Low Power-Loss Voltage Regulators

PQ30RV1/PQ30RV11/PQ30RV2/PQ30RV21

Variable Output Low Power-Loss Voltage Regulators

■ Features
- Compact resin full-mold package
- Low power-loss (Dropout voltage: MAX.0.5V)
- Variable output voltage (setting range: 1.5 to 30V)
- Built-in output ON/OFF control function

■ Applications
- Power supply for print concentration control of electronic typewriters with display
- Series power supply for motor drives
- Series power supply for VCRs and TVs

■ Model Line-ups

<table>
<thead>
<tr>
<th>Output voltage</th>
<th>1A output</th>
<th>2A output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference voltage precision:±4%</td>
<td>PQ30RV1</td>
<td>PQ30RV2</td>
</tr>
<tr>
<td>Reference voltage precision:±2%</td>
<td>PQ30RV11</td>
<td>PQ30RV21</td>
</tr>
</tbody>
</table>

■ Equivalent Circuit Diagram

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Internet Internet address for Electronic Components Group http://sharp-world.com/ecg/
Low Power-Loss Voltage Regulators  PQ30RV1/PQ30RV11/PQ30RV2/PQ30RV21

### Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIN Input voltage</td>
<td>V&lt;sub&gt;IN&lt;/sub&gt;</td>
<td>35</td>
<td>V</td>
</tr>
<tr>
<td>VADJ Output voltage adjustment</td>
<td>V&lt;sub&gt;ADJ&lt;/sub&gt;</td>
<td>7</td>
<td>V</td>
</tr>
<tr>
<td>I&lt;sub&gt;0&lt;/sub&gt; Output current</td>
<td>I&lt;sub&gt;0&lt;/sub&gt;</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>PD&lt;sub&gt;1&lt;/sub&gt; Power dissipation (No heat sink)</td>
<td>PD&lt;sub&gt;1&lt;/sub&gt;</td>
<td>1.5</td>
<td>W</td>
</tr>
<tr>
<td>PD&lt;sub&gt;2&lt;/sub&gt; Power dissipation (With infinite heat sink)</td>
<td>PD&lt;sub&gt;2&lt;/sub&gt;</td>
<td>15</td>
<td>W</td>
</tr>
<tr>
<td>T&lt;sub&gt;j&lt;/sub&gt; Junction temperature</td>
<td>T&lt;sub&gt;j&lt;/sub&gt;</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Topr Operating temperature</td>
<td>Topr</td>
<td>–20 to +80</td>
<td>°C</td>
</tr>
<tr>
<td>T&lt;sub&gt;stg&lt;/sub&gt; Storage temperature</td>
<td>T&lt;sub&gt;stg&lt;/sub&gt;</td>
<td>–40 to +150</td>
<td>°C</td>
</tr>
<tr>
<td>T&lt;sub&gt;sol&lt;/sub&gt; Soldering temperature</td>
<td>T&lt;sub&gt;sol&lt;/sub&gt;</td>
<td>260(For 10s)</td>
<td>°C</td>
</tr>
</tbody>
</table>

- All are open except GND and applicable terminals.
- Overheat protection may operate at T<sub>j</sub>≥125 °C.

