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FAIRCHILD SEMICONDUCTOR®

December 2013

FPDB30PH60
PFC SPM® 3 Series for 2-Phase Bridgeless PFC

Features

- UL Certified No. E209204 (UL1557)
- 600 V - 30 A 2-Phase Bridgeless PFC with Integral Gate Driver and Protection
- Very Low Thermal Resistance Using Al_2O_3 DBC Substrate
- Built-in NTC Thermistor for Temperature Monitoring
- Built-in Shunt Resistor for Current Sensing
- Optimized for 20kHz Switching Frequency
- Isolation Rating: 2500 Vrms/min.

Applications

- 2-Phase Bridgeless PFC Converter

Related Source

- AN-9041 - Bridgeless PFC SPM 3 Series Design Guide

General Description

The FPDB30PH60 is a PFC SPM® 3 module providing a fully-featured, high-performance Bridgeless PFC (Power Factor Correction) input power stage for consumer, medical, and industrial applications. These modules integrate optimized gate drive of the built-in IGBTs to minimize EMI and losses, while also providing multiple on-module protection features including under-voltage lockout, over-current shutdown, thermal monitoring, and fault reporting. These modules also feature high-performance output diodes and shunt resistor for additional space savings and mounting convenience.

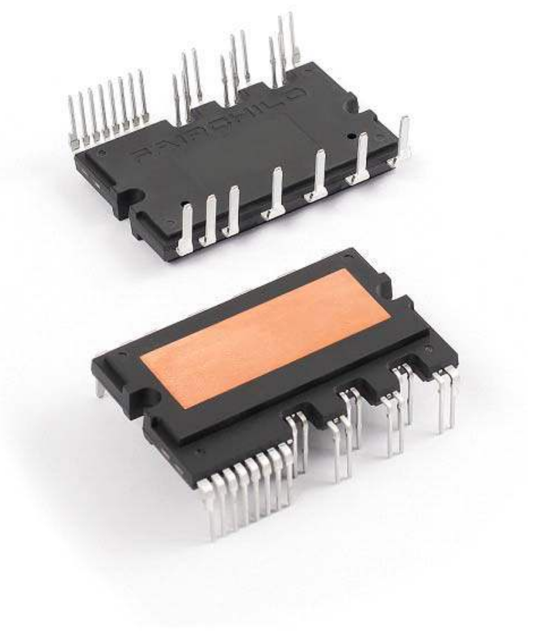


Figure 1. Package Overview

Package Marking & Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FPDB30PH60	FPDB30PH60	SPMGA-027	Rail	10

Integrated Power Functions

- PFC converter for single-phase AC / DC power conversion.(please refer to Figure 3)

Integrated Drive, Protection and System Control Functions

- For IGBTs: gate drive circuit, Over-Current Protection (OCP), control supply circuit Under-Voltage Lock-Out (UVLO) Protection
- Fault signal: corresponding to OC and UV fault
- Built-in thermistor: temperature monitoring
- Input interface: active-HIGH interface, works with 3.3 / 5 V logic, Schmitt-trigger input

