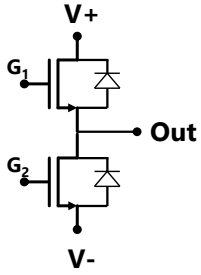
High-Temperature Silicon Carbide (SiC) Half-Bridge Power Module

N-Channel DMOS Version

1200 V / 285 A / 13.5 mΩ

FEATURES

- **High temperature: $T_{c(max)}$ = 225 °C**
  $T_{j(max)}$ = 225 °C
- **AS9100:Rev. C-certified manufacturing, traceable throughout value chain**
- **Ultra-fast switching (<30 ns), low inductance**
- **High system efficiency**
- **Flux-free, void-free packaging**
- **Low profile, small form factor, extremely lightweight**
- **High reliability**



APPLICATIONS

- **High-efficiency converters / inverters**
- **Motor drives**
- **Aerospace: Military & Commercial**
- **Smart grid/grid-tie distributed generation**

DESCRIPTION

The APE HT-2101-A Silicon Carbide (SiC) half-bridge power module was designed specifically to address the growing demand for higher power densities, higher temperatures, and higher switching frequencies.

COMPANION PARTS

Maximum performance may be obtained through use of the companion high-temperature gate driver, part number APE MTGD2-2011, designed especially for driving the Silicon Carbide module.

Power Module Absolute Maximum Ratings (T_c = 25 °C unless otherwise specified)

Symbol	Parameter	Condition(s)	Value	Units
V_{DSS}	Drain-source voltage		1200	V
V_{GSS}	Gate-source voltage		-5 to 20	V
I_D	Continuous drain current	T_c = 25 °C	285	A
		T_c = 100 °C	TBD	
		T_c = 225 °C	TBD	
I_{DM}	Peak pulsed drain current	Pulse width ≤ 10 µs, duty cycle ≤ 2%	TBD	A
P_D	Maximum power dissipated		1600	W
$T_{c(max)}$	Maximum case temperature[1]		225	°C
$T_{j(min)}$	Minimum operating junction temperature		- 50	°C
$T_{j(max)}$	Maximum operating junction temperature		225	
T_{stg}	Storage temperature		- 50 to 225	°C
V_{isol}	Insulation test voltage	AC, 1 min.	TBD	V
		AC, 1 s.	TBD	

[1]The packaging materials have been qualified at this temperature.

Power Module Switch Position Electrical Characteristics (T_c = 25 °C unless otherwise specified)						
Symbols	**Parameter**	**Condition(s)**	**Values**			**Units**
			Min.	**Typical**	**Max.**	
$V_{(BR)DSS}$	Drain-source breakdown voltage	V_{GS} = 0 V, I_D = 1 mA	1200	-	-	V
$V_{GS(th)}$	Gate-source threshold voltage	V_{DS} = V_{GS}, I_D = 1 mA	2.0	2.1	4.0	V
		V_{DS} = V_{GS}, I_D = 1 mA, T_j = 205 °C	1.0	1.1	3.0	
I_{DSS}	Drain-source leakage current	V_{GS} = - 2 V, V_{DS} = 1200 V	-	-	200	µA
		V_{GS} = 2 V, V_{DS} = 1200 V, T_j = 205 °C	-	-	2000	
I_{GSS}	Gate-source leakage current	V_{GS} = 20 V, V_{DS} = 0 V	-	-	250	nA
$R_{DS(on)}$	Drain-source turn-on resistance	V_{GS} = 20 V, I_D = 75 A	-	13.5	14.5	mΩ
		V_{GS} = 20 V, I_D = 75 A, T_j = 205 °C	-	19.5	22.5	
C_{iss}	Input capacitance	V_{GS} = 0 V V_{DS} = 800 V f = 1 MHz	-	5750	-	pF
C_{oss}	Output capacitance		-	600	-	
C_{rss}	Reverse transfer capacitance		-	40	-	
$t_{d(on)}$	Turn-on delay time	V_{DD} = 600 V, V_{GS} = - 4 to 20 V I_D = 60 A $R_{G(ext)}$ = 0 Ω, R_L = 60 Ω	-	36	-	ns
t_{rv}	Rise time		-	14	-	
$t_{d(off)}$	Turn-off delay time		-	68	-	
t_{fv}	Fall time		-	34	-	

