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March 2014

FBA42060

PFC SPM® 45 Series for Single-Phase Boost PFC

Features

- UL Certified No. E209204 (UL1557)
- 600 V - 20 A Single-Phase Boost PFC with Integral Gate Driver and Protection
- Low Thermal Resistance Using Ceramic Substrate
- Full-Wave Bridge Rectifier and High-Performance Output Diode
- Optimized for 20kHz Switching Frequency
- Built-in NTC Thermistor for Temperature Monitoring
- Isolation Rating: 2000 Vrms/min.

Applications

- Single-Phase Boost PFC Converter

Related Source

- *AN-9091 - Boost PFC Inductor Design Guide*
- *AN-9072 - Motion SPM® 45 Series Mounting Guidance*

General Description

The FBA42060 is an advanced PFC SPM® 45 module providing a fully-featured, high-performance Boost PFC (Power Factor Correction) input power stage for consumer, medical, and industrial applications. These modules integrate optimized gate drive of the built-in IGBT 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 a full-wave rectifier and high-performance output diode for additional space savings and mounting convenience.

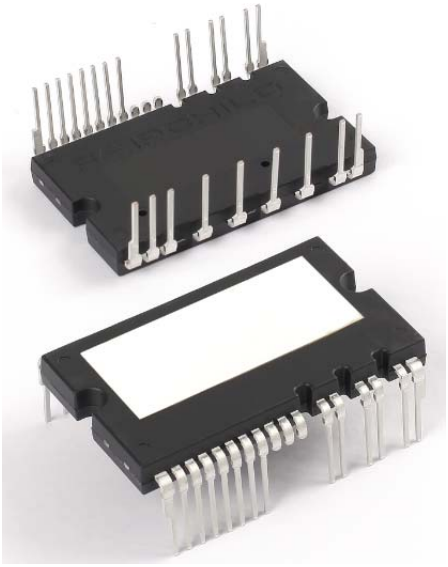

Figure 1. Package Overview

Package Marking & Ordering Information

Device	Device Marking	Package	Packing Type	Quantity
FBA42060	FBA42060	SPMAA-F26	Rail	12

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 NTC thermistor: temperature monitoring
- Input interface: active-HIGH interface, works with 3.3 / 5 V logic, Schmitt trigger input