Pin Configuration

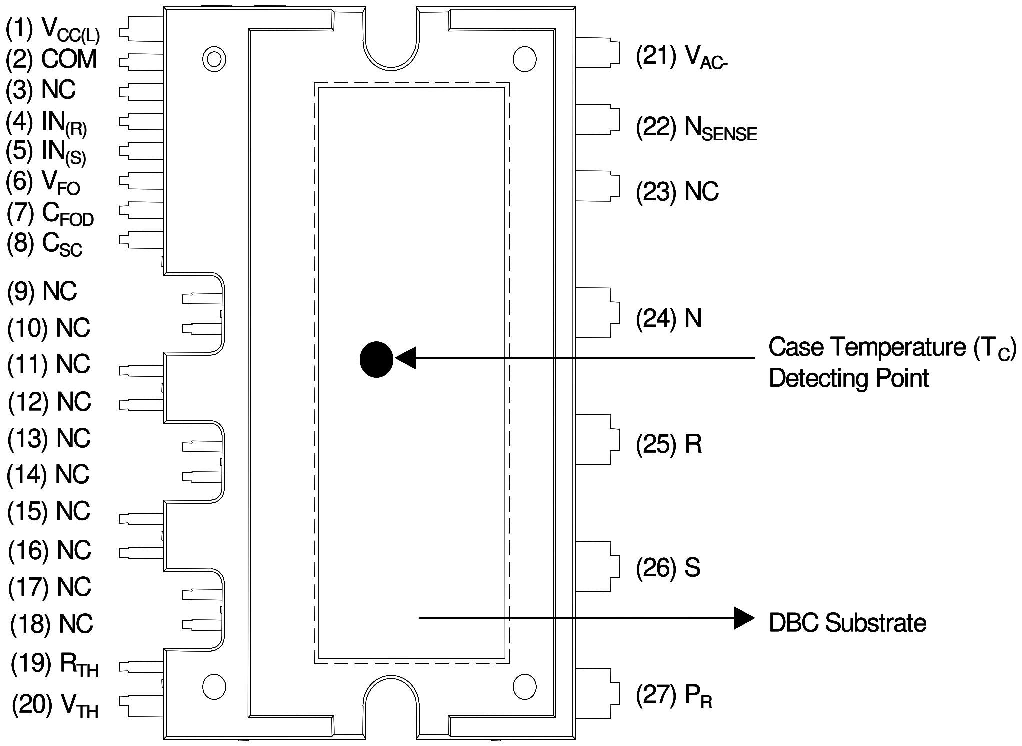


Figure 2. Top View

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	V_{CC}	Common Bias Voltage for IC and IGBTs Driving
2	COM	Common Supply Ground
4	$IN_{(R)}$	Signal Input for Low-Side R-Phase IGBT
5	$IN_{(S)}$	Signal Input for Low-Side S-Phase IGBT
6	V_{FO}	Fault Output
7	C_{FOD}	Capacitor for Fault Output Duration Selection
8	C_{SC}	Capacitor(Low-Pass Filter) for Over-Current Detection
19	$R_{(TH)}$	Series Resistor for The Use of Thermistor
20	$V_{(TH)}$	Thermistor Bias Voltage
21	V_{AC-}	Current Sensing Terminal
22	N_{SENSE}	Current Sensing Reference Terminal
24	N	Negative Rail of DC-Link
25	R	Output for R-Phase
26	S	Output for S-Phase
27	P_R	Positive Rail of DC-Link
3, 9~18, 23	NC	No Connection

Internal Equivalent Circuit

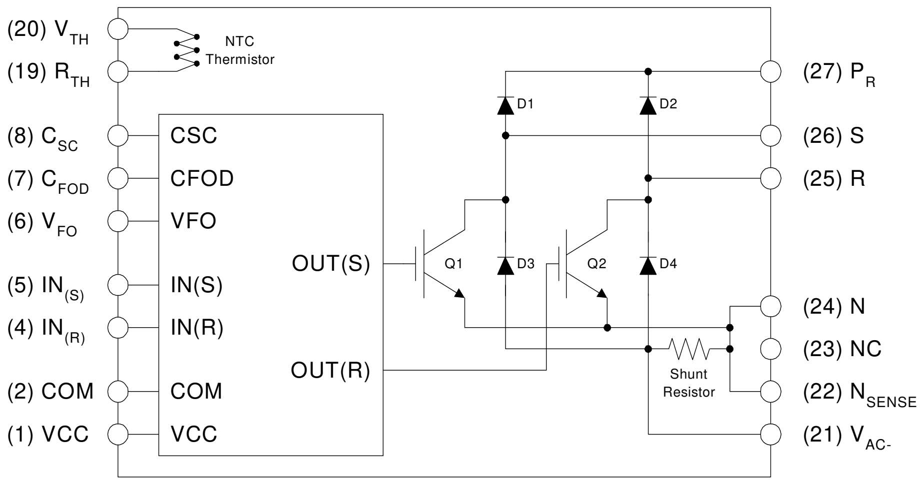


Figure 3. Internal Block Diagram

Notes:

1. Converter is composed of two IGBTs including four diodes and one IC which has gate driving and protection functions.

Absolute Maximum Ratings (T_J = 25°C, unless otherwise specified.)

