IR3M92N4

AC-DC conversion type IC for LED Lighting

**Description**

IR3M92N4 is a AC/DC power supply IC for LED lighting which built-in power factor improvement circuit, quasi-resonant operation circuit and PWM dimming circuit. Primary-side control by transformer realizes the constant current operation suitable for LED lighting.

**Features**

1. Input voltage range:
   - 10V to 18V
   - *VCC=23V(Max.) at start up.
2. Output current (LED current):
   - Constant current control
3. Feature Function:
   - Power factor improvement, quasi-resonant operation, PWM dimming operation and Standby operation
4. Error detection / Protection:
   - VCC under voltage lock-out
   - Output over voltage lock-out
   - Over temperature protection
   - Over current protection
5. P-type silicon monolithic IC
6. Radiation-proof design:
   - This product is not radiation-proof design.
7. Lead finish: Lead Free
8. 8 pin SOP plastic package

**Agency approvals/Compliance**

1. Compliant with RoHS directive (2002/95/EC)

**Applications**

1. Light bulb
2. Ceiling light
3. Tube light

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### Pin assignment

<table>
<thead>
<tr>
<th>Pin name</th>
<th>Equivalent circuit</th>
<th>Pin description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT</td>
<td><img src="image1" alt="Equivalent Circuit" /></td>
<td>Gate drive for the external switching MOSFET</td>
</tr>
<tr>
<td>GND</td>
<td><img src="image2" alt="Equivalent Circuit" /></td>
<td>Ground terminal</td>
</tr>
<tr>
<td>ISE</td>
<td><img src="image3" alt="Equivalent Circuit" /></td>
<td>Current sense of the primary winding</td>
</tr>
<tr>
<td>VSE</td>
<td><img src="image4" alt="Equivalent Circuit" /></td>
<td>Voltage sense of the auxiliary winding</td>
</tr>
<tr>
<td>FL1</td>
<td><img src="image5" alt="Equivalent Circuit" /></td>
<td>The input terminal of error amplifier. Please connect capacitor CFL1 to this terminal.</td>
</tr>
<tr>
<td>FL2</td>
<td><img src="image6" alt="Equivalent Circuit" /></td>
<td>The output terminal of error amplifier. Please connect capacitor CFL2 to this terminal.</td>
</tr>
</tbody>
</table>
| FUNC     | ![Equivalent Circuit](image7) | Mode setting terminal  
  - Flyback mode : Open  
  - Step-down mode : 200kohm  
  - PWM dimming input : pulse input  
  - Standby input terminal : GND |
| VCC      | ![Equivalent Circuit](image8) | Power Supply |
Block diagram and basic connection diagram
Functional description

1. Constant current function

1-1. Concept of constant current operation (Flyback mode)

By monitoring VSE and ISE signals and controlling them, LED current (output current) can be controlled to be a constant level. Figure 1.2 shows FET Drain voltage, primary current and secondary current waveform during FET on and off. VSE signal is resistance-divided voltage of auxiliary winding output. Drain voltage waveform of FET and VSE waveform are same polarity and similar. As LED current (output current) is the average of secondary current, it is shown by equation (1).

\[ I_{\text{out}} = \frac{1}{2} \cdot I_{pk2} \cdot \frac{T_{\text{res}}}{T_c} \quad (1) \]

where
- \( I_{pk2} \): secondary peak current
- \( T_{\text{res}} \): period during secondary current flows
- \( T_c \): switching cycle

It is also shown by equation (2).

\[ I_{\text{out}} = \frac{1}{2} \cdot \frac{N_p}{N_s} \cdot I_{pk1} \cdot \frac{T_{\text{res}}}{T_c} \quad (2) \]

where
- \( N_p \): primary winding turns
- \( N_s \): secondary winding turns
- \( I_{pk1} \): primary peak current

As \( N_p/N_s \) value is constant in equation(2), LED current (output current) can be controlled to be a constant value by keeping \( I_{pk1} \cdot T_{\text{res}}/T_c \) constant. \( I_{pk1} \) can be monitored by ISE terminal and \( T_{\text{res}} \) can be monitored by VSE terminal.
1-2. Constant current operation (Flyback mode)

IC operation, how to control LED current (output current) to be a constant value, is explained as below.

