin(1pin) voltage is over $V_{ZTL}$ (typ=5.0V) until $T_{MASK}$(typ=100us), switching is stopped.

- **Pulse detection**
  When the pulse of ZT (1pin) voltage larger than $V_{ZTL}$(typ=5.0V) is applied 3 count and for $T_{MASK}$(typ=100us) time, switching is stopped.

It shows ZT OVP voltage setting method below. (auxiliary winding voltage : $V_a$, ZT upper resistor : $R_{zt1}$, ZT lower resistor : $R_{zt2}$)

Secondary voltage : $V_o$, transformer winding ratio(secondary / auxiliary) : $N_s/N_a$, ZT input current : $I_{zt}$

The voltage which detects over voltage protection in secondary side : $V_{OVP}$

$$V_{OVP} = (N_a/N_s)\times V_a = (N_a/N_s) \times (V_{ZT} \times R_{zt1} + R_{zt2} + R_{zt1} \times I_{zt})$$

When ZT voltage $= 5.35V$, ZT input current is calculated to $I_{zt}$(max)=28µA, OVP maximum voltage is set below:

$$V_{OVP}$(max)=$(N_a/N_s)/(5.35\times (R_{zt1} + R_{zt2}) + (R_{zt2} + R_{zt1}\times 28\mu A))$

$R_{zt1}$ setting is decided by AC voltage compensation function of (4-4).

$R_{zt2}$ setting is calculated below

$R_{zt2} = V_{zt0} \times R_{zt1}/(V_{ovp} \times (N_a/N_s) - I_{zt} \times R_{zt1} - V_{zt0})$

BM1Q041FJ don't have ZTOVP function.
(7) CS (3pin) Open Protection
When CS (3pin) is OPEN, to prevent OUT pin from changing to H by noise, IC builds in CS(3pin) open protection. When CS (3pin) is open, OUT (5pin) switching is stopped by the function. (This is auto-recovery)

(8) OUTPUT Over Load Protection (FB OLP comparator)
When secondary output is over load, IC detects it by FB (2pin), IC stops switching. In OLP state, because secondary photo-coupler is not flown current, FB (2pin) voltage is up. When the condition continues for $T_{FOLP}$ (typ = 64ms), IC judges over load state, OUT (5pin) is L fixed. After FB (2pin) voltage is over $V_{FOLP1A}$ (typ = 2.8V), when FB (2pin) voltage is lower than $V_{FOLP1B}$ (typ = 2.6V) within $T_{FOLP}$ (typ = 64ms), over load protection timer is reset. In starting, because FB (2pin) is pull-up by a resistor to internal voltage, FB (2pin) voltage starts to operate in the state which is more than $V_{FOLP1A}$ (typ = 2.8V).
For that, please set stable time of secondary output voltage within $T_{FOLP}$ (typ = 64ms).
After detecting over load, IC is stopped for $T_{OLPST}$ (typ = 512ms), IC is auto-recovery operation. In stopping switching, though VCC (6pin) voltage falls, but IC operates re-charge function by starter circuit, VCC (6pin) voltage keeps VCC pin voltage > $V_{UVLO2}$.

A: When FB voltage is over $V_{FOLP1A}$ (typ = 2.8V), FBOLP comparator detects over load.
B: When the state A continues for $T_{FOLP}$ (typ = 64ms), IC stops switching by over load protection.
C: During stopping switching by over load protection, VCC (6pin) voltage drops. When VCC (6pin) voltage is lower than $V_{CHG1}$, VCC re-charge function operate, VCC (6pin) voltage is up.
D: When VCC (6pin) voltage is higher than $V_{CHG2}$ by re-charge function, VCC re-charge function is stopped.
E: From B, it takes for $T_{OLPST}$ (typ = 512ms), IC starts switching with soft-start.
F: When over load state continues, FB (2pin) voltage is over $V_{FOLP1A}$. When it takes for $T_{FOLP}$ (typ = 64ms) from E, IC stops switching.
G: During stopping switching by over load protection, VCC (6pin) voltage drops. When VCC (6pin) voltage is lower than $V_{CHG1}$, VCC re-charge function operate, VCC (6pin) voltage is up.
H: When VCC (6pin) voltage is higher than $V_{CHG2}$ by re-charge function, VCC re-charge function is stopped.
(9) OUT (5pin) Voltage Clamp Function
By the purpose which protects external MOSFET, H level of OUT (5pin) is clamped to \( V_{OUTH} (typ=12.5V) \)
It prevents gate destruction of MOSFET by rising VCC (6pin) voltage. (It refers to Figure-26)
OUT (5pin) is pull-down \( R_{PDOUT} (typ=100k\Omega) \).

