MITSUBISHI ELECTRIC

HVIC
APPLICATION NOTE

Mar. 2009

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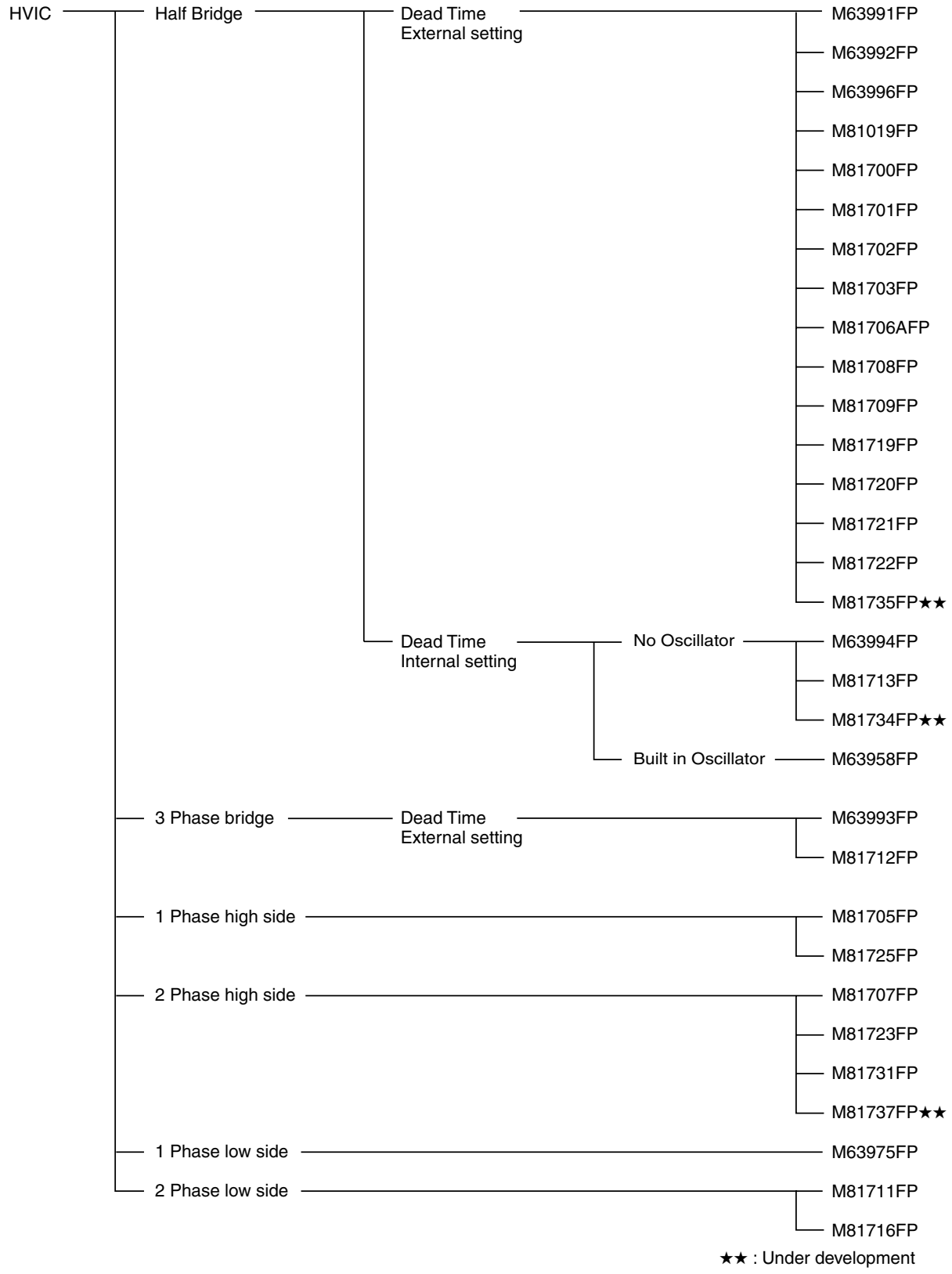
Products line reference by functions

1. Products line reference by functions



Products line reference by targeted applications

2. Products line reference by targeted applications

General Purpose HVIC

Type name	Floating supply source	Output current	Power supply	Driving method	Dead time control/ Interlock(etc)	Number of input signal	UV trip /Reset voltage	Package
M81019FP (Pb free)	1200V	1A	15V	Half Bridge	External/Yes	2 Active-High	10.8V 11.3V	SSOP-24 (24P2Q)
M63991FP		500mA	5V/15V	Half Bridge	External/No	2 Active-High	10.5V 11.0V	SOP-16 (16P2N)
M63992FP		2A						
M63993FP		300mA		3 Phase Bridge	External/Yes	2 (1 phase) Active-Low	8.0V 8.5V Note 1	SOP-36 (36P2R)
M63994FP		500mA	15V	Half Bridge	Interlock/–	1 Active-High (IN to HO)	8.0V 8.5V	SOP-8 (8P2S)
M63996FP (Pb free)		2A			External/No	2 Active-High	10.5V 11.0V	SOP-16 (16P2N)
M81700FP					External/Yes (With Shutdown)		8.2V 8.6V	
M81701FP					External/Yes			
M81702FP					External/No (With Shutdown)			
M81703FP					External/No			
M81705FP		+150mA -125mA		One Phase High Side	–/–	1 Active-Low	11.0V 11.5V	SOP-8 (8P2S)
M81706AFP (Pb free)	600V	+120mA -250mA		Half Bridge	External/Yes	2 Active-High	8.2V 8.9V	
M81707FP (Pb free)		100mA		Dual High Side	–/–		8.2V 8.6V	SOP-16 (16P2N)
M81708FP (Pb free)		+120mA -250mA		Half Bridge	External/Yes		8.2V 8.9V	
M81709FP (Pb free)		2A						
M81712FP (Pb free)		+200mA -500mA		3 Phase Bridge	External/Yes	2 (1 phase) Active-High	8.0V 8.5V	SOP-28 (28X9R)
M81713FP (Pb free)		500mA		Half Bridge	Interlock/–	1 Active-High (IN to HO)	8.2V 8.9V	SOP-8 (8P2S)
M81719FP (Pb free)		+120mA -250mA		Half Bridge	External/No	2 Active-High	8.2V 8.9V	SOP-8 (8P2S)
M81720FP (Pb free)					External/Yes			
M81721FP (Pb free)		1A					10.8V 11.3V	SSOP-24 (24P2Q)
M81722FP (Pb free)		3A			External/No		8.2V 8.9V	SOP-8 (8P2S)
M81723FP (Pb free)		+100mA -130mA		Dual High Side	–/–	1×2 Active-High	8.0V 8.4V	SOP-16 (16P2N)

