200mA LDO Regulator with Voltage Detector and Watchdog Timer

BD3010AFV

General Description
BD3010AFV is a regulator with an integrated WDT (Watch Dog Timer), a high output voltage accuracy of ±2.0% and a low circuit current consumption of 80 µA (Typ). BD3010AFV is suitable to use with low ESR ceramic capacitor to attain good output stability. BD3010AFV also integrates an automatic WDT ON/OFF feature using an output current detection and an output clamping circuit to prevent output overshoot caused by current flow. The reset detection voltage can be adjusted by connecting resistors on the RADJ terminal. BD3010AFV can be used as a stable power supply for any applications while detecting malfunction of microcontrollers.

Features
- VCC Max Voltage: 50 V
- Output Circuit: P-ch DMOS
- Supports Low ESR Ceramic Capacitor
- Integrated Over Current Protection and Thermal Shut Down
- Integrated WDT Reset Circuit (Adjustable Detection Voltage through RADJ pin)
- Integrated Automatic WDT ON/OFF Function Through Output Current Detection
- WDT can be Switched ON/OFF by Using INH Pin
- Integrated Output Voltage Clamping Circuit

Applications
Any application using a microcontroller or a DSP such as automotive (body control), display, server, DVD, phone, etc

Typical Application Circuit

Key Specifications
- Regulator Supply Voltage Range: 5.6 V to 36 V
- WDT Supply Voltage Range: 6.0 V to 36 V
- High Output Voltage Accuracy: (Ta = −40 °C to +125 °C) ± 2.0 %
- Low Circuit Current: 80 µA (Typ)
- Operating Temperature Range: -40 °C to +125 °C

Package
SSOP-B20

6.50mm × 6.40mm × 1.45mm
Pin Configuration

(TOP VIEW)

Pin Description

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Function</th>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCC</td>
<td>Power supply pin</td>
<td>11</td>
<td>RO</td>
<td>Reset output pin</td>
</tr>
<tr>
<td>2</td>
<td>N.C.</td>
<td>-</td>
<td>12</td>
<td>RADJ</td>
<td>Reset detection voltage set pin</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>GND</td>
<td>13</td>
<td>WADJ</td>
<td>WDT operating current set pin</td>
</tr>
<tr>
<td>4</td>
<td>GND</td>
<td>GND</td>
<td>14</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>GND</td>
<td>15</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td>GND</td>
<td>16</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>GND</td>
<td>GND</td>
<td>17</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>8</td>
<td>CLK</td>
<td>Clock input from microcontroller</td>
<td>18</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>INH</td>
<td>WDT ON / OFF function pin</td>
<td>19</td>
<td>OUT</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>CT</td>
<td>External capacitance for reset output delay time, WDT monitor time setting connection pin</td>
<td>20</td>
<td>OUT</td>
<td>Voltage output pin</td>
</tr>
</tbody>
</table>

Block Diagram

(TOP VIEW)
### Absolute Maximum Ratings (Ta = 25 °C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>VCC</td>
<td>-0.3 to +50</td>
<td>V</td>
</tr>
<tr>
<td>VADJ Set Pin Voltage</td>
<td>V_RADJ</td>
<td>-0.3 to +7</td>
<td>V</td>
</tr>
<tr>
<td>Regulator Output Pin Voltage</td>
<td>V_OUT</td>
<td>-0.3 to +7</td>
<td>V</td>
</tr>
<tr>
<td>INH Pin Voltage</td>
<td>V_INH</td>
<td>-0.3 to +15</td>
<td>V</td>
</tr>
<tr>
<td>Reset Output Pin Voltage</td>
<td>V_RO</td>
<td>-0.3 to +7</td>
<td>V</td>
</tr>
<tr>
<td>Watchdog Input Pin Voltage</td>
<td>V_CLK</td>
<td>-0.3 to +15</td>
<td>V</td>
</tr>
<tr>
<td>Watchdog Time Set Pin Voltage</td>
<td>V_CT</td>
<td>-0.3 to +7</td>
<td>V</td>
</tr>
<tr>
<td>Watchdog Operation Current Set Pin Voltage</td>
<td>V_WADJ</td>
<td>-0.3 to +7</td>
<td>V</td>
</tr>
<tr>
<td>Power Dissipation</td>
<td>Pd</td>
<td>1.25</td>
<td>W</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>Topr</td>
<td>-40 to +125</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>Tstg</td>
<td>-55 to +150</td>
<td>°C</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>Tjmax</td>
<td>150</td>
<td>°C</td>
</tr>
</tbody>
</table>

(Note 1) Should not exceed Pd.

