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3 Phase Inverter Automotive Power Module

FAM04V18DT1

ON Semiconductor®

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APM20CBB / 20LD,
CASE MODFZ

Features

- Full Bridge Inverter for Variable Speed Motor Drive
- Temperature Sensing
- R−C Snubber Circuits for each MOSFET
- Electrically Isolated DBC Substrate for Low Rthjc
- Compact Design for Low Total Module Resistance
- Module Serialization for Full Traceability
- Lead Free, RoHS and UL94 V−0 Compliant
- Automotive Qualified
- This Device is Pb−Free and is RoHS Compliant

Applications

- 12 V Motor Control
- Brake System, Electrical Streering, Turbo Charger

Benefits

- Enable Design of Small, Efficient and Reliable System for Reduced Vehicle Fuel Consumption and CO_2 Emission
- High Current Application
- Low Thermal Resistance
- Simplified Vehicle Assembly
- High EMI Performance

ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

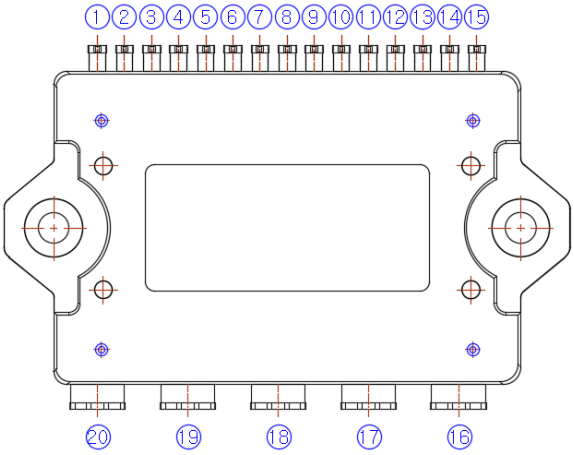

Figure 1. Pin Configuration

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Table 1. ORDERING INFORMATION

Part Number	Package	Pb−Free and RoHS Compliant	Operating Temperature Range	Packing Method
FAM04V18DT1	APM20−CBB	Yes	−40C ~ 125°C	Tube

Table 2. PIN DESCRIPTION

Pin No.	Pin Name	Pin Descriptions
1	NTC+	NTC Thermistor Terminal 1
2	NTC−	NTC Thermistor Terminal 2
3	U_DN	Gate of Q4
4	U_UP	Gate of Q1
5	U_SENSE	Sense Pin for Source of Q1 and Drain of Q4
6	V_DN	Gate of Q5
7	V_UP	Gate of Q2
8	NC	Not used
9	V_SENSE	Sense Pin for Source of Q2 and Drain of Q5
10	W_DN	Gate for Q6
11	W_UP	Gate for Q3
12	NC	Not used
13	W_SENSE	Sense Pin for Source of Q3 and Drain of Q6
14	V_LINK	Sense Pin for Battery Voltage and Drain of High Side MOSFETs
15	B−_SENSE	B− Sense
16	B−	Battery−
17	B+	Battery+
18	W Phase	W Phase Power lead
19	V Phase	V Phase Power lead
20	U Phase	U Phase Power lead

Block Diagram

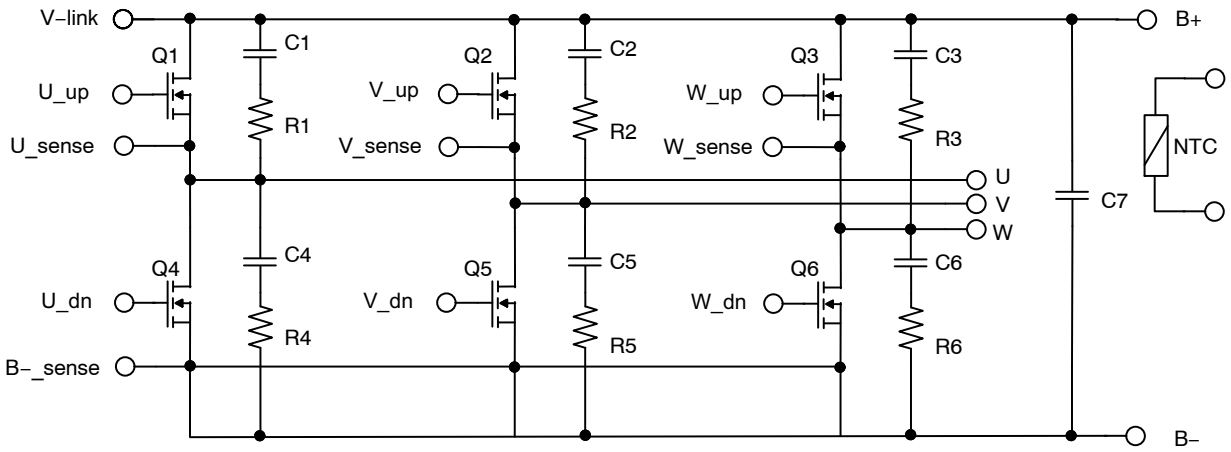


Figure 2. Schematic

Flammability Information

All materials present in the power module meet UL flammability rating class 94 V−0.