Figure 1.3 shows block diagram relating constant current operation. As V\textsubscript{ISE} is proportional to primary current and sensing resistance Rs, ISE terminal can monitor primary current. V\textsubscript{PHOLD} is the output of peak hold circuit. It outputs the peak value of V\textsubscript{ISE} every switching cycle, shown by equation (3).

\[
V_{PHOLD} = I_{pk1} \cdot Rs
\]  

(3)

Multiplier divides Ipk1 \cdot Rs by Tres/Tc ratio.

\[
V_{FL1} = I_{pk1} \cdot Rs \cdot \frac{Tc}{Tres}
\]  

(4)

Time constant of FL1 terminal should be set to much larger than switching period, where time constant of FL1 is decided by the resistance between the output of peak hold circuit and FL1 terminal (typ: 110 k ohm) and capacitor C\textsubscript{FL1} connected to FL1 terminal. V\textsubscript{FL1} shown by equation (4) is input of error amplifier, and is controlled to be equal to reference voltage V\textsubscript{ref} (0.9). FET on period is decided by the output of error amplifier.

In case of V\textsubscript{FL1}< V\textsubscript{ref}, FET on period increases by VFL2 increase, which leads Ipk1 increase and V\textsubscript{FL1} becomes to near V\textsubscript{ref} value. In case of V\textsubscript{FL1}>V\textsubscript{ref}, FET on period decreases by VFL2 decrease, which leads Ipk1 decrease and V\textsubscript{FL1} becomes to near V\textsubscript{ref} value. After all, V\textsubscript{FL1} is controlled to be same value as V\textsubscript{ref}, and LED current (output current) is shown by equation (5), which is derived from equation (1), (2), (3), and (4).

\[
I_{out} = \frac{1}{2} \cdot \frac{Np}{Ns} \cdot \frac{V_{ref}}{Rs}
\]  

(5)

Equation (5) shows that LED current (output current) is decided by circuit constant value Np, Ns, and Rs.
2-1. Concept of constant current operation (Step-down mode)

Figure 1.4 shows FET Drain voltage, primary current and secondary current waveform during FET on and off. VSE signal is resistance-divided voltage of auxiliary winding output. Drain voltage waveform of FET and VSE waveform are same polarity and similar. As LED current (output current) is the average of secondary current, it is shown by equation (6).

\[
\overline{I_{\text{out}}} = \frac{1}{2} \cdot I_{pk1} \\
\text{where } I_{pk1} : \text{primary peak current}
\]

LED current (output current) can be controlled to be a constant value by keeping \( I_{pk1} \) constant. \( I_{pk1} \) can be monitored by ISE terminal and \( T_{\text{res}} \) can be monitored by VSE terminal.

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**Figure 1.4 Circuit diagram**

**Figure 1.5 Waveform of each point of Figure 1.4 diagram**
2-2. Constant current operation (Step-down mode)

IC operation, how to control LED current (output current) to be a constant value, is explained as below. Figure 1.6 shows block diagram relating constant current operation. As \( V_{ISE} \) is proportional to primary current and sensing resistance \( R_s \), ISE terminal can monitor primary current. \( V_{PHOLD} \) is the output of peak hold circuit. It outputs the peak value of \( V_{ISE} \) every switching cycle, shown by equation (7).

\[
V_{PHOLD} = I_{pk1} \cdot R_s \quad (7)
\]

In Multiplier, \( V_{HOLD} \) is outputted to FL1 terminal through internal 110kohm (TYP.).

\[
V_{FL1} = I_{pk1} \cdot R_s \quad (8)
\]

Time constant of FL1 terminal should be set to much larger than switching period, where time constant of FL1 is decided by the resistance between the output of peak hold circuit and FL1 terminal (typ: 110 k ohm) and capacitor \( C_{FL1} \) connected to FL1 terminal. \( V_{FL1} \) shown by equation (8) is input of error amplifier, and is controlled to be equal to reference voltage \( V_{ref} \) (0.9). FET on period is decided by the output of error amplifier.

