Vishay Siliconix



Power MOSFET

TO-220AB S N-Channel MOSFET

PRODUCT SUMMARY				
V _{DS} (V)	600			
R _{DS(on)} (Ω)	$V_{GS} = 10 V$	0.75		
Q _g max. (nC)	49			
Q _{gs} (nC)	13			
Q _{gd} (nC)	20			
Configuration	Single			

FEATURES

- · Low gate charge Qg results in simple drive requirement **RoHS**³
- Improved gate, avalanche and dynamic dV/dt ruggedness
- Fully characterized capacitance and avalanche voltage and current
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- Switch mode power supply (SMPS)
- Uninterruptible power supply
- · High speed power switching

APPLICABLE OFF LINE SMPS TOPOLOGIES

- · Active clamped forward
- · Main switch

ORDERING INFORMATION				
Package	TO-220AB			
Lead (Pb)-free	IRFB9N60APbF			
Lead (Pb)-free and halogen-free	IRFB9N60APbF-BE3			

ABSOLUTE MAXIMUM RATINGS ($T_C = 25 \degree C$, unless otherwise noted)							
PARAMETER			SYMBOL	LIMIT	UNIT		
Drain-source voltage			V _{DS}	600	N		
Gate-source voltage			V _{GS}	± 30	- V		
Continuous drain current	V	T _C = 25 °C	- I _D	9.2			
	V _{GS} at 10 V	T _C = 100 °C		5.8	А		
Pulsed drain current ^a			I _{DM}	37			
Linear derating factor				1.3	W/°C		
Single pulse avalanche energy ^b			E _{AS}	290	mJ		
Repetitive avalanche current ^a			I _{AR}	9.2	A		
Repetitive avalanche energy ^a			E _{AR}	17	mJ		
Maximum power dissipation	T _C =	25 °C	PD	170	W		
Peak diode recovery dV/dt ^c			dV/dt	5.0	V/ns		
Operating junction and storage temperature range			T _J , T _{stg}	-55 to +150	*0		
Soldering recommendations (peak temperature) ^d	For	10 s	-	300	°C		
Mounting torque	6-32 or M3 screw			10	lbf ∙ in		
				1.1	N·m		

Notes

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- b. Starting $T_J = 25 \text{ °C}$, L = 6.8 mH, $R_q = 25 \Omega$, $I_{AS} = 9.2 \text{ A}$ (see fig. 12)
- c. $I_{SD} \le 9.2$ Å, dI/dt ≤ 50 Å/µs, $V_{DD} \le V_{DS}$, $T_J \le 150$ °C
- d. 1.6 mm from case



