# AC/DC Drivers

## AC/DC Controller IC for LED Lighting

**Included 650V MOSFET BM520Q15F**

### General Description

The AC/DC quasi-resonant controller type LED driver IC BM520Q15F can be applied to a non-isolated application, making the designs for various types of low power converter easy.

The low power consumption and high-speed start are achieved through the start-up circuit with 650V withstand voltage.

Due to the quasi-resonant mode, soft switching is achieved. The EMI is also improved by the alterable operating frequency. A power supply design with a high degree of freedom can also be achieved by the external current setting resistance.

A low-cost application can be achieved with the built-in MOSFET with 650V withstand voltage. It also makes the application design easy.

### Key Specifications

- Operating Power Supply Voltage Range:
  - VCC: 8.9V to 26.0V
  - DRAIN: ~650V

- Operating Current: Normal Operation: 0.35mA (Typ)

- Operating Temperature Range: -40°C to +105°C

- MOSFET ON Resistance: 4.0Ω (Typ)

### Features

- Quasi-resonant Switching Mode
- Built-in 650V Starter Circuit
- Built-in 650V Switching MOSFET
- Maximum Frequency of 200kHz
- VCC pin: Under Voltage Protection
- VCC pin: Over Voltage Protection (latch)
- SOURCE pin: Leading-Edge-Blanking Function
- ZT pin: Trigger Mask Function
- ZT pin: Over Voltage Protection (latch)
- NTC pin: Temperature Detecting Protection (Automatic Recovery)

### Package

- SOP8: 5.00mm × 4.40mm (Typ) pitch 1.27mm (Typ)

### Application

- LED bulb, sealed-type LED lighting
- Electrical machineries for LED lighting

### Typical Application Circuit

![Application Circuit](image)
### 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 to 30</td>
<td>V</td>
<td>VCC</td>
</tr>
<tr>
<td>Input Voltage Range 2</td>
<td>Vmax2</td>
<td>-0.3 to 6.5</td>
<td>V</td>
<td>SOURCE, NTC, ZT</td>
</tr>
<tr>
<td>Input Voltage Range 3</td>
<td>Vmax3</td>
<td>650</td>
<td>V</td>
<td>DRAIN</td>
</tr>
<tr>
<td>Drain Current Pulse</td>
<td>Ipr</td>
<td>2.60</td>
<td>A</td>
<td>Pd=10us, Duty cycle=1%</td>
</tr>
<tr>
<td>Maximum Power Dissipation</td>
<td>Pd</td>
<td>563</td>
<td>mW</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>Topr</td>
<td>-40 to +105</td>
<td>℃</td>
<td></td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>Tjmax</td>
<td>150</td>
<td>℃</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>Tstr</td>
<td>-55 to +150</td>
<td>℃</td>
<td></td>
</tr>
</tbody>
</table>

(Note1) When mounted (on 70 mm × 70 mm, 1.6 mm thick, glass epoxy on single-layer substrate). Derate by 4.563 mW/℃ above Ta = 25℃.

### Recommended Operating Conditions (Ta=25°C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage Range 1</td>
<td>VCC</td>
<td>8.9 to 26.0</td>
<td>V</td>
<td>VCC voltage</td>
</tr>
<tr>
<td>Input Voltage Range 2</td>
<td>VDRAIN</td>
<td>0 to 650</td>
<td>V</td>
<td>DRAIN voltage</td>
</tr>
</tbody>
</table>

### Electrical Characteristics (Ta=25°C)

**MOSFET (Unless otherwise specified Ta = 25°C, VCC = 15V)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Specification</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain-Source Breakdown Voltage</td>
<td>V(BR)DDS</td>
<td>650</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Drain Leakage Current</td>
<td>ISSS</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>ON Resistance</td>
<td>RDS(on)</td>
<td>-</td>
<td>4</td>
<td>5.5</td>
</tr>
</tbody>
</table>
### Electrical Characteristics