Power Module Switch Position Gate Charge Electrical Characteristics (T_c = 25 °C unless otherwise specified)						
Symbols	**Parameter**	**Condition(s)**	**Values**			**Units**
			Min.	**Typical**	**Max.**	
Q_{gs}	Gate to source charge	V_{DD} = 800 V, V_{GS} = - 4 to 20 V I_D = 75 A $R_{G(ext)}$ = xx Ω, R_L = xx Ω	72	-	-	nC
Q_{gd}	Gate to drain charge		130	-	-	
Q_g	Gate charge total		280	-	-	

Power Module Diode Position Electrical Characteristics (T_c = 25 °C unless otherwise specified)						
Symbols	**Parameter**	**Condition(s)**	**Values**			**Units**
			Min.	**Typical**	**Max.**	
V_{FM}	Forward voltage	I_F = 60 A	-	TBD	TBD	V
		I_F = 60 A, T_j = 200 °C	-	TBD	TBD	
I_R	Reverse current	V_R = 1200 V	-	-	-	µA
		V_R = 1200 V, T_j = 200 °C	-	-	-	
Q_C	Capacitive charge	V_R = 1200 V, I_F = 120 A, di/dt = 7500 A/µs	-	TBD	-	nC

Power Module Thermal Characteristics[2] (T_j = 25 °C unless otherwise specified)						
Symbols	Parameter	Condition(s)	Values			Units
			Min.	Typical	Max.	
$R_{\theta(j-c)}$	FET thermal resistance junction-case			0.125		°C/W

Power Module Mechanical Characteristics (T_j = 25 °C unless otherwise specified)						
Symbols	Parameter	Condition(s)	Values			Units
			Min.	Typical	Max.	
w	Weight			140		g
M_s	Lead frame mounting torque	6-32 steel screw for lead frame, 10-32 steel screw for baseplate		40		in·lb

SiC MOSFET Electrical Characteristics[3] (T_c = 25 °C unless otherwise specified)						
Symbols	Parameter	Condition(s)	Values			Units
			Min.	Typical	Max.	
$V_{(BR)DSS}$	Drain-source breakdown voltage	V_{GS} = 0 V, I_D = 1 mA	1200	-	-	V
$V_{GS(th)}$	Gate-source threshold voltage	V_{DS} = V_{GS}, I_D = 4.4 mA	1.7	-	3.7	V
I_{DSS}	Zero gate voltage drain current	V_{DS} = 1200 V, V_{GS} = 0 V	-	-	10	µA
I_{GSS}	Gate-source leakage current	V_{GS} = 22 V, V_{DS} = 0 V	-	-	100	nA
		V_{GS} = -6 V, V_{DS} = 0 V	-	-	-100	
$R_{DS(on)}$	Drain-source turn-on resistance	V_{GS} = 18 V, I_D = 10 A	-	90	120	mΩ
		V_{GS} = 18 V, I_D = 10 A, T_c = 150 °C	-	130	170	
g_{fs}	Transconductance	V_{DS} = 10 V, I_D = 10 A	-	4	-	S
C_{iss}	Input capacitance	V_{GS} = 0 V V_{DS} = 25 V f = 1 MHz	-	2200	-	pF
C_{oss}	Output capacitance		-	381	-	pF
C_{rss}	Reverse transfer capacitance		-	46	-	pF
$t_{d(on)}$	Turn-on delay time	V_{DD} = 300 V, V_{GS} = 18 V I_D = 10 A $R_{G(ext)}$ = 0 Ω, R_L = 30 Ω	-	29	-	ns
t_{rv}	Rise time		-	31	-	ns
$t_{d(off)}$	Turn-off delay time		-	75	-	ns
t_{fv}	Fall time		-	19	-	ns
E_{on}	Turn-On switching loss		-	-	-	µJ
			-	-	-	
E_{off}	Turn-Off switching loss		-	-	-	µJ
			-	-	-	
R_G	Internal gate resistance		-	-	-	Ω