Note1 : UV circuit is built in high side only, low side has no UV circuit.

Products line reference by targeted applications

General Purpose HVIC (Continue)

Type name	Floating supply source	Output current	Power supply	Driving method	Dead time control/ Interlock(etc)	Number of input signal	UV trip /Reset voltage	Package
M81725FP (Pb free)	600V	3A	15V	One Phase High Side	–/–	1 Active-High (IN to OUT)	8.2V 8.9V	SOP-8 (8P2S)
M81731FP (Pb free)		1A		Dual High Side	–/–	1×2 Active-High	8.2V 8.9V	SOP-16 (16P2N)
M81734FP (Pb free)★★		500mA		Half Bridge	Interlock/–	1 Active-High (IN to HO)	8.2V 8.9V	SOP-8 (8P2S)
M81735FP (Pb free)★★					External/Yes	2 Active-High	8.1V 8.6V	SOP-16 (16P2N)
M81737FP (Pb free)★★		-200mA -260mA		Dual High Side	–/–	1×2 Active-High	8.0V 8.4V	

General Purpose LVIC

Type name	Floating supply source	Output current	Power supply	Driving method	Dead time control/ Interlock(etc)	Number of input signal	UV trip /Reset voltage	Package
M63975FP	24V	600mA	15V	Single Low Side	–/–	1 Active-Low	11.5V 12.0V	SOP-10 (10P2N)
M81711FP (Pb free)		+800mA -600mA		Dual Low Side		2 Active-Low	–	SOP-8 (8P2S)
M81716FP (Pb free)						2 Active-High		

Fluorescent Lamp HVIC

Type name	Floating supply source	Output current	Power supply	Driving method	Dead time control	Lamp connection/ Abnormal detection	Lighting sequential control	UV trip /Reset voltage	Package
M63958FP	600V	500mA -250mA	15V	Half Bridge	Internal	Internal	Internal	9.6V 11.4V	SOP-16 (16P2N)

★★ : Under development

Features, Attention points when using HVIC

3. Features

· By 600V junction isolation process with MFFP (Multiple Floating Field Plate) structure, 8V/24V CMOS, 24V Bipolar and high voltage DMOS can be built in one chip. As a result, control circuits, protection circuits, high voltage level shift circuits, and driver circuits can be achieved by single-chip.

· MCU, DSP can control IGBT/MOSFET by HVIC directly without photo coupler.

· By RESURF (REduced SURface Field) technology, Mitsubishi Electric Corporation has developed a 1200V horizontal MOSFET for level shift circuits.
We have further developed a split RESURF structure for level shift technology without high-potential wiring. Our HVIC (high-voltage integrated circuits) have a high rating of 1200V.

· By adding bootstrap circuit outside of HVIC, high side and low side can supplied with a signal power source. It can make system miniaturization.

4. Attention points when using HVIC

4-1. High side power supply (Floating power supply method)

①Floating power supply method

The source potential referenced to power GND of high side power unit (MOSFET) would have to be close to the voltage of the terminal HV from 0V by operating the application. Therefore, to drive high side MOSFET, the power supply of the high side drive circuit of HVIC should become potential whose only V_{CC} is higher than the source potential on high side MOSFET.
The method to apply this voltage calls the floating power supply method.
Fig. 1 shows the example of connecting the floating power supply method.

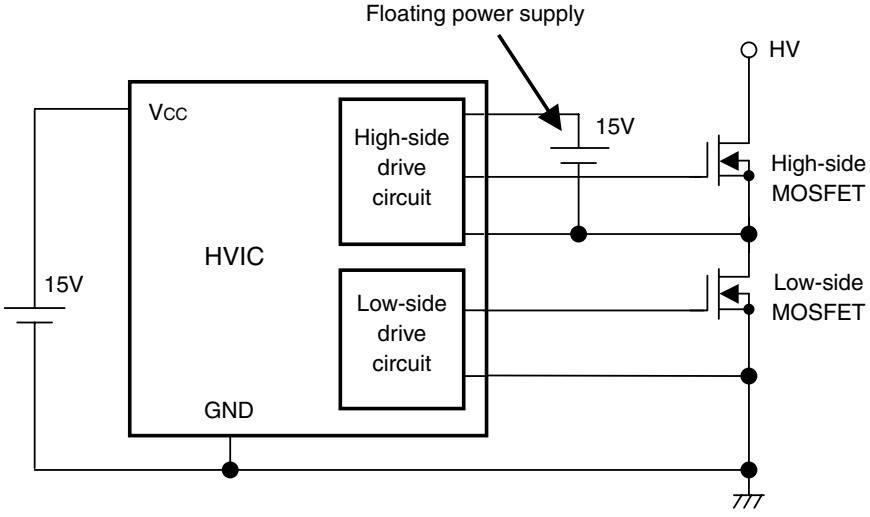


Fig. 1 Floating power supply method

4-2. High side power supply (Bootstrap circuit method)

