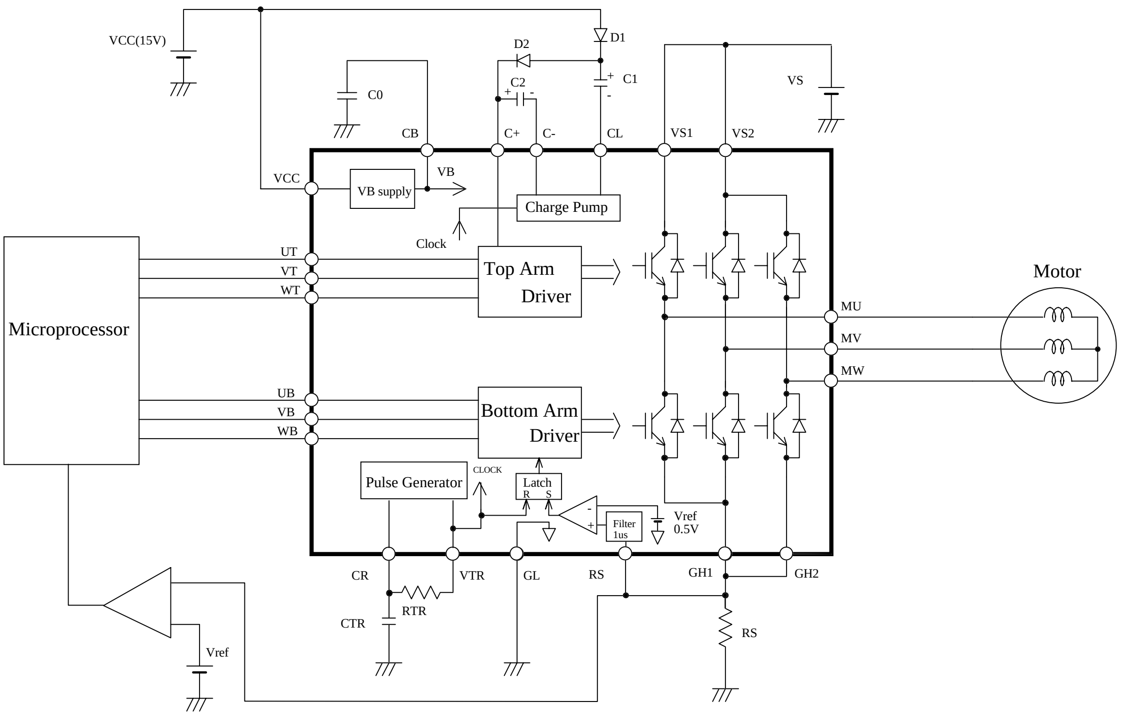
ECN3063/ECN3064 Application Note

1. Introduction

ECN3063/ECN3064 is a one-chip three-phase bridge inverter IC which has 6 IGBTs in the circuit. The 6 IGBTs are operated by 6 input signals. Especially, it is very suitable for controlling the speed of three-phase DC brushless motors to which converted AC200~230V power supplies are applied. Fig. 1 shows the internal block diagram.



2. The function of input terminals and equivalent circuits

(1)UT, VT, WT, UB, VB, WB terminal

- These are input terminals which control the output devices of the three-phase bridge. UT, VT and WT operates the top arm IGBTs, and UB, VB and WB operates the bottom arm IGBTs.
- When the input signal is high, the IGBT is turned on for each top and bottom arm.

- They have a compatibility for the input voltage with 5V-CMOS logic and TTL. And each terminal has a pull-down resistance of typ. 200kΩ.

