

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

N-Channel DMOS Version

FEATURES

- High temperature: $T_{c(max)} = 225\text{ }^{\circ}\text{C}$
 $T_{j(max)} = 225\text{ }^{\circ}\text{C}$
- 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

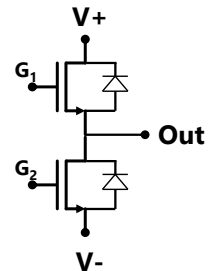
DESCRIPTION

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.

1200 V / 285 A / 13.5 mΩ



Power Module Absolute Maximum Ratings ($T_c = 25\text{ }^{\circ}\text{C}$ 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	$T_c = 25\text{ }^{\circ}\text{C}$	285	A
		$T_c = 100\text{ }^{\circ}\text{C}$	TBD	
		$T_c = 225\text{ }^{\circ}\text{C}$	TBD	
I_{DM}	Peak pulsed drain current	Pulse width $\leq 10\text{ }\mu\text{s}$, duty cycle $\leq 2\%$	TBD	A
P_D	Maximum power dissipated		1600	W
$T_{c(max)}$	Maximum case temperature ¹		225	$^{\circ}\text{C}$
$T_{j(min)}$	Minimum operating junction temperature		- 50	$^{\circ}\text{C}$
$T_{j(max)}$	Maximum operating junction temperature		225	
T_{stg}	Storage temperature		- 50 to 225	$^{\circ}\text{C}$
V_{isol}	Insulation test voltage	AC, 1 min.	TBD	V
		AC, 1 s.	TBD	

¹The packaging materials have been qualified at this temperature.

Power Module Switch Position Electrical Characteristics ($T_c = 25\text{ }^\circ\text{C}$ unless otherwise specified)						
Symbols	Parameter	Condition(s)	Values			Units
			Min.	Typical	Max.	
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$	1200	-	-	V
$V_{GS(th)}$	Gate-source threshold voltage	$V_{DS} = V_{GS}, I_D = 1\text{ mA}$	2.0	2.1	4.0	V
		$V_{DS} = V_{GS}, I_D = 1\text{ mA}, T_j = 205\text{ }^\circ\text{C}$	1.0	1.1	3.0	
I_{DSS}	Drain-source leakage current	$V_{GS} = -2\text{ V}, V_{DS} = 1200\text{ V}$	-	-	200	μA
		$V_{GS} = 2\text{ V}, V_{DS} = 1200\text{ V}, T_j = 205\text{ }^\circ\text{C}$	-	-	2000	
I_{GSS}	Gate-source leakage current	$V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$	-	-	250	nA
$R_{DS(on)}$	Drain-source turn-on resistance	$V_{GS} = 20\text{ V}, I_D = 75\text{ A}$	-	13.5	14.5	m Ω
		$V_{GS} = 20\text{ V}, I_D = 75\text{ A}, T_j = 205\text{ }^\circ\text{C}$	-	19.5	22.5	
C_{iss}	Input capacitance	$V_{GS} = 0\text{ V}$	-	5750	-	pF
C_{oss}	Output capacitance	$V_{DS} = 800\text{ V}$	-	600	-	
C_{rss}	Reverse transfer capacitance	$f = 1\text{ MHz}$	-	40	-	
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 600\text{ V}, V_{GS} = -4\text{ to }20\text{ V}$ $I_D = 60\text{ A}$ $R_{G(ext)} = 0\text{ }\Omega, R_L = 60\text{ }\Omega$	-	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 ($T_c = 25\text{ }^\circ\text{C}$ unless otherwise specified)						
Symbols	Parameter	Condition(s)	Values			Units
			Min.	Typical	Max.	
Q_{gs}	Gate to source charge	$V_{DD} = 800\text{ V}, V_{GS} = -4\text{ to }20\text{ V}$ $I_D = 75\text{ A}$ $R_{G(ext)} = xx\text{ }\Omega, R_L = xx\text{ }\Omega$	72	-	-	nC
Q_{gd}	Gate to drain charge		130	-	-	
Q_g	Gate charge total		280	-	-	

