Rectifier Device Data

. . . employing the Schottky Barrier principle in a large area metal–to–silicon power diode. State–of–the–art geometry features chrome barrier metal, epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low–voltage, high–frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low \( v_T \)
- Low Power Loss/High Efficiency
- Low Stored Charge, Majority Carrier Conduction

**Mechanical Characteristics:**
- Case: Epoxy, Molded
- Weight: 1.1 gram (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Lead and Mounting Surface Temperature for Soldering Purposes: 220°C Max. for 10 Seconds, 1/16” from case
- Shipped in plastic bags, 5,000 per bag
- Available Tape and Reeled, 1500 per reel, by adding a “RL” suffix to the part number
- Polarity: Cathode indicated by Polarity Band
- Marking: 1N5820, 1N5821, 1N5822

**MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>1N5820</th>
<th>1N5821</th>
<th>1N5822</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Repetitive Reverse Voltage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working Peak Reverse Voltage</td>
<td>( V_{RRM} )</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>V</td>
</tr>
<tr>
<td>DC Blocking Voltage</td>
<td>( V_{RWM} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non–Repetitive Peak Reverse Voltage</td>
<td>( V_{RSM} )</td>
<td>24</td>
<td>36</td>
<td>48</td>
<td>V</td>
</tr>
<tr>
<td>RMS Reverse Voltage</td>
<td>( V_R(RMS) )</td>
<td>14</td>
<td>21</td>
<td>28</td>
<td>V</td>
</tr>
<tr>
<td>Average Rectified Forward Current (2)</td>
<td>( V_R(equiv) \leq 0.2 ) ( V_{Rdc} ), ( T_L = 95°C )</td>
<td>90</td>
<td>85</td>
<td>80</td>
<td>°C</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>( T_A )</td>
<td>3.0</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Rated ( V_R(dc), \ P_F(AV) = 0 )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R_{θ JA} = 28°C/W )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non–Repetitive Peak Surge Current (Surge applied at rated load conditions, half wave, single phase 60 Hz, ( T_L = 75°C ))</td>
<td>( I_{FSM} )</td>
<td>80 (for one cycle)</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Operating and Storage Junction Temperature Range (Reverse Voltage applied)</td>
<td>( T_{J, T_{stg}} )</td>
<td>-65 to +125</td>
<td></td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Peak Operating Junction Temperature (Forward Current applied)</td>
<td>( T_{J(pk)} )</td>
<td>150</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

**THERMAL CHARACTERISTICS** (Note 2)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Resistance, Junction to Ambient</td>
<td>( R_{θ JA} )</td>
<td>28</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

(1) Pulse Test: Pulse Width = 300 μs. Duty Cycle = 2.0%.
(2) Lead Temperature reference is cathode lead 1/32” from case.
* Indicates JEDEC Registered Data for 1N5820–22.

**Designer’s Data for “Worst Case” Conditions** — The Designer’s Data Sheet permits the design of most circuits entirely from the information presented. SOA Limit curves — representing boundaries on device characteristics — are given to facilitate “worst case” design.

**Preferred devices** are Motorola recommended choices for future use and best overall value.
**ELECTRICAL CHARACTERISTICS** \((T_L = 25^\circ C\) unless otherwise noted) \((2)\)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>1N5820</th>
<th>1N5821</th>
<th>1N5822</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Instantaneous Forward Voltage ((1)) ((i_F = 1.0) Amp)</td>
<td>(V_F)</td>
<td>0.370</td>
<td>0.380</td>
<td>0.390</td>
<td>V</td>
</tr>
<tr>
<td>((i_F = 3.0) Amp)</td>
<td></td>
<td>0.475</td>
<td>0.500</td>
<td>0.525</td>
<td></td>
</tr>
<tr>
<td>((i_F = 9.4) Amp)</td>
<td></td>
<td>0.850</td>
<td>0.900</td>
<td>0.950</td>
<td></td>
</tr>
<tr>
<td>Maximum Instantaneous Reverse Current (@) Rated dc Voltage ((1)) (T_L = 25^\circ C)</td>
<td>(i_R)</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>mA</td>
</tr>
<tr>
<td>(T_L = 100^\circ C)</td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

(1) Pulse Test: Pulse Width = 300 \(\mu s\), Duty Cycle = 2.0%.
(2) Lead Temperature reference is cathode lead 1/32” from case.

* Indicates JEDEC Registered Data for 1N5820–22.

**NOTE 1 — DETERMINING MAXIMUM RATINGS**

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.1 \(V_{RWM}\). Proper derating may be accomplished by use of equation (1).

\[
T_{A(max)} = T_{J(max)} - R_{\theta JA} P_F(AV) - R_{\theta JA} P_R(AV)
\]

where

\[
T_{A(max)} = \text{Maximum allowable ambient temperature}
\]

\[
T_{J(max)} = \text{Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest)}
\]

\[
P_F(AV) = \text{Average forward power dissipation}
\]

\[
P_R(AV) = \text{Average reverse power dissipation}
\]

\[
R_{\theta JA} = \text{Junction-to-ambient thermal resistance}
\]

Figures 1, 2, and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2).

\[
T_R = T_{J(max)} - R_{\theta JA} P_R(AV)
\]

Substituting equation (2) into equation (1) yields:

\[
T_{A(max)} = T_R - R_{\theta JA} P_F(AV)
\]

Inspection of equations (2) and (3) reveals that \(T_R\) is the ambient temperature at which thermal runaway occurs or where \(T_J = 125^\circ C\), when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2, and 3 as a difference in the rate of change of the slope in the vicinity of 115°C.

