

## SiHP24N65EF-VB Datasheet

## N-Channel 650V(D-S) Super Junction Power MOSFET

**PRODUCT SUMMARY**

|                                    |                 |       |
|------------------------------------|-----------------|-------|
| $V_{DS}$ (V) at $T_J$ max.         | 650             |       |
| $R_{DS(on)}$ at 25 °C ( $\Omega$ ) | $V_{GS} = 10$ V | 0.160 |

**FEATURES**

- Low figure-of-merit (FOM)  $R_{on} \times Q_g$
- Low input capacitance ( $C_{iss}$ )
- Reduced switching and conduction losses
- Ultra low gate charge ( $Q_g$ )
- Avalanche energy rated (UIS)

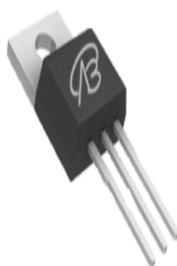


RoHS

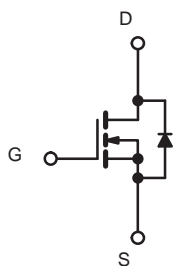
**APPLICATIONS**

- Server and telecom power supplies
- Switch mode power supplies (SMPS)
- Power factor correction power supplies (PFC)
  - Lighting
    - High-intensity discharge (HID)
    - Fluorescent ballast lighting
- Industrial

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Top View



N-Channel MOSFET


**ABSOLUTE MAXIMUM RATINGS** ( $T_C = 25$  °C, unless otherwise noted)

| PARAMETER                                                 | SYMBOL           | LIMIT          | UNIT |      |
|-----------------------------------------------------------|------------------|----------------|------|------|
| Drain-Source Voltage                                      | $V_{DS}$         | 650            | V    |      |
| Gate-Source Voltage                                       | $V_{GS}$         | $\pm 30$       |      |      |
| Continuous Drain Current ( $T_J = 150$ °C)                | $V_{GS}$ at 10 V | $T_C = 25$ °C  | 20   | A    |
|                                                           |                  | $T_C = 100$ °C | 12   |      |
| Pulsed Drain Current <sup>a</sup>                         | $I_{DM}$         | 60             |      |      |
| Linear Derating Factor                                    |                  | 1.67           | W/°C |      |
| Single Pulse Avalanche Energy <sup>b</sup>                | $E_{AS}$         | 820            | mJ   |      |
| Maximum Power Dissipation                                 | $P_D$            | 180            | W    |      |
| Operating Junction and Storage Temperature Range          | $T_J, T_{stg}$   | -55 to +150    | °C   |      |
| Drain-Source Voltage Slope                                | $dV/dt$          | $T_J = 125$ °C | 50   | V/ns |
| Reverse Diode $dV/dt$ <sup>d</sup>                        |                  | 15             |      |      |
| Soldering Recommendations (Peak Temperature) <sup>c</sup> | for 10 s         | 260            | °C   |      |

**Notes**

- Repetitive rating; pulse width limited by maximum junction temperature.
- $V_{DD} = 100$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 10$  A.
- 1.6 mm from case.
- $I_{SD} \leq I_D$ ,  $dI/dt = 100$  A/ $\mu$ s, starting  $T_J = 25$  °C.

| THERMAL RESISTANCE RATINGS       |            |      |      |      |
|----------------------------------|------------|------|------|------|
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 62   | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 0.7  |      |