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

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

Power Module Mechanical Characteristics ($T_j = 25\text{ }^\circ\text{C}$ 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 ($T_c = 25\text{ }^\circ\text{C}$ unless otherwise specified)						
Symbols	Parameter	Condition(s)	Values			Units
			Min.	Typical	Max.	
$V_{(BR)DSS}$	Drain-source breakdown voltage	$V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$	1200	-	-	V
$V_{GS(th)}$	Gate-source threshold voltage	$V_{DS} = V_{GS}, I_D = 4.4\text{ mA}$	1.7	-	3.7	V
I_{DSS}	Zero gate voltage drain current	$V_{DS} = 1200\text{ V}, V_{GS} = 0\text{ V}$	-	-	10	μA
I_{GSS}	Gate-source leakage current	$V_{GS} = 22\text{ V}, V_{DS} = 0\text{ V}$	-	-	100	nA
		$V_{GS} = -6\text{ V}, V_{DS} = 0\text{ V}$	-	-	-100	
$R_{DS(on)}$	Drain-source turn-on resistance	$V_{GS} = 18\text{ V}, I_D = 10\text{ A}$	-	90	120	m Ω
		$V_{GS} = 18\text{ V}, I_D = 10\text{ A}, T_c = 150\text{ }^\circ\text{C}$	-	130	170	
g_{fs}	Transconductance	$V_{DS} = 10\text{ V}, I_D = 10\text{ A}$	-	4	-	S
C_{iss}	Input capacitance	$V_{GS} = 0\text{ V}$	-	2200	-	pF
C_{oss}	Output capacitance	$V_{DS} = 25\text{ V}$	-	381	-	pF
C_{rss}	Reverse transfer capacitance	$f = 1\text{ MHz}$	-	46	-	pF
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 300\text{ V}, V_{GS} = 18\text{ V}$ $I_D = 10\text{ A}$ $R_{G(ext)} = 0\text{ }\Omega, R_L = 30\text{ }\Omega$	-	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 $^\circ\text{C}$ 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 Characteristics⁴ ($T_c = 25\text{ }^\circ\text{C}$ unless otherwise specified)

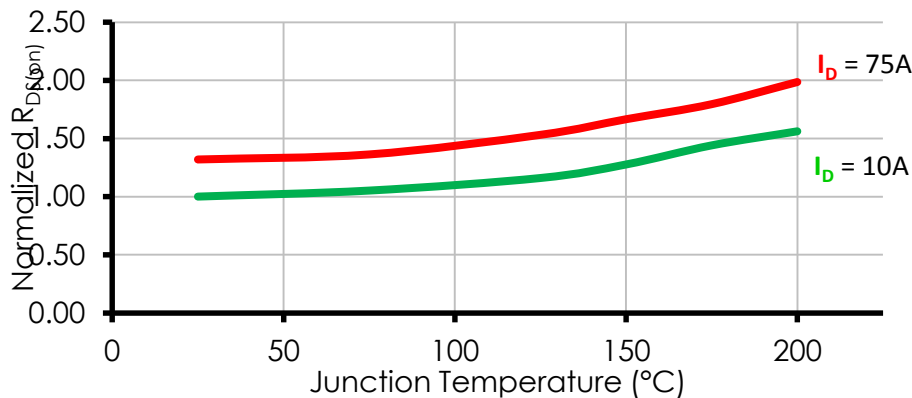
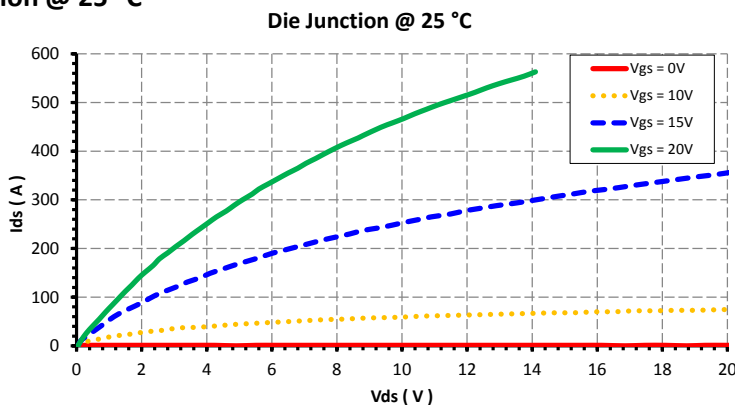
Symbols	Parameter	Condition(s)	Values			Units
			Min.	Typical	Max.	
V_{SD}	Diode forward voltage	$V_{GS} = -3\text{ V}$, $I_F = 10\text{ A}$	-	4.5	-	V
t_{rr}	Reverse recovery time	$V_{GS} = 0\text{ V}$, $I_F = 10\text{ A}$ $V_R = 800\text{ V}$ $di_F/dt = 400\text{ A}/\mu\text{s}$	-	TBD	-	ns
Q_{rr}	Reverse recovery charge		-	120	-	nC
I_{rrm}	Peak reverse recovery current		-	TBD	-	A

SiC MOSFET Gate Charge Electrical Characteristics⁴ ($T_c = 25\text{ }^\circ\text{C}$ unless otherwise specified)