Vishay Siliconix

$\begin{array}{ c c c c c c } \hline PARAMETER & SYMBOL & TYP. & MAX. & UNIT \\ \hline Maximum junction-to-cambient & R_{h,A} & - & 62 \\ \hline Case-to-sink, fiat, greased surface & R_{h,CS} & 0.50 & - & \\ \hline Case-to-sink, fiat, greased surface & R_{h,CS} & 0.50 & - & \\ \hline Maximum junction-to-case (drain) & R_{h,C} & - & 0.75 \\ \hline \end{array} \\ \hline \hline \\ \hline SPECIFICATIONS (T_J = 25 °C, unless otherwise noted) \\ \hline \hline PARAMETER & SYMBOL & TEST CONDITIONS & MIN. & TYP. & MAX. \\ \hline \\ \hline \\ Static & & & & & & & & & & & & & & & & & & &$	THERMAL RESISTANCE RAT	INGS								
$ \begin{array}{ c c c c c } \hline Case-to-sink, flat, greased surface $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$$	PARAMETER	SYMBOL	ТҮР	P. MAX.			UNIT			
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	Maximum junction-to-ambient	R _{thJA}								
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	Case-to-sink, flat, greased surface						°C/W			
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	Maximum junction-to-case (drain)		- 0.75							
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$										
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	SPECIFICATIONS (T _{.1} = 25 °C, 0	unless otherw	/ise noted)							
$\begin{array}{c c c c c c c c c c c c c c c c c c c $					ONS	MIN.	TYP.	MAX.	UNIT	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Static	4	4			Į	Į	Į	Į	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Drain-source breakdown voltage	V _{DS}	V _{GS}	= 0 V, I _D = 25	50 µA	600	-	-	V	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	V _{DS} temperature coefficient					-	660	-	mV/°C	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $						2.0	-	4.0	V	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Gate-source leakage					-	-	± 100	nA	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Zeve este veltere ducie comont		V _{DS} =	$V_{DS} = 600 \text{ V}, \text{ V}_{GS} = 0 \text{ V}$		-	-	25		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Zero gate voltage drain current	IDSS	V _{DS} = 480 V			-	-	250	μA	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Drain-source on-state resistance	R _{DS(on)}	$V_{GS} = 10 V$	I _D =	= 5.5 A ^b	-	-	0.75	Ω	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Forward transconductance		$V_{DS} = 50 \text{ V}, \text{ I}_{D} = 5.5 \text{ A}$		5.5	-	-	S		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Dynamic	- <u>-</u>	*				•		-	
$ \begin{array}{ c c c c c } \hline \text{Output capacitance} & C_{OSS} & V_{DS} = 25 V, & - & 180 & - & - & - & - & - & - & - & - & - & $	Input capacitance	C _{iss}		$V_{DS} = 25 V,$		-	1400	-	pF	
$\begin{array}{c c c c c c c c c } \hline \mbox{Horese transfer capacitance} & C_{rss} & V_{GS} & V_{GS} = 1.0 \ V, \ f = 1.0 \ MHz & - & 1957 & - \\ \hline \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	Output capacitance	C _{oss}				-	180	-		
$ \begin{array}{ c c c c c } \hline Output capacitance & C_{oss} & G_{oss} & G_{os$	Reverse transfer capacitance	C _{rss}	f = 1			-	7.1	-		