(Note 2) Reduced by 10.0 mW / °C over Ta = 25 °C, when mounted on 70 mm × 70 mm × 1.6 mm glass epoxy board:

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.

### Recommended Operating Conditions (Ta = -40 °C to +125 °C)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>V_CC</td>
<td>5.6</td>
<td>36.0</td>
<td>V</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>V_CC</td>
<td>6.0</td>
<td>36.0</td>
<td>V</td>
</tr>
<tr>
<td>Output Current</td>
<td>I_OUT</td>
<td>0</td>
<td>200</td>
<td>mA</td>
</tr>
</tbody>
</table>

(Note 3) For the output voltage, consider the voltage drop (dropout voltage) due to the output current.

(Note 4) Operating condition for automatic WDT ON / OFF.
### Electrical Characteristics

(Unless otherwise specified, Ta = -40 °C to +125 °C, VCC = 13.5 V, INH = 5 V, CLK = GND, IOUT = 0 mA)

<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>[Entire Device]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit Current 1</td>
<td>ICC1</td>
<td>-</td>
<td>80</td>
<td>140</td>
<td>µA</td>
<td>IOUT = 50 mA (Ta = 25 °C)</td>
</tr>
<tr>
<td>Circuit Current 2</td>
<td>ICC2</td>
<td>-</td>
<td>110</td>
<td>170</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>[Regulator]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage</td>
<td>VOUT</td>
<td>4.90</td>
<td>5.00</td>
<td>5.10</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Line Regulation</td>
<td>Line.Reg</td>
<td>-</td>
<td>5</td>
<td>30</td>
<td>mV</td>
<td>VCC = 5.6 V to 36 V</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>Load.Reg</td>
<td>-</td>
<td>20</td>
<td>60</td>
<td>mV</td>
<td>IOUT = 5 mA</td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>ΔVo</td>
<td>-</td>
<td>0.25</td>
<td>0.50</td>
<td>V</td>
<td>VCC = 4.75 V, IOUT = 150 mA</td>
</tr>
<tr>
<td>Ripple Rejection</td>
<td>R.R.</td>
<td>45</td>
<td>55</td>
<td>-</td>
<td>dB</td>
<td>f = 120 Hz, EIN = 1 Vrms, IOUT = 100 mA</td>
</tr>
<tr>
<td>WADJ Mirror Current Ratio</td>
<td>ΔI</td>
<td>0.002</td>
<td>0.010</td>
<td>0.025</td>
<td>-</td>
<td>IOUT = 50 mA (output)</td>
</tr>
<tr>
<td>Output Voltage Clamp (Comparator)</td>
<td>VCLP</td>
<td>5.2</td>
<td>5.5</td>
<td>5.8</td>
<td>V</td>
<td>IOUT = 20 mA (input)</td>
</tr>
<tr>
<td>[Reset]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection Voltage</td>
<td>VDET</td>
<td>4.12</td>
<td>4.25</td>
<td>4.38</td>
<td>V</td>
<td>RADJ = Open</td>
</tr>
<tr>
<td>Hysteresis Width</td>
<td>VHYS</td>
<td>35</td>
<td>70</td>
<td>150</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Output Delay Time L to H (Power On Reset)</td>
<td>tDLH</td>
<td>1.8</td>
<td>2.3</td>
<td>2.8</td>
<td>ms</td>
<td>VOUT = VDET ± 0.5 V, CT = 0.01 µF</td>
</tr>
<tr>
<td>Low Output Voltage</td>
<td>VRST</td>
<td>-</td>
<td>0.1</td>
<td>0.4</td>
<td>V</td>
<td>VOUT = 4.0 V</td>
</tr>
<tr>
<td>Minimum Operating Voltage</td>
<td>VOLP</td>
<td>1.5</td>
<td>1.5</td>
<td>-</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>[Watchdog Timer]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Switching Threshold Voltage</td>
<td>VHSH</td>
<td>1.08</td>
<td>1.15</td>
<td>1.25</td>
<td>V</td>
<td>WDT ON, INH = Open</td>
</tr>
<tr>
<td>Lower Switching Threshold Voltage</td>
<td>VBL</td>
<td>0.13</td>
<td>0.15</td>
<td>0.17</td>
<td>V</td>
<td>WDT ON, INH = Open</td>
</tr>
<tr>
<td>WDT Charge Current</td>
<td>ICTC</td>
<td>3.5</td>
<td>5.0</td>
<td>6.5</td>
<td>µA</td>
<td>WDT ON, INH = Open, CT = 0 V</td>
</tr>
<tr>
<td>WDT Discharge Current</td>
<td>ICTD</td>
<td>0.8</td>
<td>1.3</td>
<td>1.7</td>
<td>µA</td>
<td>WDT ON, INH = Open, CT = 1.3 V</td>
</tr>
<tr>
<td>WDT Watch Time</td>
<td>(Note 5) tWH</td>
<td>6.4</td>
<td>8.0</td>
<td>9.6</td>
<td>ms</td>
<td>WDT ON, INH = Open, CT = 0.01 µF (Ceramic Cap)</td>
</tr>
<tr>
<td>WDT Reset Time</td>
<td>(Note 5) tWL</td>
<td>1.6</td>
<td>2.0</td>
<td>2.4</td>
<td>ms</td>
<td>WDT ON, INH open, 5 kΩ resistor is placed between WADJ and OUT pins.</td>
</tr>
<tr>
<td>WDT Operating Current</td>
<td>(Note 6) IOA</td>
<td>0.3</td>
<td>1.7</td>
<td>4.0</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>[INH]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WDT OFF Threshold Voltage</td>
<td>VINNH</td>
<td>VOUT</td>
<td>x0.8</td>
<td>-</td>
<td>VOUT</td>
<td>V</td>
</tr>
<tr>
<td>WDT ON Threshold Voltage</td>
<td>VLINH</td>
<td>0</td>
<td>-</td>
<td>VOUT</td>
<td>x0.3</td>
<td>V</td>
</tr>
<tr>
<td>INH Input Current</td>
<td>IINH</td>
<td>-</td>
<td>15</td>
<td>30</td>
<td>µA</td>
<td>VINH = 5 V</td>
</tr>
<tr>
<td>[CLK]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLK OFF Threshold Voltage</td>
<td>VCLK</td>
<td>0</td>
<td>-</td>
<td>VOUT</td>
<td>x0.3</td>
<td>V</td>
</tr>
<tr>
<td>CLK ON Threshold Voltage</td>
<td>VHCLK</td>
<td>VOUT</td>
<td>x0.8</td>
<td>-</td>
<td>VOUT</td>
<td>V</td>
</tr>
<tr>
<td>CLK Input Pulse Width</td>
<td>tWCLK</td>
<td>500</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
</tbody>
</table>