Compliance to RoHS directives

The power module is 100% lead free and RoHS compliant 2000/53/C directive.

Solder

Solder used is a lead free SnAgCu alloy.

Table 3. ABSOLUTE MAXIMUN RATINGS (T_J = 25°C, Unless Otherwise Specified)

Symbol	Parameter	Rating	Unit
V_{DS}(Q1~Q6)	Drain to Source Voltage	40	V
V_{GS}(Q1~Q6)	Gate to Source Voltage	±20	V
E_{AS}(Q1~Q6)	Single Pulse Avalanche Energy (Note 1)	1466	mJ
T_J	Maximum Junction Temperature	175	°C
T_{STG}	Storage Temperature	−40 ~ +125	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Table 4. ELECTRICAL SPECIFICATIONS (T_J = 25°C, Unless Otherwise Specified)

Parameter		Conditions	Min	Typ	Max	Units
B_{VDSS}	Drain−to−Source Breakdown Voltage	I_D = 250 μA, V_{GS} = 0 V	40			V
$V_{GS(th)}$	Gate to Source Threshold Voltage	V_{GS} = V_{DS}, I_D = 250 μA	2		4	V
V_{SD}	Source−to−Drain Diode Voltage	I_{SD} = 80 A, V_{GS} = 0 V			1.1	V
$R_{DS(ON)}$Q1	Q1 Inverter High Side MOSFETs (Note 2)	V_{GS} = 10 V, I_D = 80 A		0.60	0.85	mΩ
$R_{DS(ON)}$Q2	Q2 Inverter High Side MOSFETs (Note 2)	V_{GS} = 10 V,I_D = 80 A		0.53	0.75	mΩ
$R_{DS(ON)}$Q3	Q3 Inverter High Side MOSFETs (Note 2)	V_{GS} = 10 V, I_D = 80 A		0.45	0.65	mΩ
$R_{DS(ON)}$Q4	Q4 Inverter Low Side MOSFETs (Note 2)	V_{GS} = 10 V, I_D = 80 A		1.03	1.48	mΩ
$R_{DS(ON)}$Q5	Q5 Inverter Low Side MOSFETs (Note 2)	V_{GS} = 10 V, I_D = 80 A		0.90	1.28	mΩ
$R_{DS(ON)}$Q6	Q6 Inverter Low Side MOSFETs (Note 2)	V_{GS} = 10 V, I_D = 80 A		0.77	1.25	mΩ
I_{GSS}	Gate−to−Source Leakage Current	V_{GS} = ±20 V, V_{DS} = 0 V	−100		+100	nA
I_{DSS}	Drain−to−Source Leakage Current	V_{DS} = 40 V, V_{GS} = 0 V			2	μA
Total loop resistance, Total Module RDS(ON): Vbatt(+) → Phase → GND(−)		V_{GS} = 10 V, I_D = 80 A		2.36	3.4	mΩ
Switching Characteristics	Tdon, Turn−on delay time	V_{GS} = 10 V, V_{DD} = 14 V, I_D = 30 A			500	nS
	Tr, Rise time				400	nS
	Tdoff, Turn−off delay time				1000	nS
	Tf, Fall time				400	nS

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

1. Starting T_J = 25°C, L = 0.47 mH, I_{AS} = 79 A, V_{DD} = 40 V during inductor charging and V_{DD} = 0 V during time in avalanche.
2. All MOSFETs (bare die) have same die size and Rdson level, The different Rdson values listed in the datasheet are due to the different access points available inside the module for Rdson measurement.