Converter Part

Symbol	Item	Condition	Rating	Unit
V_i	Supply Voltage	Applied between R - S	264	V_{rms}
$V_{i(Surge)}$	Supply Voltage (Surge)	Applied between R - S	500	V
V_{PN}	Output Voltage	Applied between P - N	450	V
$V_{PN(Surge)}$	Output Voltage (Surge)	Applied between P - N	500	V
V_{CES}	Collector - Emitter Voltage		600	V
I_i	Input Current (100% Load)	T_C < 95°C, V_i = 220 V, V_{PN} = 390 V, V_{PWM} = 20 kHz	20	A
$I_{i(125\%)}$	Input Current (125% Load)	T_C < 95°C, V_i = 220V , V_{PN} = 390 V, V_{PWM} = 20 kHz, 1 min Non-Repetitive	25	A
P_C	Collector Dissipation	T_C = 25°C per IGBT	83	W
P_{RSH}	Power Rating of Shunt Resistor	T_C < 125°C	2	W
T_J	Operating Junction Temperature	(Note 2)	-20 ~ 125	°C

Notes:
2. The maximum junction temperature rating of the power chips integrated within the PFC SPM® product is 150 °C(@T_C ≤ 100°C). However, to insure safe operation of the PFC SPM product, the average junction temperature should be limited to $T_{J(ave)}$ ≤ 125°C (@T_C ≤ 100°C)

Control Part

Symbol	Item	Condition	Rating	Unit
V_{CC}	Control Supply Voltage	Applied between V_{CC} - COM	20	V
V_{IN}	Input Signal Voltage	Applied between IN - COM	-0.3 ~ 17.0	V
V_{FO}	Fault Output Supply Voltage	Applied between V_{FO} - COM	-0.3 ~ V_{CC}+0.3	V
I_{FO}	Fault Output Current	Sink Current at V_{FO} Pin	5	mA
V_{SC}	Current Sensing Input Voltage	Applied between C_{SC} - COM	-0.3~V_{CC}+0.3	V

Total System

Symbol	Item	Condition	Rating	Unit
T_C	Module Case Operation Temperature		-20 ~ 100	°C
T_{STG}	Storage Temperature		-40 ~ 125	°C
V_{ISO}	Isolation Voltage	60 Hz, Sinusoidal, AC 1 Minute, Connect Pins to Heat-Sink Plate	2500	V_{rms}

Thermal Resistance

Symbol	Item	Condition	Min.	Typ.	Max.	Unit
$R_{\theta(j-c)Q}$	Junction to Case Thermal Resistance (Referenced to PKG Center)	IGBT	-	-	1.2	°C/W
$R_{\theta(j-c)HD}$		High-Side Diode	-	-	2.0	°C/W
$R_{\theta(j-c)LD}$		Low-Side Diode	-	-	1.4	°C/W

Notes :
3. For the measurement point of case temperature(T_C), please refer to Figure 2.

Electrical Characteristics (T_J = 25°C, unless otherwise specified.)

Converter Part

Symbol	Item	Condition	Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$	IGBT Saturation Voltage	V_{CC} = 15 V, V_{IN} = 5 V, I_C =30 A	-	2.4	3.1	V
V_{FH}	High-Side Diode Voltage	I_F = 30 A	-	1.9	2.5	V
V_{FL}	Low-Side Diode Voltage	I_F = 30 A	-	1.2	1.6	V
t_{ON}	Switching Times	V_{PN} = 400 V, V_{CC} = 15 V, I_C =30 A V_{IN} = 0 V ↔ 5 V, Inductive Load (Note 4)	-	550	-	ns
$t_{C(ON)}$			-	200	-	ns
t_{OFF}			-	430	-	ns
$t_{C(OFF)}$			-	180	-	ns
t_{rr}			-	60	-	ns
I_{rr}			-	6	-	A
R_{SENSE}	Current-Sensing Resistor		1.8	2.0	2.2	mΩ
I_{CES}	Collector - Emitter Leakage Current	V_{CE} = V_{CES}	-	-	250	μA

Notes:
4. t_{ON} and t_{OFF} include the propagation delay of the internal drive IC. $t_{C(ON)}$ and $t_{C(OFF)}$ are the switching time of IGBT itself under the given gate driving condition internally. For the detailed information, please see Figure 4.