The data of Figures 1, 2, and 3 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design, that is:

\[
V_{R(equiv)} = V_{FM} \times F
\]

The factor \(F\) is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

**EXAMPLE:** Find \(T_{A(max)}\) for 1N5821 operated in a 12-volt dc supply using a bridge circuit with capacitive filter such that \(I_{DC} = 2.0\) A \((I_{F(AV)} = 1.0\) A\), \(I_{F(AV)}/I_{FM} = 10\), Input Voltage = 10 \(V_{rms}\), \(R_{\theta JA} = 40^\circ C/W\).

1. **Step 1.** Find \(V_{R(equiv)}\). Read \(F = 0.65\) from Table 1,

\[
V_{R(equiv)} = (1.41) (10) (0.65) = 9.2 \, V
\]

2. **Step 2.** Find \(T_R\) from Figure 2. Read \(T_R = 108^\circ C\) @ \(V_R = 9.2\) V and \(R_{\theta JA} = 40^\circ C/W\).

3. **Step 3.** Find \(P_F(AV)\) from Figure 6. **Read \(P_F(AV) = 0.85\) W @ \(I_{FM}/I_{AV} = 10\) and \(I_{F(AV)} = 1.0\) A.**

4. **Step 4.** Find \(T_{A(max)}\) from equation (3).

\[
T_{A(max)} = 108 - (0.85) (40) = 74^\circ C
\]

**Values given are for the 1N5821. Power is slightly lower for the 1N5820 because of its lower forward voltage, and higher for the 1N5822. Variations will be similar for the MBR-prefix devices, using \(P_F(AV)\) from Figure 7.**

---

**Table 1. Values for Factor F**

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Half Wave</th>
<th>Full Wave, Bridge</th>
<th>Full Wave, Center Tapped*†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>Resistive</td>
<td>Capacitive*</td>
<td>Resistive</td>
</tr>
<tr>
<td>Sine Wave</td>
<td>0.5</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Square Wave</td>
<td>0.75</td>
<td>1.5</td>
<td>0.75</td>
</tr>
</tbody>
</table>

*Note that \(V_R(P_K) = 2.0 \, V_{In(P_K)}\). †Use line to center tap voltage for \(V_{In}\).
Figure 1. Maximum Reference Temperature
1N5820

Figure 2. Maximum Reference Temperature
1N5821

Figure 3. Maximum Reference Temperature
1N5822

Figure 4. Steady–State Thermal Resistance
The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of \( T_L \), the junction temperature may be determined by:

\[
T_J = T_L + \Delta T_{JL}
\]

where:

\( \Delta T_{JL} = P_{pk} \cdot R_{\theta JL} \cdot [D + (1 - D) \cdot \{r(t_1 + t_p) + r(t_p) - r(t_1)\}] \)

- \( \Delta T_{JL} \) is the increase in junction temperature above the lead temperature.
- \( r(t) \) is the normalized value of transient thermal resistance at time, \( t \), i.e.:
  - \( r(t_1 + t_p) \) is the normalized value of transient thermal resistance at time \( t_1 + t_p \), etc.

**Figure 5. Thermal Response**

**Figure 6. Forward Power Dissipation 1N5820–22**

**NOTE 2 — MOUNTING DATA**

Data shown for thermal resistance junction-to-ambient (\( R_{\theta JA} \)) for the mountings shown is to be used as typical guideline values for preliminary engineering, or in case the tie point temperature cannot be measured.

<table>
<thead>
<tr>
<th>Mounting Method</th>
<th>Lead Length, L (in)</th>
<th>( R_{\theta JA} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/8</td>
<td>50</td>
</tr>
<tr>
<td>1/4</td>
<td>51</td>
<td>53</td>
</tr>
<tr>
<td>1/2</td>
<td>53</td>
<td>55</td>
</tr>
<tr>
<td>3/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>58</td>
<td>59</td>
</tr>
<tr>
<td>3</td>
<td>61</td>
<td>63</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>( ^\circ )C/W</td>
</tr>
</tbody>
</table>

**NOTE 3 — APPROXIMATE THERMAL CIRCUIT MODEL**

Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

- \( T_A \) = Ambient Temperature
- \( T_C \) = Case Temperature
- \( T_J \) = Junction Temperature
- \( R_{\theta RS} \) = Thermal Resistance, Heat Sink to Ambient
- \( R_{\theta JL} \) = Thermal Resistance, Lead to Heat Sink
- \( R_{\theta JL} \) = Thermal Resistance, Junction to Case
- \( P_D \) = Total Power Dissipation = \( P_F + P_R \)
- \( P_F \) = Forward Power Dissipation
- \( P_R \) = Reverse Power Dissipation

(Subscripts (A) and (K) refer to anode and cathode sides, respectively.) Values for thermal resistance components are:

- \( R_{\theta JL} \) = 42\(^\circ\)C/W/in typically and 48\(^\circ\)C/W/in maximum
- \( R_{\theta JL} \) = 10\(^\circ\)C/W typically and 16\(^\circ\)C/W maximum

The maximum lead temperature may be found as follows:

\[
T_L = T_{J(max)} - \Delta T_{JL}
\]

where \( \Delta T_{JL} = R_{\theta JL} \cdot P_D \)
NOTE 4 — HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11.)
Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. “Typical” parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including “Typicals” must be validated for each customer application by customer’s technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.