Symbols	Parameter	Condition(s)	Values			Units
			Min.	Typical	Max.	
Q_{gs}	Gate to source charge	$V_{DD} = 600\text{ V}$, $V_{GS} = 18\text{ V}$ $I_D = 10\text{ A}$ $R_{G(ext)} = 10\text{ }\Omega$, $R_L = 60\text{ }\Omega$	-	30	-	nC
Q_{gd}	Gate to drain charge		-	30	-	
Q_g	Gate charge total		-	98	-	

TYPICAL PERFORMANCE CURVES

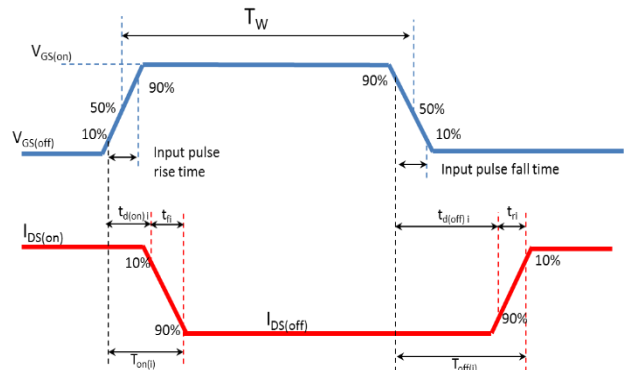
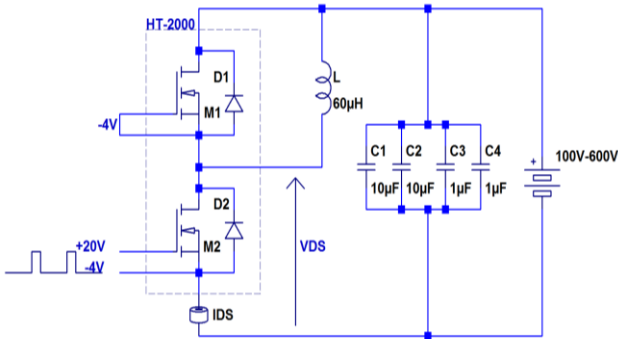
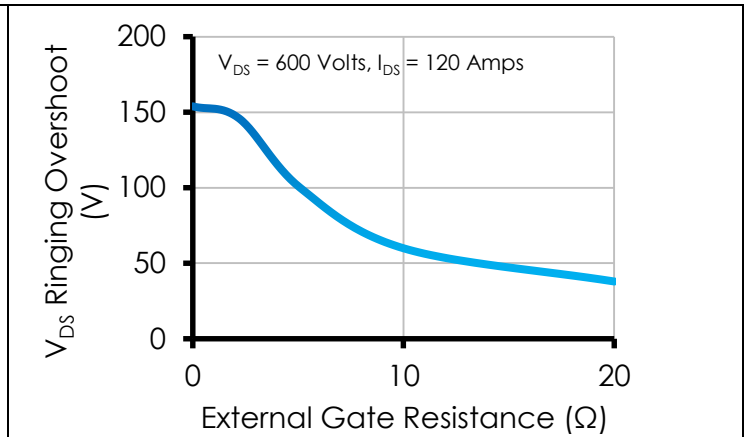
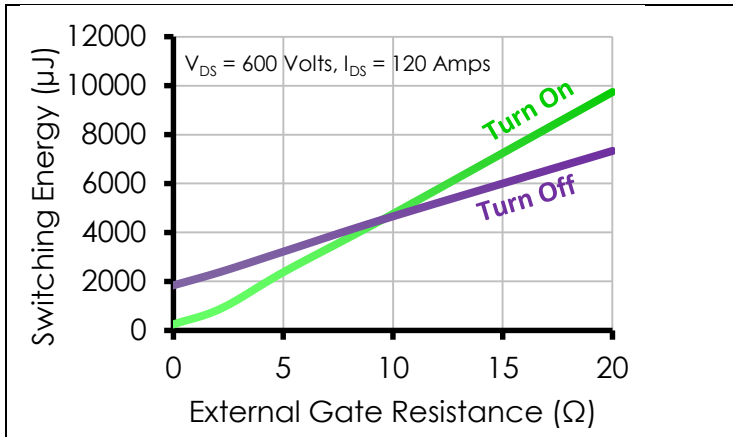
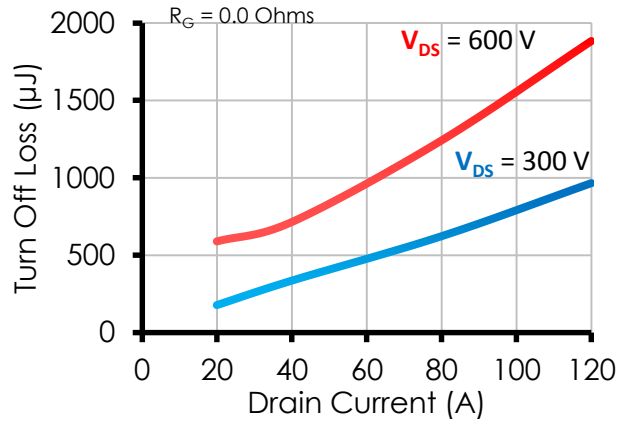
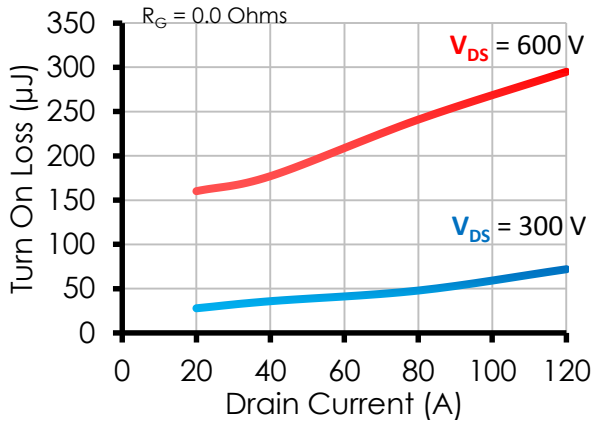
Die Junction @ 25 °C