#### IC

(Unless otherwise specified, Ta = 25°C, VCC = 15 V)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Specification</th>
<th>Unit</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
</tr>
<tr>
<td>Circuit current</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit Current (ON)1</td>
<td>$I_{ON1}$</td>
<td>120</td>
<td>350</td>
<td>700 μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NTC=2.0V(PULSE operating) BM520Q15F</td>
</tr>
<tr>
<td>Circuit Current (ON)2</td>
<td>$I_{ON2}$</td>
<td>-</td>
<td>220</td>
<td>400 μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NTC=0V(PULSE OFF)</td>
</tr>
<tr>
<td>VH pin start up circuit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VH Starting Current 1</td>
<td>$I_{START1}$</td>
<td>0.20</td>
<td>0.55</td>
<td>0.90 mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VCC= 0V</td>
</tr>
<tr>
<td>VH Starting Current 2</td>
<td>$I_{START2}$</td>
<td>1</td>
<td>3</td>
<td>6 mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VCC=10V</td>
</tr>
<tr>
<td>VH OFF Current</td>
<td>$I_{START3}$</td>
<td>-</td>
<td>10</td>
<td>20 μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VCC UVLO released VH pin sink current</td>
</tr>
<tr>
<td>VH Starting Current</td>
<td>$V_{SC}$</td>
<td>0.3</td>
<td>0.7</td>
<td>1.6 V</td>
</tr>
<tr>
<td>Switching Voltage</td>
<td></td>
<td></td>
<td></td>
<td>VCC pin</td>
</tr>
<tr>
<td>VCC pin protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCC UVLO Voltage 1</td>
<td>$V_{UVLO1}$</td>
<td>12.5</td>
<td>13.5</td>
<td>14.5 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VCC rising up</td>
</tr>
<tr>
<td>VCC UVLO Voltage 2</td>
<td>$V_{UVLO2}$</td>
<td>7.5</td>
<td>8.2</td>
<td>8.9 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VCC falling down</td>
</tr>
<tr>
<td>VCC UVLO Hysteresis</td>
<td>$V_{UVLO3}$</td>
<td>-</td>
<td>5.3</td>
<td>- V</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{UVLO}=V_{UVLO1}=V_{UVLO2}$</td>
</tr>
<tr>
<td>VCC OVP Trigger Voltage</td>
<td>$V_{OVP1}$</td>
<td>25.0</td>
<td>27.5</td>
<td>30.0 V</td>
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<tr>
<td></td>
<td></td>
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<td></td>
<td>VCC falling down</td>
</tr>
<tr>
<td>VCC OVP Release Voltage</td>
<td>$V_{OVP2}$</td>
<td>21.0</td>
<td>23.5</td>
<td>26.0 V</td>
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<td>VCC falling down</td>
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<tr>
<td>Latch Released VCC Voltage</td>
<td>$V_{LATCH1}$</td>
<td>-</td>
<td>$V_{UVLO}=0.5$</td>
<td>- V</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>VCC rising up</td>
</tr>
<tr>
<td>VCC Recharge Start Voltage</td>
<td>$V_{CHG1}$</td>
<td>7.7</td>
<td>8.7</td>
<td>9.7 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VCC falling down</td>
</tr>
<tr>
<td>VCC Recharge End Voltage</td>
<td>$V_{CHG2}$</td>
<td>12</td>
<td>13</td>
<td>14 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VCC rising up</td>
</tr>
<tr>
<td>Latch Mask Time</td>
<td>$T_{LATCH}$</td>
<td>60</td>
<td>100</td>
<td>140 us</td>
</tr>
<tr>
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<tr>
<td>DC/DC comparator (turn-on)</td>
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</tr>
<tr>
<td>ZT Comparator Voltage 1</td>
<td>$V_{ZT1}$</td>
<td>40</td>
<td>100</td>
<td>160 mV</td>
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<td></td>
<td></td>
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<td>ZT falling down</td>
</tr>
<tr>
<td>ZT Comparator Voltage 2</td>
<td>$V_{ZT2}$</td>
<td>120</td>
<td>200</td>
<td>280 mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ZT rising up</td>
</tr>
<tr>
<td>ZT Comparator Hysteresis</td>
<td>$V_{ZTHYS}$</td>
<td>-</td>
<td>100</td>
<td>- mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$V_{ZTHYS}=V_{ZT1}=V_{ZT2}$</td>
</tr>
<tr>
<td>ZT Trigger Mask Time</td>
<td>$T_{ZT1}$</td>
<td>-</td>
<td>0.8</td>
<td>- us</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>$V_{ZT}=V_{H}-&gt;L$ for preventing from noise</td>
</tr>
<tr>
<td>ZT Trigger Timeout</td>
<td>$T_{ZTOUT}$</td>
<td>10</td>
<td>15</td>
<td>20 us</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>DC/DC comparator (turn-off)</td>
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<td></td>
</tr>
<tr>
<td>Current Trigger Voltage</td>
<td>$V_{CA}$</td>
<td>0.57</td>
<td>0.6</td>
<td>0.63 V</td>
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<td></td>
<td>No AC compensation</td>
</tr>
<tr>
<td>Maximum Frequency</td>
<td>$F_{max}$</td>
<td>180</td>
<td>200</td>
<td>220 KHz</td>
</tr>
<tr>
<td>Leading Edge Blank Time</td>
<td>$T_{LEB}$</td>
<td>-</td>
<td>0.2</td>
<td>- us</td>
</tr>
<tr>
<td>Maximum ON Time</td>
<td>$T_{MAX}$</td>
<td>30</td>
<td>39</td>
<td>50.7 us</td>
</tr>
<tr>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>DC/DC protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZT OVP Voltage</td>
<td>$V_{ZT1}$</td>
<td>3.250</td>
<td>3.500</td>
<td>3.750 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NTC pin protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NTC Pin Source current</td>
<td>$I_{NTC}$</td>
<td>45</td>
<td>50</td>
<td>55 μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NTC voltage=1.0V</td>
</tr>
<tr>
<td>NTC Trigger Voltage</td>
<td>$V_{NTC}$</td>
<td>0.06</td>
<td>0.12</td>
<td>0.18 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NTC voltage falling down</td>
</tr>
<tr>
<td>NTC Hysteresis</td>
<td>$V_{NTCHYS}$</td>
<td>0.04</td>
<td>0.08</td>
<td>0.12 V</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>NTC voltage rising up</td>
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</table>
Pin Description