Pin Configuration

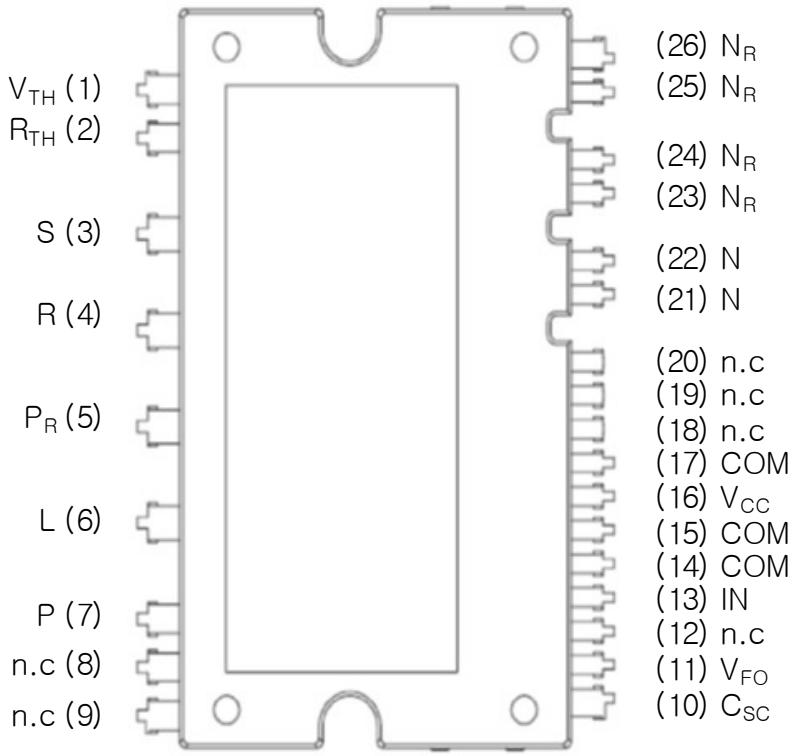

Figure 2. Top View

Pin Descriptions

Pin Number	Pin Name	Pin Description
1	V_{TH}	Thermistor Bias Voltage
2	R_{TH}	Series Resistor for The Use of Thermistor
3	S	AC Input for S-Phase
4	R	AC Input for R-Phase
5	P_R	Positive DC-Link of Rectifier
6	L	Inductor Connection
7	P	Positive DC-Link Input
8, 9	N.C	-
10	C_{OC}	Signal Input for Over-Current Detection
11	V_{FO}	Fault Output
12	N.C	-
13	IN	PWM Input for IGBT Drive
14	COM	Common Supply Ground
15	COM	Common Supply Ground
16	V_{CC}	Common Supply Voltage of IC for IGBT Drive
17	COM	Common Supply Ground
18 ~ 20	N.C	-
21, 22	N	Negative DC-Link Input
23 ~ 26	N_R	Negative DC-Link of Rectifier Diode

Internal Equivalent Circuit

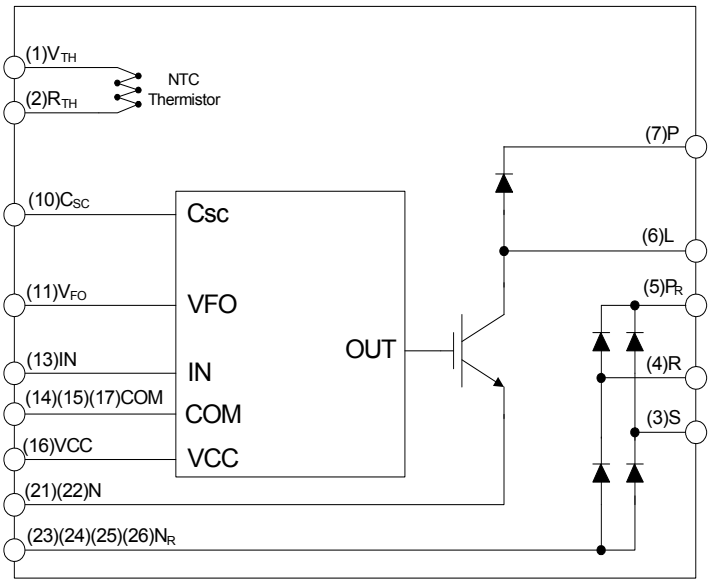

Figure 3. Internal Block Diagram

Absolute Maximum Ratings

Converter Part

Symbol	Parameter	Conditions	Rating	Unit
V_i	Input Supply Voltage	Applied between R - S	276	V_{rms}
$V_{i(Surge)}$	Input Supply Voltage (Surge)	Applied between R - S	500	V
V_{PN}	Output Voltage	Applied between P_R - N_R	450	V
$V_{PN(Surge)}$	Output Supply Voltage (Surge)	Applied between P_R - N_R	500	V
V_{CES}	Collector - Emitter Voltage		600	V
V_{RRM}	Repetitive Peak Reverse Voltage		600	V
± I_C	Each IGBT Collector Current	T_C = 25°C, V_{CC} = 15 V	20	A
± I_{CP}	Each IGBT Collector Current (Peak)	T_C = 25°C, Under 1 ms Pulse Width	30	A
I_{FSM}	Peak Forward Surge Current	Single Half Sine-Wave	200	A
T_J	Operating Junction Temperature		-40 ~ 150	°C

Control Part

Symbol	Parameter	Conditions	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 ~ V_{CC} + 0.3	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	1	mA
V_{SC}	Current Sensing Input Voltage	Applied between C_{SC} - COM	-0.3 ~ V_{CC} + 0.3	V

Total System

Symbol	Parameter	Conditions	Rating	Unit
T_{STG}	Storage Temperature		-40 ~ 125	°C
V_{ISO}	Isolation Voltage	60 Hz, Sinusoidal, AC 1 Minute, Connect Pins to Heat Sink Plate	2000	V_{rms}

Thermal Resistance

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$R_{th(j-c)Q}$	Junction to Case Thermal Resistance at Chip Center	IGBT	-	-	2.5	°C/W
$R_{th(j-c)D}$		FRD	-	-	2.5	°C/W
$R_{th(j-c)R}$		Rectifier	-	-	2.5	°C/W

