# ECN3018 Application Note

## 1. Introduction

ECN3018 is a single chip 3-phase bridge inverter IC which has 6 IGBTs in the circuit. Especially, it is very suitable for controlling the speed of three-phase DC brushless motors to which converted AC100~115V power supplies are applied. Fig. 1 shows the internal block diagram.

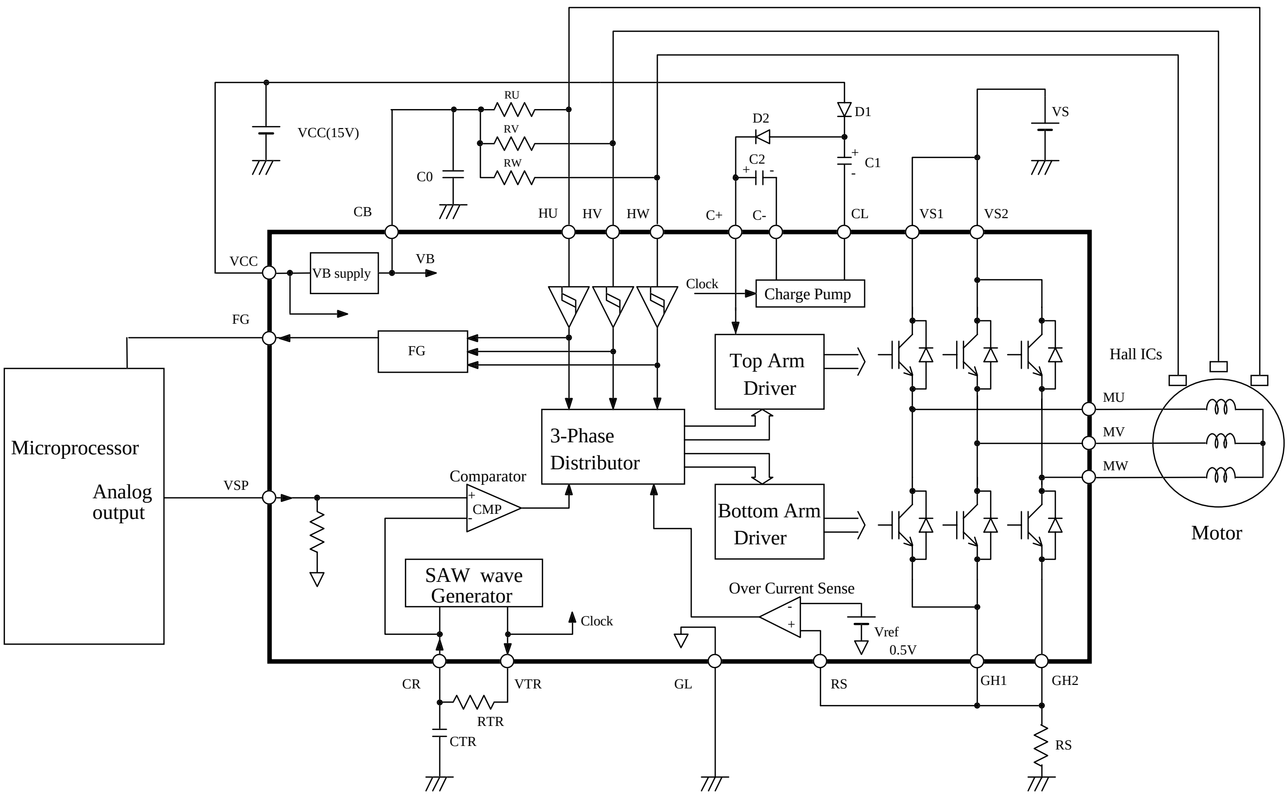


Fig. 1 Block diagram

## 2. The function of input terminals and equivalent circuits

(1)HU, HV, HW terminals

- These are input terminals which control the output devices of the three-phase bridge. They have a compatibility for the input voltage with 5V-CMOS logic and TTL. And each terminal has a pull-up resistance of typ. 200kΩ.

- The terminals have a possibility to get an influence from some noise because of their high impedance. In this case, it is recommended to have a 5.6 kΩ pull-up resistance between these terminals and CB terminal, to have a ceramic capacitor of about 500pF near these terminals, or to have both of them.