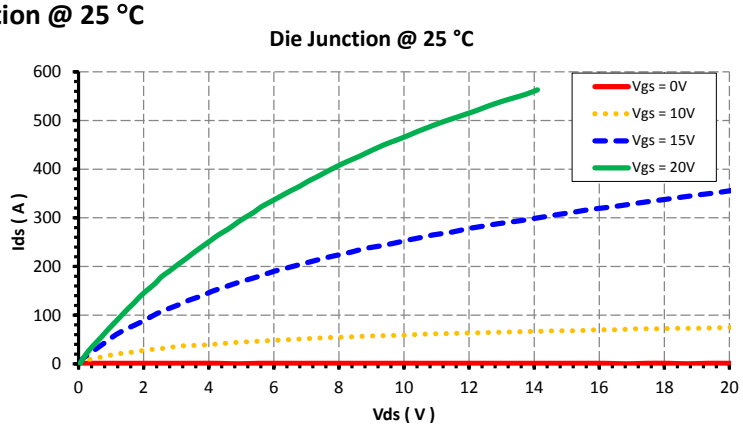
[2] FET thermal resistance junction-case is calculated measured with a 105 °C coldplate and full power distributed through the FETs. The thermal properties typically improve at lower temperatures.
[3] Obtained from Rohm Co., Ltd., S2101 Rev. 1 datasheet

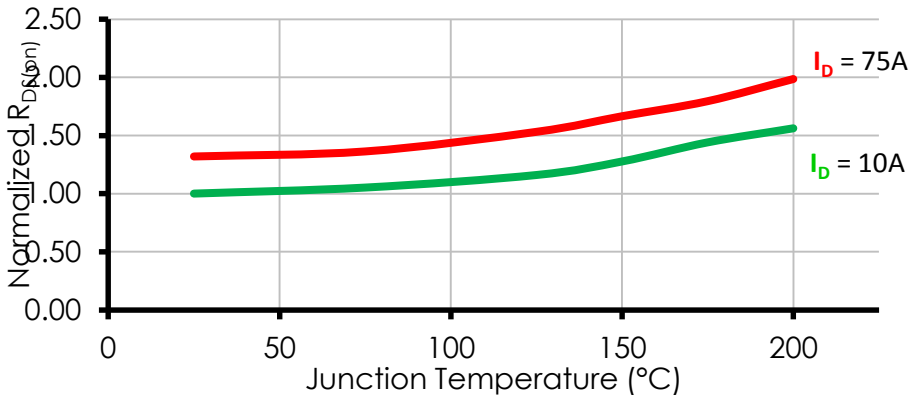
SiC MOSFET Inverse Body Diode Electrical Characteristics[4] (T_c = 25 °C unless otherwise specified)						
Symbols	**Parameter**	**Condition(s)**	**Values**			**Units**
			Min.	**Typical**	**Max.**	
V_{SD}	Diode forward voltage	V_{GS} = -3 V, I_F = 10 A	-	4.5	-	V
t_{rr}	Reverse recovery time	V_{GS} = 0 V, I_F = 10 A	-	TBD	-	ns
Q_{rr}	Reverse recovery charge	V_R = 800 V	-	120	-	nC
I_{rrm}	Peak reverse recovery current	di_F/dt = 400 A/µs	-	TBD	-	A

SiC MOSFET Gate Charge Electrical Characteristics[4] (T_c = 25 °C unless otherwise specified)						
Symbols	**Parameter**	**Condition(s)**	**Values**			**Units**
			Min.	**Typical**	**Max.**	
Q_{gs}	Gate to source charge	V_{DD} = 600 V, V_{GS} = 18 V	-	30	-	nC
Q_{gd}	Gate to drain charge	I_D = 10 A	-	30	-	
Q_g	Gate charge total	$R_{G(ext)}$ = 10 Ω, R_L = 60 Ω	-	98	-	