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

Converter Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{CE(SAT)}$	IGBT Collector - Emitter Saturation Voltage	V_{CC} = 15 V, V_{IN} = 5V, I_C = 20 A	-	2.2	2.7	V
V_{FF}	FRD Forward Voltage	I_F = 20 A	-	2.1	2.6	V
V_{FR}	Rectifier Forward Voltage	I_F = 20 A	-	1.1	1.4	V
t_{ON}	Switching Characteristic	V_{PN} = 300 V, V_{CC} = 15 V, I_C = 20 A, V_{IN} = 0 V ↔ 5 V, Inductive Load (1st Note 1)	-	770	-	ns
t_{OFF}			-	640	-	ns
$t_{C(ON)}$			-	130	-	ns
$t_{C(OFF)}$			-	50	-	ns
trr			-	40	-	ns
Irr			-	4.0	-	A
I_{CES}	Collector - Emitter Leakage Current	V_{CE} = V_{CES}	-	-	1	mA

1st Notes:

1. 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.

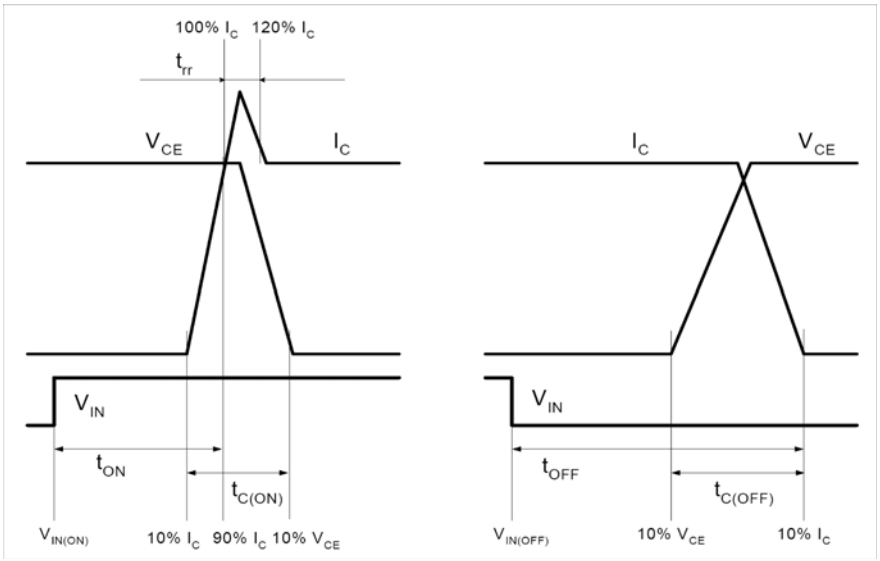

Figure 4. Switching Time Definitions

Control Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
I_{QCC}	Quiescent V_{CC} Supply Current	V_{CC} = 15 V, V_{IN} = 0V, V_{CC} - COM	-	-	2.65	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 Protection Trip Level Voltage of C_{SC} pin	V_{CC} = 15 V (1st Note 2)	0.45	0.50	0.55	V
UV_{CCD}	Supply Circuit Under-Voltage Protection	Detection Level	10.5		13.0	V
UV_{CCR}		Reset Level	11.0		13.5	V
$V_{IN(ON)}$	ON Threshold Voltage	Applied between IN - COM	-	-	2.6	V
$V_{IN(OFF)}$	OFF Threshold Voltage		0.8	-	-	V
R_{TH}	Resistance of Thermistor	T_{TH} = 25°C (1st Note 3)	-	47.0	-	kΩ
		T_{TH} = 100°C	-	2.9	-	kΩ

1st Notes:

2. Over-current protection is functioning on IGBT.

3. T_{TH} is the temperature of thermister itself. To know case temperature (T_C), please make the experiment considering your application.