①Bootstrap circuit method & Basic operation

The above mentioned floating power supply can be replaced by a capacitor. It inserts a set of resistor (R1) and bootstrap diode (D1) between Vcc terminal and VB terminal. Then it inserts the bootstrap capacitor (C1) between VB terminal and VS terminal. So we call this configration bootstrap circuit method.

Fig.2 shows bootstrap circuit.

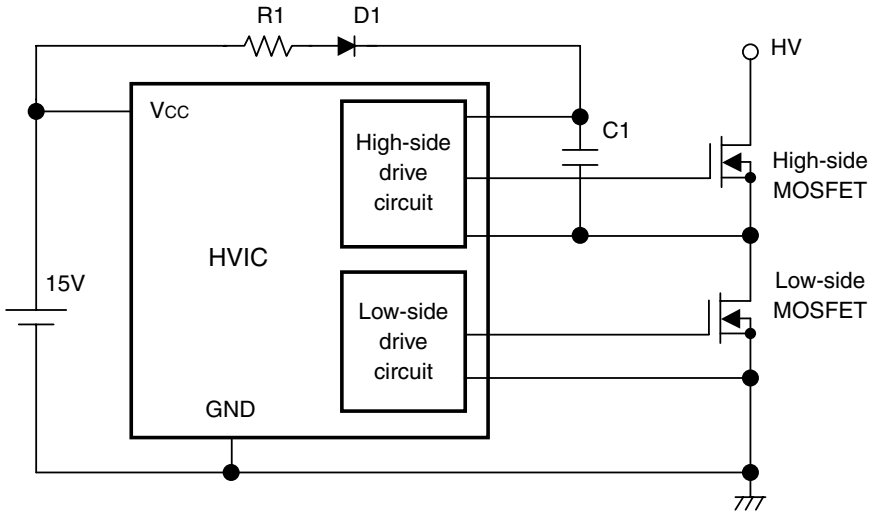


Fig. 2 Bootstrap circuit method

②Electrical charge and discharge current route when HVIC operates

Fig. 3 shows the electrical charge and discharge current route to C1 when HVIC is regularly operated.

Heavy line: Charge route and broken line: Electrical discharge route

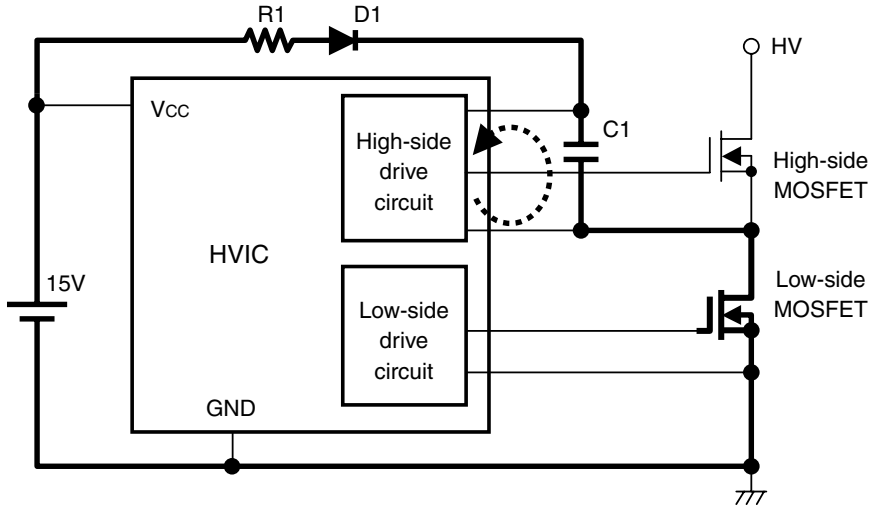


Fig. 3 Electrical charge and discharge current route

Attention points when using HVIC

③Initial charge and the voltage of the terminal C1

Although it was shown that the high side drive circuit of HVIC operates with the voltage between terminals of C1 in the preceding clause, it is necessary to charge with the voltage of C1 up to a high voltage (more than the trip voltage + margin of UV circuit of HVIC) enough first of all to operate this high side drive circuit after the power supply is turned on to HVIC.

This is called an initial charge of C1, and it is necessary to input the control signal that turns on low side MOSFET and to charge with initial of C1 in Fig. 3.

Moreover, at the time of regular operation of HVIC, as for the time which the low side MOSFET of Fig. 3 turns off, the potential of C1 falls by the consumption current of the high side drive circuit of HVIC, and the leak current of C1. Also, it is necessary to set off time of the low side MOSFET so that the voltage of the terminal C1 should not become below the trip voltage of the UV circuit of HVIC.