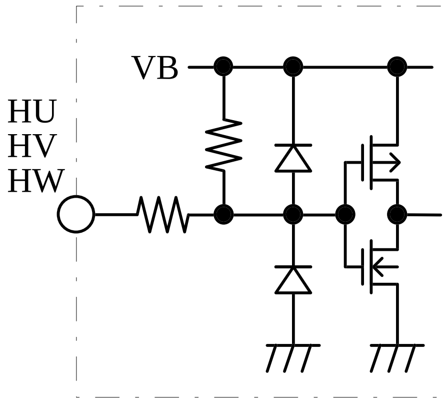

Fig.2 Equivalent circuit of the input terminals

(2)VSP terminal

- This is an input terminal which controls the motor speed.
A PWM signal is produced by comparing the triangular wave signal from CR terminal with the analog signal which is put into VSP terminal. The duty of the PWM signal can be changed by the triangular wave amplitude level, from the minimum point of VSAWL to the maximum point of VSAWH, and when the level is under VSAWL, the duty becomes 0%, and when the level is over VSAWH, the duty becomes 100%.
- This terminal has an input resistance of typ. 300Ω and a pull-down resistance of typ. 200kΩ.
- Attention should be paid when the input voltage into this terminal exceeds the voltage of VB.
In this case, it happens that current flows into the internal circuit. If this is inevitable, an external resistance R should be connected between the VSP signal and the VSP terminal, and the current should be under 1mA. For reference, the next equation shows how to determine the value of the external resistance,

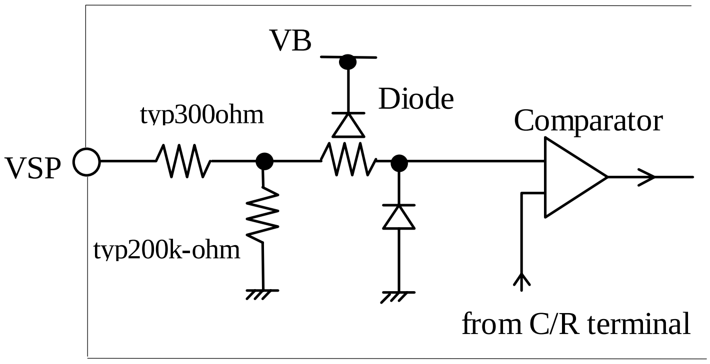

Fig. 3 Equivalent circuit around VSP

$$(VSP-VB-VF_{diode})/(R+300\Omega)\leq 1mA$$

$VF_{diode}$=0.5V(at high temperature)

300Ω; the internal resistance

- When an external resistance R is connected, the input voltage to the comparator is divided by the external resistance R and the internal resistance. Therefore, there is a voltage difference between the voltage of VSP and the voltage of the input for the comparator.

(3)CR, VTR terminal

- The frequency of the triangular wave is decided by a resistance and a capacitor which are connected at two terminals as shown in Fig. 4. Approximately, the frequency can be calculated by the following equation,

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

- Error factor for the frequency of the triangular wave is suppose to be as follows. The value of the internal resistance(the output resistance for VTR terminal which is written in the specification) is added to the external resistance. And a floating capacitance which exists on the circuit board is added to the external capacitance.
- Variation factor of the amplitude level for the triangular wave is supposed to be as follows. The voltage of VSAWH and VSAWL is produced from dividing VB by the three resistances. Theoretically, they can be calculated by these equations,

  VSAWH=VB×5.4/7.5

  VSAWL=VB×2.1/7.5

  Therefore, main factor of the variation of the frequency comes from the variation of the internal power supply VB.