Table 1. I/O PIN functions

<table>
<thead>
<tr>
<th>NO.</th>
<th>Pin Name</th>
<th>I/O</th>
<th>Function</th>
<th>ESD protection</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>VCC</td>
<td>I/O</td>
<td>Power Supply pin</td>
<td>VCC GND</td>
</tr>
<tr>
<td>2</td>
<td>N.C.</td>
<td>-</td>
<td>Non Connection</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>N.C.</td>
<td>-</td>
<td>Non Connection</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>DRAIN</td>
<td>I/O</td>
<td>MOSFET DRAIN pin</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>SOURCE</td>
<td>I</td>
<td>MOSFET DRAIN pin</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inductor Current Sensing pin</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>NTC</td>
<td>I/O</td>
<td>NTC Detect Input pin</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>I/O</td>
<td>GND pin, Input pin for Feedback Signal</td>
<td>○ -</td>
</tr>
<tr>
<td>8</td>
<td>ZT</td>
<td>I</td>
<td>Zero Current Detecting pin</td>
<td>-</td>
</tr>
</tbody>
</table>

I/O Equivalent Circuit Diagram

1PIN : VCC

4PIN : DRAIN

5PIN : SOURCE

6PIN : NTC

8PIN : ZT

Figure 2. I/O equivalent circuit diagram
●Block Diagram

Figure 3. Block diagram

●External Dimensions

Figure 4. SOP8 package external dimensions
● Block Descriptions

(1) Start-up circuit (DRAIN: 4pin, VCC:1pin)

(1-1) Block Descriptions
A bootstrap circuit with 650V withstand voltage is built in this IC. Thus, low-power standby and high-speed start can be achieved. After the IC was booted up, the power consumption becomes only the idling current \( \text{typ}=10\mu\text{A} \). The reference value of the start-up time is showed in Figure 7. When \( \text{C}_{\text{VCC}}=10\mu\text{F} \), the start-up time can be less than 0.1s.

![Start-up circuit block diagram](image)

![Start-up current-VCC voltage curve](image)

![Start-up time-VCC capacitance characteristics](image)

The start-up current means the current from the DRAIN pin.

ex: When \( V_{\text{ac}}=100\text{V} \), the power consumption of bootstrap circuit is \( P_{\text{VH}}=100\text{V} \times \sqrt{2} \times 10\mu\text{A}=1.41\text{mW} \)

ex: When \( V_{\text{ac}}=240\text{V} \), the power consumption of bootstrap circuit is \( P_{\text{VH}}=240\text{V} \times \sqrt{2} \times 10\mu\text{A}=3.38\text{mW} \)
(1-2) Start sequences 1 (VCC supply with auxiliary winding)

The time chart of the start sequences are showed in Figure 9. The DC/DC circuit which reduces the power consumption of the IC can be composed by using the auxiliary winding of the transformer.