Effective output capacitance C_{oss} eff. $V_{GS} = 0$ V $V_{DS} = 480$ V, f = 1.0 MHz-49-Effective output capacitance C_{oss} eff. $V_{DS} = 0$ V to 480 V-96-Total gate charge Q_g $V_{GS} = 10$ V $I_D = 9.2$ A, $V_{DS} = 400$ V see fig. 6 and 13 b49Gate-drain charge Q_{gd} $V_{GS} = 10$ V $I_D = 9.2$ A, $V_{DS} = 400$ V see fig. 6 and 13 b13Turn-on delay time $t_{d(on)}$ $V_{DD} = 300$ V, $I_D = 9.2$ A, $V_{DD} = 300$ V, $I_D = 9.2$ A, $R_g = 9.1 \Omega$, $R_D = 35.5 \Omega$, see fig. 10 b-13-Fall time $t_{d(off)}$ $F = 1$ MHz, open drain0.5-3.2-Gate input resistance R_g $f = 1$ MHz, open drain0.5-3.2-Drain-Source Body Diode CharacteristicsMOSFET symbol showing the integral reverse $P - n$ junction diode9.2-Pulsed diode forward current a I_{SM} I_{SM} MOSFET symbol showing the integral reverse $P - n$ junction diode9.2		C		V _{DS} = 1.0 V, f = 1.0 MHz		-	1957	-		
$ \begin{array}{c c c c c c c } \hline Total gate charge & Q_g & \\ \hline Gate-source charge & Q_{gs} & \\ \hline Gate-drain charge & Q_{gd} & \\ \hline & & \\ \hline Gate-drain charge & Q_{gd} & \\ \hline & & \\ \hline & & \\ \hline \hline \hline \hline \\ \hline \hline \hline \\ \hline \hline \hline \hline \hline \\ \hline \hline \hline \hline \hline \\ \hline$	Output capacitance	U _{OSS}	$V_{GS} = 0 V$	$V_{DS} = 480$	V, f = 1.0 MHz	-	49	-		
Gate-source charge Q_{gs} $V_{GS} = 10 \text{ V}$ $I_D = 9.2 \text{ A}, V_{DS} = 400 \text{ V}$ see fig. 6 and 13 b13Gate-drain charge Q_{gd} Q_{gd} 1320Turn-on delay time $t_{d(on)}$ t_r $V_{DS} = 300 \text{ V}, I_D = 9.2 \text{ A}$ $R_g = 9.1 \Omega, R_D = 35.5 \Omega, see fig. 10 b$ -13-Fall time t_f $V_{DD} = 300 \text{ V}, I_D = 9.2 \text{ A}$ $R_g = 9.1 \Omega, R_D = 35.5 \Omega, see fig. 10 b$ -22-Gate input resistance R_g $f = 1 \text{ MHz}$, open drain0.5-3.2Drain-Source Body Diode CharacteristicsContinuous source-drain diode current I_S MOSFET symbol showing the integral reverse $p - n$ junction diode9.2Pulsed diode forward current a I_{SM} I_{SM} MOSFET symbol showing the integral reverse $p - n$ junction diode9.2	Effective output capacitance	C _{oss} eff.		$V_{DS} = 0$	0 V to 480 V	-	96	-		
Gate-source charge Q_{gg} $V_{GS} = 10$ Vsee fig. 6 and 13 b $ 13$ Gate-drain charge Q_{gd} $ 13$ $ 20$ Turn-on delay time $t_{d(on)}$ $V_{DD} = 300$ V, $I_D = 9.2$ A $ 13$ $-$ Rise time t_r $V_{DD} = 300$ V, $I_D = 9.2$ A $ 25$ $-$ Turn-off delay time $t_{d(off)}$ $R_g = 9.1 \Omega$, $R_D = 35.5 \Omega$, see fig. 10 b $ 22$ $-$ Gate input resistance R_g $f = 1$ MHz, open drain 0.5 $ 3.2$ Drain-Source Body Diode CharacteristicsMOSFET symbol showing the integral reverse $p - n$ junction diode $ 9.2$ Pulsed diode forward current a I_{SM} I_{SM} $MOSFET$ symbol showing the integral reverse $p - n$ junction diode $ 9.2$	Total gate charge	Qg		I _D = 9.2 A, V _{DS} = 400 V see fig. 6 and 13 ^b	-	-	49	nC		
$ \begin{array}{c c c c c c c c c } \hline Gate-drain charge & Q_{gd} & & & & & & & & & & & & & & & & & & &$	Gate-source charge	Q _{gs}	V _{GS} = 10 V		-	-	13			
