Gate Drive Coupler

Notes on using power device gate negative bias power supply

Description

This document provides tips for designing the gate circuit of power devices that customers should be aware of when using general-purpose gate driver couplers such as TLP5752H and smart gate driver couplers such as TLP5214A.
Gate driving circuits for power devices such as IGBT and power MOSFET may use a negative-bias power supply when the gate-input signal is turned off to prevent malfunction due to noise generated when switching high voltage and large current.
This document describes precautions and tips when using a gate negative bias power supply.

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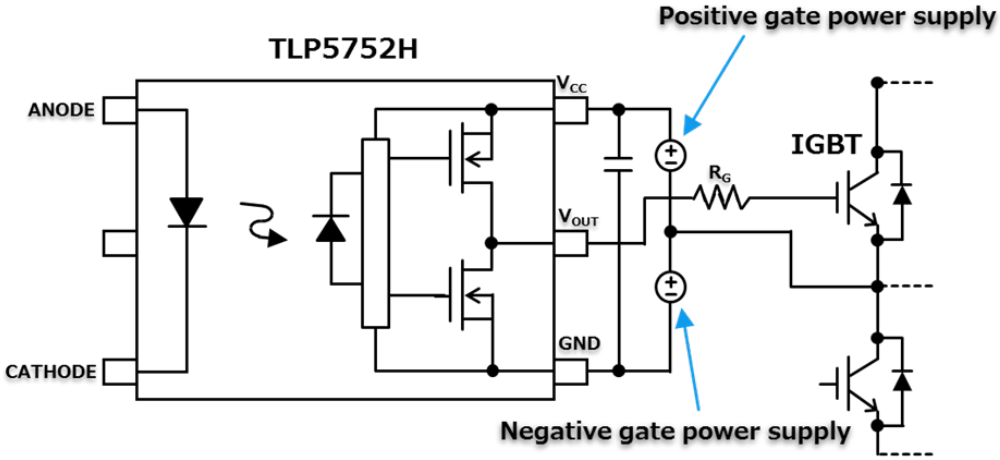
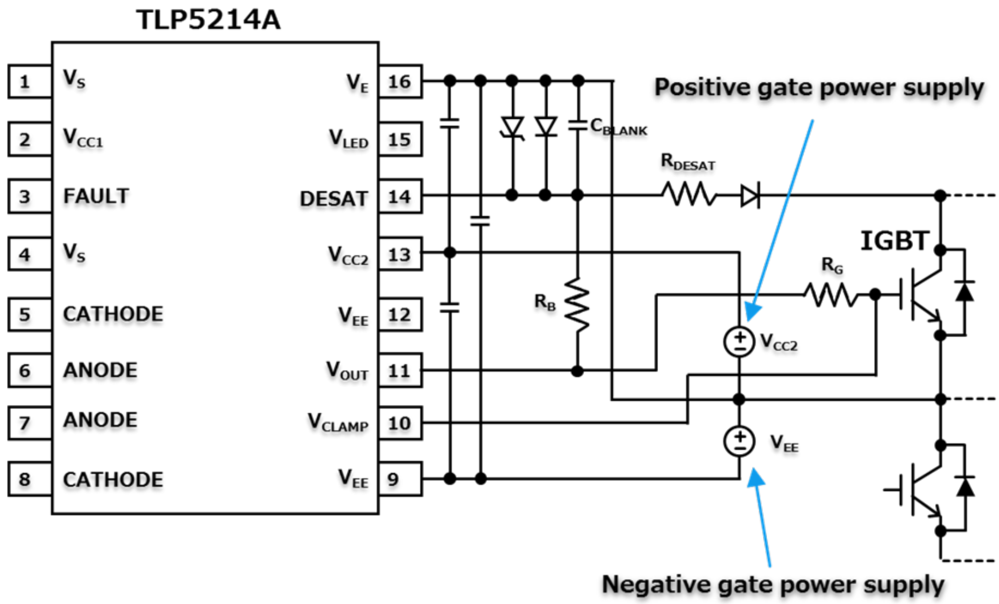
1. Example of circuit when gate negative bias power supply is used

First, an example of a power device gate drive circuit for a general-purpose gate driver coupler and a smart gate driver coupler is shown.
In these circuits, IGBT gate is driving by TLP5752H or TLP5214A. A negative bias power supply is connected between the emitter of IGBT and GND or V_{EE} terminal. When setting the supply voltage, make sure that the combined voltage of the positive bias power supply (V_{CC} or V_{CC2}) and the negative bias power supply does not exceed the maximum rating of the driver coupler or smart gate driver coupler.
When designing a V_{CC} or V_{CC2}, pay attention to UVLO (under voltage protection) function and the gate breakdown voltage of the subsequent power devices such as IGBT.



