1. Introduction

Datasheets are not required to be created to a fixed international standard. This means datasheets must be read and interpreted carefully to ensure that parameter descriptions and values are correctly understood.

This datasheet note looks at the parameters defined and described in WeEn datasheets for diodes.

2. Datasheet product profile

All WeEn’s datasheets have the product name and type, revision number and publication date on the first page heading. This is followed by three sections, “General description”, “Features and benefits” and “Applications”. These sections describe the product to allow the reader to quickly understand its technology, main advantages and uses. There are product datasheets for single and dual diodes for differing technology platforms: Silicon diodes (hyperfast, ultrafast etc.,), Schottky diodes and Silicon Carbide diodes.

![Fig. 1 Example of a Schottky diode datasheet product profile (WNS30H100CB)](image-url)
The “Quick reference data” section highlights some important parameters for the product found in the main body of the datasheet.

### 4. Quick reference data

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{RRM} )</td>
<td>repetitive peak reverse voltage</td>
<td>-</td>
<td>-</td>
<td>100</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>( I_{F(AV)} )</td>
<td>average forward current</td>
<td>( 0.5 ) ( V ); ( T_{J} \leq 154 ) °C; square-wave pulse; per diode</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>A</td>
</tr>
<tr>
<td>( I_{O(AV)} )</td>
<td>average output current</td>
<td>( 0.5 ) ( V ); ( T_{J} \leq 133 ) °C; square-wave pulse; both diodes conducting</td>
<td>-</td>
<td>-</td>
<td>30</td>
<td>A</td>
</tr>
</tbody>
</table>

**Static characteristics**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{F} )</td>
<td>forward voltage</td>
<td>( I_{R} = 5 ) A; ( T_{J} = 25 ) °C; Fig. 6: per diode</td>
<td>-</td>
<td>0.48</td>
<td>0.56</td>
<td>V</td>
</tr>
<tr>
<td>( I_{R} = 5 ) A; ( T_{J} = 125 ) °C; Fig. 6: per diode</td>
<td>-</td>
<td>0.41</td>
<td>0.48</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{R} = 10 ) A; ( T_{J} = 25 ) °C; Fig. 6: per diode</td>
<td>-</td>
<td>0.56</td>
<td>0.63</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{R} = 10 ) A; ( T_{J} = 125 ) °C; Fig. 6: per diode</td>
<td>-</td>
<td>0.52</td>
<td>0.6</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{R} = 15 ) A; ( T_{J} = 25 ) °C; Fig. 6: per diode</td>
<td>-</td>
<td>0.64</td>
<td>0.71</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{R} = 15 ) A; ( T_{J} = 125 ) °C; Fig. 6: per diode</td>
<td>-</td>
<td>0.6</td>
<td>0.67</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_{R} )</td>
<td>reverse current</td>
<td>( V_{D} = 100 ) V; ( T_{J} = 25 ) °C; Fig. 7: per diode</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>( \mu )A</td>
</tr>
<tr>
<td>( V_{D} = 100 ) V; ( T_{J} = 125 ) °C; Fig. 7: per diode</td>
<td>-</td>
<td>-</td>
<td>30</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 2 Example of a datasheet product profile (WNS30H100CB)**

“Pinning information” contains a table and diagram to aid the correct identification of the product’s electrical terminals and package type.

“Ordering information” gives the product’s part number and package version. Sometimes there is a “Marking information” section. This gives data on the labelling printed on the device and data on the packing method.

**Fig. 3 Example of a datasheet product profile (WNS30H100CB)**
3. Datasheet “Limiting Values”

“Limiting Values” describe the limiting conditions that can be applied by a circuit without risk of damage to the diode, and these limiting values reflect the diode’s capability. These are the absolute maximum ratings for the operating and environmental conditions and circuit designers should ensure these are not exceeded. These values may be maximum or minimum. “Limiting” means that the value specified in the table must not be exceeded otherwise the product may malfunction or even be permanently damaged. A limiting value is defined in accordance with the IEC-60134 international standard, known as the “Absolute Maximum Rating System”.