| SPECIFICATIONS ( $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted) |                     |                                                                                                                                                       |                                           |      |       |           |               |
|-----------------------------------------------------------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------|-------|-----------|---------------|
| PARAMETER                                                                   | SYMBOL              | TEST CONDITIONS                                                                                                                                       |                                           | MIN. | TYP.  | MAX.      | UNIT          |
| <b>Static</b>                                                               |                     |                                                                                                                                                       |                                           |      |       |           |               |
| Drain-Source Breakdown Voltage                                              | $V_{DS}$            | $V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$                                                                                                              |                                           | 650  | -     | -         | V             |
| $V_{DS}$ Temperature Coefficient                                            | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}$                                                                                         |                                           | -    | 0.70  | -         | V/°C          |
| Gate-Source Threshold Voltage (N)                                           | $V_{GS(th)}$        | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$                                                                                                       |                                           | 2.5  | -     | 4.5       | V             |
| Gate-Source Leakage                                                         | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                                            |                                           | -    | -     | $\pm 100$ | nA            |
|                                                                             |                     | $V_{GS} = \pm 30\text{ V}$                                                                                                                            |                                           | -    | -     | $\pm 1$   | $\mu\text{A}$ |
| Zero Gate Voltage Drain Current                                             | $I_{DSS}$           | $V_{DS} = 650\text{ V}, V_{GS} = 0\text{ V}$                                                                                                          |                                           | -    | -     | 1         | $\mu\text{A}$ |
|                                                                             |                     | $V_{DS} = 520\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$                                                                         |                                           | -    | -     | 100       |               |
| Drain-Source On-State Resistance                                            | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$                                                                                                                                | $I_D = 6.5\text{ A}$                      | -    | 0.160 | -         | $\Omega$      |
| Forward Transconductance                                                    | $g_{fs}$            | $V_{DS} = 30\text{ V}, I_D = 6.5\text{ A}$                                                                                                            |                                           | -    | 5.6   | -         | S             |
| <b>Dynamic</b>                                                              |                     |                                                                                                                                                       |                                           |      |       |           |               |
| Input Capacitance                                                           | $C_{iss}$           | $V_{GS} = 0\text{ V},$<br>$V_{DS} = 100\text{ V},$<br>$f = 1\text{ MHz}$                                                                              |                                           | -    | 2400  | -         | pF            |
| Output Capacitance                                                          | $C_{oss}$           |                                                                                                                                                       |                                           | -    | 80    | -         |               |
| Reverse Transfer Capacitance                                                | $C_{rss}$           |                                                                                                                                                       |                                           | -    | 4     | -         |               |
| Effective Output Capacitance, Energy Related <sup>a</sup>                   | $C_{o(er)}$         | $V_{DS} = 0\text{ V to } 520\text{ V}, V_{GS} = 0\text{ V}$                                                                                           |                                           | -    | 62    | -         |               |
| Effective Output Capacitance, Time Related <sup>b</sup>                     | $C_{o(tr)}$         |                                                                                                                                                       |                                           | -    | 213   | -         |               |
| Total Gate Charge                                                           | $Q_g$               | $V_{GS} = 10\text{ V}$                                                                                                                                | $I_D = 8\text{ A}, V_{DS} = 520\text{ V}$ | -    | 6.6   | -         | nC            |
| Gate-Source Charge                                                          | $Q_{gs}$            |                                                                                                                                                       |                                           | -    | 15    | -         |               |
| Gate-Drain Charge                                                           | $Q_{gd}$            |                                                                                                                                                       |                                           | -    | 1.9   | -         |               |
| Turn-On Delay Time                                                          | $t_{d(on)}$         | $V_{DD} = 520\text{ V}, I_D = 8\text{ A},$<br>$V_{GS} = 10\text{ V}, R_g = 9.1\text{ }\Omega$                                                         |                                           | -    | 18    | 25        | ns            |
| Rise Time                                                                   | $t_r$               |                                                                                                                                                       |                                           | -    | 24    | 55        |               |
| Turn-Off Delay Time                                                         | $t_{d(off)}$        |                                                                                                                                                       |                                           | -    | 8.0   | -         |               |
| Fall Time                                                                   | $t_f$               |                                                                                                                                                       |                                           | -    | 1.2   | -         |               |
| Gate Input Resistance                                                       | $R_g$               | $f = 1\text{ MHz}, \text{ open drain}$                                                                                                                |                                           | -    | 0.8   | -         | $\Omega$      |
| <b>Drain-Source Body Diode Characteristics</b>                              |                     |                                                                                                                                                       |                                           |      |       |           |               |
| Continuous Source-Drain Diode Current                                       | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode  |                                           | -    | -     | 20        | A             |
| Pulsed Diode Forward Current                                                | $I_{SM}$            |                                                                                                                                                       |                                           | -    | -     | 60        |               |
| Diode Forward Voltage                                                       | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}, I_S = 8\text{ A}, V_{GS} = 0\text{ V}$                                                                               |                                           | -    | -     | 1.5       | V             |
| Reverse Recovery Time                                                       | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}, I_F = I_S = 8\text{ A},$<br>$dI/dt = 100\text{ A}/\mu\text{s}, V_R = 400\text{ V}$                                   |                                           | -    | 475   | -         | ns            |
| Reverse Recovery Charge                                                     | $Q_{rr}$            |                                                                                                                                                       |                                           | -    | 5.8   | -         | $\mu\text{C}$ |
| Reverse Recovery Current                                                    | $I_{RRM}$           |                                                                                                                                                       |                                           | -    | 35    | -         | A             |

**Notes**

- a.  $C_{oss(er)}$  is a fixed capacitance that gives the same energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DSS}$ .  
 b.  $C_{oss(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DSS}$ .