In case of \( V_{FL1} < V_{ref} \), FET on period increases by VFL2 increase, which leads \( I_{pk1} \) increase and \( V_{FL1} \) becomes to near \( V_{ref} \) value. In case of \( V_{FL1} > V_{ref} \), FET on period decreases by VFL2 decrease, which leads \( I_{pk1} \) decrease and \( V_{FL1} \) becomes to near \( V_{ref} \) value. After all, \( V_{FL1} \) is controlled to be same value as \( V_{ref} \), and LED current (output current) is shown by equation (9), which is derived from equation (6),(7) and (8).

\[
\frac{I_{out}}{2} = \frac{V_{ref}}{R_s} \quad (9)
\]

Equation (9) shows that LED current (output current) is decided by circuit constant value \( R_s \).
3. Power factor improvement by FET constant on-time control

Power factor improvement is explained as below. Changing period of FET on-time and flattery period of error amplifier are controlled to be much longer, compared to AC period (1/50Hz or 1/60Hz). As time constant of FL2 terminal shown by equation (10) is much larger than AC period, FET on-time can be considered to constant value during one AC cycle. Where time constant of FL2 is decided by the output resistance of error amplifier 78kohm (TYP.) (@FL1=0.9V±0.3) and capacitor C_{FL2} connected to FL2 terminal (ex. 1uF). As Ton is constant value in equation (11), Ipk1 is proportional to Von.

\[ \tau = RC = 78k\Omega \cdot 1uF = 0.078s > 0.01s \text{@AC}50Hz \]  \hspace{1cm} (10)

\[ I_{pk1} = \frac{Ton}{L} \cdot Von = \alpha \cdot Von \]  \hspace{1cm} (11)

where  \( L \): primary winding inductance

![Figure 1.7 Power factor improvement](image)

4. EMI improvement by quasi-resonant operation

EMI improvement by quasi-resonant operation is explained below. This IC operates in critical conduction mode. If it operates in discontinuous mode, after releasing transformer’s energy, ringing occurs by parasitic inductance and capacitor of the transformer and FET, as shown in Figure 1.8. This ringing generates EMI noise. The moment when transformer release its energy completely is detected by VSE terminal, and this IC turns on FET at the bottom point of ringing waveform (quasi-resonant operation) as shown in Figure 1.9. Therefore this IC can minimizes EMI noise.

![Figure 1.8 When FT is not driven on transition mode](image)

![Figure 1.9 Quasi-resonant operation](image)
5. Mode Judging Circuit

It is necessary to set up a FUNC terminal according to operational mode. The input circuit of a FUNC terminal is shown in Fig. 1.10. In the case of the flyback mode, please make a FUNC terminal open. The example of connection of PWM dimming operation is indicated to Fig. 1.10.

<table>
<thead>
<tr>
<th>Mode</th>
<th>FUNC terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flyback</td>
<td>4.5V&gt;FUNC&gt;3.2V</td>
</tr>
<tr>
<td>Step-down</td>
<td>2.85V&gt;FUNC&gt;1.45V</td>
</tr>
<tr>
<td>Standby</td>
<td>0.8V&gt;FUNC (※)</td>
</tr>
</tbody>
</table>

(※) It is necessary to input the voltage beyond 1.3V into the return from standby mode at FUNC terminal.

A mode judging sequence is shown in Fig. 1.11. In a-point, Va is starting voltage and it starts it by VCC=18V (TYP.). MOSFET switching is started after a mode judging (a-point~b-point). in FUNC terminal, PWM dimming becomes effective after a mode judging.

![Diagram](image-url)

Figure 1.10 FUNC terminal input circuit diagram

Figure 1.11 Mode judging sequence
A standby mode sequence is shown in Fig. 1.12.

When judged with standby mode in a mode judging period (a-point–b-point), a switching stop is kept. Operation is stopped at \( V_b \) (UVLO voltage 6V (TYP.)), and the operation which will restart if the starting voltage 18V (TYP.) is reached, is repeated. The return from standby mode is carrying out a FUNC terminal more than 1.3V (e-point), discharges the capacity connected to VCC and becomes normal operation from the following restart timing (g-point).

![Figure 1.12 Standby mode sequence](image)

Figure 1.12 Standby mode sequence
6. PWM dimming Function

LED output current can be adjusted according to the PWM signal inputted into a FUNC terminal. The input condition of the PWM signal of a FUNC terminal becomes as follows, and shows operation in Fig. 1.13.