3.1 $V_{RRM}$, $V_{RWWM}$ and $V_R$

$V_{RRM}$ is the maximum allowable instantaneous repetitive peak reverse voltage (including transients) that the circuit can apply to the diode. “RRM” describes the voltage as “Reverse”, “Repetitive” and “Maximum”. Similarly, $V_{RWWM}$ is the maximum allowable repetitive crest working voltage including transients with “RWM” meaning “Reverse”, “Working” and “Maximum”. $V_{RSM}$ is the maximum allowable non-repetitive peak reverse voltage including all non-repetitive transients. $V_R$ is the maximum allowable constant reverse voltage.

The rated values of $V_{RRM(max)}$, $V_{RWWM(max)}$ and $V_{R(max)}$ may be applied continuously over the entire operating junction temperature range, provided that the thermal resistance between junction and ambient is low enough to avoid the possibility of thermal runaway.
3.2 $I_{F(AV)}$ and $I_{O(AV)}$

| Parameter | Description | Conditions | Value
|-----------|-------------|------------|--------
| $I_{F(AV)}$ | Average forward current | $\delta = 0.5$; $T_{j(\text{max})} \leq 134^\circ C$; square-wave pulse, per diode. | - 15 A
| $I_{O(AV)}$ | Average output current | $\delta = 0.5$; $T_{j(\text{max})} \leq 133^\circ C$; square-wave pulse, both diodes conducting | - 30 A

Fig. 6 Diode voltage definitions

Fig. 7 Example of current ratings (WNS30H100CB)

$I_{F(AV)}$ is the value of current for the diode which under steady state conditions results in the rated temperature $T_{j(\text{max})}$ being reached for a given package-related temperature condition. This temperature condition is specified as $T_{mb}$ for “mounting-base” or “tab” type packages, $T_{h}$ for plastic packages for “heatsink” mounting, $T_{lead}$ for smaller plastic packages that cannot be heatsink mounted or $T_{sp}$ for the solder point of surface mounted packages. $I_{F(AV)}$ is related to the $I_{f(\text{rms})}$ current parameter by the equation, $I_{f(\text{rms})} / I_{f(AV)} = \text{form factor}$.

$I_{O(AV)}$ shows the average output current with the two diodes conducting alternatively. With each diode conducting at 15A with a duty cycle $d = 0.5$, this means each diode conducts alternatively with a square wave peak of 30A.
A graph relating the average forward current to the package-related temperature condition – the derating graphic is usually found in WeEn diode datasheets. Power dissipation graphics for square and sinusoidal conditions are also shown. (See Fig. 8 and Fig.9).

This derating graph (Fig. 8) indicates the reduction of the maximum current recommended for temperatures that may exceed \( T_{mb} = 134 \, ^\circ C \) (for this WNS30H100CB example).
These graphs show forward power dissipation as a function of average current for square waveforms over a range of duty cycles and similarly for sinusoidal waveforms over a range of form factors. Operating the diode at $I_{(AV)}$ values above the rated limiting value will lead to exceeding the maximum allowable junction temperature $T_{j(max)}$.

The average junction temperature rise can be calculated by multiplying the power dissipation at the rated average current by the thermal resistance (e.g. $R_{th(j-mb)}$ or $R_{th(j-h)}$ for single or two diodes conducting). By subtracting this average junction temperature rise from the maximum allowable temperature, $T_{j(max)}$, the maximum allowable mounting base or heatsink temperature is obtained. This is the value shown in the datasheet text and value indicated on the derating graphic.

It should be remembered that to operate the diode(s) under these conditions means the external heatsinking and cooling arrangements need to dissipate the generated power to the ambient surroundings. This may mean devices in real applications are derated from the maximum $I_{(AV)}$ conditions in the datasheet, especially devices surface-mounted on PCBs which usually have high $R_{th(mb-amb)}$ values.

### 3.3 $I_{FSM}$ and $I_{FRM}$

$I_{FSM}$ is the maximum non-repetitive peak forward surge current that may be applied to the diode. It is specified for a one half-sine wave pulse at an initial junction temperature of 25 °C before surge with an AC mains frequency of 50 or 60Hz. The shorter the time period of the surge (higher frequency) the higher the $I_{FSM}$ capability. Exceeding the $I_{FSM}$ rating may damage the diode.
In WeEn datasheets the $I_{FRM}$ rating is defined such that it is an additional clarification of the $I_{F(AV)}$ rating in the continuous current conduction condition. $I_{FRM}$ is the maximum allowable repetitive peak forward current including transients which occur every cycle. The junction temperature should not exceed $T_{j(max)}$ during repetitive current transients.