![Figure-26 OUT (5pin) Construction](image)

**Operation Mode of Protection Circuit**
Operation mode of protection functions are shown in table3.

<table>
<thead>
<tr>
<th>Item</th>
<th>BM1Q021FJ</th>
<th>BM1Q041FJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC Under Voltage Locked Out</td>
<td>Self restart</td>
<td>Self restart</td>
</tr>
<tr>
<td>VCC Over Voltage Protection</td>
<td>Self restart</td>
<td>Self restart</td>
</tr>
<tr>
<td>FB Over Load Protection</td>
<td>Self restart (64ms delay, 512ms stop)</td>
<td>Self restart (64ms delay, 512ms stop)</td>
</tr>
<tr>
<td>CS Open Protection</td>
<td>Self restart</td>
<td>Self restart</td>
</tr>
<tr>
<td>ZT Over Voltage Protection</td>
<td>Self restart (100us delay, 512ms stop)</td>
<td>None</td>
</tr>
<tr>
<td>VCC Charge Protection</td>
<td>Self restart</td>
<td>Self restart</td>
</tr>
</tbody>
</table>
Power Dissipation

The thermal design should set operation for the following conditions.
(Since the temperature shown below is the guaranteed temperature, be sure to take a margin into account.)

1. The ambient temperature $T_a$ must be 105°C or less.
2. The IC's loss must be within the allowable dissipation $P_d$.

The thermal abatement characteristics are as follows.
(PCB: 70 mm × 70 mm × 1.6 mm, mounted on glass epoxy substrate)

![SOP-J8 Thermal Abatement Characteristics](image)

Figure-27 SOP-J8 Thermal Abatement Characteristics
Operational Notes

1. Reverse Connection of Power Supply
Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC’s power supply terminals.

2. Power Supply Lines
Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. Ground Voltage
Except for pins the output and the input of which were designed to go below ground, ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. Ground Wiring Pattern
When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. Thermal Consideration
Should by any chance the power dissipation rating be exceeded, the rise in temperature of the chip may result in deterioration of the properties of the chip. The absolute maximum rating of the Pd stated in this specification is when the IC is mounted on a 70mm x 70mm x 1.6mm glass epoxy board. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the Pd rating.

6. Recommended Operating Conditions
These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

7. Rush Current
When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

8. Operation Under Strong Electromagnetic Field
Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

9. Testing on Application Boards
When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC’s power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

10. Inter-pin Short and Mounting Errors
Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.
Operational Notes – continued

11. Unused Input Terminals
   Input terminals of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input terminals should be connected to the power supply or ground line.

12. Regarding the Input Pin of the IC
   This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

   - When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.
   - When GND > Pin B, the P-N junction operates as a parasitic transistor.

   Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

Example of monolithic IC structure

13. Ceramic Capacitor
   When using a ceramic capacitor, determine the dielectric constant considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

14. Area of Safe Operation (ASO)
   Operate the IC such that the output voltage, output current, and power dissipation are all within the Area of Safe Operation (ASO).

15. Thermal Shutdown Circuit (TSD)
   This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC’s power dissipation rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit that will turn OFF all output pins. When the Tj falls below the TSD threshold, the circuits are automatically restored to normal operation.

   Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

16. Over Current Protection Circuit (OCP)
   This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

Status of this document
The Japanese version of this document is formal specification. A customer may use this translation version only for a reference to help reading the formal version.
If there are any differences in translation version of this document formal version takes priority
Ordering Information

BM1Q0X1FJ

Product name

Package
FJ – SOP-J8

Packaging and forming specification
E2: Embossed tape and reel

Marking Diagram

1PIN MARK

LOT No.

Line Up

<table>
<thead>
<tr>
<th>Product (BM1Q0X1FJ)</th>
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</thead>
<tbody>
<tr>
<td>BM1Q021FJ</td>
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<tr>
<td>BM1Q041FJ</td>
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### Physical Dimension Tape and Reel Information

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<th>Package Name</th>
<th>SOP-J8</th>
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</table>

<table>
<thead>
<tr>
<th><strong>Tape and Reel information</strong></th>
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<tbody>
<tr>
<td><strong>Tape</strong></td>
<td>Embossed carrier tape</td>
</tr>
<tr>
<td><strong>Quantity</strong></td>
<td>2500pcs</td>
</tr>
<tr>
<td><strong>Direction of feed</strong></td>
<td>E2</td>
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</tbody>
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The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand.

Order quantity needs to be multiple of the minimum quantity.
Revision History

<table>
<thead>
<tr>
<th>Date</th>
<th>Revision</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.Sep.2016</td>
<td>001</td>
<td>New Release</td>
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Notice

Precaution on using ROHM Products

1. Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note1), transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property (“Specific Applications”), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM’s Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

<table>
<thead>
<tr>
<th>JAPAN</th>
<th>USA</th>
<th>EU</th>
<th>CHINA</th>
</tr>
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<tr>
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2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM’s Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc., prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl2, H2S, NH3, NO2, SO2, and NOx
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification
Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic
This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation
1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label
A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition
When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act
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