Rise time t_r $V_{DD} = 300 \text{ V}, I_D = 9.2 \text{ A}$ $ 25$ $-$ Turn-off delay time $t_{d(off)}$ $R_g = 9.1 \Omega, R_D = 35.5 \Omega$, see fig. 10 b $ 22$ $-$ Fall time t_f $ 22$ $ 22$ $-$ Gate input resistance R_g $f = 1 \text{ MHz}$, open drain 0.5 $ 3.2$ Drain-Source Body Diode CharacteristicsContinuous source-drain diode current I_S MOSFET symbol showing the integral reverse $p - n$ junction diode $ 9.2$ Pulsed diode forward current a I_{SM} I_{SM} $P_{integral reverse}$ 	Gate-drain charge	Q _{gd}				-	-	20	1	
Rise time t_r $V_{DD} = 300 \text{ V}, I_D = 9.2 \text{ A}$ -25-Turn-off delay time $t_{d(off)}$ $R_g = 9.1 \Omega, R_D = 35.5 \Omega$, see fig. 10 b-20-Fall time t_f -22-Gate input resistance R_g $f = 1 \text{ MHz}$, open drain0.5-3.2Drain-Source Body Diode CharacteristicsContinuous source-drain diode current I_S MOSFET symbol showing the integral reverse $p - n$ junction diode-9.2Pulsed diode forward current a I_{SM} I_{SM} I_{SM} 37	Turn-on delay time	t _{d(on)}				-	13	-		
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	Rise time	t _r	V _{DD} =	$V_{DD} = 300 V_{c} I_{D} = 9.2 A$		-	25	-	1 _	
Fall time t_f -22-Gate input resistance R_g $f = 1 \text{ MHz}$, open drain 0.5 $ 3.2$ Drain-Source Body Diode CharacteristicsContinuous source-drain diode current I_S $MOSFET$ symbol showing the integral reverse $p - n$ junction diode $ 9.2$ Pulsed diode forward current a I_{SM} I_{SM} P_n junction diode $ 37$	Turn-off delay time	t _{d(off)}	${\sf R}_g$ = 9.1 $\Omega,{\sf R}_D$ = 35.5 $\Omega,$ see fig. 10 $^{\rm b}$		-	30	-	ns		
Drain-Source Body Diode Characteristics Continuous source-drain diode current Is MOSFET symbol showing the integral reverse p - n junction diode - - 9.2 Pulsed diode forward current ^a I _{SM} Is MOSFET symbol showing the integral reverse p - n junction diode - - 9.2	Fall time					-	22	-	1	
Continuous source-drain diode current Is MOSFET symbol showing the integral reverse p - n junction diode - - 9.2	Gate input resistance	R _g	f = 1 MHz, open drain			0.5	-	3.2	Ω	
Continuous source-drain diode current Is showing the integral reverse p - n junction diode - - 9.2 Pulsed diode forward current a Ism p - n junction diode - - 37	Drain-Source Body Diode Characterist	cs								
Pulsed diode forward current ^a I _{SM} p - n junction diode 37	Continuous source-drain diode current	١ _S	showing the integral reverse		-	-	9.2	A		
Body diode voltage V_{SD} $T_J = 25 ^{\circ}C$, $I_S = 9.2 A$, $V_{GS} = 0 V^{b}$ - 1.5	Pulsed diode forward current ^a	I _{SM}			-	-	37			
	Body diode voltage	V _{SD}	T_{J} = 25 °C, I_{S} = 9.2 A, V_{GS} = 0 V $^{\rm b}$		-	-	1.5	V		
Body diode reverse recovery time t_{rr} $T_J = 25 °C$, $I_F = 9.2 A$, $dI/dt = 100 A/\mu s^{b}$ - 530 800	Body diode reverse recovery time	t _{rr}			-	530	800	ns		
Body diode reverse recovery charge Q_{rr} $I_J = 25$ C, $I_F = 9.2$ A, $di/dt = 100$ A/µs -3.0 4.4	Body diode reverse recovery charge	Q _{rr}	$I_{\rm J} = 25$ C, $I_{\rm F} = 9.2$ A, $dI/dI = 100$ A/ μ S			-	3.0	4.4	μC	
Forward turn-on time ton Intrinsic turn-on time is negligible (turn-on is dominated by L _S and L	Forward turn-on time	t _{on}	Intrinsic turn-on time is negligible (turn			-on is dor	dominated by L_S and L_D)			