The $I_{FRM}$ rating and its definition is discussed further in the WDN001 datasheet note, “Understanding IFRM for power diodes”. This parameter is defined differently by different manufacturers.

3.4 $T_{stg}$ and $T_j$

$T_{stg}$ gives the values for the range of temperature allowable for storage (dispatching, handling, warehousing) of the diode. $T_{j(max)}$ is the maximum operating junction temperature for the diode in the on-state or blocking state. Although the junction temperature may transiently exceed $T_{j(max)}$ without damage, (e.g. during exceptional, brief, non-repetitive overload or fault conditions), for repetitive operation the peak junction temperature must remain below the absolute maximum rating.
4. Datasheet “Characteristics”

“Characteristics” are the inherent measurable parameters for the diode and are often stated with minimum or maximum values or both. Sometimes typical values are given. The limits define a range of values for the diode inherent parameter characteristics. These values are useful to the designer for optimizing the circuit and ensuring reliable operation.

4.1 Thermal characteristics, $R_{th}$ and $Z_{th}$

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th(ma)}$</td>
<td>thermal resistance from junction to mounting base</td>
<td>per diode; Fig. 5</td>
<td>-</td>
<td>-</td>
<td>1.3</td>
<td>KW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>both diodes conducting</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
<td>KW</td>
</tr>
<tr>
<td>$R_{th(ta)}$</td>
<td>thermal resistance from junction to ambient</td>
<td>in free air</td>
<td>-</td>
<td>60</td>
<td>-</td>
<td>KW</td>
</tr>
</tbody>
</table>

Fig. 13 Example of thermal characteristics (WNS30H100CB)

Maximum steady-state thermal resistance values are given in the datasheet and are used to specify the diode’s current and power ratings. As previously mentioned, the average junction temperature rise for a given power dissipation is the mathematical product of the average dissipation and the thermal resistance.

A typical value of junction to ambient thermal resistance is given which assumes that through-hole leaded devices are mounted vertically on a PCB in free air. The value for surface mount packages is for a device soldered to a pad area on a given PCB material.

Fig. 14 Example of transient thermal impedance graphic (WNS30H100CB)

Fig. 5. Transient thermal impedance from junction to mounting base as a function of pulse duration; maximum values; per diode
Although average junction temperature rise may be calculated from the thermal resistance value, the peak junction temperature calculation requires knowledge of the current waveform and the transient thermal impedance curve. This curve in the datasheet is based on rectangular power pulses. Increasing the pulse duration results in higher transient thermal impedance ($Z_{th}$) until the steady-state, thermal resistance ($R_{th}$) is reached. If the application operates under transient (pulse) conditions, $Z_{th}$ instead of $R_{th}$ should be considered since $R_{th}$ is applicable only to steady state, continuous operation. The temperature rise is calculated as the mathematical product of peak dissipation during the pulse by the thermal impedance for the given pulse width.

In practice, a power device must frequently handle composite waveforms rather than a simple rectangular pulse. This type of pulse can be simulated by superimposing several rectangular pulses which have a common time period but with both positive and negative amplitudes. Similarly, a burst of pulses can be treated as a composite waveform. Triangular, trapezoidal and sinusoidal waveforms can also be approximated by a series of rectangles. This analysis is covered elsewhere.

### 4.2 $V_F$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_F$</td>
<td>$I_T = 5 , A; , T_J = 25 , ^{\circ}C$; Fig. 8; per diode</td>
<td>-</td>
<td>0.40</td>
<td>0.55</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$I_T = 10 , A; , T_J = 125 , ^{\circ}C$; Fig. 6; per diode</td>
<td>-</td>
<td>0.41</td>
<td>0.48</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$I_T = 15 , A; , T_J = 25 , ^{\circ}C$; Fig. 6; per diode</td>
<td>-</td>
<td>0.56</td>
<td>0.63</td>
<td>V</td>
</tr>
</tbody>
</table>

**Fig. 15 Example of $V_F$ characteristics (WNS30H100CB)**

$V_F$ is the forward voltage for the diode at a specified load current and junction temperature condition. This is the maximum instantaneous forward voltage measured under pulse conditions to avoid excessive power dissipation. It is important to check the specified current and temperature values and whether these are typical or maximum. These values along with $V_F / I_T$ curves at $25 \, ^{\circ}C$ and $I_{J(max)}$ enable fair comparison of device specifications between manufacturers. $V_F$ is lower at smaller current values and usually lower at higher temperatures. $V_F$ is an important parameter to consider for DCM PFC circuit applications.
V₀ is the “knee voltage” and Rₛ is the slope resistance and their values are usually shown in the VF / IF graphic in the datasheet (See Fig 17). These values are sometimes also shown in the power dissipation graphics.