Figure 8. Schematic of the DC/DC Part while Supplying with the Auxiliary Winding

Figure 9. ON/OFF Sequences (supplying VCC with auxiliary winding)

A: Input voltage VH is applied. (Though the LED and the transformer, a high voltage is applied to DRAIN pin from VH.)
B: The capacitor connected to the VCC pin is charged by the start-up current from the DRAIN pin.
C: The IC starts operating when VCC > V_{UVLO1}
D: The soft start is achieved by the voltage rise of the NTC pin. (The switching starts when VNTC>0.2V)
E: The current is supplied to VCC pin from the auxiliary winding by the switching operation.

※ The power is supplied by the auxiliary winding, and the VCC voltage is determined by the specification of transformer.
F: While the voltage of NTC pin is falling down, the LED current decreases from VNTC<0.6V.
G: The switching operation stops when V_{NTC}<0.1V. The current supply to VCC pin disappears, the recharge operation of VCC pin is repeated.
H: The switching operation restarts when V_{NTC}>0.2V. The VCC is supplied by the auxiliary winding.
I: When the power supply turns OFF, VCC voltage falls down due to descend of the voltage of DRAIN pin. The IC turns OFF when the V_{UVLO2} is triggered.
(1-3) Start sequences 2 (no VCC supply with auxiliary winding)

While IC operates after VCCUVLO is released, VCC pin operates by the charge/discharge to the external capacitor. The VCC is supplied with the start-up circuit. This circuit can be composed without the auxiliary winding of the transistor. Figure 10 shows the schematic of the DC/DC part.

It is necessary to pay attention to the heat which is caused by the power consumption of the JFET of the start-up circuit, while there is no VCC supply to the auxiliary winding of the transformer.

![Schematic of the DC/DC Part without Power Supply by Auxiliary Winding](image)

Figure 10. Schematic of the DC/DC Part without Power Supply by Auxiliary Winding

A: Input voltage VH is applied. (Though the LED and the transformer, a high voltage is applied to DRAIN pin from VH.)
B: The capacitor connected to the VCC pin is charged by the start-up current from the DRAIN pin.
C: The IC starts operating when VCC > VUVLO1
D: The soft start is achieved by the voltage rise of the NTC pin. (The switching starts when VNTC > 0.2V)
E: The VCC repeats charge/recharge operations between the recharge trigger voltage VCHG1 and VCHG2.
F: The switching operation stops when VNTC < 0.12V.
G: The switching operation restarts when VNTC > 0.2V.
H: When the power supply turns OFF, VCC voltage falls down due to descend of DRAIN pin voltage. The IC turns OFF when the VUVLO2 is triggered.

![ON/OFF Sequences (no VCC supply with auxiliary winding)](image)

Figure 11. ON/OFF Sequences (no VCC supply with auxiliary winding)
(2) VCC pin protection function
The VCC under voltage protection function VCC UVLO (Under Voltage Lock Out), over voltage protection function VCC OVP (Over Voltage Protection), and a VCC recharge function which operates when a voltage drop occurs at VCC pin are all built in this IC. The VCC UVLO and VCC OVP functions are used for preventing the destructions of the switching MOSFET which occurs when the VCC voltage is too high or too low. Due to the VCC charge function, the VCC pin is charged from high voltage lines by the start circuit when the VCC voltage drops, and the secondary output voltage is stabilized.

(2-1) VCC UVLO / VCC OVP function
VCC UVLO and VCC OVP are auto recovery comparators which have voltage hysteresis. VCC OVP has a built-in mask time TLATCH (Typ=100us).

The detection is executed when the VCC voltage is over V overloaded (typ=27.5V), and this state lasts TLATCH (typ=100us). By this function, the surge which occurs at VCC pin can be masked.

(2-2) VCC charge function
When the VCC pin voltage is over V UVLO, the IC starts up. In this case, if the VCC pin voltage drops below V CHG, VCC charge function operates. At this time, the VCC pin is charged from the DRAIN pin through the bootstrap circuit. Due to this operation, the failure of start-up can be prevented.