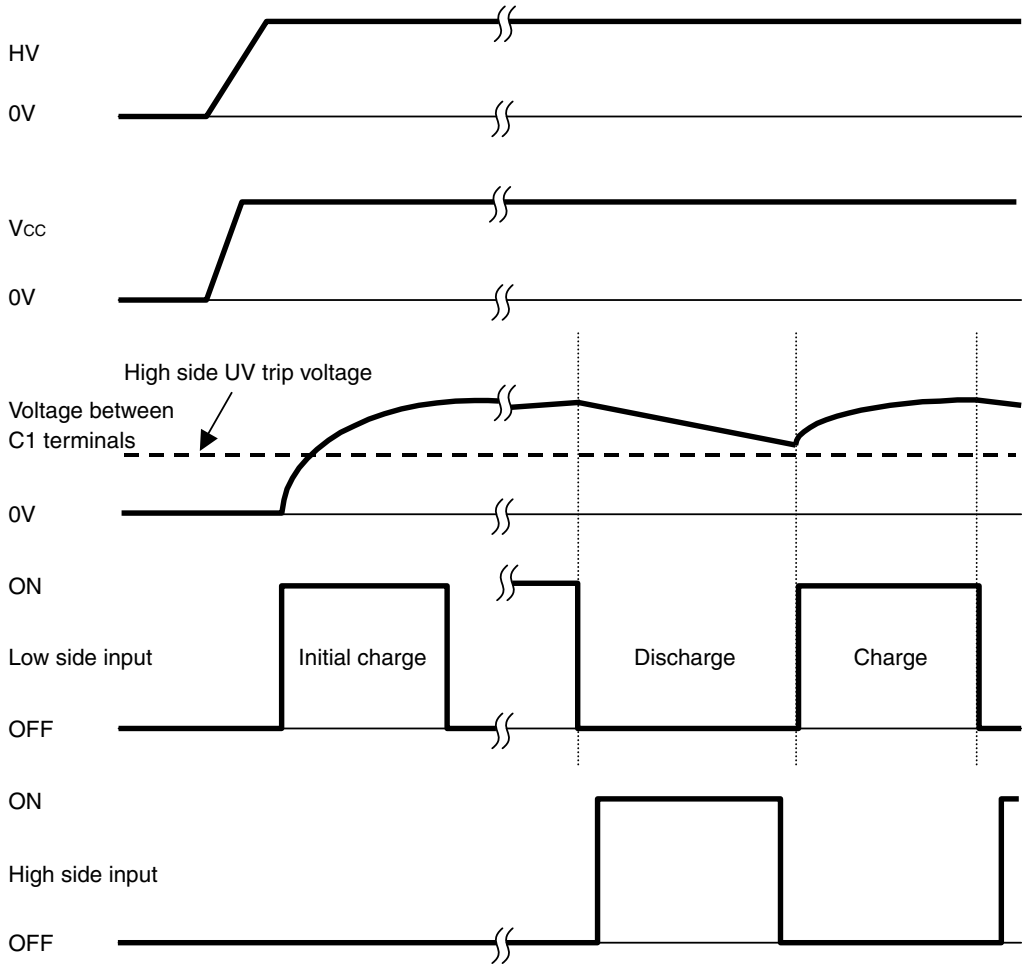


Fig. 4 Charge electric discharge timing chart when initial charge and regularity operate

Attention points when using HVIC

④Each constant value setting (R1,C1,D1) of the bootstrap circuit

· Setting of bootstrap capacitor (C1)

The above-mentioned ③, the amount of drop [in the ON time of the high side MOSFET at the time of regular operation] between C1 terminals sets up so that it may have a margin to high side UV trip voltage.

The maximum ON time of the high side MOSFET : T1
High side drive circuit consumption current of HVIC : IB
Terminal C1 electrical discharge allowance voltage : ΔV

$$C1 = IB \times (T1/\Delta V) + margin$$

✻ About the kind of capacitor, it recommends that the electrolysis capacitor which was excellent in temperature and the frequency characteristic connected with the ceramic capacitor for noise removal which was excellent in temperature and the frequency characteristic in parallel.

· Setting of resistor (R1)

The above-mentioned ③, time to charge C1 is decided by C1 and R1. Therefore, when the minimum ON time of the low side MOSFET is set to T2, the value of R1 is set up so that it may become a time constant of C1xR1 to which only ΔV can charge C1 in the time of T2.

· Selection of diode (D1)

The high-speed recovery diode of the brake down voltage 1200V/600V or more is recommended.

4-3. Prevention of simultaneous turn-on of high/low-side devices (Applicable to HVICs with built-in interlock)

Some of our HVICs contain an interlock feature which prevents the high-side and low-side devices from simultaneously becoming “high” state when high/low-side simultaneous turn-on signals are input. The interlock feature comes in two types of specifications as follows. For the type of the interlock built in each HVIC, please refer to the datasheet.

4-3-1 Interlock for turning the high/low-side outputs to “low” in response to the input of simultaneous turn-on signals

· Active high type

When HIN = LIN = “high” (ON), the logic circuit shown in Fig. 5 works to turn the high-side and low-side outputs to “low” (OFF) thus preventing a short circuit between external power devices (IGBT and power MOSFET).

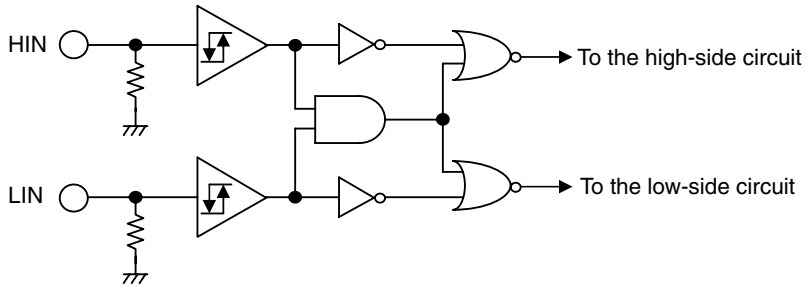


Fig. 5 Circuit for Prevention of Simultaneous Turn-On of High/Low-side Devices

· Active low type

The high/low-side outputs become ON when HIN = LIN = “low,” i.e., the circuit logic is inverse to that of the active high type described above. However, the simultaneous turn-on prevention circuit is configured according to the same principle as for the active high type.