**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



**Fig. 1 - Typical Output Characteristics**



**Fig. 4 - Normalized On-Resistance vs. Temperature**



**Fig. 2 - Typical Output Characteristics**



**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**



**Fig. 3 - Typical Transfer Characteristics**



**Fig. 6 - C<sub>oss</sub> and E<sub>oss</sub> vs. V<sub>DS</sub>**

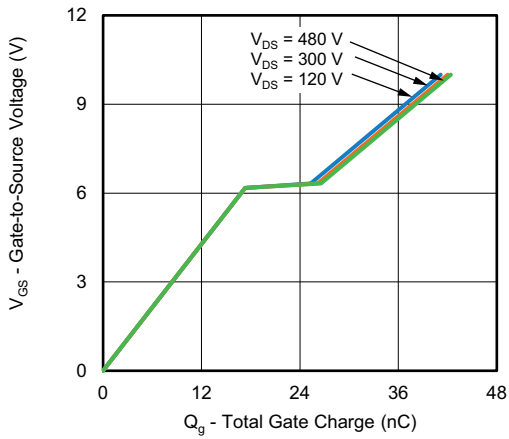


Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage



Fig. 10 - Maximum Drain Current vs. Case Temperature



Fig. 8 - Typical Source-Drain Diode Forward Voltage



Fig. 11 - Temperature vs. Drain-to-Source Voltage



Fig. 9 - Maximum Safe Operating Area

**Note**

a.  $V_{GS} >$  minimum  $V_{GS}$  at which  $R_{DS(on)}$  is specified



Fig. 12 - Normalized Transient Thermal Impedance, Junction-to-Case



Fig. 13 - Switching Time Test Circuit



Fig. 16 - Unclamped Inductive Waveforms

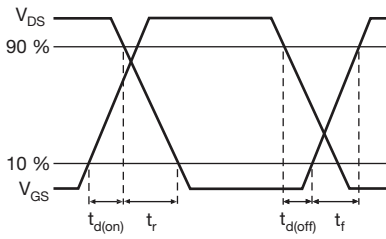


Fig. 14 - Switching Time Waveforms



Fig. 17 - Basic Gate Charge Waveform

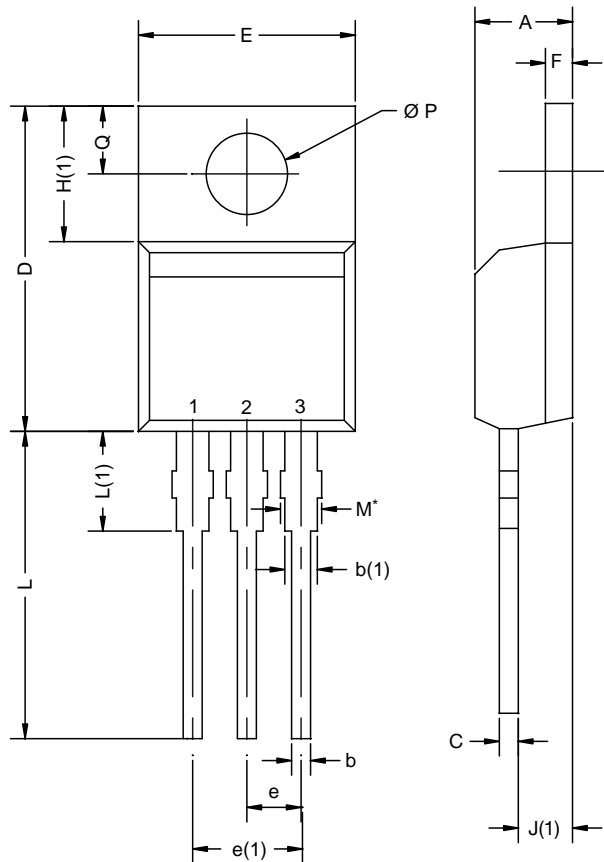


Fig. 15 - Unclamped Inductive Test Circuit



Fig. 18 - Gate Charge Test Circuit

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| DIM.            | MILLIMETERS |       | INCHES |       |
|-----------------|-------------|-------|--------|-------|
|                 | MIN.        | MAX.  | MIN.   | MAX.  |
| A               | 4.25        | 4.65  | 0.167  | 0.183 |
| b               | 0.69        | 1.01  | 0.027  | 0.040 |
| b(1)            | 1.20        | 1.73  | 0.047  | 0.068 |
| c               | 0.36        | 0.61  | 0.014  | 0.024 |
| D               | 14.85       | 15.49 | 0.585  | 0.610 |
| E               | 10.04       | 10.51 | 0.395  | 0.414 |
| e               | 2.41        | 2.67  | 0.095  | 0.105 |
| e(1)            | 4.88        | 5.28  | 0.192  | 0.208 |
| F               | 1.14        | 1.40  | 0.045  | 0.055 |
| H(1)            | 6.09        | 6.48  | 0.240  | 0.255 |
| J(1)            | 2.41        | 2.92  | 0.095  | 0.115 |
| L               | 13.35       | 14.02 | 0.526  | 0.552 |
| L(1)            | 3.32        | 3.82  | 0.131  | 0.150 |
| $\varnothing P$ | 3.54        | 3.94  | 0.139  | 0.155 |
| Q               | 2.60        | 3.00  | 0.102  | 0.118 |

ECN: X12-0208-Rev. N, 08-Oct-12  
DWG: 5471

Notes

\* M = 1.32 mm to 1.62 mm (dimension including protrusion)  
Heatsink hole for HVM

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