Design Guidelines for Power Module Remote On/Off Circuits

Introduction

The remote on/off feature on the board-mounted power modules (BMPMs) allows the user to switch the module on and off electronically. This feature provides greater flexibility in the start-up sequencing and provides fault control of the user's power system. this application note outlines the types of remote on/off circuits, explains the parameters defining their operation, and provides helpful design tips targeted at robust remote on/off control.

Types of Remote On/Off Control

BMP modules are available in **positive logic** and/or **negative logic** versions for remote on/off. Table 1 shows a cross-reference for naming conventions of codes with the different logic types.

Table 1. Remote On/Off Naming Conventions

BMP Code Family	Example Name Without On/Off	Example Name with Negative Logic	Example Name with Positive Logic
MA/MH005	MA005A	NA	NA
MC/MW/ ME005	MC005A	NA	NA
MA/MH010	MA010A	MA010A1	NA
MC/MW/ ME010	MC010A	MW010A1	NA
JC/JW030	NA	JC030A1*	JC030A
CC/CW/DC/ DW025XX	NA	CC025BK1*	CC025BK
CC/CW/DC/ DW025XXX	NA	CC025ABK1*	CC025ABK
FC/FW050/ 100/150	NA	FC150A	NA
FE200	NA	FE200A	NA
JC050/100	NA	JC100A1	JC100A*
JW050/100-150	NA	JW150A1	JW150A*
FW300	NA	FW300A1	NA
FC/FW 250	NA	FW250A1	NA

* Optional remote on/off logic.
Note:NA—not available.

Isolated-Closure Remote On/Off

An isolated closure is a closure with both high- and low-impedance states that sinks current, but does not source current. For on/off control, the closure is between the ON/OFF pin and $V_I(–)$, and can be provided by a device such as a mechanical switch, and open-collector transistor, or an optoisolator. Figure 1 shows an example of an optoisolator connected to a BMPM. Note the $V_{on/off}$ is defined as the voltage at the ON/OFF pin with respect to the $V_I(–)$ pin. $I_{on/off}$ is the current flowing out of the ON/OFF pin.

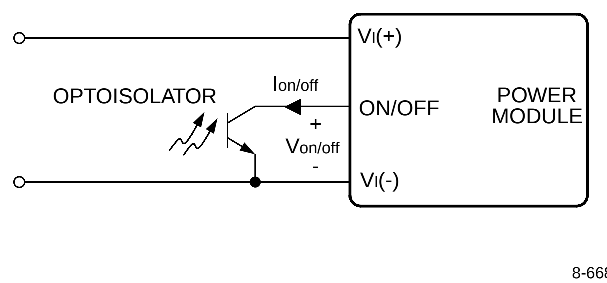

Figure 1. Isolated-Closure Remote On/Off

There are two types of isolated-closure on/off control circuits used in BMPMs. With negative logic, when $V_{on/off}$ is pulled low by the external closure, the unit operates. When $V_{on/off}$ is left isolated to float high, the unit is off. With positive logic, when $V_{on/off}$ is left isolated to float high, the unit operates, and when $V_{on/off}$ is pulled low or shorted to $V_I(–)$, the unit is off. Table 2 summarizes the logic levels and module states.

Table 2. Isolated-Closure Logic Table

Logic State	Negative Logic	Positive Logic
Logic Low– Switch Closed	Module on	Module off
Logic High– Switch Open	Module off	Module on

Types of Remote On/Off Control (continued)

Isolated-Closure Remote On/Off (continued)

Isolated-closure negative-logic on/off control has been established as a Tyco standard being implemented in all new designs. this logic provides accurate control of the module during start-up since the module starts in a known state. Table 3 summarizes the electrical specifications for the ON/OFF pin and the switch for isolated-closure negative-logic on/off.

Table 3. Isolated-Closure Negative-Logic Remote On/Off

Parameter	Symbol	Min	Max	Unit
Remote On/Off; Negative Logic:				
Logic Low—Module On				
Logic High—Module Off				
Module Specifications:				
On/Off current—Logic Low (switch closed)	$I_{on/off}$	—	1.0	mA
On/Off Voltage:				
Logic Low (switch closed)	$V_{on/off}$	0	1.2	V
Logic High (switch open)	$V_{on/off}$	—	18	V
Open-collector Switch Specifications:				
Leakage Current—Logic High ($V_{on/off}$ = 18 V)	$I_{on/off}$	—	50	µA
Output Low Voltage During Logic Low ($I_{on/off}$ = 1 mA)	$V_{on/off}$	0	1.2	V