(Note 5) Characteristics of ceramic cap not considered.

(Note 6) Characteristics of external resistor not considered.
Typical Performance Curves
(Unless otherwise specified, $Ta = 25 \, ^\circ C$, $V_{CC} = 13.5 \, V$, $INH = 5 \, V$, $CLK = GND$, $I_{OUT} = 0 \, mA$)

Figure 1. Circuit Current 1 vs Supply Voltage
Figure 2. Circuit Current 2 vs Output Current
Figure 3. Output Voltage vs Supply Voltage
Figure 4. Output Voltage vs Output Current
Typical Performance Curves - continued
(Unless otherwise specified, \(T_a = 25^\circ C\), \(V_{CC} = 13.5\) V, \(I_{NH} = 5\) V, \(CLK = \text{GND}\), \(I_{OUT} = 0\) mA)

- **Dropout Voltage vs Output Current**
  - \(V_{CC} = 4.75\) V
- **Ripple Rejection vs Frequency**
  - \(e_{in} = 1\) Vrms, \(I_O = 100\) mA

**Figure 5. Dropout Voltage vs Output Current**
\(T_a = 25^\circ C\), \(T_a = 125^\circ C\), \(T_a = -40^\circ C\)

**Figure 6. Ripple Rejection vs Frequency**
\(T_a = 125^\circ C\), \(T_a = 25^\circ C\), \(T_a = -40^\circ C\)

- **Output Voltage vs Ambient Temperature**
- **Output Voltage vs Ambient Temperature**

**Figure 7. Output Voltage vs Ambient Temperature**

**Figure 8. Output Voltage vs Ambient Temperature**
Typical Performance Curves – continued
(Unless otherwise specified, Ta = 25 °C, VCC = 13.5 V, INH = 5 V, CLK = GND, IOUT = 0 mA)