Table 5. TEMPERATURE SENSE (NTC THERMISTOR)

Parameter	Test Conditions	Min	Max	Units
Resistance	Current = 1 mA	7.5	13	kΩ

Table 6. MOSFETS RDSON MEASUREMENT PATHS

	+ Force	– Force	+ Sense	– Sense		+ Force	– Force	+ Sense	– Sense
Q1	B+	U phase	Vlink	U sense	Q4	U phase	B–	U sense	B– sense
	Pin 17	Pin 20	Pin 14	Pin 5		Pin 20	Pin 16	Pin 5	Pin 15
Q2	B+	V phase	Vlink	V sense	Q5	V phase	B–	V sense	B– sense
	Pin 17	Pin 19	Pin 14	Pin 9		Pin 19	Pin 16	Pin 9	Pin 15
Q3	B+	W phase	Vlink	W sense	Q6	W phase	B–	W sense	B– sense
	Pin 17	Pin 18	Pin 14	Pin 13		Pin 18	Pin 16	Pin 13	Pin 15

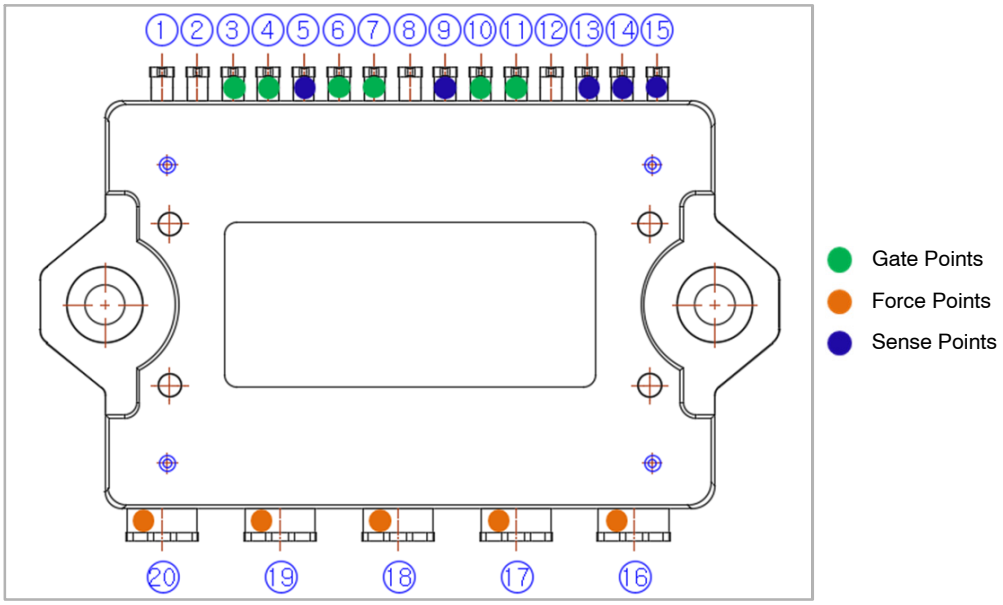


Figure 3.

Table 7. MODULE RDSON MEASUREMENT PATHS

	+ Force	− Force	+ Sense	− Sense		+ Force	− Force	+ Sense	− Sense
Q1	B+	U phase	B+	U phase	Q4	U phase	B−	U phase	B−
	Pin 17	Pin 20	Pin 17	Pin 20		Pin 20	Pin 16	Pin 20	Pin 16
Q2	B+	V phase	B+	V phase	Q5	V phase	B−	V phase	B−
	Pin 17	Pin 19	Pin 17	Pin 19		Pin 19	Pin 16	Pin 19	Pin 16
Q3	B+	W phase	B+	W phase	Q6	W phase	B−	W phase	B−
	Pin 17	Pin 18	Pin 17	Pin 18		Pin 18	Pin 16	Pin 18	Pin 16