Table 4. Isolated-closure Positive-Logic Remote On/Off

Parameter	Symbol	Min	Max	Unit
Remote On/Off; Negative Logic:				
Logic Low—Module On				
Logic High—Module Off				
Module Specifications:				
On/Off current—Logic Low (switch closed)	$I_{on/off}$	—	500	µA
On/Off Voltage:				
Logic Low (switch closed)	$V_{on/off}$	0	0.4	V
Logic High (switch open)	$V_{on/off}$	—	11	V
Open-collector Switch Specifications:				
Leakage Current—Logic High ($V_{on/off}$ = 11 V)	$I_{on/off}$	—	10	µA
Output Low Voltage During Logic Low ($I_{on/off}$ = 500 µA)	$V_{on/off}$	0	0.4	V

Table 5. Level-Controlled Remote On/Off

Parameter	Symbol	Min	Max	Unit
Remote On/Off; Level Controlled:				
Unit Off:				
Voltage Level High	$V_{on/off}$	2	8	V
Source Current	$I_{on/off}$	25	160	µA
Unit On:				
Voltage Level Low	$V_{on/off}$	—	1.25	V
Sink Current	$-I_{on/off}$	—	10	µA

Types of Remote On/Off Control (continued)

Isolated-Closure Remote On/Off (continued)

Isolated-closure positive-logic on/off is used in several BMPM families including the 674, Fx020, SK025, and ME025. Table 4 summarizes the electrical specifications for the ON/OFF pin and the switch for isolated closure positive-logic on/off.

In order to satisfy the requirements for the low-impedance state, the closure must maintain a voltage less than the maximum logic-low on/off voltage while sinking the maximum logic-low on/off current. These specifications, therefore, define the maximum saturation or contact voltage of the switch and the current-sink requirement. The logic-high on/off voltage defines the maximum voltage to which the ON/OFF pin floats when the isolated closure is in the high-impedance state. The isolated closure must be rated to handle the logic-low on/off current during its low-impedance state and withstand the logic-high on/off voltage during its high-impedance state. The specified leakage current is the maximum allowable $I_{on/off}$ while the switch is in the high-impedance state. The leakage current of the selected switch must be less than this value over the required application temperature range.

For example, consider the negative -logic specification of Table 3. To activate the module, the user's switch must go to a low-impedance state and be capable of sinking up to 1 mA while providing less than 1.2 V with respect to $V_I(–)$. In particular, high-saturation voltage switches such as Darlington output optoisolators need to be checked carefully against this specification. To turn the module off, the switch must go to a high-impedance state and be able to withstand the 18 V on the output of the ON/OFF pin. The leakage current must be less than 50 µA while the switch is blocking a $V_{on/off}$ of 18 V over the required temperature range.

For negative-logic applications that do not require remote on/off, the ON/OFF pin can be shorted to $V_I(–)$. For positive-logic applications not requiring remote on/off, leave the ON/OFF pin open. control of the on/off with positive logic may require particular care because a falsely triggered switch can result in an undesired shutdown of the BMPM. If noisy traces are routed near the remote ON/OFF pin, it may be advisable to add filtering with a small capacitor (≅100 pF) between the ON/OFF pin and $V_I(–)$. the capacitor prevents high-frequency noise from triggering the on/off circuit.

Level-Controlled Remote On/Off

Some power modules employ a voltage-level-controlled remote on/off. Table 5 shows the specification for a level-controlled remote on/off.

$V_{on/off}$ is defined as the voltage at the ON/OFF pin with respect to the $V_I(–)$ pin. $I_{on/off}$ is the current flowing into the ON/OFF pin. For this type of module, the ON/OFF pin is an input, since control is achieved by applying a voltage and injecting a current.

Voltage level high is the voltage range that must be maintained at the ON/OFF pin ($V_{on/off}$) to turn the unit off. The source current must be provided in order to pull the ON/OFF pin high. From Table 5, between 2 V and 8 V must be provided at the ON/OFF pin to turn the module off. The module draws between 25 µA and 160 µA. Exceeding 8 V may damage the module. The minimum source current can be used as a guideline for the maximum amount of noise current that can be tolerated before shutdown of the module.

Voltage level low is the voltage range that must be maintained at the ON/OFF pin ($V_{on/off}$) to turn the unit on. Sink current is the amount of current that the supply must be able to sink to maintain a logic low. The polarity of this current is opposite the source current. Table 5 specifies a level control that maintains less than 1.25 V while sinking 10 µA.

Figure 2 shows a TTL output control. In order to meet the data sheet specification example in Table 5, the TTL gate must be capable of sourcing 160 µA and sinking 10 µA at an ouput-low voltage less than 1.25 V. The logic voltage, Vcc, must not exceed 8 V. An open-collector logic gate with a pull-up resistor could also be used here. A Vcc of 5 V with a 10 kΩ pull-up would be appropriate for the Table 5 specifications.