(Some wiring is omitted for the gate output side circuit, and the gate signal input circuit is omitted.)

Figure 1.1 Example of TLP5752H IGBT gate drive application circuit



(A DESAT circuit is used for the gate output side circuit. Some wiring is omitted. A gate signal input circuit is omitted.)

Figure 1.2 Example of TLP5214A IGBT gate drive application circuit

2. Notes on gate power supply design

Six power devices, such as IGBT or MOSFET, are used in conventional inverter circuits, and more power devices are used in recent multi-level circuits, for example. In particular, the gate power supply of the high-side power devices requires GND isolation from the gate circuit of other power devices, and the floating power supply by the insulated transformer or a bootstrap capacitor is used.
If the smaller isolated power supply is required or if sufficient capacitor capacity cannot be secured, note the following parameters in addition to the gate charge and discharge of the power devices.
General-purpose gate driver coupler: Supply current I_{CC}
Smart-gated driver couplers: Supply current I_{CC}, blanking capacitor charging current and the complementary boosting current,
FAULT Feedback-LED Current

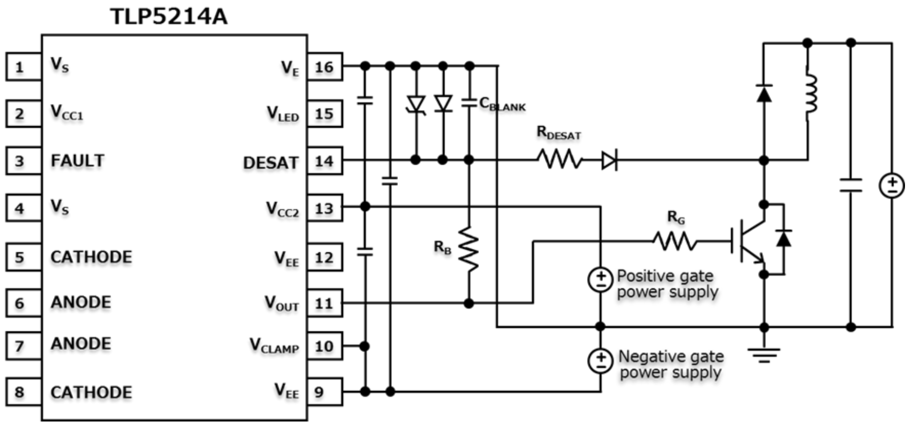
Table 2.1 Comparison of the supply current of TLP5752H and TLP5214A

Part number	Item	Symbol	Typ.	Max
TLP5752H	"H" level supply current	I_{CCH}	1.8 mA	3.0 mA
	"L" level supply current	I_{CCL}	1.7 mA	3.0 mA
TLP5214A	"H" level supply current	I_{CC2H}	2.4 mA	3.8 mA
	"L" level supply current	I_{CC2L}	2.3 mA	3.8 mA

In particular, the smart gate driver coupler may have a FAULT feedback-LED current of 10mA when the protective function is activated, and a blanking capacitor boost current of 9mA* when the gate becomes low level, then a total current of 20mA or more may flow when the protective function is activated.
In addition, the power consumption increases to approximately 480mW. Therefore, immediately stop the system or reset the protection function with the next gate input signal.
The boost current for blanking capacitors is explained in Section 5.
*: VCC_2~V_{EE} = 30V, V_{EE} = -10V, R_B = 1kΩ

3. Example of Operation Waveform When Using Gate Negative Bias

The following figures show the test circuit and waveforms when IGBT is switched by TLP5214A.