<table>
<thead>
<tr>
<th>FUNC terminal</th>
<th>OUT: switching</th>
<th>OUT: OFF (※)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5V&gt;FUNC&gt;1.45V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8V&gt;FUNC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(※) In FUNC < 1V, the value of FL1 and FL2 is kept and the switching-on pulse is kept constant.

When a PWM function is used, please use it after are satisfactory or checking enough with the system, since sound may occur with a transformer, a coil, etc.

![Figure 1.13 PWM dimming function](image)

Figure 1.13 PWM dimming function
7. Error detection/Protection function
   Over temperature protection, VCC under voltage lock-out, output Over voltage lock-out and Over current protection are built in this IC.

7-1. Over temperature protection
   When junction temperature of this IC is over 150°C, thermal error is detected and following operation is performed.
   • IC shut down
   • Discharge CFL2 (Capacitor connected to CFL2)
   • Discharge capacitor connected to VCC
   • Discharge stops when VCC goes down to UVLO (6V)

7-2. VCC under voltage lock-out
   IC operation stops when VCC voltage goes down to 6V(typ.) or less, because of VCC voltage down or short between VCC and GND. IC operation restarts when VCC voltage goes up to 18V or more (start up voltage).

7-3. Output over voltage lock-out
   When VCC terminal and VSE terminal goes up to VOVP (Over voltage threshold voltage) or more, over voltage error is detected and following operation is performed.
   • IC shut down
   • Discharge CFL2 (Capacitor connected to CFL2)
   • Discharge capacitor connected to VCC
   • Discharge stops when VCC goes down to UVLO (6V).

Over voltage error is detected by VCC terminal voltage (typ. 22.7V) and VSE terminal voltage (typ. 2.1V). Over voltage threshold voltage is shown by equation (12).

\[ V_{OVP,VSE} \geq 2.1V \text{(TYP.)} & V_{OVP,VCC} \geq 22.7V \text{(TYP.)} \]  \hspace{1cm} (12)

where \( V_{OVP,VCC} \) : Over voltage threshold voltage for VCC
\( V_{OVP,VSE} \) : Over voltage threshold voltage for VSE

\[ V_{OVP,VCC} = 23V \]  
\[ V_{OVP,VSE} = 2.1V \]

Figure 6.14 Circuit diagram
7-4. FET over current protection

When FET current goes up to VOCP (Over current threshold voltage) or more, over current error is detected and following operation is performed.

Cycle by cycle over current limit operation (default configuration).
- OUT turns Low and stops switching.
- IC do not shut down.
- OFF period will be more than 70us (typ.).

A waveform is shown in Fig. 1.16.

The voltage of ISE terminal at over-current detection is as follows.
The circuit configuration of over-current detecting is shown in Fig. 1.15.

<table>
<thead>
<tr>
<th>Mode</th>
<th>over-current detection voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flyback</td>
<td>ISE ≤ 1.6V (TYP.)</td>
</tr>
<tr>
<td>Step-down</td>
<td>ISE ≤ 0.8V (TYP.)</td>
</tr>
</tbody>
</table>

Over Current is detected by ISE terminal voltage (typ 1.6V). Over Current threshold voltage is shown as the figure below.

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**Figure 1.15** Circuit diagram relating over current protection

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**Figure 1.16** Over current judging waveform
8. Start-up sequence

Figure 1.17 shows start-up sequence waveform. This IC starts up at point (a) in Figure 1.17 and Va is start up voltage, typ. 18V. MOSFET switching is started after a mode judging (a-point~b-point).

Then auxiliary winding starts to supply power to IC. Capacitor CVCC which is connected between VCC and GND should be adjusted so that Vc, VCC voltage at point (c) does not go down below VCC undervoltage lock-out threshold (6V).

Example) Cvcc: 10uF @Vout35.5V, Iout700mA

![Figure 1.17 Start-up sequence](image)

9. Precautions

9-1. FL1 and FL2 terminal

The value shown below is recommended for capacitor connected to FL1 and FL2.

- CFL1 = 0.1uF ~ 1uF
- CFL2 = 0.2uF ~ 2uF
- CFL1 ≤ CFL2 * 0.5

9-2. FUNC Terminal

Please connect 200kΩ between FUNC terminal and GND terminal for Step-down mode.

Although the resistance connected permits the accuracy within 5% of variation, and 100 ppm/°C, it recommends the accuracy within 1% of variation, and 100 ppm/°C.