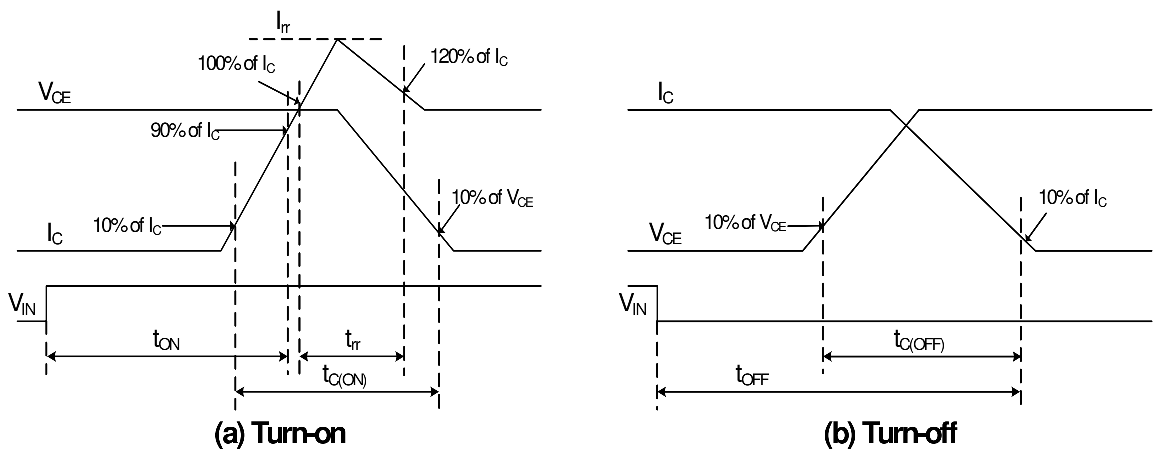


Figure 4. Switching Time Definition

Control Part

Symbol	Item	Condition	Min.	Typ.	Max.	Unit
I_{QCCL}	Quiescent V_{CC} Supply Current	V_{CC} = 15 V, IN = 0 V; V_{CC} - COM	-	-	26	mA
V_{FOH}	Fault Output Voltage	V_{SC} = 0 V, V_{FO} Circuit: 4.7 kΩ to 5 V Pull-up	4.5	-	-	V
V_{FOL}		V_{SC} = 1 V, V_{FO} Circuit: 4.7 kΩ to 5 V Pull-up	-	-	0.8	V
$V_{SC(ref)}$	Over-Current Trip Level	V_{CC} = 15 V	0.45	0.50	0.55	V
UV_{CCD}	Supply Circuit Under-Voltage Protection	Detection Level	10.7	11.9	13.0	V
UV_{CCR}		Reset Level	11.2	12.4	13.2	V
t_{FOD}	Fault-Out Pulse Width	C_{FOD} = 33 nF (Note 5)	1.4	1.8	2.0	ms
$V_{IN(ON)}$	ON Threshold Voltage	Applied between IN - COM	3.0	-	-	V
$V_{IN(OFF)}$	OFF Threshold Voltage		-	-	0.8	V
R_{TH}	Resistance of Thermistor	at T_C = 25°C (See Figure 5)	-	50	-	kΩ
		at T_C = 80°C (See Figure 5)	-	5.76	-	kΩ

Notes:
5. The fault-out pulse width t_{FOD} depends on the capacitance value of C_{FOD} according to the following approximate equation : $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD}$[F]