### Electrical Characteristics

Unless otherwise specified, condition shall be

- V<sub>IN</sub>=15V, V<sub>O</sub>=10V, I<sub>0</sub>=0.5A, R<sub>1</sub>=390Ω (PQ30RV1/PQ30RV11)
- V<sub>IN</sub>=15V, V<sub>O</sub>=10V, I<sub>0</sub>=1.0A, R<sub>1</sub>=390Ω (PQ30RV2/PQ30RV21)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage</td>
<td>V&lt;sub&gt;IN&lt;/sub&gt;</td>
<td>–</td>
<td>4.5</td>
<td>–</td>
<td>35</td>
<td>V</td>
</tr>
<tr>
<td>Output voltage</td>
<td>V&lt;sub&gt;O&lt;/sub&gt;</td>
<td>R&lt;sub&gt;2&lt;/sub&gt;=94Ω to 8.5kΩ</td>
<td>1.5</td>
<td>–</td>
<td>30</td>
<td>V</td>
</tr>
<tr>
<td>Load regulation</td>
<td>R&lt;sub&gt;2&lt;/sub&gt;L</td>
<td>I&lt;sub&gt;0&lt;/sub&gt;=5mA to 1A</td>
<td>–</td>
<td>0.3</td>
<td>1.0</td>
<td>%</td>
</tr>
<tr>
<td>Line regulation</td>
<td>R&lt;sub&gt;2&lt;/sub&gt;I</td>
<td>V&lt;sub&gt;IN&lt;/sub&gt;=11 to 28V</td>
<td>–</td>
<td>0.5</td>
<td>2.5</td>
<td>%</td>
</tr>
<tr>
<td>Ripple rejection</td>
<td>RR</td>
<td>C&lt;sub&gt;ref&lt;/sub&gt;=0</td>
<td>45</td>
<td>55</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td>Reference voltage</td>
<td>V&lt;sub&gt;ref&lt;/sub&gt;</td>
<td>–</td>
<td>1.20</td>
<td>1.25</td>
<td>1.30</td>
<td>V</td>
</tr>
<tr>
<td>Temperature coefficient of reference voltage</td>
<td>T&lt;sub&gt;c&lt;/sub&gt;V&lt;sub&gt;ref&lt;/sub&gt;</td>
<td>T&lt;sub&gt;c&lt;/sub&gt;=0 to 125 °C</td>
<td>–</td>
<td>±1.0</td>
<td>–</td>
<td>%</td>
</tr>
<tr>
<td>Dropout voltage</td>
<td>V&lt;sub&gt;r&lt;/sub&gt;O</td>
<td>I&lt;sub&gt;0&lt;/sub&gt;=0.5A</td>
<td>–</td>
<td>–</td>
<td>0.5</td>
<td>V</td>
</tr>
<tr>
<td>Quiescent current</td>
<td>I&lt;sub&gt;q&lt;/sub&gt;</td>
<td>I&lt;sub&gt;0&lt;/sub&gt;=0</td>
<td>–</td>
<td>–</td>
<td>7</td>
<td>mA</td>
</tr>
</tbody>
</table>

- Input voltage shall be the value when output voltage is 95% in comparison with the initial value.

### Fig. 1 Test Circuit

![Test Circuit](image)

V<sub>0</sub>=V<sub>ref</sub>×\(I<sub>0</sub>\cdot\frac{R<sub>2</sub>}{R<sub>1</sub>}\)

[R<sub>1</sub>=390Ω, V<sub>ref</sub> Nearly=1.25V]

### Fig. 2 Test Circuit of Ripple Rejection

![Test Circuit of Ripple Rejection](image)

I<sub>0</sub>=0.5A
f=120Hz (sine wave)
\(e<sub>r</sub>\cdot\text{rms}=0.5V\)
RR=20 log(\(e<sub>r</sub>\cdot\text{rms})/e<sub>o</sub>\cdot\text{rms})
Low Power-Loss Voltage Regulators

**Fig. 3** Power Dissipation vs. Ambient Temperature (PQ30RV1/PQ30RV11)

<table>
<thead>
<tr>
<th>Power dissipation PD (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature $T_a$ (°C)</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

$P_{D1}$: No heat sink
$P_{D2}$: With infinite heat sink

Note) Oblique line portion: Overheat protection may operate in this area.

**Fig. 4** Power Dissipation vs. Ambient Temperature (PQ30RV2/PQ30RV21)

<table>
<thead>
<tr>
<th>Power dissipation PD (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient temperature $T_a$ (°C)</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

$P_{D1}$: No heat sink
$P_{D2}$: With infinite heat sink

Note) Oblique line portion: Overheat protection may operate in this area.

**Fig. 5** Overcurrent Protection Characteristics (PQ30RV1/PQ30RV11)

- Relative output voltage (%)
- Output current $I_o$ (A)

**Fig. 6** Overcurrent Protection Characteristics (PQ30RV2/PQ30RV21)

- Relative output voltage (%)
- Output current $I_o$ (A)

**Fig. 7** Output Voltage Adjustment Characteristics

- Output voltage $V_o$ (V)
- $R_1 = 390$ Ω

**Fig. 8** Reference Voltage Deviation vs. Junction Temperature

- Reference voltage deviation $\Delta V_{ref}$ (mV)
- Junction temperature $T_j$ (°C)

$R_1 = 390$ Ω, $R_2 = 2.7$ kΩ, $V_{IN} = 15$ V

$I_o = 0.5A$ (PQ30RV1/PQ30RV11)

$I_o = 1A$ (PQ30RV2/PQ30RV21)
Fig. 9 Output Voltage vs. Input Voltage (PQ30RV1/PQ30RV11)

- $R_L=\infty$
- $R_L=10\Omega$

$V_{out}=f(V_{in})$

Fig. 10 Output Voltage vs. Input Voltage (PQ30RV2/PQ30RV21)