10. Absolute maximum ratings

Absolute maximum ratings are values or ranges which can cause permanent damage. Please do not exceed this range even when start up or shut down.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Rating</th>
<th>unit</th>
<th>Applied terminal</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Voltage</td>
<td>Vcc</td>
<td>-0.3 ~ 28.0</td>
<td>V</td>
<td>VCC</td>
<td></td>
</tr>
<tr>
<td>Input Terminal Voltage</td>
<td>VI1</td>
<td>-0.3 ~ 6.0</td>
<td>V</td>
<td>FL1, FL2, ISE, VSE, FUNC</td>
<td></td>
</tr>
<tr>
<td>Output Terminal Voltage</td>
<td>VO1</td>
<td>-0.3 ~ 28.0</td>
<td>V</td>
<td>OUT</td>
<td></td>
</tr>
<tr>
<td>Power Dissipation *</td>
<td>PD</td>
<td>600</td>
<td>mW</td>
<td></td>
<td>Ta =25°C</td>
</tr>
<tr>
<td>Thermal Resistance *</td>
<td>θa</td>
<td>166.7</td>
<td>°C/W</td>
<td></td>
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<tr>
<td>Operating Temperature</td>
<td>TOPR</td>
<td>-30 ~ 100</td>
<td>°C</td>
<td></td>
<td></td>
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<tr>
<td>Storage Temperature</td>
<td>TSTG</td>
<td>-40 ~ 150</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Measured on JEDEC-JESD51-7 4-layer board.
### 11. Electrical characteristics

Unless otherwise specified, condition shall be GND=ISE=VSE=0V, VCC=16V, Ta=25°C

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>Unit</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VCC section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCC Input Voltage</td>
<td>VCC1</td>
<td>10</td>
<td>16</td>
<td>18</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VCC Startup Current</td>
<td>ICC1</td>
<td></td>
<td>30</td>
<td>80</td>
<td>uA</td>
<td>VCC=startup voltage – 0.1V</td>
</tr>
<tr>
<td>VCC Operating supply current</td>
<td>ICC2</td>
<td></td>
<td>1.0</td>
<td>2.0</td>
<td>mA</td>
<td></td>
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<tr>
<td>VCC Turn on threshold</td>
<td>Vst</td>
<td>15.5</td>
<td>18.0</td>
<td>20.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>VCC Turn off threshold</td>
<td>Vvlo</td>
<td>5.0</td>
<td>6.0</td>
<td>7.5</td>
<td>V</td>
<td></td>
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<tr>
<td><strong>Gate driver section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Output Low Resistance</td>
<td>RL</td>
<td></td>
<td></td>
<td>15</td>
<td>Ω</td>
<td>OUT=0.1V</td>
</tr>
<tr>
<td>Output High Current</td>
<td>IOH</td>
<td>40</td>
<td></td>
<td></td>
<td>mA</td>
<td>OUT&lt;8V</td>
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<tr>
<td><strong>Oscillator section</strong></td>
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<td></td>
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<tr>
<td>Frequency</td>
<td>fosc</td>
<td>135</td>
<td>210</td>
<td>300</td>
<td>kHz</td>
<td>FL2=2.5V</td>
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<tr>
<td><strong>Error Amplifier Section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Reference Voltage</td>
<td>VREF</td>
<td>2.94</td>
<td>3.00</td>
<td>3.06</td>
<td>V</td>
<td>design assurance</td>
</tr>
<tr>
<td>Feedback Voltage</td>
<td>VFB</td>
<td>873</td>
<td>900</td>
<td>927</td>
<td>mV</td>
<td>VSE=1V, ISE=0.3V, FL2=2.5V</td>
</tr>
<tr>
<td>Transconductance</td>
<td>Gm</td>
<td></td>
<td>43</td>
<td></td>
<td>uA/V</td>
<td>FL1=0.9V</td>
</tr>
<tr>
<td>FL2 Operating range</td>
<td>Vfl2</td>
<td>0.5</td>
<td></td>
<td>4.0</td>
<td>V</td>
<td></td>
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<tr>
<td><strong>Zero Cross Detect Section</strong></td>
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</tr>
<tr>
<td>VSE Threshold Voltage</td>
<td>VVSE</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>V</td>
<td>FL2=2.5V</td>
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<tr>
<td><strong>FUNC section</strong></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Threshold Voltage of Flyback mode</td>
<td>VFLY</td>
<td>3.2</td>
<td></td>
<td>4.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Threshold Voltage of StepDown mode</td>
<td>VStepD</td>
<td>1.45</td>
<td></td>
<td>2.85</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Threshold Voltage of Standby mode</td>
<td>Vstby</td>
<td></td>
<td></td>
<td>0.8</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Threshold High Voltage of PWM</td>
<td>VPWMH</td>
<td>1.45</td>
<td></td>
<td>4.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Threshold Low Voltage of PWM</td>
<td>VPWML</td>
<td></td>
<td></td>
<td>0.8</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>FUNC Bias Current</td>
<td>IFUNC</td>
<td>8.7</td>
<td>10.0</td>
<td>12.5</td>
<td>uA</td>
<td></td>
</tr>
<tr>
<td><strong>Over Current Protection Section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshold Voltage of Flyback</td>
<td>VOCP_FLY</td>
<td>1.45</td>
<td>1.60</td>
<td>1.75</td>
<td>V</td>
<td>FL2=2.5V</td>
</tr>
<tr>
<td>Threshold Voltage of StepDown</td>
<td>VOCP_StepD</td>
<td>0.65</td>
<td>0.80</td>
<td>0.95</td>
<td>V</td>
<td>FL2=2.5V</td>
</tr>
<tr>
<td>Minimum Off Time in OCP</td>
<td>tmin</td>
<td>40</td>
<td>70</td>
<td>120</td>
<td>us</td>
<td></td>
</tr>
<tr>
<td>Leading edge blanking time</td>
<td>tleb1</td>
<td></td>
<td>200</td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td><strong>Over Voltage Protection Section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshold Voltage of VSE</td>
<td>VOVP_VSE</td>
<td>1.9</td>
<td>2.1</td>
<td>2.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Threshold Voltage of VCC</td>
<td>VOVP_VCC</td>
<td>21.0</td>
<td>22.7</td>
<td>24.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Leading edge blanking time</td>
<td>tleb2</td>
<td></td>
<td>600</td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td><strong>Over Temperature Protection Section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshold Temperature</td>
<td>TSD</td>
<td>135</td>
<td>150</td>
<td>165</td>
<td>°C</td>
<td>Junction temperature, design assurance</td>
</tr>
</tbody>
</table>
12. Test Circuit