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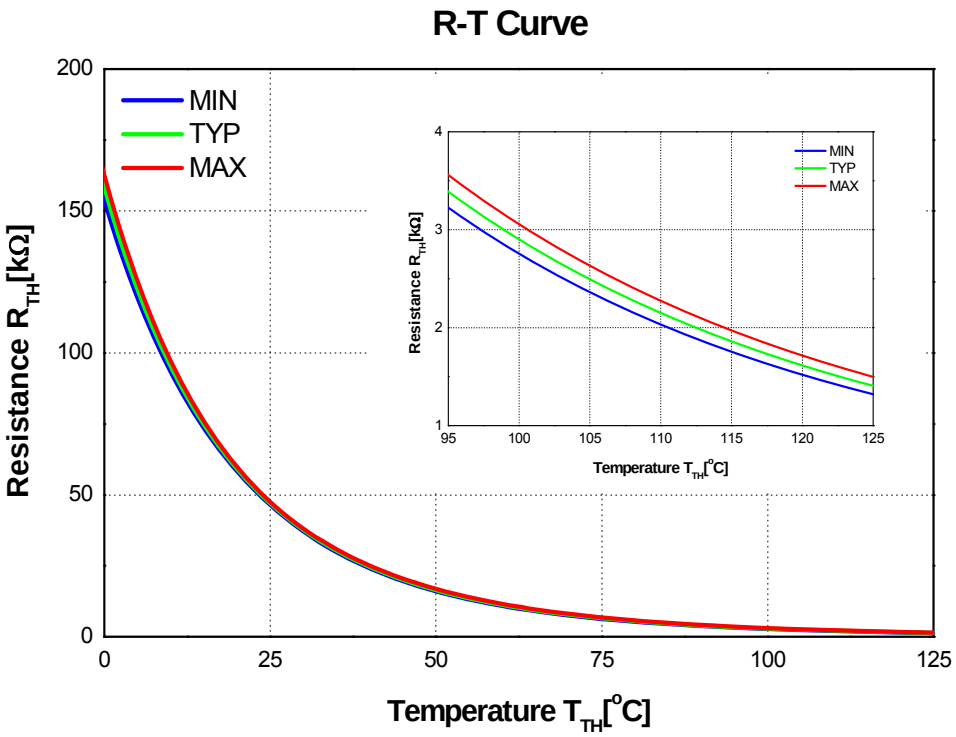


Figure 5. R-T Curve of The Built-in Thermistor

Recomended Operating Conditions

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_i	Input Supply Voltage	Applied between R - S	198	220	242	V_{rms}
V_{PN}	Supply Voltage	Applied between P_R - N	-	360	400	V
I_i	Input Current	V_{DC} = 360 V, F_{SW} = 20 kHz, V_{CC} = 15 V, T_C = 90°C, $T_J \leq$ 150°C	-	20	-	A_{peak}
V_{CC}	Supply Voltage for inverter	Applied between V_{CC} - COM	13.5	15.0	16.5	V
$P_{WIN(ON)}$	Minimum Input Pulse Width	(1st Note 4)	0.5	-	-	µs
$P_{WIN(OFF)}$			0.5	-	-	µs
dV_{CC}/dt	Supply Variation		-1	-	1	V/µs
f_{PWM}	PWM Input Frequency	$T_J \leq$ 150°C	-	20	-	kHz
V_{SEN}	Voltage for Current Sensing	Applied between N - COM (Including surge voltage)	-4	-	4	V

1st Notes:

4. The PFC SPM® product might not make response if input pulse width is less than the recommended value.

Mechanical Characteristics and Ratings

Parameter	Conditions		Min.	Typ.	Max.	Unit
Mounting Torque	Mounting Screw: M3	Recommended 0.7 N•m	0.6	0.7	0.8	N•m
Device Flatness		See Figure 6	0	-	+120	µm
Weight			-	11	-	g