Test circuit (The V_{CLAMP} pin is connected to V_{EE}. The output buffer circuit and gate-signal input circuit are omitted)

Measurement conditions
・ V_{CC}=750V, I_C≈540 A, Ta=25° C, reactor: 200 μH

Figure 3.1 IGBT double pulse test TLP5214A gate drive circuit

Examples of switching waveform

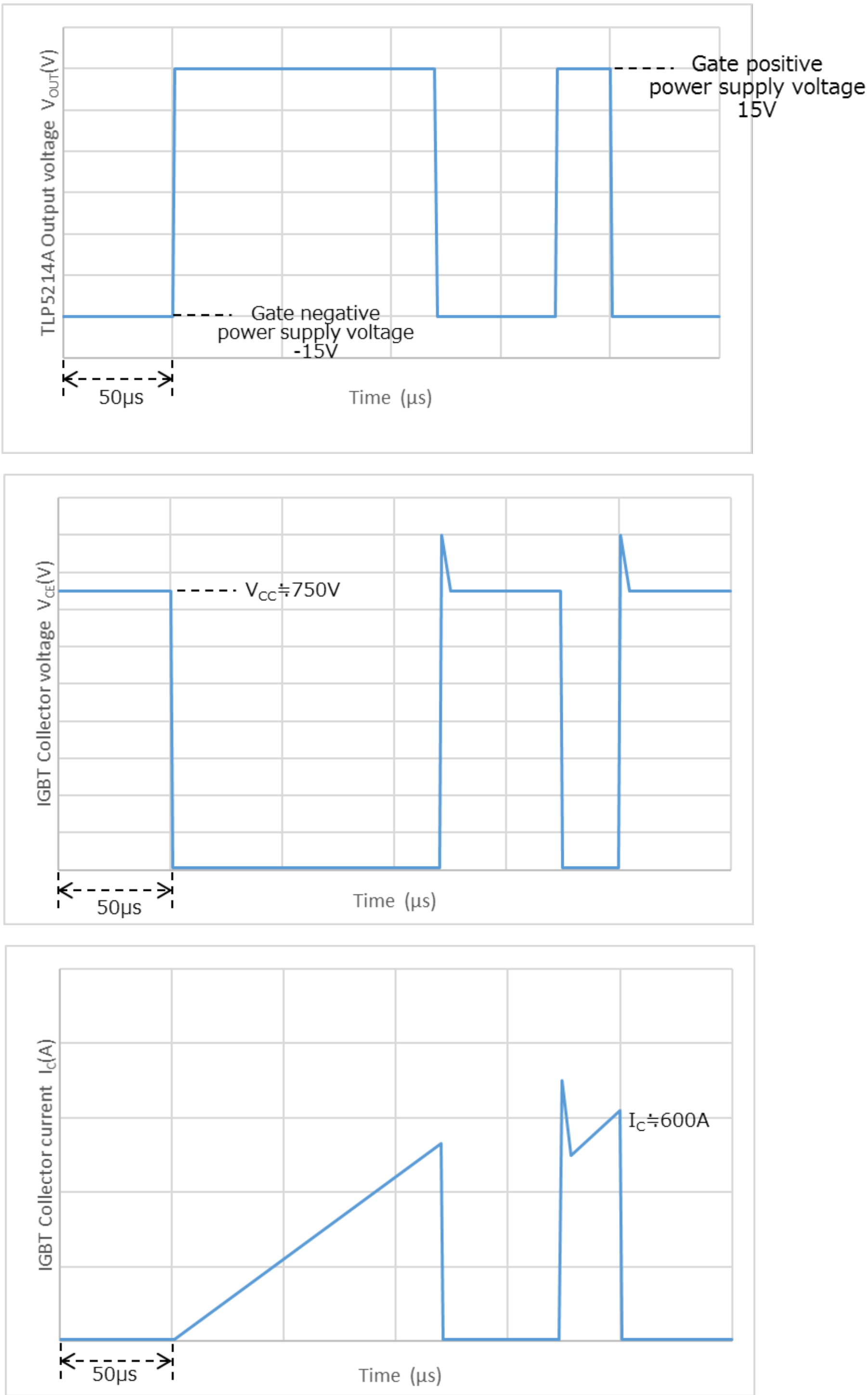


Figure 3.2 IGBT double pulse test examples of waveforms

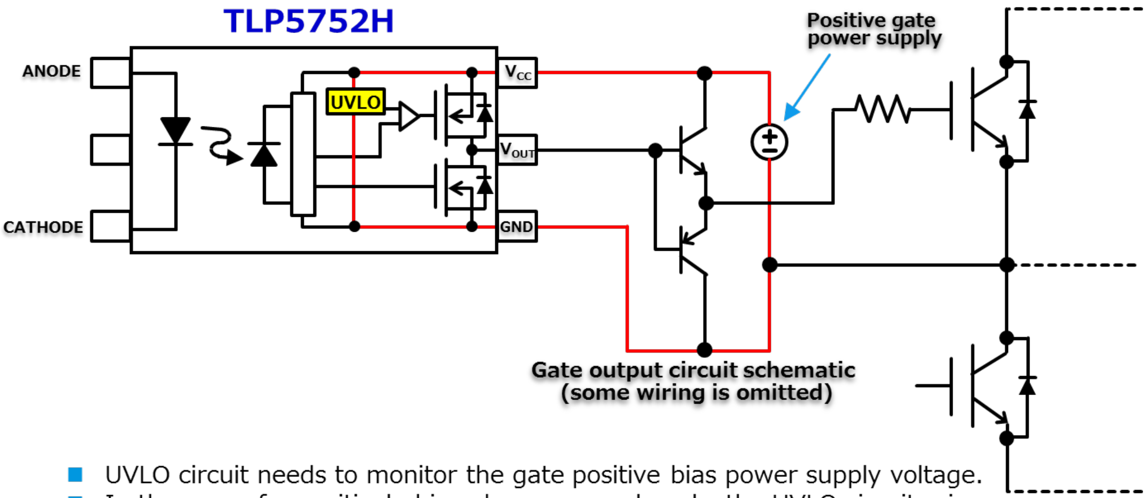
4. Precautions When Using UVLO/AMC function

Outline of UVLO function

UVLO is an abbreviation for Under Voltage Lock Out, which is used to prevent low-voltage gate drive. When power supply voltage falls below the UVLO threshold voltage, an internal circuit stops a gate output in order to prevent desaturated operation. When the power supply voltage rises and exceeds UVLO release voltage, UVLO is released and operation restarts.