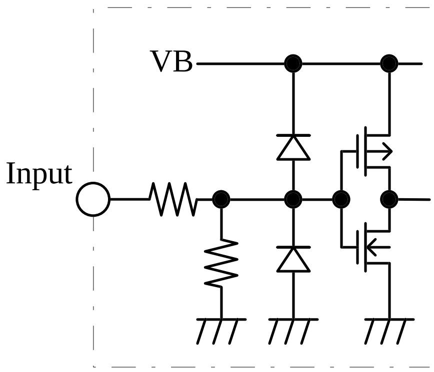


Fig. 2 Equivalent circuit of the input terminals

- In this IC, 6 IGBTs can be operated independently. The output device has a totem pole structure of IGBTs. When the top IGBT and the bottom IGBT in the same phase are turned on simultaneously, the IC can be broken. Therefore, when the output control is moved from turn-off of the top(bottom) IGBT to turn-on of the bottom(top) IGBT in the same phase, a dead time should be set up to avoid the simultaneous turn-on. Fig. 3 shows an example for the dead time.
- When the turn-on is moved from the top arm to the bottom arm in the same phase, a dead time over turn-off time for top arms(TdOFFT) is needed. When the turn-on is moved from the bottom arm to the top arm in the same phase, a dead time over turn-off time for bottom arms(TdOFFB) is needed.

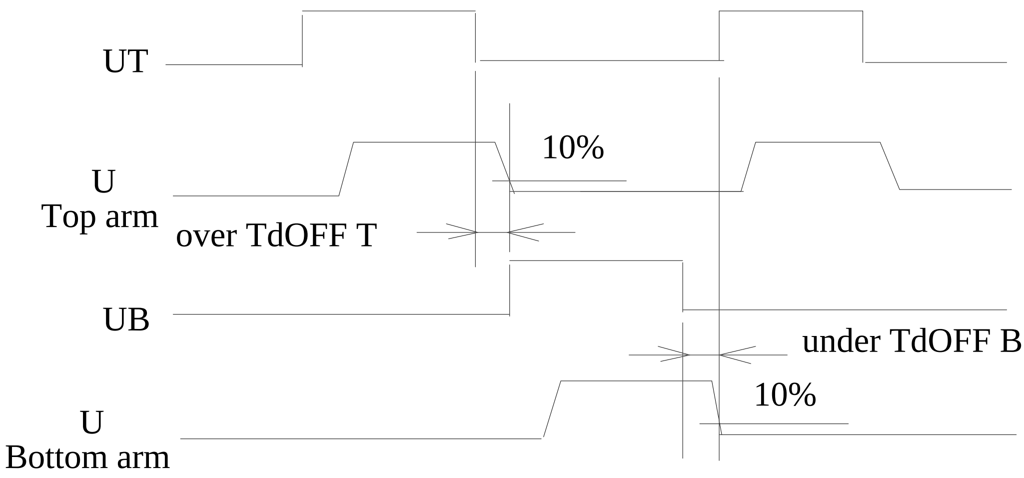


Fig 3. Example of the dead time

(2)CR, VTR terminal

- The frequency of the internal clock is decided by a resistance and a capacitor which are connected between these two terminals. Fig. 4 shows the equivalent circuit around these terminals. The internal clock is used for generating power supply for top arms. Approximately, the frequency can be calculated by this equation,