- $R_L=\infty$
- $R_L=5\Omega$

$V_{out}=f(V_{in})$

Fig. 11 Dropout Voltage vs. Junction Temperature (PQ30RV1/PQ30RV11)

- $R_L=390\Omega, R_C=2.7k\Omega$

$V_{dropout}=f(T_j)$

Fig. 12 Dropout Voltage vs. Junction Temperature (PQ30RV2/PQ30RV21)

- $R_L=390\Omega, R_C=2.7k\Omega$

$V_{dropout}=f(T_j)$

Fig. 13 Quiescent Current vs. Junction Temperature

- $V_{IN}=35V$
- $I_O=0$

$I_{Q}=f(T_j)$

Fig. 14 Ripple Rejection vs. Input Ripple Frequency (PQ30RV1/PQ30RV11)

- $T_j=25^\circ C$
- $R_L=390\Omega, R_C=2.7k\Omega$
- $I_O=0.5A, e_i(rms)=0.5V, V_{IN}=15V$

$R_{ref}=3.3\mu F$

No $R_{ref}$
Fig. 15 Ripple Rejection vs. Input Ripple Frequency (PQ30RV2/PQ30RV21)

Fig. 17 Ripple Rejection vs. Output Current (PQ30RV2/PQ30RV21)

Fig. 19 Output Peak Current vs. Dropout Voltage (PQ30RV2/PQ30RV21)

Fig. 16 Ripple Rejection vs. Output Current (PQ30RV1/PQ30RV11)

Fig. 18 Output Peak Current vs. Dropout Voltage (PQ30RV1/PQ30RV11)

Fig. 20 Output Peak Current vs. Junction Temperature (PQ30RV1/PQ30RV11)
### Standard Connection

![Diagram](image)

- **D1**: This device is necessary to protect the element from damage when reverse voltage may be applied to the regulator in case of input short-circuiting.
- **Cref**: This device is necessary when it is required to enhance the ripple rejection or to delay the output start-up time (※1). (※1) Otherwise, it is not necessary.
  - (Care must be taken since Cref may raise the gain, facilitating oscillation.)
  - (※1) The output start-up time is proportional to Cref×R2.
- **CIN, CO**: Be sure to mount the devices CIN and CO as close to the device terminal as possible so as to prevent oscillation.
  - The standard specification of CIN and CO is 0.33μF and 47μF, respectively. However, adjust them as necessary after checking.
- **R1, R2**: These devices are necessary to set the output voltage. The output voltage Vo is given by the following formula:

  \[ V_o = V_{ref} \times (1 + \frac{R_2}{R_1}) \]

  (Vref is 1.25V TYP)
  - The standard value of R1 is 390Ω. But value up 10kΩ does not cause any trouble.
ON/OFF Operation

- ON/OFF operation is available by mounting externally D2 and R3.
- When \( V_{ADJ} \) is forcibly raised above \( V_{ref}(1.25\, \text{V TYP}) \) by applying the external signal, the output is turned off (pass transistor of the regulator is turned off). When the output is OFF, \( V_{ADJ} \) must be higher than \( V_{ref\, \text{MAX.}} \), and at the same time must be lower than maximum rating 7V.

In OFF-state, the load current flows to \( RL \) from \( V_{ADJ} \) through \( R2 \). Therefore the value of \( R2 \) must be as high as possible.

- \( VO'=V_{ADJ} \times \frac{RL}{RL+R2} \) occurs at the load. OFF-state equivalent circuit \( R1 \) up to 10kΩ is allowed. Select as high value of \( R1 \) and \( R2 \) as possible in this range. In some case, as output voltage is getting lower (\( VO<1\, \text{V} \)), impedance of load resistance rises. In such condition, it is sometime impossible to obtain the minimum value of \( VO' \). So add the dummy resistance indicated by \( RD \) in the figure to the circuit parallel to the load.

An Example of ON/OFF Circuit Using the 1-chip Microcomputer Output Port (PQ30RV1)

<table>
<thead>
<tr>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output port of microcomputer</td>
</tr>
<tr>
<td>( V_{OH,(\text{max})}=0.5, \text{V} )</td>
</tr>
<tr>
<td>( V_{OH,(\text{min})}=2.4, \text{V} ) (( I_{OH}=0.2, \text{mA} ))</td>
</tr>
<tr>
<td>MAX. rating of ( I_{OH}=0.5, \text{mA} )</td>
</tr>
<tr>
<td>Output should be set as follows.</td>
</tr>
<tr>
<td>15.6V ( RL=52, \Omega ) (( IO=0.3, \text{A} ))</td>
</tr>
</tbody>
</table>