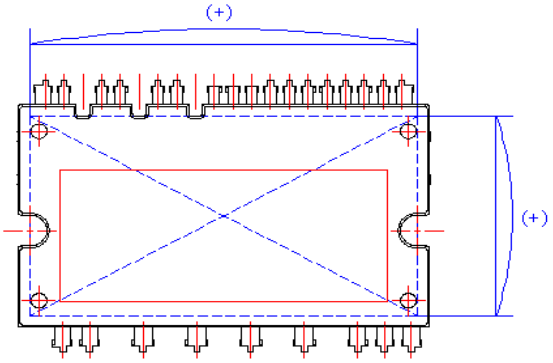
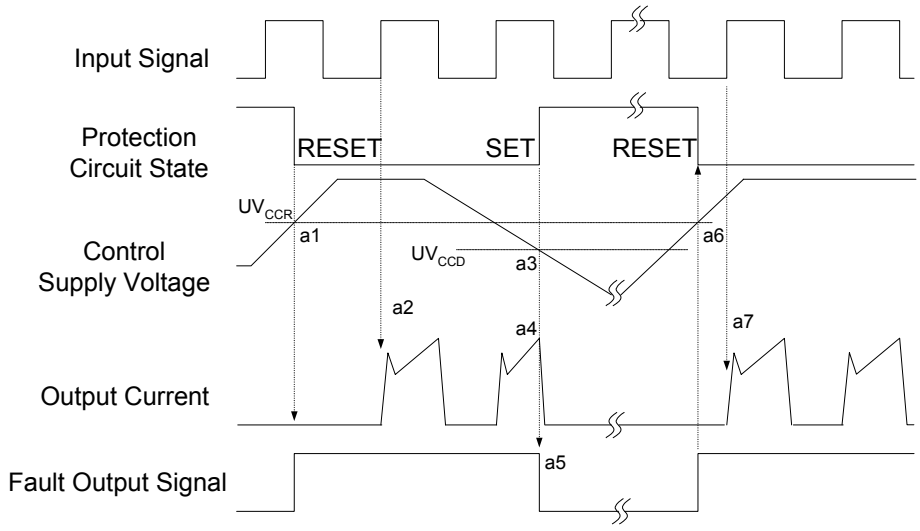


Figure 6. Flatness Measurement Position

Time Charts of Protective Function



a1 : Control supply voltage rises: after the voltage rises UV_{CCR}, the circuits start to operate when the next input is applied.

a2 : Normal operation: IGBT ON and carrying current.

a3 : Under-voltage detection (UV_{CCD}).

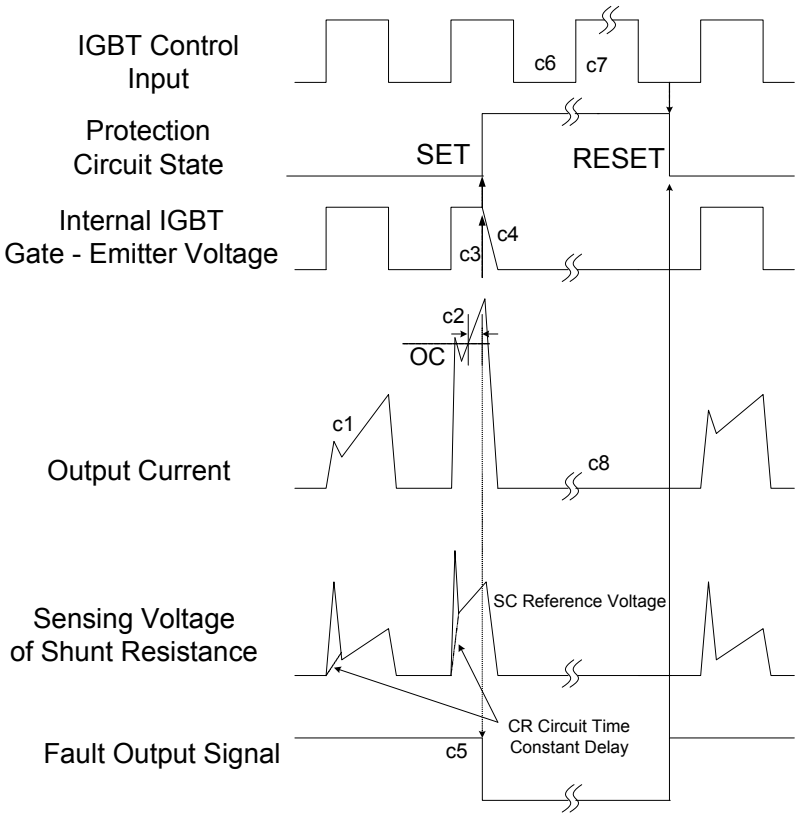
a4 : IGBT OFF in spite of control input condition.

a5 : Fault output operation starts.

a6 : Under-voltage reset (UV_{CCR}).

a7 : Normal operation: IGBT ON and carrying current.