Notes

a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)

b. Pulse width \leq 300 µs; duty cycle \leq 2 %

c. C_{oss} effective is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 % to 80 % V_{DS}

2



Vishay Siliconix

TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)

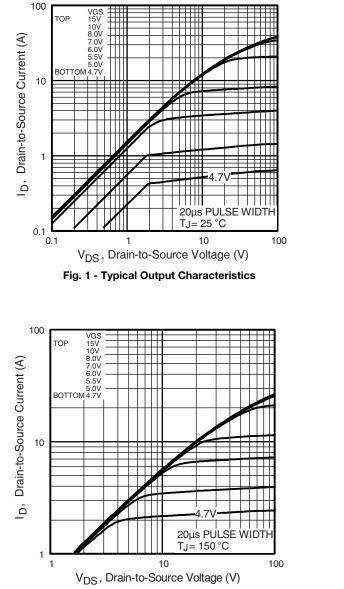


Fig. 2 - Typical Output Characteristics

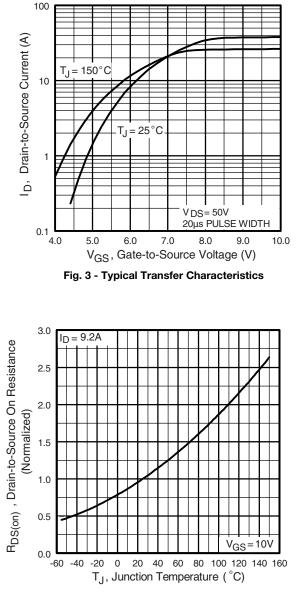


Fig. 4 - Normalized On-Resistance vs. Temperature



Vishay Siliconix

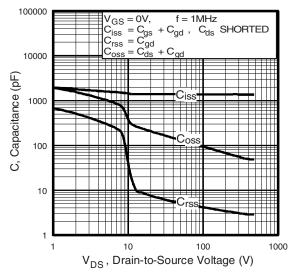


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

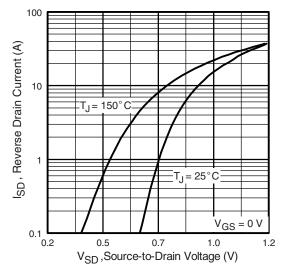


Fig. 7 - Typical Source-Drain Diode Forward Voltage

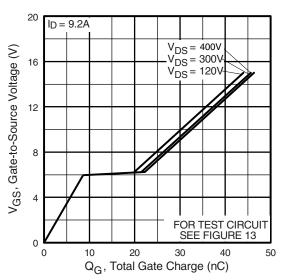


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

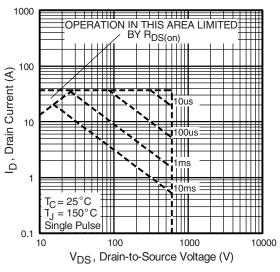


Fig. 8 - Maximum Safe Operating Area

4



Vishay Siliconix

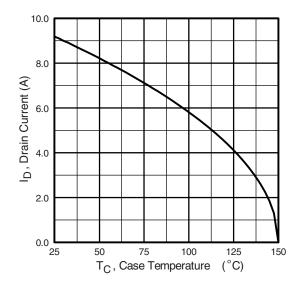


Fig. 9 - Maximum Drain Current vs. Case Temperature

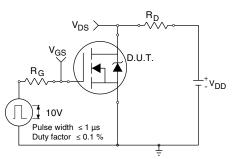


Fig. 10a - Switching Time Test Circuit

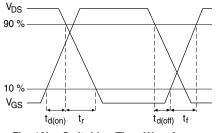


Fig. 10b - Switching Time Waveforms

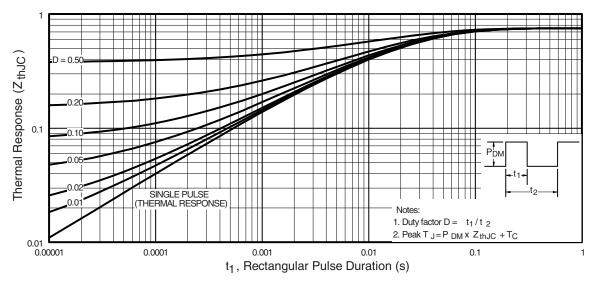


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

5



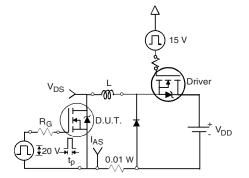


Fig. 12a - Unclamped Inductive Test Circuit

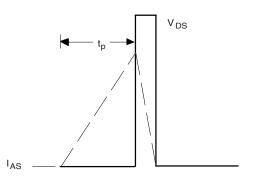


Fig. 12b - Unclamped Inductive Waveforms

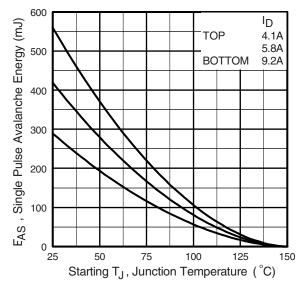
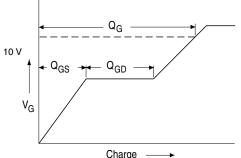


Fig. 12c - Maximum Avalanche Energy vs. Drain Current





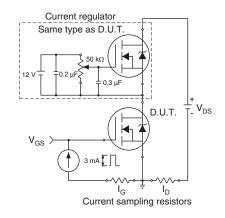


Fig. 13b - Gate Charge Test Circuit

S21-0867-Rev. E, 16-Aug-2021

6

Document Number: 91103

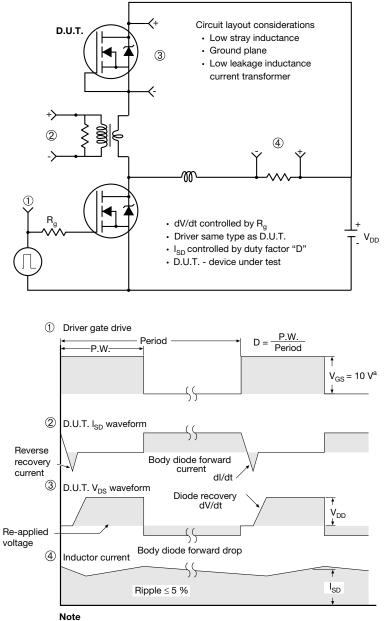
IRFB9N60A

Vishay Siliconix



Vishay Siliconix

Peak Diode Recovery dV/dt Test Circuit



a. $V_{GS} = 5 V$ for logic level devices

Fig. 14 - For N-Channel

Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see www.vishay.com/ppg?91103.

For technical questions, contact: <u>hvm@vishay.com</u> THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE. THE PRODUCTS DESCRIBED HEREIN AND THIS DOCUMENT ARE SUBJECT TO SPECIFIC DISCLAIMERS, SET FORTH AT <u>www.vishay.com/doc?91000</u>



Vishay

Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Hyperlinks included in this datasheet may direct users to third-party websites. These links are provided as a convenience and for informational purposes only. Inclusion of these hyperlinks does not constitute an endorsement or an approval by Vishay of any of the products, services or opinions of the corporation, organization or individual associated with the third-party website. Vishay disclaims any and all liability and bears no responsibility for the accuracy, legality or content of the third-party website or for that of subsequent links.

Vishay products are not designed for use in life-saving or life-sustaining applications or any application in which the failure of the Vishay product could result in personal injury or death unless specifically qualified in writing by Vishay. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.

© 2025 VISHAY INTERTECHNOLOGY, INC. ALL RIGHTS RESERVED

Revision: 01-Jan-2025

1