From \( V_{O}=1.25\, \text{V}(1+R2/R1) \) we get \( V_{O}=15.6\, \text{V} \).
\( R2/R1=11.48 \)
Assuming that \( VF\,(\text{max})=0.8\, \text{V} \) for D2 in case of \( V_{OH\,(\text{min})}=2.4\, \text{V} \), we get \( V_{ADJ}=V_{OH\,(\text{min})}-VF\,(\text{max})=2.4\, \text{V}-0.8\, \text{V}=1.6\, \text{V} \). From \( V_{ref\,(\text{max})}=1.3\, \text{V} \) we get \( R3=0\, \Omega \).
If \( R1=10k\, \Omega \), we get \( R2=11.48\times R1=114.8k\, \Omega \) and \( IOH \) as follows, ignoring \( RL \) (52Ω):
\( IOH=1.6\, \text{V}\times (R1+R2)/R1\times R2 \)
\( =1.6\, \text{V}\times (10k\, \Omega +114.8k\, \Omega )/10k\, \Omega \times 114.8k\, \Omega =0.17\, \text{mA} \)
Hence, \( IOH=0.2\, \text{mA} \). Therefore \( V_{OH\,(\text{min})} \) is ensured.
Next, assuming that \( VF\,(\text{min})=0.5\, \text{V} \) for D2 in case of \( V_{OH\,(\text{max})} \), we get:
\( IOH=(5V-0.5\, \text{V})/(R1+R2)/R2\times R2=0.49\, \text{mA} \) which is less than the rating.

Figure 1 shows the \( VO-V_C \) characteristics when \( R1=10k\, \Omega \), \( R2=115k\, \Omega \), \( R3=0\, \Omega \), \( VIN=17\, \text{V} \), \( RL=52\, \Omega \), and \( D1=1S2076A \) (Hitachi).
Low Power-Loss Voltage Regulators

PQ30RV1/PQ30RV11/PQ30RV2/PQ30RV21

Output Voltage vs. Control Voltage (PQ30RV1)

Model Line-ups for Lead Forming Type

<table>
<thead>
<tr>
<th>Output current</th>
<th>1A output</th>
<th>2A output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output voltage precision: ±2.5%</td>
<td>PQ30RV1B</td>
<td>PQ30RV2B</td>
</tr>
</tbody>
</table>

Outline Dimensions (PQ30RV1B/PQ30RV2B)

<table>
<thead>
<tr>
<th>(Unit : mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2MAX</td>
</tr>
<tr>
<td>7.4±0.2</td>
</tr>
<tr>
<td>6.3±0.1</td>
</tr>
<tr>
<td>4–1.4</td>
</tr>
<tr>
<td>4–0.6</td>
</tr>
<tr>
<td>3–(2.54)</td>
</tr>
<tr>
<td>4.5±0.2</td>
</tr>
<tr>
<td>2.8±0.2</td>
</tr>
<tr>
<td>1.6±0.7</td>
</tr>
<tr>
<td>6±0.9</td>
</tr>
<tr>
<td>4.4MIN</td>
</tr>
<tr>
<td>3±0.5</td>
</tr>
<tr>
<td>16±0.5</td>
</tr>
<tr>
<td>(3.2)</td>
</tr>
<tr>
<td>(0.5)</td>
</tr>
<tr>
<td>(0.5)</td>
</tr>
<tr>
<td>(0.5)</td>
</tr>
</tbody>
</table>

• ( ) : Typical value
• Radius of lead forming portion : R=0.5 to 1.5mm

Internal connection diagram

1. DC input (Vin)
2. DC output (Vo)
3. GND
4. Output voltage minute adjustment terminal (Vadj)

Note) The value of absolute maximum ratings and electrical characteristics is same as ones of PQ30RV1/2 series.
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      --- Personal computers
      --- Office automation equipment
      --- Telecommunication equipment [terminal]
      --- Test and measurement equipment
      --- Industrial control
      --- Audio visual equipment
      --- Consumer electronics

  (ii) Measures such as fail-safe function and redundant design should be taken to ensure reliability and safety when SHARP devices are used for or in connection with equipment that requires higher reliability such as:
      --- Transportation control and safety equipment (i.e., aircraft, trains, automobiles, etc.)
      --- Traffic signals
      --- Gas leakage sensor breakers
      --- Alarm equipment
      --- Various safety devices, etc.

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      --- Space applications
      --- Telecommunication equipment [trunk lines]
      --- Nuclear power control equipment
      --- Medical and other life support equipment (e.g., scuba).

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