Figure 7. Under-Voltage Protection



(with the external shunt resistance and CR connection)

c1 : Normal operation: IGBT ON and carrying current.

c2 : Over-current detection (OC trigger).

c3 : Hard IGBT gate interrupt.

c4 : IGBT turns OFF.

c5 : Fault output timer operation starts.

c6 : Input “LOW”: IGBT OFF state.

c7 : Input “HIGH”: IGBT ON state, but during the active period of fault output the IGBT doesn’t turn ON.

c8 : IGBT OFF state

Figure 8. Over Current Protection

Recommand circuit for Application

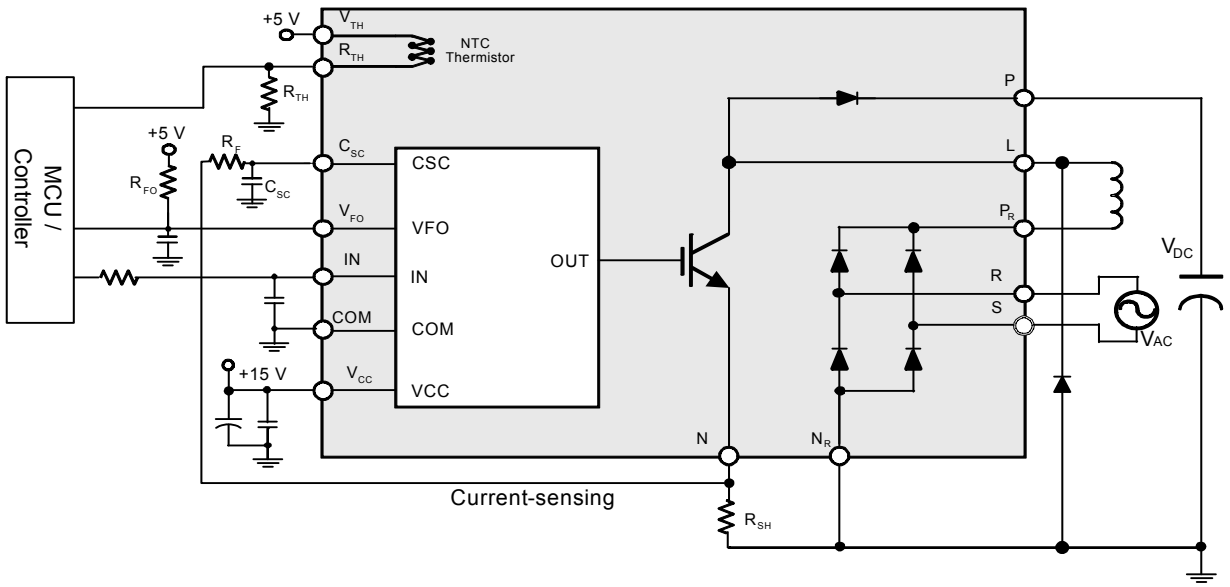
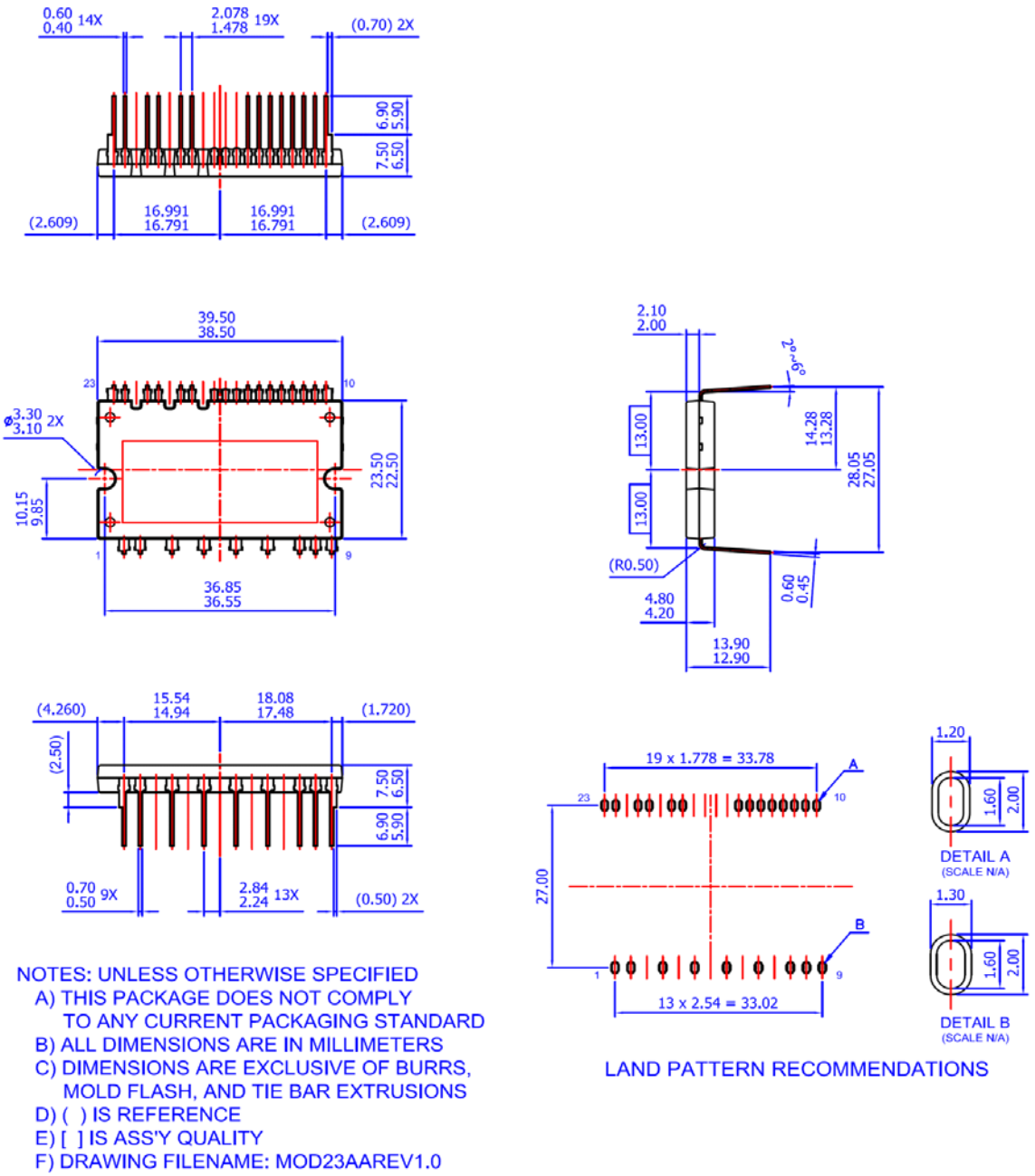