$$f_{PWM}=-1/(2CRLn(1-3.5/5.5))=0.494/(CR) \qquad (H_Z)$$

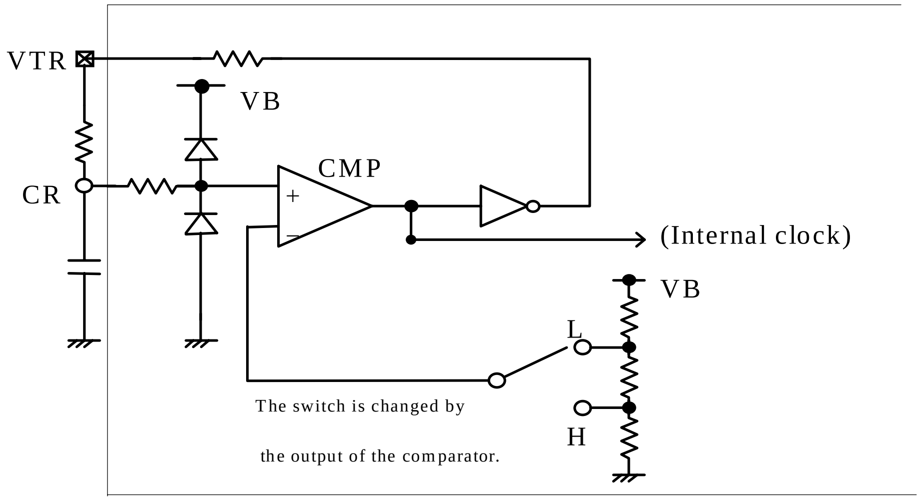


Fig. 4 Equivalent circuit around CR, VTR

(3)C+, C−, CL terminal

- These are terminals for a charge pump circuit. Generally, 3-phase bridge circuits have totem pole structure which has a n-channel MOSFET for the output device. Therefore, higher voltage than VS is needed to drive top arms. In this IC, another power supply is not needed because it has a charge pump circuit which produces voltage for driving top arms.
- C+ terminal is a terminal where the driving voltage for top arms is supplied. The supplied voltage is about (VS+Vcc).
- C− terminal has a connection to VS1,2 terminal inside the IC.
- CL terminal works for pumping up the voltage from Vcc terminal to the capacitor which is connected to C+ terminal. The voltage at this terminal can be changed from 0V to VS.
- The charge pump circuit is operated by the clock inside the IC. Looking at Fig. 1, when CL is 0V, this circuit charges C1 capacitor, while the charge comes from Vcc via D1. Next, the voltage of CL terminal goes up to VS and the charge which C1

capacitor had is pumped up to C2 capacitor via D2. By repeating this operation with a frequency which is set up in the triangular wave circuit, the voltage for driving top arms is supplied at C+ terminal.

- Diodes D1, D2 should be connected to these terminals.(Ref. Fig. 1) When using diodes with axial leads, it is recommended to use high speed diodes, like Hitachi diode DFG1C6(600V, 1A, 100ns). High voltage diodes are needed because CL is changed from 0V to VS.
- Capacitors C1, C2 should be connected to these terminals. (Ref. Fig. 1) Top arm IGBTs are driven by the voltage which is charged in these capacitors. It is recommended that the capacity of the capacitors should be 0.5μF±20% for ECN3063, 1.0μF±20% for ECN3064. When other capacitors are used for them, the voltage(VCP) between C+ and C− should not be under 10V. The stress voltage in the capacitors exceeds Vcc because of the circuit operation.

(4)MU, MV, MW

These terminals are connected to the coils of the motor. The terminals are also connected to 6 IGBTs and 6 fast recovery diodes. The 3-phase bridge is made up of them.

(5)Vcc terminal

- The voltage which operates top arm drivers, bottom arm drivers, and high voltage circuit, like a charge pump circuit, is supplied to this terminal. And the internal power supply VB is produced from the supplied voltage at this terminal.
- The capacity of the power supply for Vcc terminal needs some margin. The current which is calculated by addition of the stand-by current Icc and the current from CB terminal can be a reference for it.

(6)CB terminal

- This is an output terminal for the internal power supply VB. VB supplies operation voltage for the circuits of input, 3-phase distributor, FG, rotation direction monitor, triangular wave generator, over-current detection, and so on.
- A capacitor of over 0.22μF should be connected to this terminal for making smooth VB.

(7)VS1, VS2 terminal

These are terminals for the supplied voltage for the IGBTs. Both terminals should be connected near IC pins. When one terminal is opened, the IC has a possibility to be broken.

(8)GL terminal

This is a ground terminal for Vcc and the internal power supply VB.