TYPICAL PERFORMANCE CURVES

Die Junction @ 25 °C

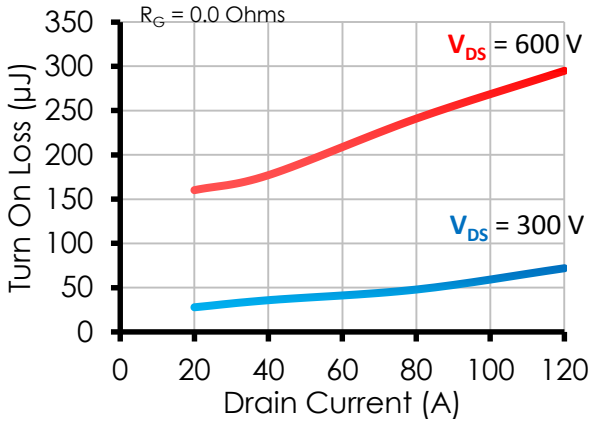


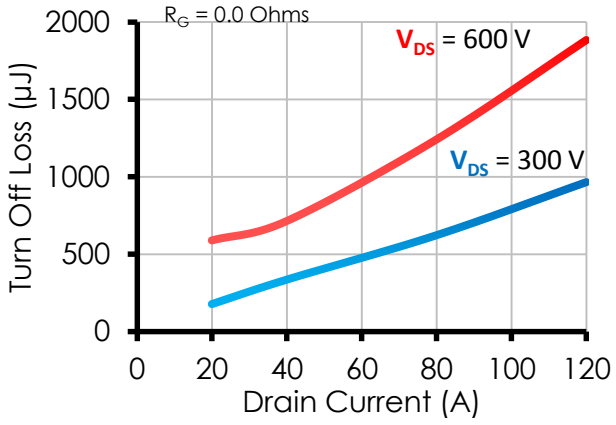


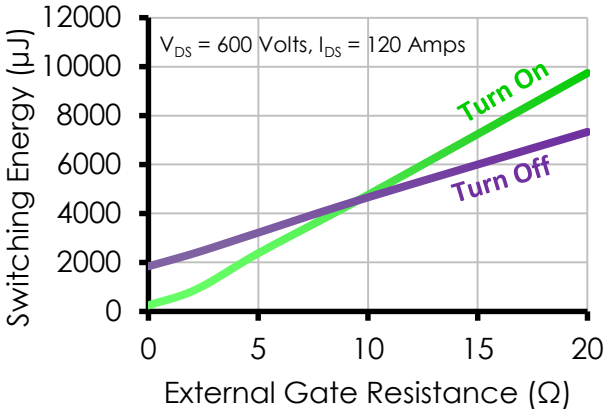
Typical Normalized On Resistance

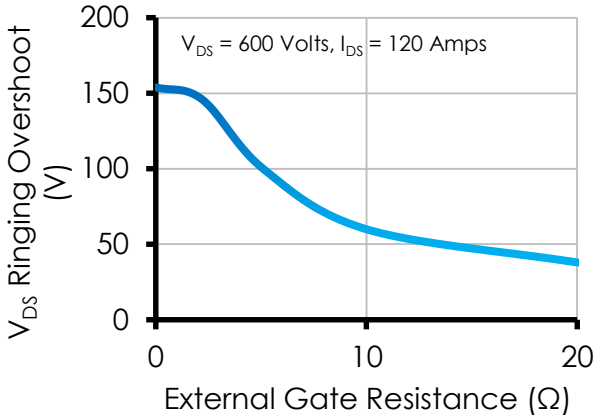
Normalized to an on resistance value of 23.1 mΩ (I_D = 10 A, T_j =25 °C)