Figure 9. Reset Output vs Output Voltage
(RADJ = Open)

Figure 10. CT Pin Current vs CT Pin Voltage
(VCC = 5 V, INH = Open)

Figure 11. Reset DET Voltage vs Ambient Temperature

Figure 12. WDT Time vs Ambient Temperature
(CCT = 0.01 μF, VCC = 5 V, INH = Open)
Typical Performance Curves – continued
(Unless otherwise specified, Ta = 25 °C, Vcc = 13.5 V, INH = 5 V, CLK = GND, Iout = 0 mA)

Figure 13. Reset Current vs Reset Supply Voltage
(Vout = 1.5 V, Vro = 0.5 V)

Figure 14. INH Current vs INH Supply Voltage

Figure 15. SAT Detection vs Ambient Temperature
(INH = Open)

Figure 16. DET Output Current vs Ambient Temperature
(Wadj - OUT = 5 kΩ, INH = Open)
Typical Performance Curves – continued
(Unless otherwise specified, Ta = 25 °C, VCC = 13.5 V, INH = 5 V, CLK = GND, IOUT = 0 mA)

Figure 17. DET Output Current vs Supply Voltage
(WADJ - OUT = 5 kΩ, INH = Open)
Measurement Circuit for Electrical Data

Measurement Circuit of Figure 1 and Figure 2

Measurement Circuit of Figure 3, Figure 7 and Figure 8

Measurement Circuit of Figure 4

Measurement Circuit of Figure 5

Measurement Circuit of Figure 6

Measurement Circuit of Figure 9 and Figure 11

Measurement Circuit of Figure 10

Measurement Circuit of Figure 12

Measurement Circuit of Figure 13

Measurement Circuit of Figure 14

Measurement Circuit of Figure 15

Measurement Circuit of Figure 16 and Figure 17
Application Information

1. Detection Voltage Adjustment (Resistance Value is Typical Value)

IC Internal Block Diagram

When typical detection voltage is 4.25 V

\[ V_{DET} \approx V_{RADJ} \times \left( \frac{R_1 + R_2}{R_1} \right) \]

where:
- \( V_{DET} \) is the reset detection voltage
- \( V_{RADJ} \) is the internal reference voltage (MOS input)
- \( R_1, R_2 \) is the IC internal resistor (Voltage detection precision is tightened up to ±3% by laser-trimming \( R_1 \) and \( R_2 \))

\( V_{RADJ} \) will fluctuate 1.23 V ±6.0%

Insert pull down resistor \( R_3 \) (lower resistance than \( R_1 \)) in between RADJ-GND, and pull-down resistor \( R_4 \) (lower resistance than \( R_2 \)) in between RADJ-OUT to adjust the detection voltage.

By doing so, the detection voltage can be adjusted using the formula below.

\[ V_{DET} = V_{RADJ} \times \left[ \frac{R_2 \times R_4}{(R_2 + R_4)} + \frac{R_3 \times (R_1 + R_3)}{R_3 \times (R_1 + R_3)} \right] \]

When the output resistance value is as small enough to ignore the IC internal resistance, you can find the detection voltage by the formula below.

\[ V_{DET} \approx V_{RADJ} \times \left( \frac{R_3 + R_4}{R_3} \right) \]

Adjust the resistance value by application as the circuit current increases due to the added resistor.
2. WDT Voltage Detection (Resistance Value is Typical Value)

WDT can be automatically switched ON/OFF by the output load current. To detect the output load current, insert a resistor between OUT-WADJ. Current detection is adjustable by varying the resistance value from 1 kΩ to 15 kΩ.

Calculation:
\[
I_{\text{OUT}} \times \Delta I \times \frac{\text{External } R}{140 \text{ kΩ}} \geq 100 \text{ mV}
\]

(Note 1) is the IC internal resistance between WADJ - OUT (tolerance approx ±30 %, temperature coefficient approx 2000 ppm)

(Note 2) is an offset of the detection comparator (tolerance approx 100 mV ±10 %)

When there is no resistor between WADJ - OUT, \(I_{\text{OUT}} = 70 \mu\text{A}\) can be detected by the formula below

\[
I_{\text{OUT}} \times \Delta I \times 140 \text{ kΩ} \geq 100 \text{ mV}
\]

(Note) If the OUT - WADJ resistance value is not same as the condition on the electrical characteristics table, i.e. 5 KΩ, choose the resistance value in ratio referring to the above equation.