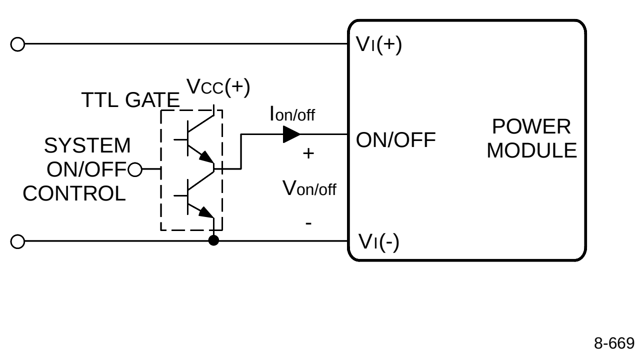

Figure 2. Level control Using TTL Output

Types of Remote On/Off Control (continued)

Level-Controlled Remote On/Off (continued)

An example of a line-voltage driven circuit is shown in Figure 3. The Zener diode is sized to clamp $V_{on/off}$ below the maximum level high voltage, while the resistor limits the power dissipation in the Zener. If a Darlington optoisolator is used, the saturation voltage must be less than the maximum level low voltage (1.25 V in Table 5) to turn on the module.

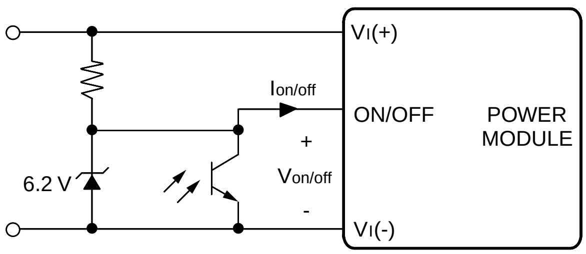

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Figure 3. Level Control Using Line Voltage

Design Guidelines

Power modules equipped with remote on/off respond very quickly when the appropriate signal is applied to the ON/OFF pin. this available speed gives users the most flexibility in their individual applications. However, the lack of filtering that makes this performance possible requires that users take certain precautions in their applications. The following design guidelines aid the user in developing robust, noise-insensitive circuits with which to control the remote on/off.

Preventing High Leakage Current

As stated earlier, a switch with a high-impedance state is required for control of the remote on/off. When in the high-impedance state, switch leakage currents greater than 50 µA may be sufficient to trigger the on/off to the logic-low state. If a transistor is used as the switch, leakage currents of this magnitude can occur if the device is operated in an open-base configuration (see Figure 4).

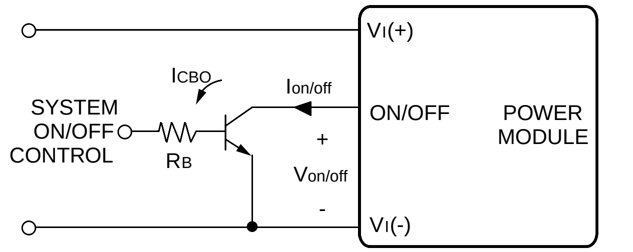

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Figure 4. High-Leakage Open-Base Transistor (Not Recommended)

Here, the typically small collector cut-off current (L_{CBO}) is amplified by the current gain of the transistor, resulting in substantial leakage currents. In addition, maximum leakage currents for the open-base arrangement at temperature extremes are generally not specified by device vendors, and can therefore be very unpredictable for the user. Consequently, use of a base-emitter resistor, as shown in Figure 5, is highly recommended to reduce leakage current and provide a more robust design.

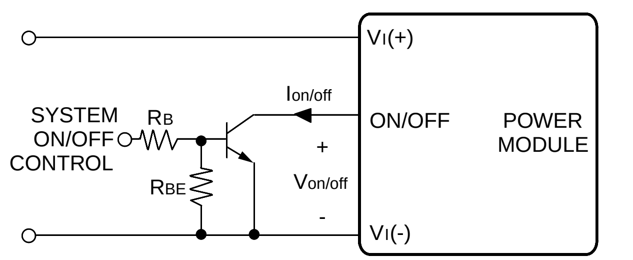

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Figure 5. Recommended Base-to-Emitter Resistor Configuration

Filtering Capacitively Coupled Noise

Designers should be cautions of circuits susceptible to high-frequency noise. Circuits using an open-base transistor as the switch can again be extremely sensitive. Noise coupling into the base of the transistor through parasitic capacitance is amplified by the transistor gain, possibly generating enough collector current to switch the on/off circuit to the logic-low state, as shown in Figure 6.