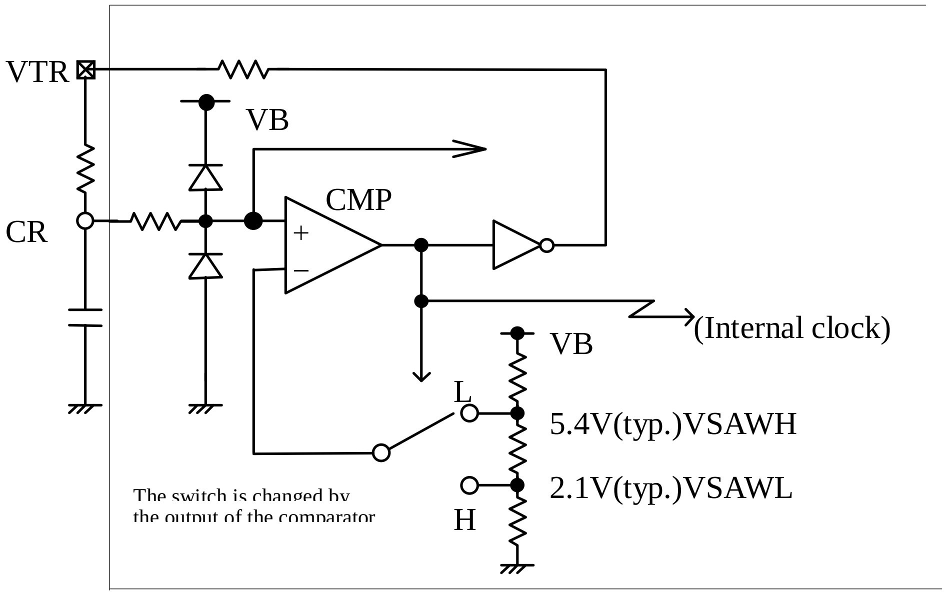


Fig. 4 Equivalent circuit around CR, VTR

(4)RS terminal

- This is an input terminal for over-current detection. RS shunt resistance is connected to GH1 and GH2, and the voltage drop at this resistance is put into RS terminal. Over current can be detected by this input signal. The detected current IO is calculated by this equation,

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

When the detected current exceeds Vref, bottom arms are turned off. The reset after the detection of over current is done every period of the internal clock.

- RS terminal has an internal filter which consists of a capacitance and a resistance (C ; typ.5pF, R ; typ.220kΩ). Therefore, external filters are not needed generally.

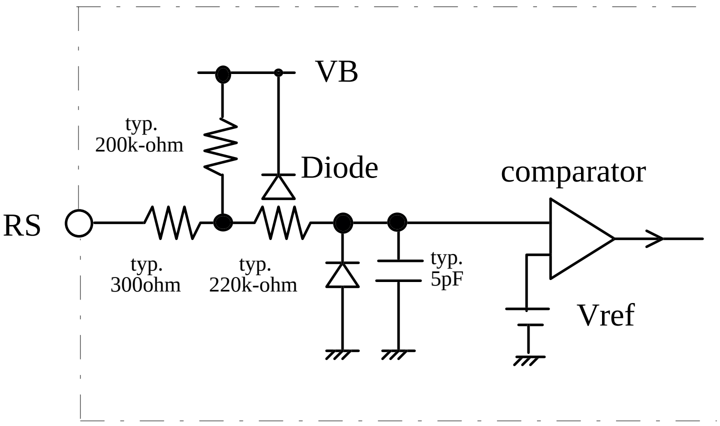


Fig. 5 Equivalent circuit around RS terminal

(5)FG terminal

- The number of rotations of the motor can be monitored by the signal at this terminal. An output pulse is produced according to input signals for HU, HV, HW. Only when two signals are high among HU, HV and HW, a high signal comes out at FG terminal. The frequency of the output signal increases as the number of rotations of the motor increases.

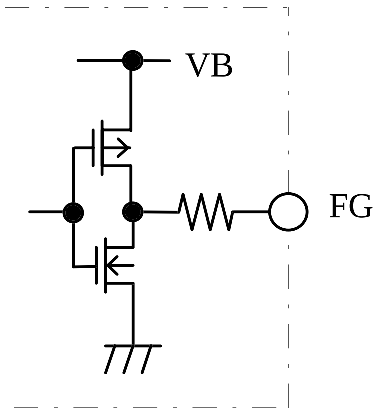


Fig. 6 Equivalent circuit around DM, FG terminal

(6)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.

(7)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.

(8)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.

(9)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.

(10)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 DFG1C4(400V, 1A, 100ns, glass mold type), DFM1F4(400V, 1A, 100ns, resin mold type). 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 1.0μF±20%. 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.

(11)GL terminal

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

(12)GH1, GH2 terminal

These are connected to the emitters of the bottom arm IGBTs. Over-current can be detected by comparing the voltage drop which is produced at a shunt resistance RS with Vref. GH1 should be connected to GH2 near IC pins.

## 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 0.5V. When Vcc is under about 12V, the operation of top and bottom arms stops.
- When VSP is lower than VSAWL, the power supply sequence is free. When the power supply is turned on and off, it is recommended that VSP should be lower than VSAWL. When the power supply sequence is Vcc on → VS on → Operation → VS off → Vcc off, VSP does not need to be lower than VSAWL.
- When the power supply sequence is except the described case, it should be accounted that VS may jump up because of re-produced voltage especially at the turn off of the power supply. Therefore, the jumping voltage should be examined in proportion to the load of the motor.

(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.

(6)Insulation breakdown voltage examination

When the fin(around two screw holes) of this IC is connected to the outside part of a motor in order to emit heat, the following caution should be paid. This IC can not pass the examination of an insulation breakdown which applies high voltage between the outside part of a motor and GL. Therefore, in this examination, miller sheets which can hold high voltage should be used.

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