13. Application circuit example
Package and packing specification

[Applicability]
This specification applies to an IC package of the LEAD-FREE delivered as a standard specification.

1. Storage Conditions
Storage conditions required after opening the packing.
(1) Storage conditions for soldering. (Convection reflow*1, IR/Convection reflow.)*1
・ Temperature : 5 ~ 30°C
・ Humidity : 70% max.
・ Period : In order to prevent oxidation of leads, please implement as soon as possible.
*1: Air or nitrogen environment.

2. Package outline specification
2-1. Package outline
Refer to the attached drawing.
2-2. LEAD FINISH
LEAD FREE TYPE (Sn-2%Bi)
2-3. Package weight
0.08g/pcs. About

3. Surface mount conditions
The following soldering conditions are recommended to ensure device quality.

3-1. Soldering
(1) Convection reflow or IR/Convection reflow. (one-time soldering or two-time soldering in air or nitrogen environment)
・ Temperature and period :
  A) Peak temperature 260°C max.
  B) Heating temperature 40 seconds as 230°C
  C) Preheat temperature It is 150 to 180°C, and is 120 seconds Max.
  D) Temperature increase rate It is 1 to 3°C/seconds
・ Measuring point : IC package surface
・ Temperature profile:

- Reflow times : 2 times max

![Temperature profile diagram]
4. Package outline

5. Markings

Marking details (The information on the package should be given as follows.)

(1) Product name: IR3M92
(2) Date code: (Example) YMA

Y → Denotes the production year. (Year code)

M → Denotes the production month. (1・2・…・8・9・0・N・D)
A → Denotes the production ref code.