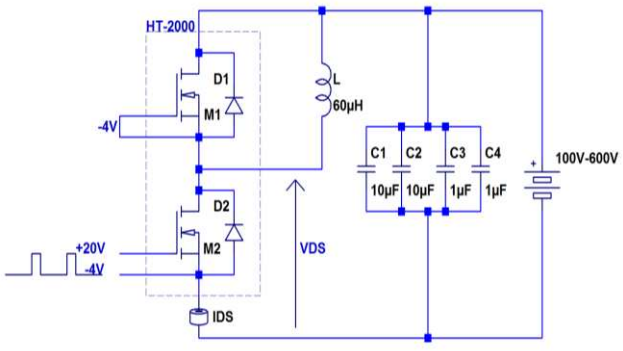
Typical Switching Losses

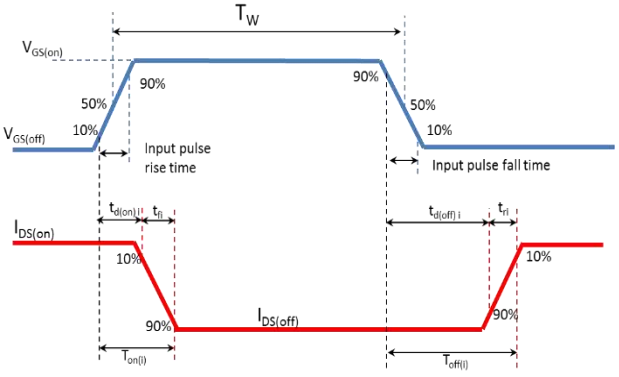






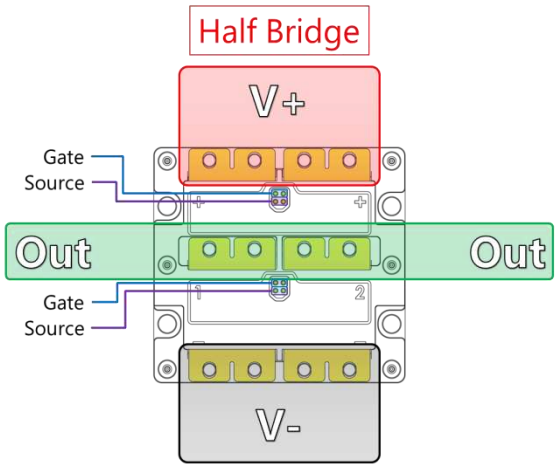


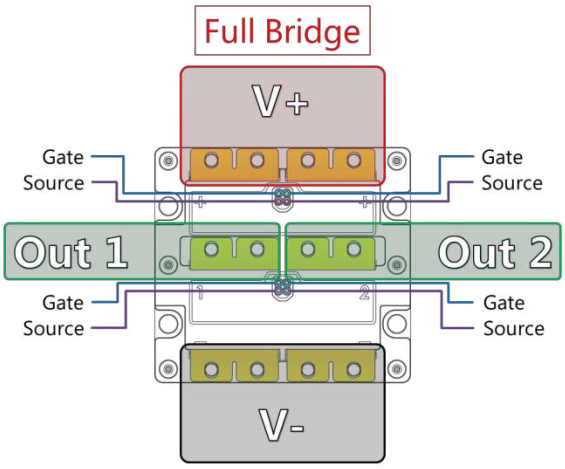


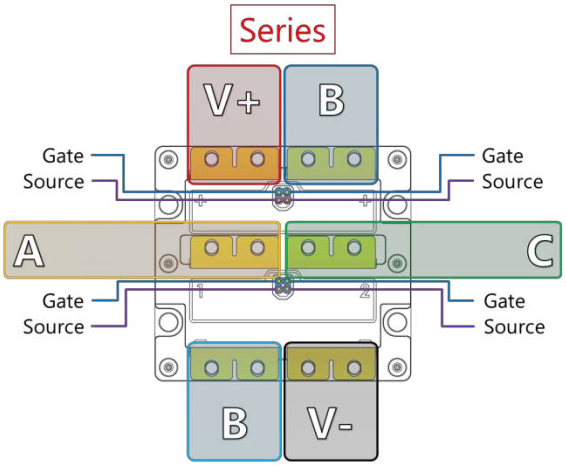


Energy values obtained using companion gate driver (T_{amb} = 25 °C).