(9)GH1, GH2 terminal

- These are connected to the emitters of the bottom arm IGBTs. These terminals are used for over-current detection by connecting a shunt resistance RS.
- Over current can be detected as follows. GH1 should be connected to GH2 near IC pins, and a shunt resistance RS should be connected to these terminals. Dealing with the voltage drop of RS by an external over-current detection circuit, the output should be a feedback signal for the inputs of the IC. Fig. 5 shows an example for over-current detection. The voltage drop of RS is put into the comparator and it is compared with the reference voltage Vref. And the microprocessor handles the result, and controls the input for the IC. The detected current IO is calculated by this equation,

  IO=Vref/RS (A) Vref ; Standard voltage for current limitation

  And a filter which is made up of capacitance and resistance is needed for the input of the comparator.
- 0.5V is recommended for Vref. A shunt resistance is connected to the emitters of the

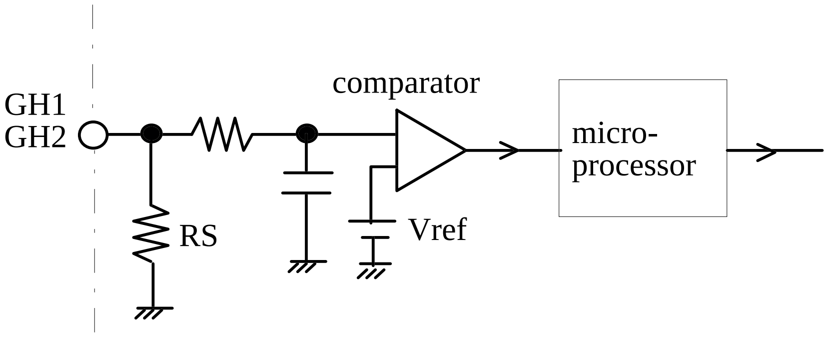


Fig. 5 Example for over current detection

IGBTs, and over-current is detected by comparing the voltage drop of the shunt resistance RS with Vref. Therefore, as the voltage drop of RS increases, the driving voltage for the IGBTs decreases. It decreases the current of the IGBTs because the gate voltage of the IGBTs decreases.

(10)RS Terminal

This IC detects overcurrent by outside resistance Rs. When Rs input voltage exceeds inner reference voltage Vref(0.5V typical), this IC turns off the bottom output. After overcurrent detection, a reset operation is done at each inner clock signal period.
In case of not using this function, please connect Rs terminal to GL terminal.

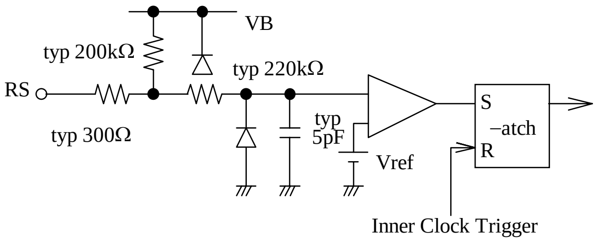


Fig.6 RS terminal inner equvalent circuit

3. Caution for using this IC

(1)Power supply sequence

- This IC has an under-voltage detection circuit for Vcc. It works at about 12V of Vcc, and it has a hysterisis of about 0.5V. When Vcc is under 12V, the operation of top and bottom arms stops.
- When VSP is low, the power supply sequence is free.

(2)Maximum output current

For the output peak current(IMP) and the output current at start and acceleration(IOM), accumulated operation time should be within 5% of all motor operation time when IMP or IOM exceeds the output current(IMDC).

(3)Preventing ICs from breakdown by surge voltage

When surge voltage is applied to VS terminal, this IC has a possibility to be broken. These methods are effective for preventing it,

1) Installing elements, like Zener diodes which absorb surge voltage near VS terminal.
2) Installing a pass capacitor near VS terminal. As the capacity is bigger, it is more effective. It is recommended to use a ceramic capacitor of over 0.1μF.

(4)Voltage at tabs

Tabs are connected to GL terminal at a high impedance. Tabs should be opened or connected to the ground.

(5)Motor lock operation

When a top arm IGBT of one phase and a bottom arm IGBT of the other phase are locked on-state by an operation like a motor lock, over-current detection always works. The reset for it should be operated every one period of the internal clock, but, in this case, the IC temperature exceeds T_{jmax}, because of the higher power. This IC does not have a protection feature for a motor lock operation. Therefore, when a motor lock operation is kept for a long time, the IC has a possibility to be broken.

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