4-3-2 Interlock for maintaining the high/low-side outputs unchanged despite the input of simultaneous turn-on signals

· Active high type

When HIN = LIN = “high” (ON), the logic circuit shown in Fig. 6 works to keep the high-side and low-side outputs in the same state as before the input of simultaneous turn-on signals thus preventing a short circuit between external power devices (IGBT and power MOSFET).

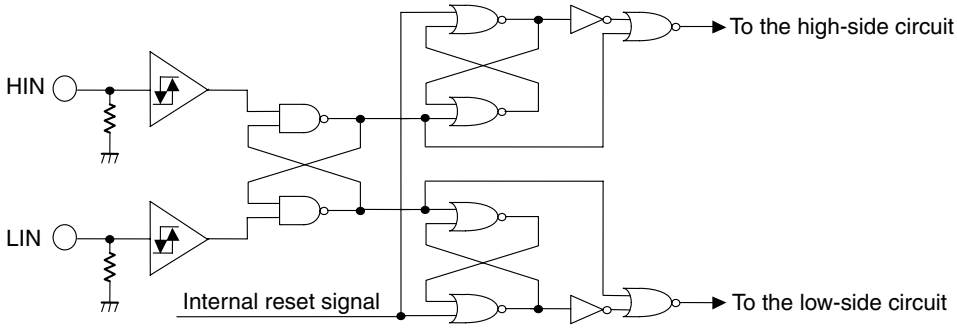


Fig. 6 Circuit for Prevention of Simultaneous Turn-On of High/Low-side Devices

· Active low type

The high/low-side outputs become ON when HIN = LIN = “low,” i.e., the circuit logic is inverse to that of the active high type described above. However, the simultaneous turn-on prevention circuit is configured according to the same principle as for the active high type.

Attention points when using HVIC

4-4. Gate voltage of power unit (IGBT/MOSFET) in operation

The gate voltage of the power unit might change according to the influence of a parasitic unit the characteristic of HVIC and in the power unit and the mounting substrate condition when carrying out ON/OFF operation of the power unit (IGBT and power MOSFET) by using HVIC and the malfunction be caused.
The mechanism and improvement plan of such a malfunction are shown below. (The bootstrap circuit is omitted) The relation of incorrect operation by parasitic capacitance is shown in Fig. 7.

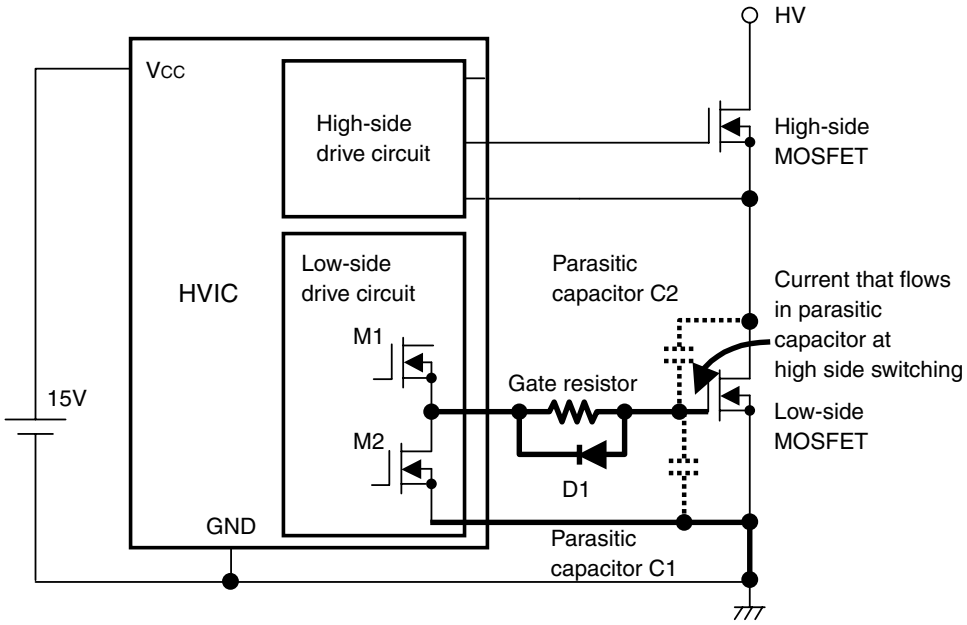


Fig. 7 Relation between parasitic capacitor and malfunction of external power unit

· Mechanism of malfunction

①Low side MOSFET has been turned off.

②OFF->ON [the high side MOSFET] rapidly.

③By the source potential of high side MOSFET and the drain potential of low side MOSFET rise, dV/dt apllied, and having impedance between the drain–gate–source (GND) of the low side MOSFET, when the gate potential rises with impedance voltage drop, and the threshold on low side MOSFET is exceeded, high side/low side power MOSFET is short-circuited.

At this time, the current route from the drain of the low side MOSFET to source (GND) is as follows.

Case 1) When the parasitic capacitor of C2 and C1 is large, gate voltage rises to the value divided by capacitor.

Case 2) The current that flows in C2 passes D1, and flows in M2 turning on in HVIC.
At this time, the gate voltage rises to M2×I+VF (D1).