<Timing Chart> Timing Chart on no load condition (Stand-by Mode)

<table>
<thead>
<tr>
<th>Time (ms)</th>
<th>VCC</th>
<th>OUT</th>
<th>INH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>13.5V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>12.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>11.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>10.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>9.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>8.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>7.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>6.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>5.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>4.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>3.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>2.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>1.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
<tr>
<td>0.5V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
</tr>
</tbody>
</table>

CT up to voltage limit
CLK acceptable
WDT watch

WDT volts

Stand by mode

The load is stopped in mode ON, pulling up CT after charging.

The load is stopped in CT during discharging, pulling up CT immediately.

The load is stopped in CT during charging, pulling up CT immediately.

The load is stopped in CT during discharging, pulling up CT immediately.
3. **Power ON Reset**

Power ON reset (output delay time) is adjustable by CT pin capacitor.

\[ t_{dlH}(S) \approx 1.15V \times CT\ capacitance(\mu F)/I_{CTC}(\mu A) \quad (Typ) \]

where:
- \( t_{dlH} \) is the output delay time (power ON reset)
- \( 1.15V \) is the upper switching threshold voltage (Typ)
- \( CT\ capacitance \) is the capacitor connected to CT pin
- \( I_{CTC} \) is the WDT charge current

<Calculation example > with 0.01 \( \mu F \) CT pin capacitor

\[ t_{dlH}(S) = 1.15V \times 0.01\mu F/5.0\mu A \]
\[ \approx 2.3\,msec \]

If the CT capacitance is not the same as the condition on the electrical characteristics table, i.e., 0.01 \( \mu F \), choose the capacitance value in ratio referring to the above equation.

<Timing Chart>  Note: Watchdog Timer OFF (INH ON)
4. **Watchdog Timer**

Watchdog Timer (WDT watch time, reset time) is adjustable by the CT pin capacitor

\[
t_{WH}(S) \approx 1.00V \times CT\ capacitance(\mu F)/I_{CTD}(\mu A) \quad (Typ)
\]

\[
t_{WL}(S) \approx 1.00V \times CT\ capacitance(\mu F)/I_{CTC}(\mu A) \quad (Typ)
\]

where:
- \(t_{WH}\) is the WDT watch time (delay time to turn the reset ON)
- \(t_{WL}\) is the WDT reset time (time the reset is ON)
- 1.00V is the upper switching threshold voltage - lower switching threshold voltage
- \(CT\) capacitance is the CT pin capacitor (Shared with power ON reset)
- \(I_{CTC}\) is the WDT charge current
- \(I_{CTD}\) is the WDT discharge current

WDT time’s accuracy is ±20 % by trimming

<Calculation example> with 0.01 \(\mu\)F CT pin capacitor

\[
t_{WH}(S) \approx 1.00V \times 0.01\mu F/1.3\mu A \approx 8.0\,\text{msec} \quad (Typ)
\]

\[
t_{WL}(S) \approx 1.00V \times 0.01\mu F/5.0\mu A \approx 2.0\,\text{msec} \quad (Typ)
\]

If the CT capacitance is not the same as the condition on the electrical characteristics table, choose the capacitance value in ratio referring to the above equation.
5. **WDT timer ON / OFF Switch INH (Resistance Value is Typical Value)**

BD3010AFV has a switch INH to turn the WDT ON / OFF

![IC Internal Block Diagram](image)

By using INH ON, CT voltage can be pulled up to internal voltage VREF\_R (invalid with power ON reset)

<Timing Chart>

<table>
<thead>
<tr>
<th>VCC</th>
<th>OUT</th>
<th>INH</th>
<th>CT</th>
<th>CLK</th>
<th>RO</th>
<th>I_OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="VCC Waveform" /></td>
<td><img src="image" alt="OUT Waveform" /></td>
<td><img src="image" alt="INH Waveform" /></td>
<td><img src="image" alt="CT Waveform" /></td>
<td><img src="image" alt="CLK Waveform" /></td>
<td><img src="image" alt="RO Waveform" /></td>
<td><img src="image" alt="I_OUT Waveform" /></td>
</tr>
</tbody>
</table>
6. Forced Watch Mode

By detecting an input voltage (battery voltage) called output SAT detection, WDT can be forced to be operated.