If values for V₀ and Rₛ are not given in the datasheet, these can be approximated using the method illustrated in Fig 16.

The forward characteristic may be approximated by a linear model and the forward voltage is then given by the equation: V_f = V_0 + I_f.Rₛ, and the instantaneous power dissipation is given by P_f = V_0. I_f + I_f² . Rₛ where I_f is the instantaneous forward current.

It can be shown mathematically that the average forward dissipation for any current waveform is given by the equation, P_f(AV) = V_0. I_f(AV) + I_f(RMS)² . Rₛ, where I_f(AV) is the forward average current and I_f(RMS) is the RMS value of the forward current.

Therefore, in diode datasheets, the graph for forward dissipation can be calculated as a function of average current. Sinusoidal waveforms are assumed, and the graphs usually show the dissipation over a range of conduction angles. (See Fig. 9).

Similar details for the derivation of V₀, Rₛ and power calculations are presented in WeEn Application Note WAN004.
The datasheet $V_F$ / $I_F$ graphic has maximum and typical curves measured at the rated operating temperature (150 °C in this example) and at 25 °C. The “maximum” curve is used to calculate the power dissipation for a given average current.
4.3 $I_R$

| $I_R$ | reverse current | $V_R = 100 \, V; \, T_j = 25 \, ^\circ C$; Fig. 7; Fig. 8: per diode | - | - | 50 | $\mu A$
| $V_R = 100 \, V; \, T_j = 125 \, ^\circ C$; Fig. 7; Fig. 8: per diode | - | - | 30 | mA

Fig. 18 Example of $I_R$ characteristic (WNS30H100CB)

The maximum reverse leakage currents are at maximum operating junction temperature and maximum reverse voltage. These are shown in Fig 19 (for this WNS30H100CB example).

4.4 Junction capacitance, $C_J$ or $C_d$

| $C_d$ | diode capacitance | $f = 1 \, MHz; \, V_R = 1 \, V; \, T_j = 25 \, ^\circ C$ | - | 510 | - | pF
| $f = 1 \, MHz; \, V_R = 400 \, V; \, T_j = 25 \, ^\circ C$ | - | 48 | - | pF
| $f = 1 \, MHz; \, V_R = 800 \, V; \, T_j = 25 \, ^\circ C$ | - | 41 | - | pF

Fig. 20 Example of junction capacitance data (WN5C201200CW)

$C_J$ or $C_d$ is the junction small signal capacitance of the diode at a specified reverse voltage. Typical values may be given for differing values of $V_R$ (Fig. 20) or a graphic may be supplied as shown in Fig. 21. The higher the current rating of the diode (usually a larger chip) the larger the junction capacitance.
4.5 Reverse recovery characteristics: $Q_r$, $t_{rr}$, and $I_{RM}$

Dynamic characteristics show how diodes cope with fast-changing conditions in a circuit. These are not to be mistakenly understood as limiting values. “Dynamic” means continuous changes in voltage and current.