A: DRAIN pin voltage is applied, VCC voltage rises by the charging current Istart1 (550uA typ).
B: VCC voltage > V SC, the charging current to VCC changes from Istart1 (550uA typ) to Istart2 (3mA typ)
C: VCC voltage > V CHG, though VCC charge function reacts, due to VCC UVLO is detected, the charge continues.
D: VCC voltage > V UVLO, the VCC UVLO is released and DC/DC operation starts, the charge to VCC stops.
E: VCC voltage > V CHG, the charge to VCC restarts.
F: VCC voltage > V OVP, VCC OVP is detected.
G: VCC voltage > V OVP, if VCC voltage drops below V OVP in 100us, VCC OVP is released and the latch will not be activated.
H: V OVP < VCC voltage < V CHG, if this state is kept longer than 100us, the switching stops by latch.
I: VCC voltage < V UVLO, VCC UVLO is detected.
J: VCC voltage < V LATCH, the latch state is released.
K: VCC voltage < V SC, the charging current to VCC changes from Istart2 (3mA typ) to Istart1 (550uA typ)
(3) LED peak current sensing
The peak current sensing is proceeded in every switching cycle. The switching turns OFF if the voltage of SOURCE pin exceeds some certain value. An AC compensation function is built in this IC. It is a function which increases the LED peak current sensing level with the increment of time. This operation is showed in Figure 13,14.

![Figure 13. Peak current sensing without AC compensation](image1)
![Figure 14. Peak current sensing with AC compensation](image2)

(4) L.E.B blanking period
When the MOSFET driver is turned ON, the capacitive components generates surge current and drive current. In this case, if the SOURCE pin voltage rises temporarily, false detections may occur in the over current limiter circuit. A L.E.B function (Leading Edge Blanking function) which masks the SOURCE voltage during the 200nsec after the OUT pin switches form L to H is built in to prevent false detections

(5) SOURCE pin open protection
The IC may be damaged by overheating when the SOURCE pin (pin 5) becomes open. To prevent this from happening, an open protection circuit is built in this IC. (Automatic recovery protection)

(6) NTC pin temperature detecting protection
Voltage is generated on the thermistor by a 50uA source current from the NTC pin. When NTC pin voltage is lower than 0.67V, the LED peak current reduces gradually. When this voltage becomes lower than 0.12V, the switching operation stops. When NTC voltage rises up again higher than 0.2V, the switching operation restarts.
● Operation mode of protection circuit

Operation mode of protection functions are shown in Table 2.

Table 2. Operation mode of protection circuit

<table>
<thead>
<tr>
<th>Abnormal state detection</th>
<th>Detect</th>
<th>Release</th>
<th>Protection operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>UVLO</td>
<td>&lt;= 8.2V</td>
<td>&gt;= 13.5V</td>
</tr>
<tr>
<td></td>
<td>OVP</td>
<td>&gt;= 27.5V</td>
<td>Before latch: &lt;= 23.5V&lt;br&gt;Latched: VCC &lt;= 7.7V</td>
</tr>
<tr>
<td>TSD</td>
<td></td>
<td>&gt;= 175°C</td>
<td>Before latch: &lt;= 155°C&lt;br&gt;Latched: VCC &lt;= 7.7V</td>
</tr>
<tr>
<td>ZT</td>
<td>OVP</td>
<td>&gt;= 3.50V</td>
<td>Before latch: &lt;= 3.33V&lt;br&gt;Latched: VCC &lt;= 7.7V</td>
</tr>
<tr>
<td>NTC</td>
<td>LED TEMP</td>
<td>&lt;= 0.12V</td>
<td>&gt;= 0.2V</td>
</tr>
</tbody>
</table>

● Sequences

The sequences diagram of all states of this IC is showed in Figure 15.

In all states, when VCC<8.2V, the states change to OFF mode.

Figure 15. Transition diagram of all states
Power Dissipation
According to the thermal design, please observe the conditions below when use this IC.

1. The ambient temperature $T_a$ must be 105°C or less.
2. The consumption of the IC must be within the allowable power dissipation $P_d$.

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

![Figure 16. Power Dissipation characteristics](image-url)
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**
  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. **Inrush 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.
● Physical Dimension, Tape and Reel Information

<table>
<thead>
<tr>
<th>Package Name</th>
<th>SOP8</th>
</tr>
</thead>
</table>

(UNIT: mm)  
PKG: SOP8  
Drawing No.: EX112-5001-1

- **Tape and Reel Information**
  - **Tape**: Embossed carrier tape  
  - **Quantity**: 2500pcs  
  - **Direction of feed**: E2  
    - 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  
  - **Reel**:  
    - 1pin  
    - Direction of feed  
    - Order quantity needs to be multiple of the minimum quantity.

- **Order quantity needs to be multiple of the minimum quantity.**
● Ordering Information

```
BM520Q1XF - XX
```

**Product name**

**Packaging and forming specification**

**XX:** Please confirm the formal name with our salesmen.

● Marking Diagram

![Marking Diagram](image)
Notice

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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, 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.

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   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

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   [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, SO2, and NO2
   [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 (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient 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; if flow soldering method is preferred, 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.

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