Typical Normalized On Resistance

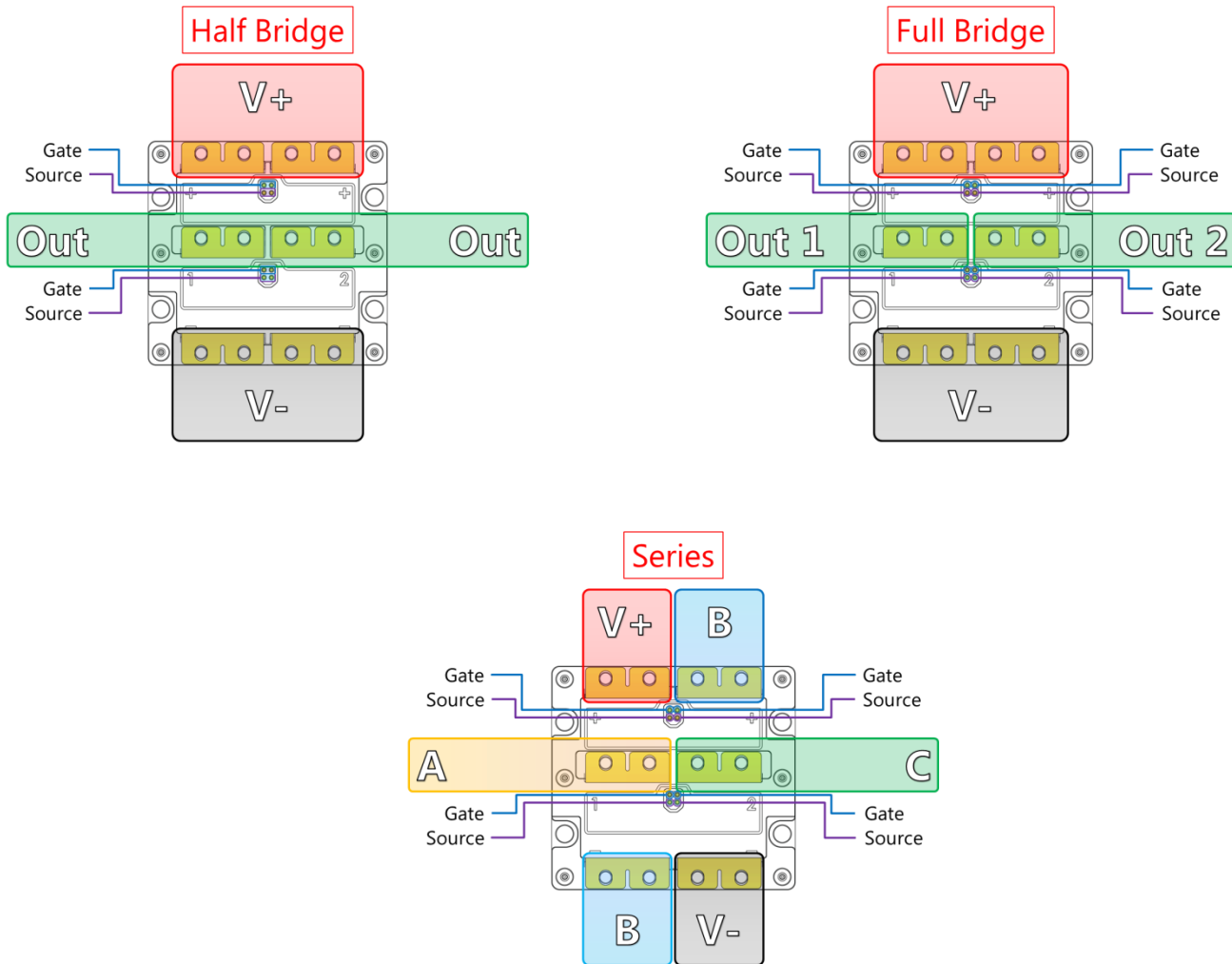
Normalized to an on resistance value of 23.1 m Ω ($I_D = 10\text{ A}$, $T_j = 25\text{ }^\circ\text{C}$)