Case 3) When current flows in the route of the heavy line of Fig. 7, the potential of a gate rises by the wiring inductance.

Case 4) Mixture of above-mentioned 1~3.

· Improvement plan

Case 1) Select the small capacitance of C1 and C2 for a power unit.

✻ Because connecting the capacitor of big external capacity with the same position as C1, and lowering the impedance in the gate terminal of MOSFET in the appearance have the possibility of latch-up by an excessive rush current when the low side output terminal of HVIC changes from OFF to ON. Thus this method is not recommended.

Case 2) Because of resistance value of M2 cannot be changed, you must select the diode that has small VF.

Case 3) The wiring length is shortened and fat.

4-5. Voltage of high side power supply terminal

HVIC might malfunction because of arrangement and the wiring for the unit on the mounting substrate when the large current switching is done by using a high-speed switching unit for the load of HVIC. Fig. 8 shows the circuit connection of L-load.

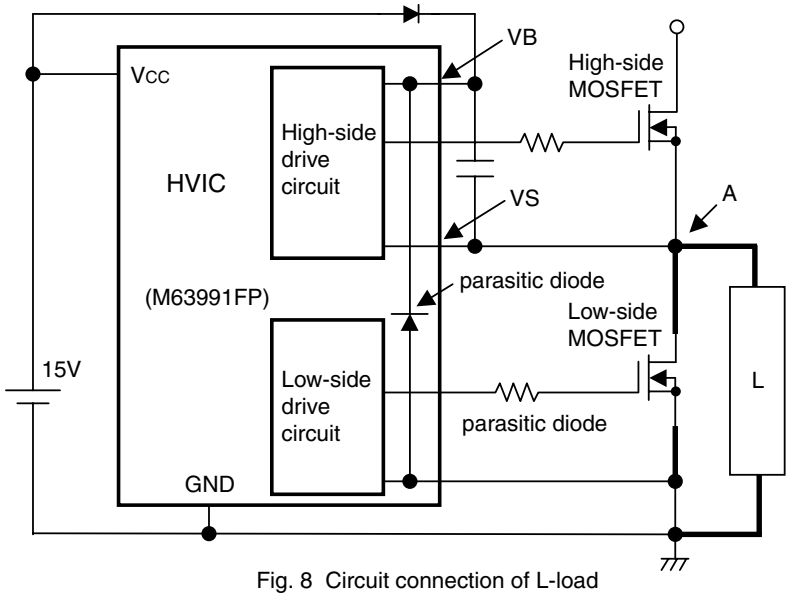


Fig. 8 Circuit connection of L-load

· Mechanism of malfunction

①Low side MOFET has been turned off.

②High side MOSFET is turned on, and a large current flows to L load.

③High side MOSFET is turned off at high speed.

④Low side MOSFET enters a freewheeling mode, and the drain potential is less than a source potential. (The potential of A point falls less than that of GND, and becomes minus potential.)

⑤The potential of the VS terminal of HVIC becomes minus potential correspond with the potential of A point, too.

⑥The Vs potential may fall so that the potential of the VB terminal of HVIC decreases.

⑦When the VB terminal falls on minus potential, a parasitic diode in HVIC is turned on. A large current flows.

⑧HVIC causes the malfunction.

· Improvement plan

① The switching speed on high side MOSFET is down.

② It inserts a resistor between A point and VS terminal. As a result, the voltage of VS terminal is not lowering.

③ It inserts a diode which has small VF between GND terminal and VS terminal.

④ The wiring length of the bold line part is shortened as much as possible.

4-6. Minimum transmission Vcc voltage

The “minimum transmission Vcc voltage” is the minimum level of supply voltage required for signal transmission, and not the voltage at which the HVIC can meet all specified characteristic requirements, such as transmission time and output performance, under recommended operating conditions.

<Regarding the phenomenon that the IC output is not reset (not turned off) despite the input of “low” signal (signal level to turn off the output) when Vcc voltage drops while VB supply voltage is normal>

Fig. 9 shows a block diagram of the M81706AFP, and Figs. 10 and 11 show the high-side I/O timing charts.

High-side I/O signals of this HVIC (M81706AFP) are transmitted as follows.

When the “high” signal is applied to the high-side input (HIN) pin, one-shot ON pulse occurs at the rising edge timing of the signal and enters the reset input pin of the latch circuit. As a result, the output of the latch circuit becomes “high,” turning the high-side output (HO) status to “high.” Similarly, when the “low” signal is applied to the HIN pin, one-shot OFF pulse occurs at the falling edge timing of the signal and enters the reset input pin of the latch circuit, causing its output to become “low,” turning the HO status to “low.”

In this way, the HO status becomes “high” or “low” in accordance with a one-shot pulse signal. If Vcc voltage drops below the minimum level for signal transmission, however, OFF pulse signal might not be transmitted, causing the HO status to remain “high” even when the signal input to the HIN pin switches from “high” to “low” at the timing of Vcc voltage falling to the minimum level for signal transmission, as shown in Fig. 10.

If the HO status remains “high” and Vcc voltage rises although the signal input to the HIN pin is “low” (signal level to turn off the output), the HO status will not be turned “low” until the next falling edge of signal input to the HIN pin, as shown in Fig. 11. If the high-side supply voltage (VB) drops and activates the under-voltage (UV) lockout circuit, however, the HO status will become “low” regardless of the HIN status.