When operating a power device such as a IGBT, if the gate voltage falls, the conduction loss becomes large and may cause overheating and device destruction. To suppress this, TLP5752H and TLP5214A have UVLO functions.

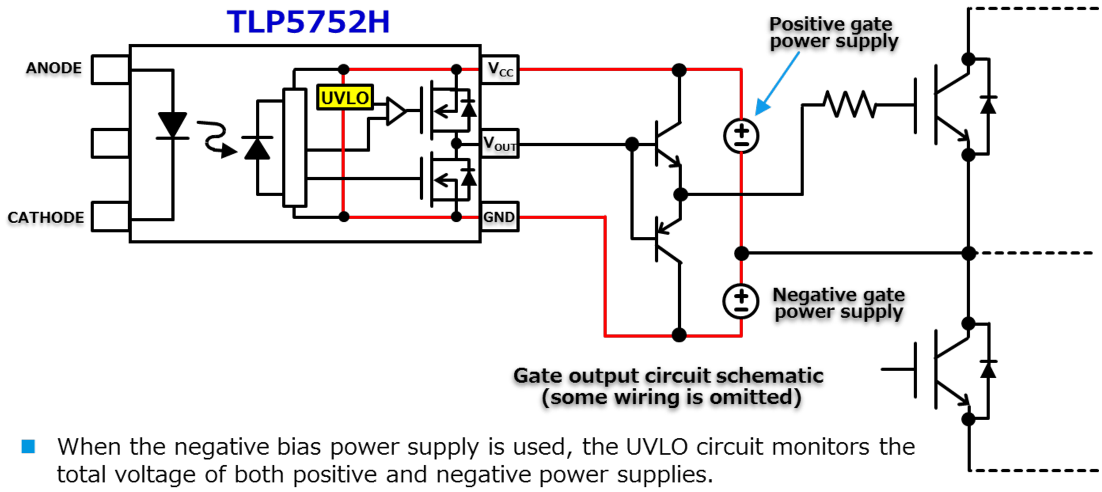
Precautions for using the gate negative bias power supply

Since the reference potential of UVLO of the general-purpose gate driver coupler such as TLP5752H is V_{EE} (GND) terminal, the threshold voltage drops by the negative bias voltage when negative bias is used. If the gate-positive-bias power supply requires a UVLO function, select a smart gate driver coupler.
Since the reference potential for UVLO is V_E terminal for TLP5214A, the positive power supply can be protected independently of the gate-negative bias power supply.



- UVLO circuit needs to monitor the gate positive bias power supply voltage.
- In the case of a positively biased power supply only, the UVLO circuitry is monitoring both ends of the power supply correctly.