WDT will be forced ON from reset cancellation voltage to V\textsubscript{CC} ≈ 5.7 V (WDT can be turned OFF by INH)

IC Internal Block Diagram

<Timing Chart including Forced Watch Mode> Note: No CLK Signal Input

![Timing Chart including Forced Watch Mode](image-url)
<Timing Chart including Forced Watch Mode>  Note: With CLK Signal Input

- **VCC**: Start up voltage
- **OUT**: 0V
- **INH**: 0V
- **CT**: 1.25V, 1.15V, 0.15V
- **CLK**: Does not accept CLK → Reset
- **RO**: Output delay time
- **IOUT**: 0mA

**Forced watch mode**: Release voltage 3.7V

- Reset detection of low voltage to turn off CT in spite of charging or discharging CT.

**Stand by mode**: Release voltage 4.25V

- Release forced watch mode during CT charging (CT pull up immediately.)

**Release forced watch mode**: 0V

- Release forced watch mode during CT charging (CT pull up immediately.)

**Release voltage**: 70mV

- Release forced watch mode during CT charging (CT pull up immediately.)

**FORCED watch mode**: 5.7V

- Release forced watch mode during CT charging (CT pull up immediately.)

**Stand by mode**: 5.7V

- Release forced watch mode during CT charging (CT pull up immediately.)

**Start up voltage**: VVHS 70 mV

- Release forced watch mode during CT charging (CT pull up immediately.)

- Does not accept CLK

**Comparator fO reset**: Reset detection of low voltage to turn off CT in spite of charging or discharging CT.

**Output delay time (Power ON reset)**: Reset
<Entire Timing Chart>
7. Pin Settings / Precautions

(1) VCC Pin

Insert a 0.33 μF to 1000 μF capacitor between the VCC and GND pins. The appropriate capacitance value varies by application. Be sure to allow a sufficient margin for input voltage levels.

(2) Output Pins

It is necessary to place capacitors between each output pin and GND to prevent oscillation on the output. Usable capacitance values range from 0.1 μF to 1000 μF. Abrupt fluctuations in input voltage and load conditions may affect the output voltage. Output capacitance values should be determined only through sufficient testing of the actual application.

(3) CT Pin

Connecting a capacitance of 0.01 μF to 1 μF on the CT pin is recommended.
Power Dissipation

Refer to thermal dissipation characteristics (Figure 18 to Figure 20) for usage above $T_a = 25 \degree C$. The IC's temperature affects heavily the IC's characteristics. If it exceeds its max junction temperature ($T_{j\text{max}}$), the chip may degrade or get destroyed. Thermal design is critical in terms of avoiding instantaneous destruction and reliability in long term usage. The IC needs to be operated below its max junction temperature ($T_{j\text{max}}$) to avoid thermal destruction. Refer to Figure 18, Figure 19 and Figure 20 for SSOP-B20 package thermal dissipation characteristics. Operate the IC within the allowable power dissipation ($P_d$) when using this IC.

Power consumption $P_c(W)$ calculation will be as below (for Figure 20)

$$P_c = (V_{CC} - V_{OUT}) \times I_{OUT} + V_{CC} \times I_{CC2}$$

where:
- $V_{CC}$ is the input voltage
- $V_{OUT}$ is the output voltage
- $I_{OUT}$ is the load current
- $I_{CC2}$ is the circuit current

If load current $I_{OUT}$ is calculated to operate within the allowable power dissipation, it will be as below, where you can find the value of the allowable max load current $I_{OMAX}$ for the applied voltage $V_{CC}$ of the thermal design.

$$I_{OUT} \leq \frac{P_d - V_{CC} \times I_{CC2}}{V_{CC} - V_{OUT}}$$

(Refer to Figure 2 for $I_{CC2}$)

Example) at $T_a = 85 \degree C$, $V_{CC} = 12 V$, $V_{OUT} = 5 V$

$$I_{OUT} \leq \frac{1.578 - 12 \times 110 \mu A}{12 - 5}$$

$$I_{OUT} \leq 200 mA \quad (I_{CC2} = 110 \mu A)$$

Refer to above and adjust the thermal design so it will be within the allowable power dissipation within the entire operation temperature range. Below is the power consumption $P_c$ calculation when OUT is shorted to GND.

$$P_c = V_{CC} \times (I_{CC2} + I_{short})$$

where:
- $I_{short}$ is the Short current

(Refer to Figure 4. for $I_{short}$)