Attention points when using HVIC

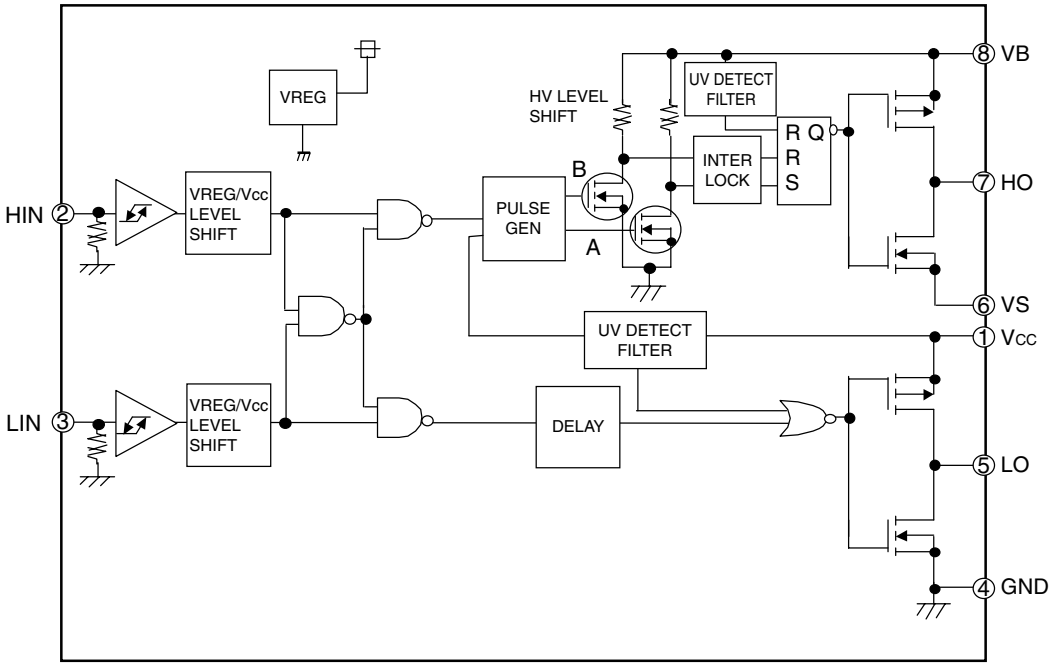


Fig. 9 Block Diagram of HVIC [M81706AFP (High Active)]

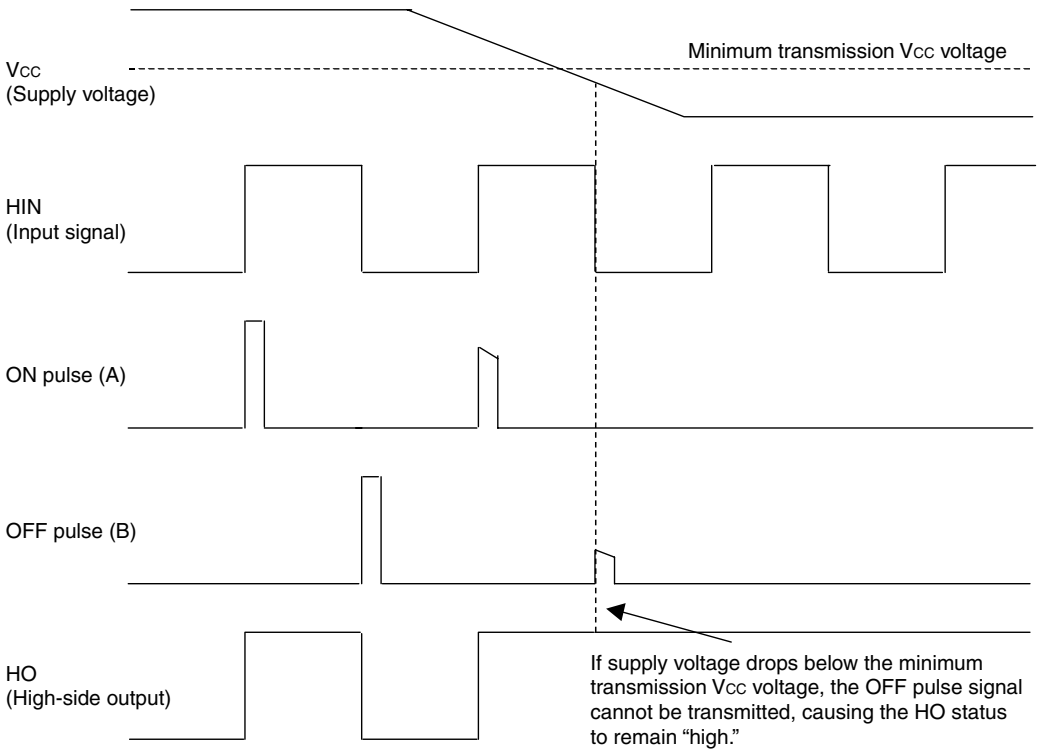


Fig. 10 I/O Timing Chart for the Case Where HO Status Remains "High" When Vcc Voltage Drops