Figure 4.1 TLP5752H with gate positive bias power supply

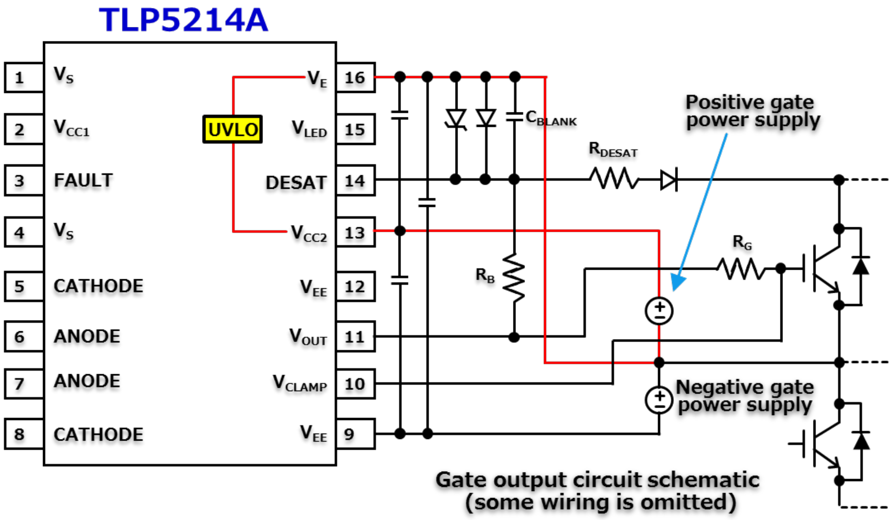


- When the negative bias power supply is used, the UVLO circuit monitors the total voltage of both positive and negative power supplies.
- Since the negative bias power supply voltage is subtracted from the UVLO threshold voltage, the UVLO function will not operate even if the positive bias power supply voltage is abnormally low.

Figure 4.2 TLP5752H with gate positive and negative bias power supplies

Table 4.1 UVLO Threshold Voltage of TLP5752H when using gate negative bias power supply

Conditions	Item	Symbol	Minimum	Maximum
Positive power supply only	UVLO threshold	V_{UVLO}^{+}	12.1V	13.5V
Negative power supply (e.g.-10V) and positive power supply			2.1V (12.1V-10V)	3.5V (13.5V-10V)



■ It is equipped with a VE pin and can operate correctly when used with a negative gate bias power supply.

Figure 4.3 TLP5214A with gate positive and negative bias power supplies

Table 4.2 UVLO Threshold Voltage of TLP5214A when using gate negative bias power supply

Conditions	Item	Symbol	Minimum	Maximum
Positive power supply only	UVLO threshold	V_{UVLO}^{+}	10.5V	13.5V
Negative power supply (e.g.-10V) and positive power supply				

Note that UVLO function of TLP5214A is only applied to the gate positive bias power supply and is not applied to the gate negative bias power supply. If the gate negative bias power supply requires a UVLO function, select the new power device pre-driver coupler TLP5231.

Outline of the AMC function

AMC is an abbreviation of Active Miller Clamp and means a gate malfunction prevention function. When switching the power device in the inverter circuit, the voltage at the midpoint connecting the high-side power device and the low-side power device rises rapidly, causing dV/dt. At this time, if the displacement current flows through the parasitic capacitance of the low-side power device to the gate resistor R_G, the gate voltage rises and the power device is erroneously turned on, causing a short circuit of the upper and lower arms.
The AMC has a function of short-circuiting the gate and emitter or source of the power device, preventing the displacement current from flowing into the gate resistor R_G and preventing erroneous turn on. Although the general-purpose gate driver coupler of Toshiba does not have this function built in, it is contained in the smart gate driver coupler TLP5214A or TLP5214.
Details of AMC function is described in Section 4 of the Smart Gate Driver Coupler TLP5214 Application Notes-Introduction. Please refer it for details.

Combination with gate negative bias power supply
Generally, malfunction caused by parasitic capacitance can be prevented by using a gate negative bias power supply. If AMC is not required, short the V_{CLAMP} terminal and the V_{EE} terminal to disable the function. Since the reference potential of the AMCs is V_{EE} terminal, it can also be used with a gate negative bias power supply. Consider this if it is difficult to adjust the gate-resistance R_G or reduce the wire-impedance.