(Note) Reduced by 10.0mW/°C over $T_a=25°C$, when mounted on 70mm x 70mm x 1.6mm glass epoxy board
I/O Equivalence Circuit
(Resistance Value is Typical Value)

<Regulator>

<table>
<thead>
<tr>
<th>VCC</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>![VCC Diagram]</td>
<td>![OUT Diagram]</td>
</tr>
</tbody>
</table>

CLK

<table>
<thead>
<tr>
<th>OUT</th>
<th>WADJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>![OUT Diagram]</td>
<td>![WADJ Diagram]</td>
</tr>
</tbody>
</table>

<Reset>

<table>
<thead>
<tr>
<th>RO</th>
<th>INH</th>
</tr>
</thead>
<tbody>
<tr>
<td>![RO Diagram]</td>
<td>![INH Diagram]</td>
</tr>
</tbody>
</table>

RADJ

<table>
<thead>
<tr>
<th>OUT</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>![OUT Diagram]</td>
<td>![CT Diagram]</td>
</tr>
</tbody>
</table>
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 pins.

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. Except for pins the output 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. **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 Pins
Input pins 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 pins 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.

Figure 21. Example of monolithic IC structure

13. 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.

14. 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.

15. Thermal Consideration
Use a thermal design that allows for a sufficient margin by taking into account the permissible power dissipation (Pd) in actual operating conditions. Consider Pc that does not exceed Pd in actual operating conditions (Pc ≤ Pd).

\[
Pd(W) = \frac{(T_{jmax} - Ta)}{\theta_{ja}}
\]

\[
Pc(W) = (V_{CC} - V_{OUT}) \times I_{OUT} + V_{CC} \times I_{CC2}
\]

where:
- \( T_{jmax} \) is the Maximum junction temperature = 150°C,
- \( Ta \) is the Peripheral temperature [°C],
- \( \theta_{ja} \) is the Thermal resistance of package-ambience [°C/W],
- \( Pd \) is the Package Power dissipation [W],
- \( Pc \) is the Power dissipation [W],
- \( V_{CC} \) is the Input Voltage,
- \( V_{OUT} \) is the Output Voltage,
- \( I_{OUT} \) is the Load,
- \( I_{CC2} \) is the Bias Current
Operational Notes – continued

16. In some application or process testing, the voltage on the VCC or other pins may be reversed. If a large capacitor is connected between the output and ground, the current from the charged capacitor can flow to the output and possibly damage the IC. In order to avoid these problems, limiting output pin capacitance to 1000 μF or less and inserting a VCC series countercurrent prevention diode or bypass diode between the various pins and the VCC is recommended.

Reverse Polarity Diode  Bypass Diode

17. Positive Voltage Surges on VCC Pin
   A power Zener diode should be inserted between Vcc and GND for protection against voltage surges of more than 50V on the VCC pin.

18. Negative Voltage Surges on VCC Pin
   A schottky barrier diode should be inserted between VCC and GND for protection against voltages lower than GND on the VCC pin.

19. Output Protection Diode
   Output loads with large inductive component may cause reverse current flow during startup or shutdown. In such cases, a protection diode should be inserted on the output to protect the IC.
Ordering Information

```
BD3010AFV - E2
```

- **Part Number**
- **Package**
  - FV: SSOP-B20
- **Packaging and forming specification**
  - E2: Embossed tape and reel

Marking Diagram

![SSOP-B20(TOP VIEW)](image)

- **Part Number Marking**
- **LOT Number**
- **1PIN MARK**
## Physical Dimension, Tape and Reel Information

<table>
<thead>
<tr>
<th>Package Name</th>
<th>SSOP-B20</th>
</tr>
</thead>
</table>

### Tape and Reel Information

<table>
<thead>
<tr>
<th>Tape</th>
<th>Embossed carrier tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>2500pcs</td>
</tr>
</tbody>
</table>

**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.

- **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.

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>
</table>
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(Note 1) Medical Equipment Classification of the Specific Applications

<table>
<thead>
<tr>
<th>JAPAN</th>
<th>USA</th>
<th>EU</th>
<th>CHINA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLASS III</td>
<td>CLASS III</td>
<td>CLASS II b</td>
<td>CLASS III</td>
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<tr>
<td>CLASS IV</td>
<td></td>
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</tbody>
</table>

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

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   - [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 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.

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Precaution for Disposition

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