Typical Switching Losses



Energy values obtained using companion gate driver ($T_{amb} = 25 \text{ }^\circ\text{C}$).

HALF- AND FULL-BRIDGE CONNECTIONS



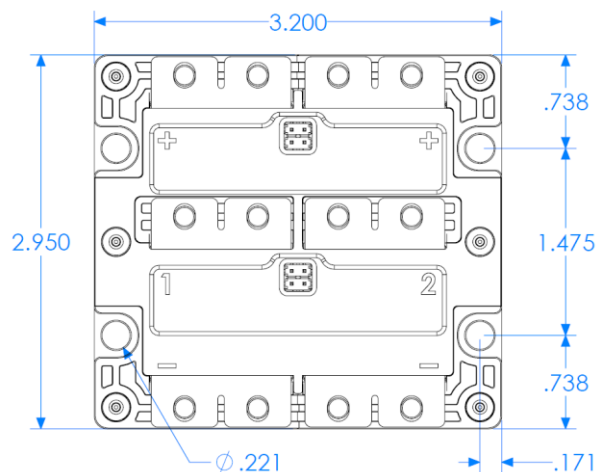
MOUNTING DIMENSIONS

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



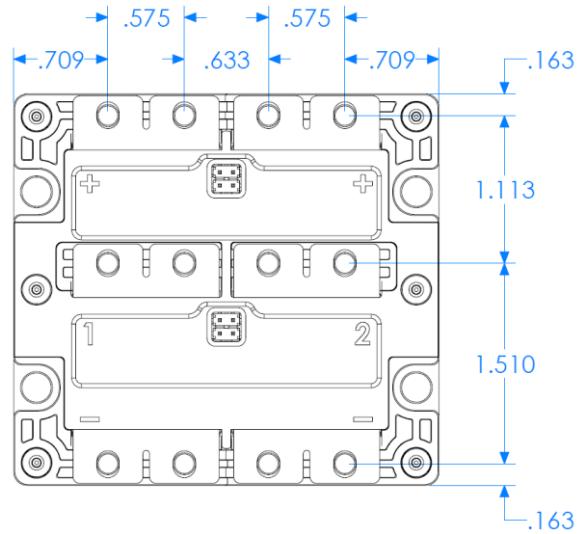
POWER CONTACT DIMENSIONS

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

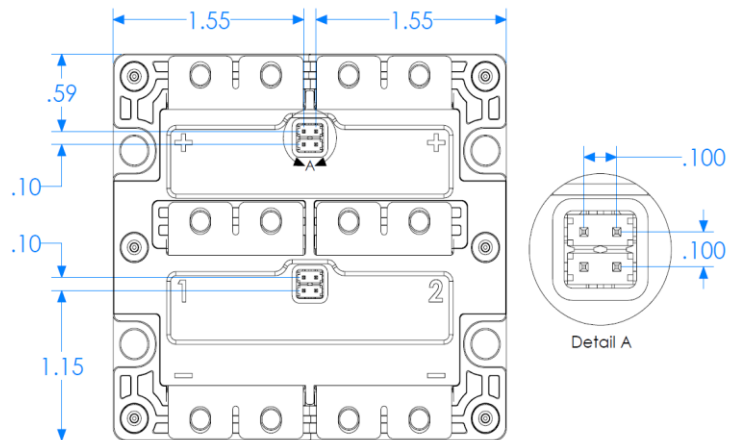
All dimensions are listed in inches

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





PRELIMINARY

APE HT-2101-A

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