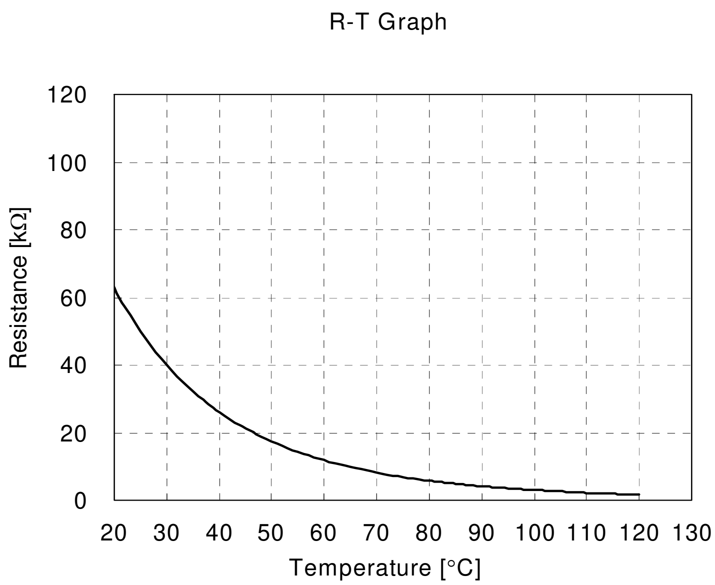


Figure 5. R-T Curve of the Built-in Thermistor

Recommended Operating conditions

Symbol	Item	Condition	Min.	Typ.	Max.	Unit
V_I	Input Supply Voltage	Applied between R - S	180	-	264	V_{rms}
V_{PN}	Output Voltage	Applied between P - N	-	280	400	V
V_{CC}	Control Supply Voltage	Applied between V_{CC} - COM	13.5	15.0	16.5	V
dV_{CC}/dt	Control Supply Variation	Applied between IN - COM	-1	-	1	V/μs
f_{PWM}	PWM Input Signal	$T_C \leq 100°C$, $T_J \leq 125°C$, per IGBT	-	20	-	kHz

Mechanical Characteristics and Ratings

Item	Condition		Min.	Typ.	Max.	Units
Mounting Torque	Mounting Screw: M3	Recommended 0.62 N•m	0.51	0.62	0.72	N•m
Device Flatness	See Figure 6		0	-	+120	μm
Weight			-	15.00	-	g

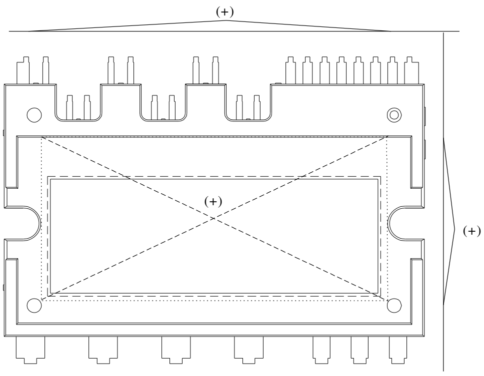
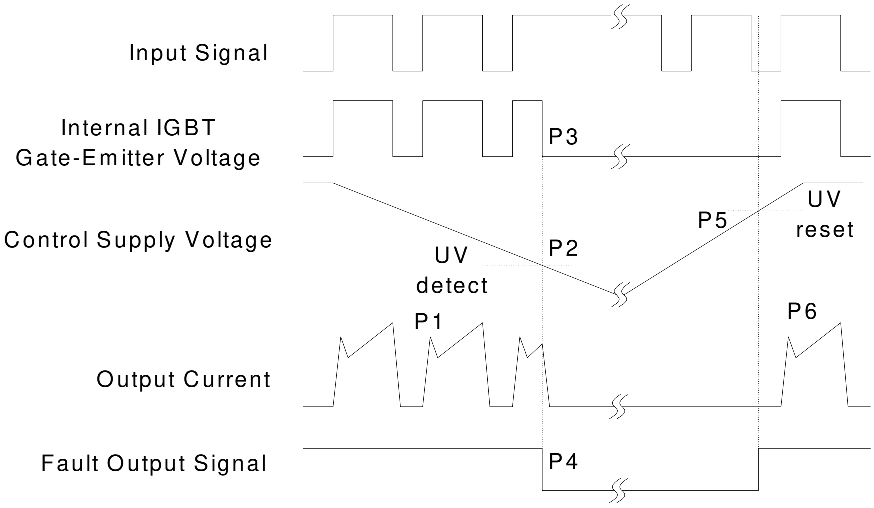