Figure 9. Typical Application Circuit

2nd Notes:

1. To avoid malfunction, the wiring of each input should be as short as possible (less than 2 - 3 cm).
2. V_{FO} output is open-drain type. This signal line should be pulled up to the positive side of the MCU or PFC controller power supply with a resistor that makes I_{FO} up to 1 mA.
3. Input signal is active-HIGH type. There is a 5 kΩ resistor inside the IC to pull-down each input signal line to GND. RC coupling circuits is recommanded for the prevention of input signal oscillation. $R_S C_{PS}$ time constant should be selected in the range 50 ~ 150 ns (recommended R_S = 100 Ω, C_{PS} = 1 nF).
4. To prevent errors of the protection function, the wiring around R_F and C_{SC} should be as short as possible.
5. In the over-current protection circuit, please select the R_F, C_{SC} time constant in the range 1~2 μs.
6. Each capacitors should be mounted as close to the pins as possible.
7. Relays are used in almost every systems of electrical equipment in home appliances. In these cases, there should be sufficient distance between the MCU and the relays.
8. Internal NTC thermistor can be used for monitoring the case temperature and protecting the device from the over-heating operation. Please select an appropriate resistor RTH according to the application. For example, use R_{TH} = 4.7 kΩ that will make the voltage across R_{TH} to be 2.5 V at 85°C of the case temperature.
9. Please use an appropriate shunt resistor R_{SH} to protect the intenal IGBT from the over-current operation.
10. It's recommended that anti-parallel diode should be connected with IGBT.

Detailed Package Outline Drawings



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Rev. I66

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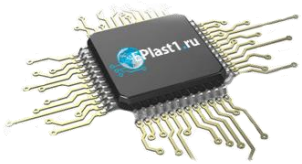

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