Design Guidelines (continued)

Filtering Capacitively Coupled Noise
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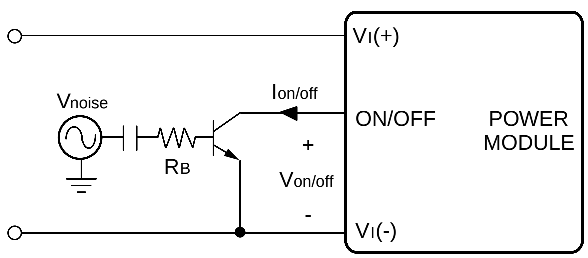

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Figure 6. Susceptible to High-Frequency Noise (Not Recommended)

To minimize switch noise susceptibility, route the path leading to the base as short as possible and away from any potentially noisy paths. Routing the base path close to V_I(–) traces provides some beneficial capacitance. More importantly, use a base-emitter capacitor and/or resistor to filter coupled noise (see Figure 7). Circuits in noisy environments may benefit from a capacitor (≅100 pF) between the remote ON/OFF pin and V_I(–) for high-frequency decoupling.

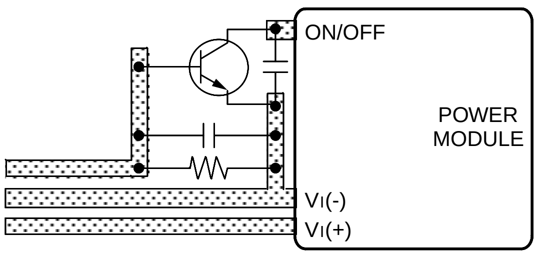

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Figure 7. Recommended Remote On/Off Layout

Minimizing Inductively Coupled Noise

Large loop areas are sensitive to inductively coupled noise. Keep loops in circuits used to control the remote on/off to a minimum area. For example, if a transistor is used, minimize the loop area between the base and emitter (use base-emitter resistors and/or capacitors placed in close proximity to the transistor). Otherwise, inductively coupled currents could be generated in the transistor base, turning the device partially on. Place the transistor close to the module to reduce the area of the loop between the collector and emitter and the power module pins (see Figure 8).

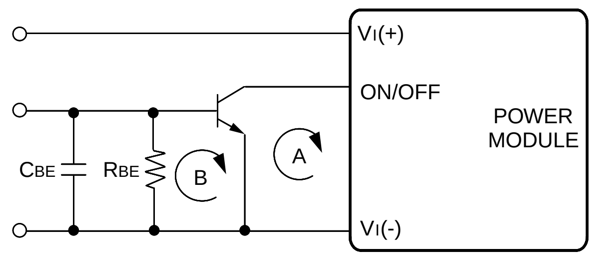

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Figure 8. Minimize Loop Areas A and B

Using an Input Inductor

If an external inductor is used for input filtering, place the switch that controls the module on/off on the module side of the inductor. Otherwise, the inductor appears in series with the switch, and the voltage developed across the inductor can interfere with the on/off control (see Figure 9). In addition, ensure that the inductor does not appear in series with the base-emitter resistor and/or the capacitor between the base and emitter.

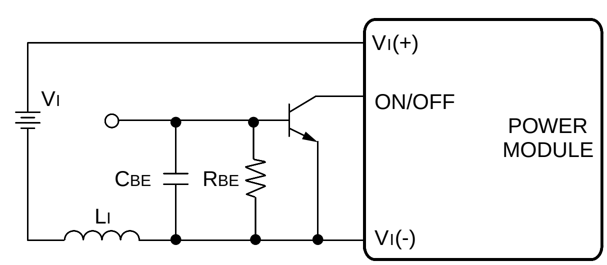

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Figure 9. Properly Placing the Input Inductor.

Design Guidelines (continued)

Start-Up Sequencing

Some start-up sequences can provide a sneak inrush-current path through the remote on/off circuit of the module. In general, the remote ON/OFF pin is normally either open or tied to V_I(–) (perhaps using a long finger on a circuit card) for the start-up sequence. If the pin is open, no sneak paths should be present. However, suppose an isolated-closure positive-logic module is being used (Type 2), and the remote ON/OFF pin is tied to the V_I(–) voltage to keep the module off while the circuit card is inserted in the system. If the V_I(+) voltage is applied to the module before the V_I(–) is applied, the transistor internal to the BMPM's remote on/off circuit can become reverse biased with the input voltage. Overvoltage stress will break down the transistor and destroy the BMPM remote on/off circuit. In this case, ensuring V_I(–) is applied before V_I(+) helps avoid any problem.

Summary

Several types of fast, high-gain circuitry are used to provide the on/off feature. Be sure to follow simple noise-reduction techniques to prevent coupled noise from begin amplified and disrupting desired operation. The noise concerns discussed above are augmented once a circuit pack is operating in a system environment where thermal and noise stresses are at their worst.

Most of the discussion above focused on problems that can result in the false turn-on of the user's switch. In modules with positive logic, this false trigger is usually much more troublesome, since the switch turn-on causes a power module shutdown. Negative logic, where the switch is closed during normal operation, eliminates many of the noise issues described here.

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