HALF- AND FULL-BRIDGE CONNECTIONS







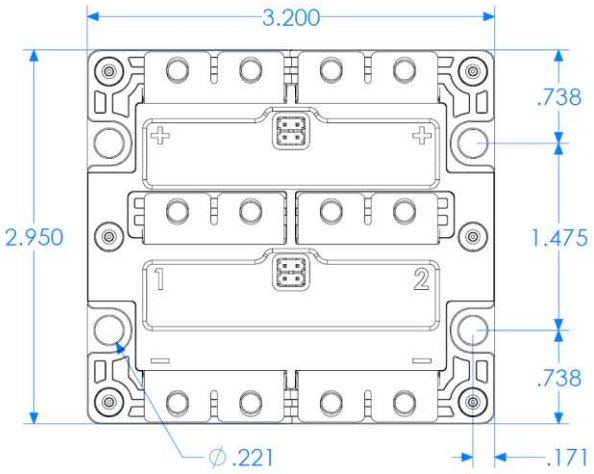
MOUNTING DIMENSIONS

All dimensions are listed in inches

#10-32 bolts are recommended for mounting

A torque of 40 in·lb is recommended

CAD models are available at www.apei.net



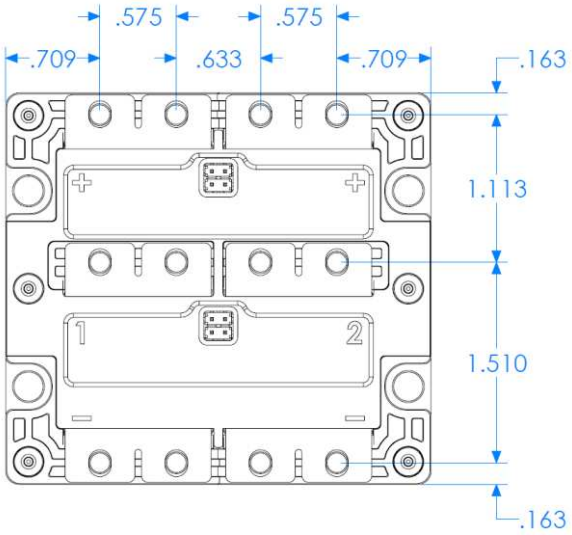
POWER CONTACT DIMENSIONS

All dimensions are listed in inches

#6-32 bolts required for the power contacts

A torque of 40 in·lb is recommended

CAD models available at www.apei.net



GATE DRIVE CONNECTIONS

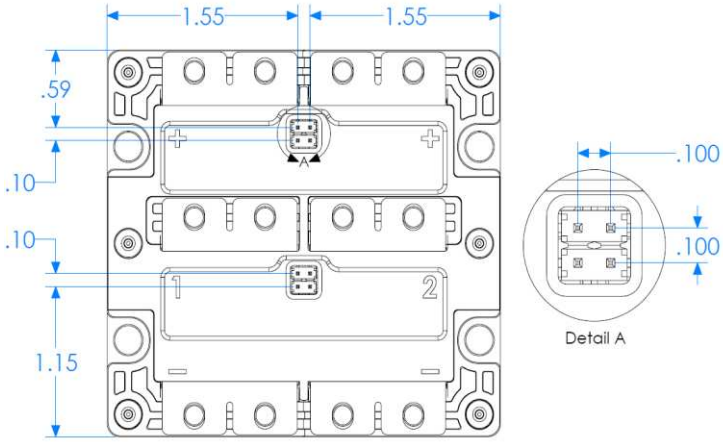
All dimensions are listed in inches

Receptacles accept pins 0.015” to 0.025” in diameter*

CAD models available at www.apei.net

Pin receptacle provided by Mill Max Mfg. Corp.
Part No. 0132-0-15-15-30-27-04

Refer to their website for a selection of mating pins



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