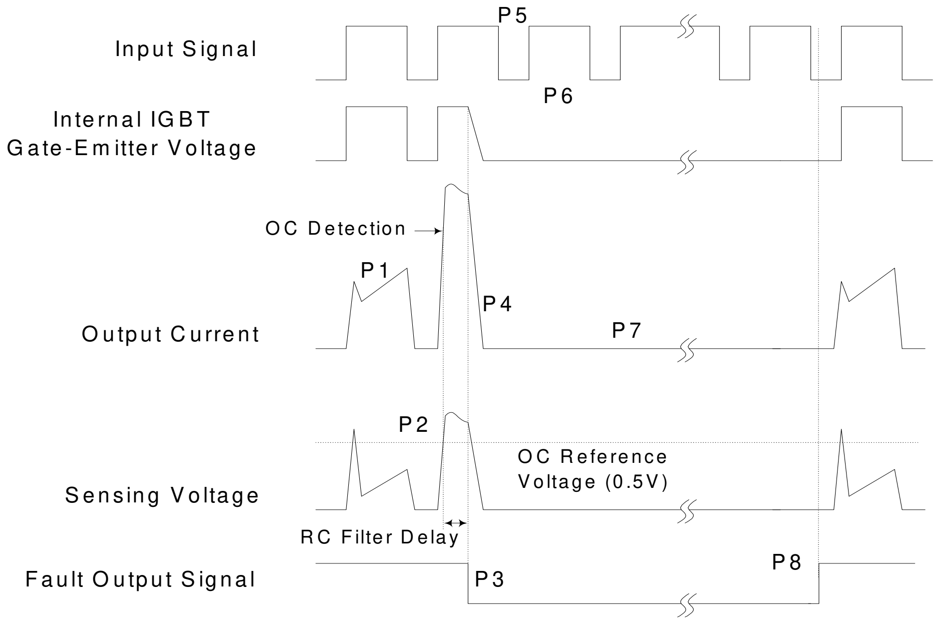
Figure 6. Flatness Measurement Position

Time Charts of Protective Function



P1 : Normal operation: IGBT ON and conducting current.
P2 : Under-voltage detection.
P3 : IGBT gate interrupt.
P4 : Fault signal generation.
P5 : Under-voltage reset.
P6 : Normal operation: IGBT ON and conducting current.

Figure 7. Under-Voltage Protection



P1 : Normal operation: IGBT ON and conducting current.
P2 : Over current detection.
P3 : IGBT gate interrupt / fault signal generation.
P4 : IGBT is slowly turned off.
P5 : IGBT OFF signal.
P6 : IGBT ON signal: but IGBT cannot be turned on during the fault output activation.
P7 : IGBT OFF state.
P8 : Fault output reset and normal operation start.