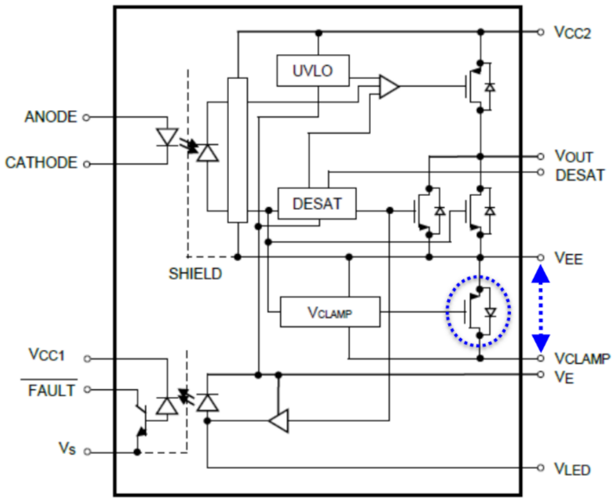


Figure 4.4 Terminal short-circuit locations when the AMC function is not used

5. Precautions for DESAT Circuitry

Details of DESAT circuit is described in the "Smart Gate Driver Coupler TLP5214/TLP5214A Application Notes-Advanced edition- "or "Smart Gate Driver Coupler Tips for Designing DESAT Detection Circuit". Please refer them for details.

Precautions for using the gate negative bias power supply
In case of the negative bias power supply, R_B and SBD are used together, when the input gate signal is off, the current continues to flow through the path shown in the figure below during the off time. Since the current flowing depends on the negative bias power supply and R_B, when complementing the blanking capacitor charge current with the current through R_B, please also note the current flowing through the gate circuit when the input gate signal is turned off.
(e.g. if V_{EE}=-10V, and R_B = 1kΩ, a current of about 9mA will flow.)

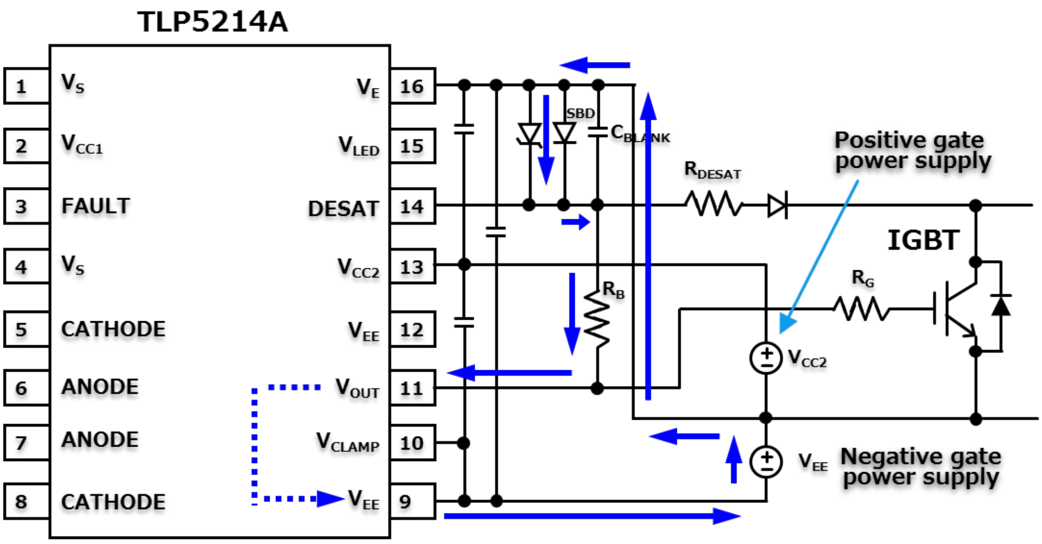


Figure 5.1 TLP5214A the current path when input gate signal is OFF

Revision history

Revision	Date	Page	Description
Rev. 1.0	2021-1-6	-	1st edition

Notes on Contents

1. **Application circuit diagram**
   Functional blocks, circuits, constants, etc. in the block diagram may be omitted or simplified in one part to explain the functions.

2. **Equivalent Circuits**
   The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. **Example of Circuit Constant Calculation**
   Numerical values in the text are provided as an example in order to explain the circuit in an easy-to-understand manner. Operation is not guaranteed with the numerical values described.

Usage Considerations

Notes on Handling of Products

(1) The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment.

(2) Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The usage beyond absolute maximum rating, the mistaken wiring, the unusual pulse noise etc. which are induced from wiring or load are the cause, and may destroy IC. As the result, it may result in emitting smoke and ignition because high current continues flowing into IC. In order to make influence into the minimum, a proper setup of the capacity of a fuse, pre-arcing time, an insertion circuit position, etc. is needed supposing inflow and an outflow of the high current in destruction.

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