<table>
<thead>
<tr>
<th>$Q_r$</th>
<th>reverse charge</th>
<th>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 500$ A/μs; $T_J = 25$ °C; [Fig. 7]</th>
<th>-</th>
<th>952</th>
<th>-</th>
<th>nC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 500$ A/μs; $T_J = 125$ °C; [Fig. 7]</td>
<td>-</td>
<td>2920</td>
<td>-</td>
<td>nC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 500$ A/μs; $T_J = 150$ °C; [Fig. 7]</td>
<td>-</td>
<td>3425</td>
<td>-</td>
<td>nC</td>
</tr>
<tr>
<td>$t_{rr}$</td>
<td>reverse recovery time</td>
<td>$I_p = 1$ A; $V_n = 30$ V; $dl/dt = 100$ A/μs; $T_J = 25$ °C; [Fig. 7]</td>
<td>-</td>
<td>55</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 500$ A/μs; $T_J = 25$ °C; [Fig. 7]</td>
<td>-</td>
<td>96</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 600$ A/μs; $T_J = 125$ °C; [Fig. 7]</td>
<td>-</td>
<td>194</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 600$ A/μs; $T_J = 150$ °C; [Fig. 7]</td>
<td>-</td>
<td>212</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>$I_{RM}$</td>
<td>peak reverse recovery current</td>
<td>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 500$ A/μs; $T_J = 25$ °C; [Fig. 7]</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 500$ A/μs; $T_J = 125$ °C; [Fig. 7]</td>
<td>-</td>
<td>30.2</td>
<td>-</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_p = 50$ A; $V_n = 400$ V; $dl/dt = 500$ A/μs; $T_J = 150$ °C; [Fig. 7]</td>
<td>-</td>
<td>32.3</td>
<td>-</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>
Ramp ("Jedec") and “step recovery” refer to the current conditions applied when measuring the recovery parameters. Step recovery methods often yield a smaller value for reverse recovery time whereas “Ramp recovery” is more representative of real circuit conditions. For bipolar PN diodes $t_{rr}$ has a much smaller value at 25 °C than 150 °C and lower values for smaller starting measurement currents and faster rate of change of the ramp $\frac{di}{dt}$.

When a bipolar PN diode has been conducting current in the forward direction sufficiently long enough to establish steady-state, there will be an internal stored charge will have built up due to minority carriers present. Before the diode can block voltage in the reverse direction this charge must be extracted. This extraction causes a transient reverse current and this current along with the reverse bias voltage brings about additional power dissipation which reduces the rectification efficiency. For sine-wave frequencies up to 400Hz these effects can often be ignored but at higher frequencies and for square waves the switching losses must be considered. The parameters for reverse recovery are $t_{rr}$, $Q_r$ (sometimes referred to as $Q_{rr}$ or $Q_S$) and $I_{RM}$. The reverse recovery time, $t_{rr}$ is an important parameter in CCM PFC circuit applications.

The characteristics shown in Fig. 22 are measured under various specified conditions, including some at maximum operating junction temperature. Bipolar PN diodes whether hyperfast, ultrafast etc., have significant storage charge to be extracted after conducting forward current and so these reverse recovery characteristics are stated in their datasheets.

In contrast, Schottky and Silicon Carbide diodes are majority carrier devices and as such do not have storage charge that needs to be extracted like bipolar PN diodes. Consequently, these characteristics are not stated in Schottky or SiC diode datasheets. Fig. 24 illustrates the different switching behaviour for the different diodes.
The stored charge, \( Q_r \), is normally quoted in nanocoulombs. Low stored charge is preferred for fast switching applications. The speed of a rectifier diode is also measured by the \( t_{rr} \) value under certain measurement conditions. Low reverse recovery times are associated with low stored charge.

The peak reverse recovery current, \( I_{RM} \) is an important characteristic in many switched-mode power supply circuits. The high transient current produced by a diode with high peak \( I_{RM} \) can be interpreted as a short circuit fault which may cause the power supply to shut down or have poor load regulation.

Just as with \( Q_r \) and \( t_{rr} \), the peak reverse current, \( I_{RM} \) increases with increasing temperature for bipolar PN diodes, so the effects on a circuit may only become apparent when the application becomes hot. \( I_{RM} \) correlates with stored charge, \( Q_{rr} \).

In many switching circuits not only the magnitude of the reverse recovery characteristic but also its shape is important. If the positively rising current edge of the characteristic has a fast rise time (a so called “snappy device”) this may cause conducted or radio frequency interference or generate high voltages across inductors which may be in series with the diode. The maximum slope of the reverse recovery current \( dI_t/dt \) is a measure of the “softness” of the characteristic and the smaller the better to reduce current ringing (oscillations) in the circuit and EMI.

The mathematical product of the transient reverse current and the reverse voltage results in a value of power dissipation for this scenario. Mostly this occurs whilst the current is decreasing from the peak value, \( I_{RM} \) to zero. In repetitive operation an average power can be calculated and added to the forward dissipation to give the total power dissipation. The peak value of the transient current, \( I_{RM} \) is known as \( I_{RRM} \) (Fig. 24).