Figure 8. Over-Current Protection

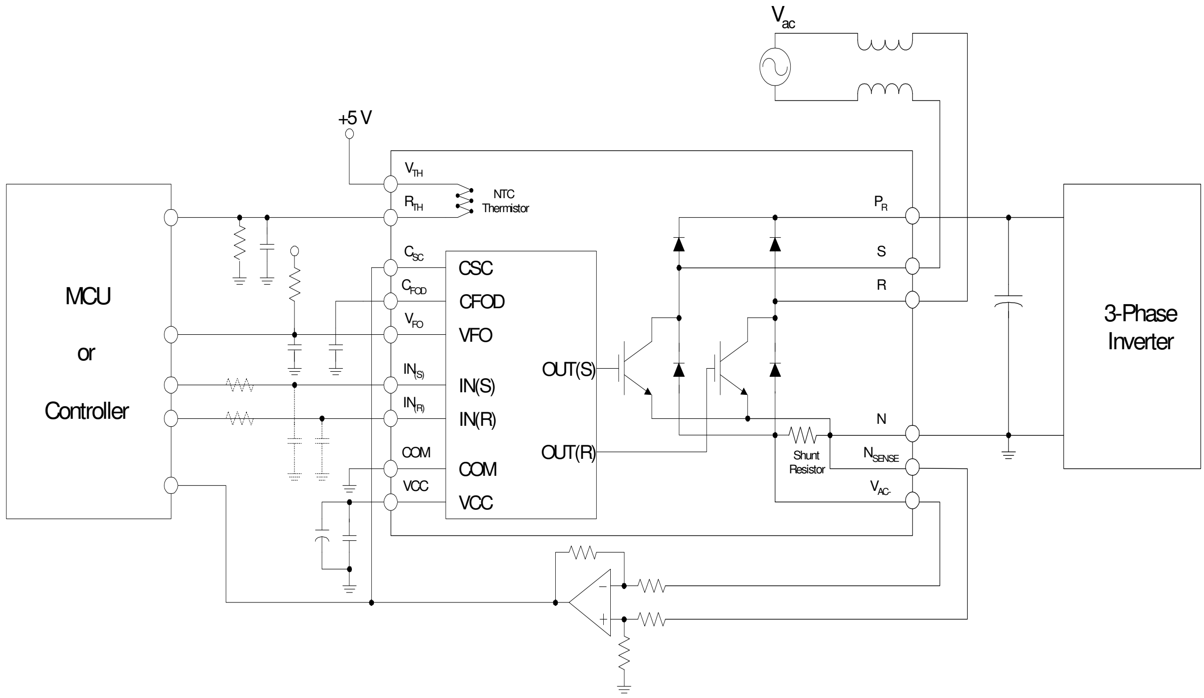
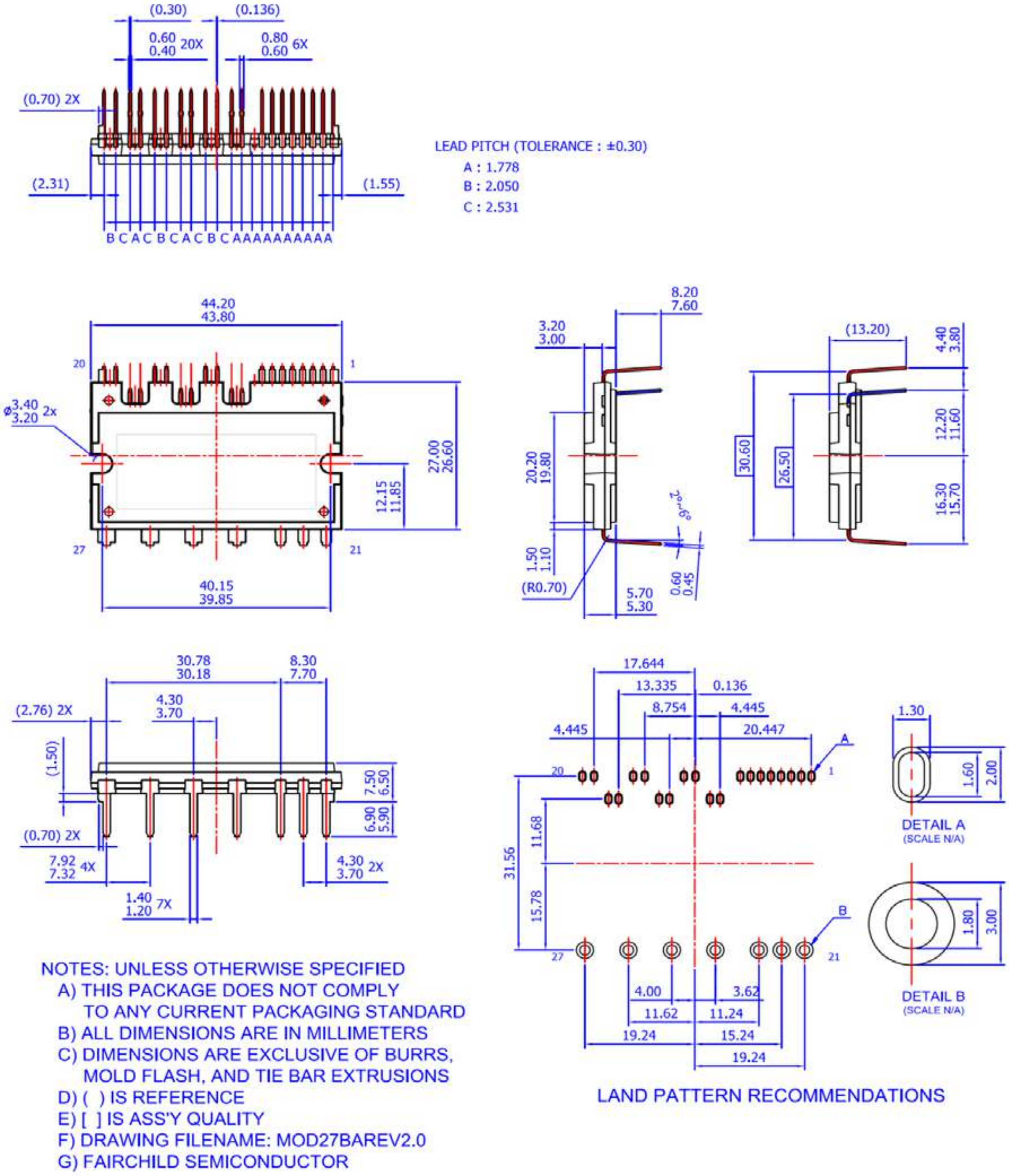


Figure 9. Application Example

Notes:
6. For the over-current protection, please set time constant in the range 3 ~ 4 μs.

Detailed Package Outline Drawings



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