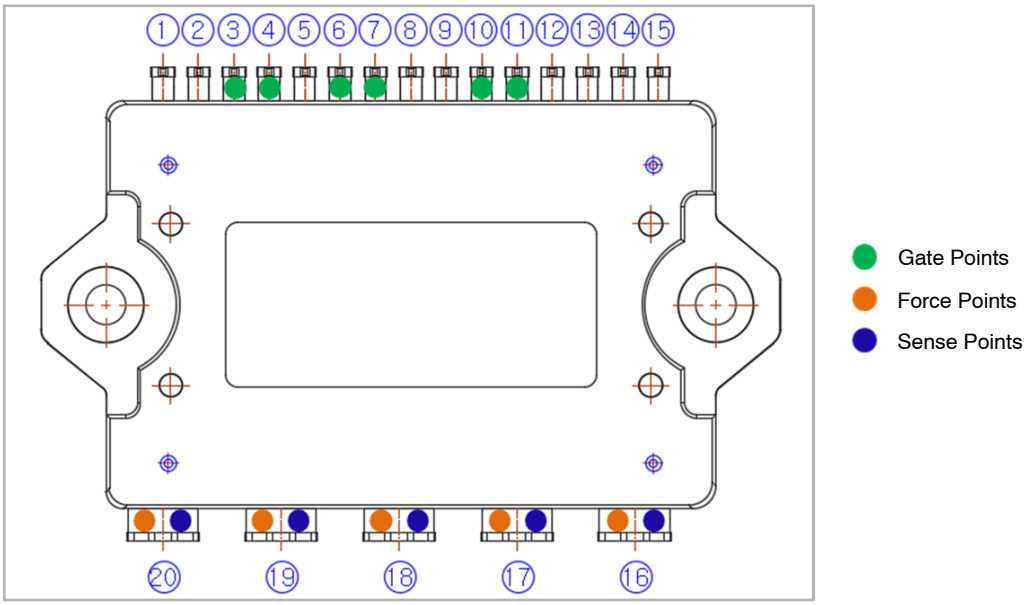


Figure 4.

Table 8. THERMAL RESISTANCE

Parameters		Min	Typ	Max	Unit
Rthjc Thermal Resistance Junction to case, Single Inverter FET	Q1−Q6 Thermal Resistance J−C	−	0.69	0.97	C/W

Table 9. ISOLATION VOLTAGE (Isolation Voltage between DBC Bottom Surface and All Module Pins)

Test	Test Conditions	Min	Max	Unit
Leakage @ Isolation Voltage (Hi−Pot)	VAC = 3 kV Frequency = 50 Hz Test Time = 1 s	−	300	μA

Table 10. REFERENCE TYPICAL CHARACTERISTICS FOR DISCRETE MOSFET FDBL9401_F085, USED IN HIGH SIDE AND LOW SIDE MOSFETS OF THIS MODULE

Symbol	Parameter	Test Conditions		Min	Typ	Max	Units
OFF CHARACTERISTICS							
B_{VDSS}	Drain−to−Source Breakdown Voltage	I_D = 250 μA, V_{GS} = 0 V		40	–	–	V
I_{DSS}	Drain−to−Source Leakage Current	V_{DS} = 40 V	T_J = 25°C	–	–	1	μA
		V_{GS} = 0 V	T_J = 175°C (Note 3)	–	–	1	mA
I_{GSS}	Gate−to−Source Leakage Current	V_{GS} = ±20 V		–	–	±100	nA
ON CHARACTERISTICS							
$V_{GS(th)}$	Gate to Source Threshold Voltage	V_{GS} = V_{DS}, I_D = 250 μA		2.0	3.0	4.0	V
$R_{DS(on)}$	Drain to Source On Resistance	I_D = 80 A	T_J = 25°C	–	0.50	0.65	mΩ
		V_{GS} = 10 V	T_J = 175°C (Note 3)	–	0.86	1.10	mΩ
DYNAMIC CHARACTERISTICS							
C_{iss}	Input Capacitance	V_{DS} = 25 V, V_{GS} = 0 V f = 1 MHz		–	15900	–	pF
C_{oss}	Output Capacitance			–	4025	–	pF
C_{rss}	Reverse Transfer Capacitance			–	604	–	pF
R_g	Gate Resistance	f = 1 MHz		–	2.6	–	Ω
$Q_{g(ToT)}$	Total Gate Charge at 10 V	V_{GS} = 0 to 10	V_{DD} = 20 V I_D = 80 A	–	220	–	nC
$Q_{g(th)}$	Threshold Gate Charge	V_{GS} = 0 to 2 V		–	29	–	nC
Q_{gs}	Gate to Source Gate Charge			–	73	–	nC
Q_{gd}	Gate to Drain “Miller” Charge			–	41	–	nC
SWITCHING CHARACTERISTICS							
t_{on}	Turn−On Time	V_{DD} = 20 V, I_D = 80 A V_{GS} = 10 V, R_{GEN} = 6 Ω		–	–	221	ns
$t_{d(on)}$	Turn−On Delay			–	54	–	ns
t_r	Rise Time			–	82	–	ns
$t_{d(off)}$	Turn−Off Delay			–	106	–	ns
t_f	Fall Time			–	52	–	ns
t_{off}	Turn−Off Time			–	–	215	ns
DRAIN−SOURCE DIODE CHARACTERISTICS							
V_{SD}	Source to Drain Diode Voltage	I_{SD} = 80 A, V_{GS} = 0 V		–	–	1.25	V
		I_{SD} = 40 A, V_{GS} = 0 V		–	–	1.2	V
t_{rr}	Reverse Recovery Time	I_F = 80 A, dI_{SD}/dt = 100 A/μs V_{DD} = 32 V		–	119	133	ns
Q_{rr}	Reverse Recovery Charge			–	228	274	nC