Attention points when using HVIC

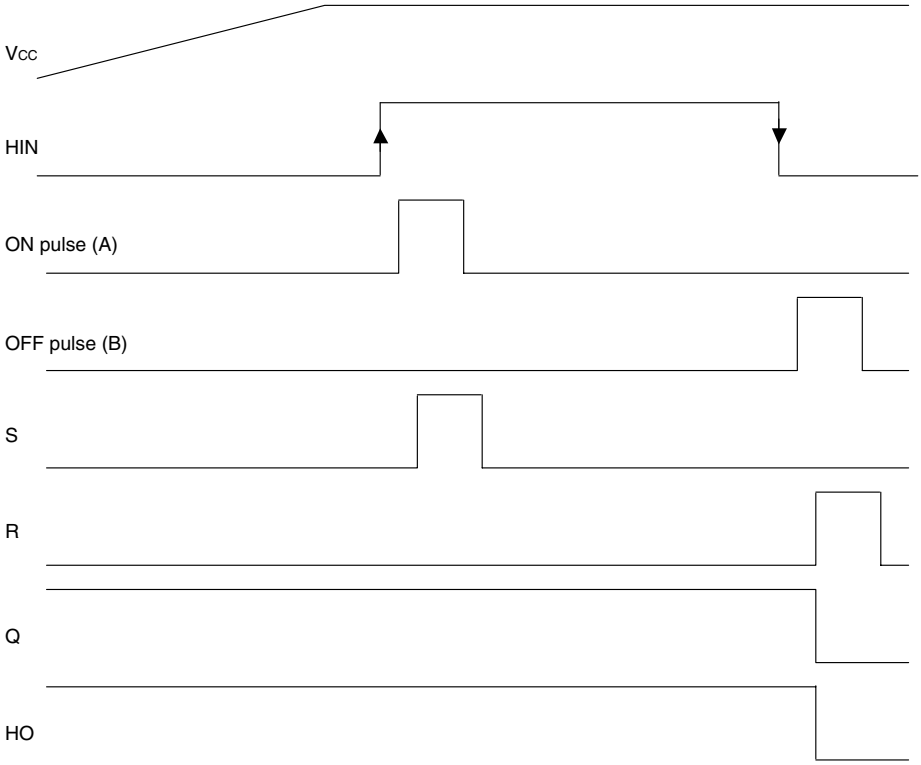


Fig. 11 I/O Timing Chart for the Case Where HO Status Remains “High” and Vcc Voltage Rises

Improvement plan

- The moment when Vcc voltage drops below the recommended operating voltage, the OFF signal is applied to the HIN pin to turn the HO status “low.”
- If the HO status remains “high,” bootstrap voltage will drop due to current consumption in the high-side circuit, so that the under-voltage lockout circuit is activated in a certain period of time, turning the HO status “low.” Therefore, signal input is commenced in the abovementioned certain period of time after the rise of Vcc voltage.

5. Notes in handling

■ To use HVIC safely

The production activity is done to reliability ..quality.. especially in the development of the HVIC unit (Hereafter, it is called an unit) and production with the best of care. However, the reliability of the unit is greatly influenced by not only a factor peculiar to the unit but also use conditions. Please often read notes shown next when you handle our unit and use it correctly.

5-1. Attention keeping unit

⚠ Cautions	
Packaging	· The packing box and the interior material of the unit shipped by our company come to be able to endure a constant environment and the condition. However when the packing box is exposed to the outside impact, rain water and pollution, the packing box and the interior material might break and the unit is exposed. Please note handling enough.
Carry	· Please put the packing box on the correct direction while transporting it. It keeps inverted, and it leans it. And then unnatural power might join, and it breaks. (this side up) · If it throw out or it drop, the unit might break. (Fragile attention) · It is necessary not to get wet by the water. Please note that it is wetting for the transportation at the rainfall snow. (water wet attention) · When another of the above-mentioned point is transported, a mechanical vibration and the impact are reduced as much as possible. Please note the way. The unit might break.
Keeping	· The temperature and the humidity of the place where the unit is kept as a standard with 5-30˚C and about 40-60% Normal temperature is preferable, and avoid each of the temperature and humidity too far apart, please. Moreover, keep it in the place where the temperature change drastically, the dew of moisture happens in the surface of the unit and the lead part. Thus keep it in the place where the temperature change is a little as much as possible, please. · Keeping by the place where causticity gas generates, an organic solvent or explosiveness dust, etc. exists causes corrosion, the malfunction, and destruction of the units. Thus avoid these places. · You must do not pile up the packing box high, and put the heavy one on the packing box. As a result, the packing box breaks, the cargo collapses, and it is dangerous.

5-2. Cautions when using unit

⚠ Cautions	
Long storage	If you need long storage, you must do not open the wrapping box. Moreover, if you use the units kept at putting on a very bad environment and a long term is passed, you must confirm it without the wound, dirt or rust.
Ratings Characteristics	Absolute maximum ratings defines that our company guarantees maximum ratings. If you use unit beyond this ratings, it brings its reliability, damage or destroy. To avoid these phenomena and realized on the interfacial devices high reliably, we recommend that unit is operated within the ratings and the regulations. And then it makes unit operate effectively for the characteristic and economical point views.
Ambient temperature	Temperature ratings have two ratings. One is operation temperature rating. Another is storage temperature rating. Please use within range of the temperature decided respectively. If it used the exceeding ratings of the operation and storage temperature, it become deterioration or destruction of the unit.
Noise	This device is composed of junction isolation structure. Therefore when I/O potential of the unit is less than -0.5V by external noise etc, a parasitic unit operates. Therefore, adjacent transistors inside of the unit can not isolate, and becoming causes of the decrease in the circuit malfunction and no output and the destruction of the device, etc.
Flame resisting	It is not nonflammability though 94-V0 recognition goods of the UL standard are used for the epoxy molding resin material of this unit.
Electorostatic protection	It is necessary to note static electricity especially in the semiconductor unit. It is preferable to suppress the static electricity level of the working environment to 100V or less, and the mind for which do not use insulation thing (especially, artificial fiber and plastics product) it that humidifies at a dry period, avoids the state of low humidity, and uses the one of electroconductive (electroconductive mat, electrostatic work wear, and Mitibidencts) is injuring necessary for that.