<table>
<thead>
<tr>
<th>パッケージ</th>
<th>SOP008-P-0150</th>
<th>単位</th>
<th>mm</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKG</td>
<td></td>
<td>UNIT</td>
<td>mm</td>
<td></td>
</tr>
</tbody>
</table>
6. Packing specifications (Embossed carrier tape specifications)
   The embossed carrier tape specifications supplied from SHARP are generally based on those described in JIS C 0806 (Japanese Industrial Standard)

6-1. Tape structure
   The embossed carrier tape is made of conductive plastic. The embossed portions of the carrier tape are filled with IC packages and a top covering tape is used to enclose them.

6-2. Taping reel and embossed carrier tape size
   For the taping reel and embossed carrier tape sizes, refer to the attached drawing.

6-3. IC package enclosure direction in embossed carrier tape
   The IC package enclosure direction in the embossed portion relative to the direction in which the tape is pulled is indicated by an index mark on the package (indicating the No. 1 pin) shown in the attached drawing.

6-4. Missing IC packages in embossed carrier tape
   The number of missing IC packages in the embossed carrier tape per reel should be less 0.1 % of the total contained on the tape per reel, or There should never be consecutive missing IC packages.

6-5. Tape joints
   There is no joint in an embossed carrier tape.

6-6. Peeling strength of the top covering tape
   Peeling strength must meet the following conditions.
   (1) Peeling angle at 165 ~ 180°
   (2) Peeling strength at 0.1 ~ 1.0N.

6-7. Packing
   (1) The top covering tape (leader side) at the leading edge of the embossed carrier tape, should be held in place with adhesive tape.
   (2) The leading and trailing edges of the embossed carrier tape should be left empty in the attached drawing.
   (3) The number of IC packages enclosed in the embossed carrier tape per reel should generally comply with the list given below.

<table>
<thead>
<tr>
<th>Number of IC Packages / Reel</th>
<th>Number of IC Packages / Outer carton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 devices / Reel</td>
<td>1000 devices / Outer carton</td>
</tr>
</tbody>
</table>
6-8. Indications
The following should be indicated on the taping reel and the packing carton.
・ Part Number (Product Name)  ・ Storage Quantity  ・ Manufacture’s Name (SHARP)

6-9. Protection during transportation
The IC packages should have no deformation and deterioration of their electrical characteristics resulting from transportation.

7. Precautions for use
(1) Opening must be done on an anti-ESD treated workbench. All workers must also have undergone anti-ESD treatment.
(2) The devices should be mounted within one year of the date of delivery.

8. Chemical substance information in the product
Product Information Notification based on Chinese law, Management Methods for Controlling Pollution by Electronic Information Products.

Names and Contents of the Toxic and Hazardous Substances or Elements in the Product

<table>
<thead>
<tr>
<th>Lead (Pb)</th>
<th>Mercury (Hg)</th>
<th>Cadmium (Cd)</th>
<th>Hexavalent Chromium (Cr(VI))</th>
<th>Polybrominated Biphenyls (PBB)</th>
<th>Polybrominated Diphenyl Ethers (PBDE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

○ : indicates that the content of the toxic and hazardous substance in all the homogeneous materials of the part is below the concentration limit requirement as described in SJ/T 11363-2006.

× : indicates that the content of the toxic and hazardous substance in at least one homogeneous material of the part exceeds the concentration limit requirement as described in SJ/T 11363-2006 standard.
**NAME**: Reel for embossed carrier tape  
**UNIT**: mm  
**NOTE**

**IC TAPING DIRECTION**

**THE DRAWING DIRECTION OF TAPE**

- Marking: First terminal position

**LEADER SIDE AND END SIDE OF TAPE**

- Empty pocket domain (25 pockets)
- Filled emboss (with IC package)
- Adhesive tape
- Empty pocket domain (25 pockets)
- Top cover tape
177~180
15.4±1.0
13.0±0.3
60~61
2±0.5
φ21±0.2
φ13±0.2

<table>
<thead>
<tr>
<th>NAME</th>
<th>Reel &amp; Carrier tape drawing</th>
<th>UNIT</th>
<th>mm</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
"R.C." is Sharp's corporate logo indicating that the product is RoHS compliant.
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      --- Office automation equipment
      --- Test and measurement equipment
      --- Industrial control
      --- Audio visual equipment
      --- Consumer electronics
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      --- Traffic signals
      --- Gas leakage sensor breakers
      --- Alarm equipment
      --- Various safety devices, etc.
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      --- Telecommunication equipment [trunk lines]
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