3. The maximum value is specified by design at T_J = 175°C. Product is not tested to this condition in production.

Table 11. COMPONENTS

	Component				Size	Maker	Remarks
1	MOSFET	PT8 40 V	PT8 40 V, bare die used in FDBL9401	6ea	260 x 145 mil	ON Semiconductor	AEC Q101 qualified by FDBL9401_F085
2	R1, 2, 3, 4, 5, 6	Resistors	1406 10 Ω 200 mV 1%	6ea	2200 x 1100 [μm]	Vishay	AEC Q200 qualified
3	C1, 2, 3, 4, 5, 6	Capacitors	8200 pF 50 V 5%	6ea	2000 x 1250 [μm]	Murata	AEC Q200 qualified
4	C7	Capacitor	1206 100 nF 100 V 10%	1ea	2010 x 1250 [μm]	Murata	AEC Q200 qualified
5	NTC	Thermistor	NCP18XH103F0SRB – 10 kΩ	1ea	1600 x 800 [μm]	Murata	AEC Q200 qualified

Mechanical Characteristics and Ratings

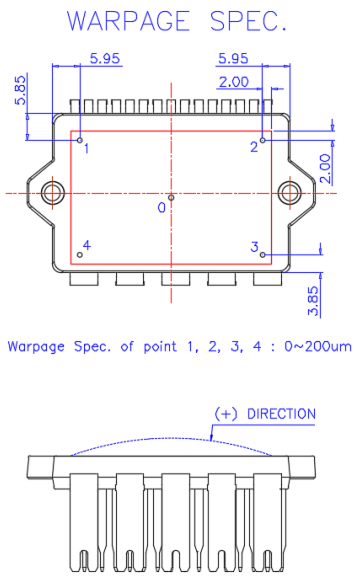
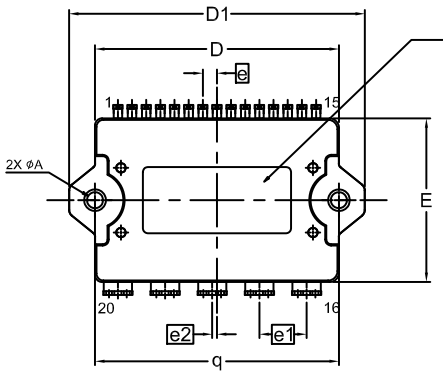


Figure 5.

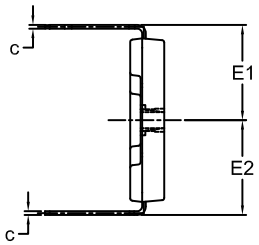
FAM04V18DT1

PACKAGE DIMENSIONS

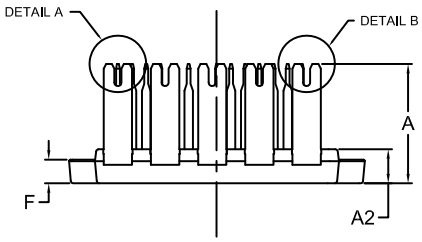
APM20CBB / 20LD, PDD STD, R−EPS MODULE
CASE MODFZ
ISSUE A



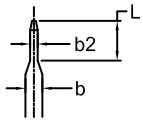
TOP VIEW



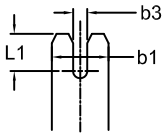
END VIEW



SIDE VIEW



DETAIL A



DETAIL B

NOTES:
1. DIMENSIONING AND TOLERANCING PER. ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR EXTRUSIONS.
4. DIMENSION b and c APPLY TO THE PLATED LEADS AND ARE MEASURED BETWEEN 1.00 AND 2.00MM FROM THE LEAD TIP.

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	25.00	25.30	25.60
A2	7.00	7.20	7.40
b	1.70	1.80	1.90
b1	5.80	6.00	6.20
b2	0.70	0.80	0.90
b3	1.40	1.50	1.60
c	0.75	0.80	0.90
D	51.50	51.70	51.90
D1	62.40	62.70	63.00
E	34.50	34.70	34.90
E1	20.00	20.20	20.40
E2	19.90	20.10	20.30
e	3.00 BSC		
e1	10.00 BSC		
e2	1.00 BSC		
F	4.80	5.00	5.20
L	4.00	4.20	4.40
L1	3.75	3.95	4.15
q	51.50	51.70	51.90
ϕA	3.30	3.40	3.50

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