Fig. 24 Graphic comparing reverse recovery for diodes of differing technology
4.6 Forward recovery characteristics: $V_{fr}$, $t_{fr}$

![Diagram showing the origin of reverse switching losses in bipolar PN diodes](image)

Total $\Delta$ Area = $Q_r$

**Fig. 25 Graphic showing the origin of reverse switching losses in bipolar PN diodes**

<table>
<thead>
<tr>
<th>$V_{fr}$</th>
<th>Forward voltage</th>
<th>$I_f = 15$ A; $T_J = 150^\circ$C</th>
<th>-</th>
<th>8</th>
<th>11</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_R$</td>
<td>Reverse current</td>
<td>$V_R = V_{WPM}$; $T_J = 100^\circ$C</td>
<td>-</td>
<td>10</td>
<td>50</td>
<td>mA</td>
</tr>
<tr>
<td>$Q_{rs}$</td>
<td>Reverse recovery charge</td>
<td>$I_{fr} = 2$ A to $V_R \geq 30$ V; $dI_{fr}/dt = 20$ A/μs</td>
<td>-</td>
<td>0.3</td>
<td>0.8</td>
<td>mA</td>
</tr>
<tr>
<td>$t_{fr}$</td>
<td>Reverse recovery time</td>
<td>$I_{fr} = 1$ A to $V_R \geq 30$ V; $dI_{fr}/dt = 100$ A/μs</td>
<td>-</td>
<td>50</td>
<td>60</td>
<td>ns</td>
</tr>
<tr>
<td>$I_{rnn}$</td>
<td>Peak reverse recovery current</td>
<td>$I_{fr} = 10$ A to $V_R \geq 30$ V; $dI_{fr}/dt = 50$ A/μs; $T_J = 100^\circ$C</td>
<td>-</td>
<td>4.2</td>
<td>5.2</td>
<td>A</td>
</tr>
<tr>
<td>$V_{fr}$</td>
<td>Forward recovery voltage</td>
<td>$I_f = 10$ A; $dI_f/dt = 10$ A/μs; $T_J = 25^\circ$C</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>V</td>
</tr>
</tbody>
</table>

**Fig. 26 Example of $V_{fr}$ characteristic (BYC10X-600)**

**Fig. 27 Example of $V_{fr}$ characteristic (BY44 series)**

**Fig. 28 Example of $V_{fr}$ characteristic (BY32E-200)**
Some WeEn diode datasheets include forward recovery characteristics: for bipolar PN diodes, at the instant of switch-on into forward conduction there are no carriers present at the junction and the forward voltage, $V_F$, may be instantaneously at a higher value than normal. As the stored charge builds up, conductivity modulation in these bipolar diodes occurs which ensures that the forward voltage rapidly falls to the steady-state value. The peak value of forward voltage, $V_F$, is known as the forward recovery voltage $V_{fr}$. The time from the instant the forward current is 10% of its steady-state value to the time that the forward voltage drops below a certain value is known as the forward recovery time, $t_{fr}$.

These definitions are shown in Figure 29.

![Figure 29 Graphic showing forward recovery characteristics for bipolar PN diodes](image)

**4.7 Reverse avalanche energy, $E_{as}$**

<table>
<thead>
<tr>
<th>$E_{as}$</th>
<th>non-repetitive avalanche energy</th>
<th>$T_{jpeak} = 25^\circ C$</th>
<th>50</th>
<th>-</th>
<th>-</th>
<th>mJ</th>
</tr>
</thead>
</table>

*Fig. 30  $E_{as}$ data (BYC60W-1200P)*

Some WeEn datasheets include reverse avalanche data. This data is helpful in designing circuits which use a diode in free-wheeling mode with an inductive load. As the reverse voltage across a diode is increased a critical value or breakdown voltage is reached which results in an avalanche effect for the leakage current. The reverse energy capability of the diode is specified at 25 $^\circ$C and this capability may reduce if the diode is at a higher junction temperature just before the avalanche effect begins.
5. Package outline drawing
The datasheet contains a package outline drawing of the device. If a surface mount package is described a soldering pad drawing may also be included.

10. Package outline

![Package outline drawing](image)

Fig. 31 Example package outline drawing (WNS30H100CB)
Revision history

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<tr>
<th>Rev</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>v.01</td>
<td>20191211</td>
<td>initial version</td>
</tr>
</tbody>
</table>

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