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# – Chapter 4 –

## Typical application circuits

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# 1 Typical application circuits

Figure 4-1 shows typical application circuits of P629.

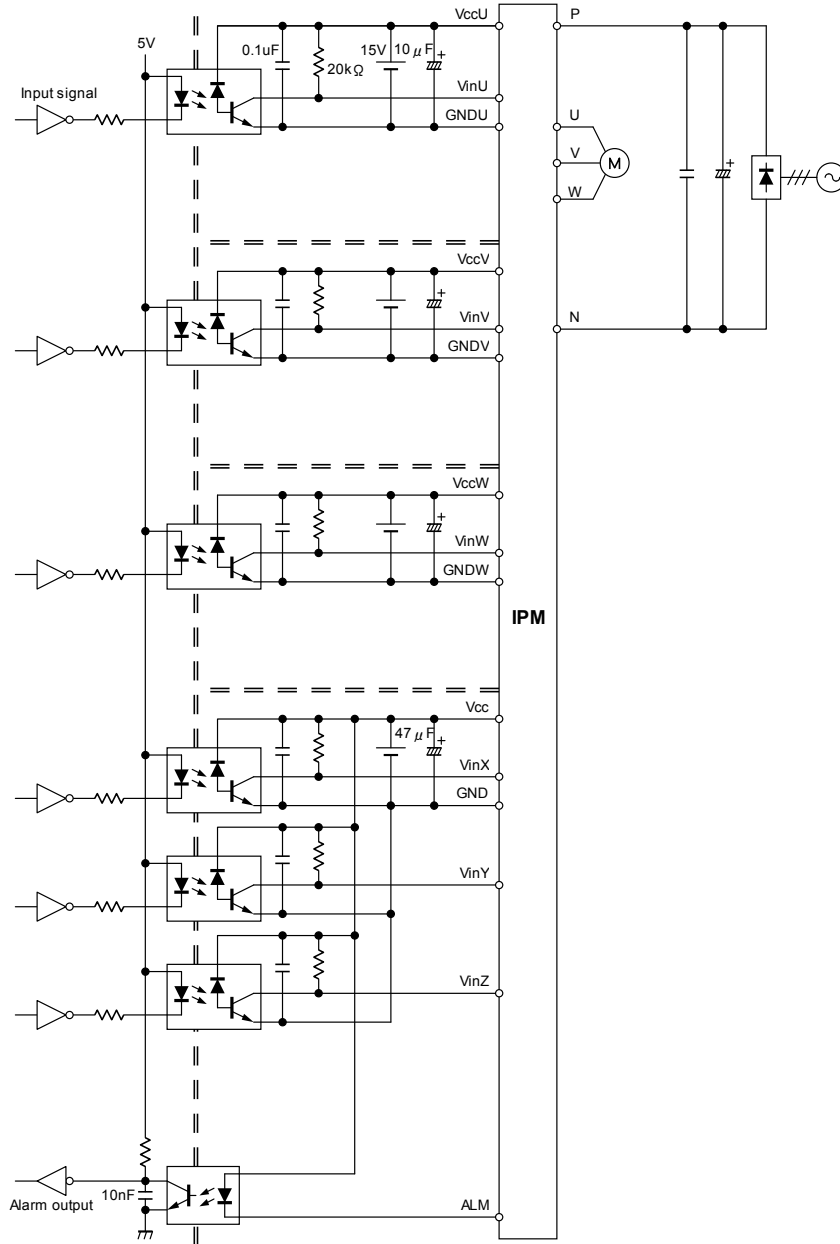
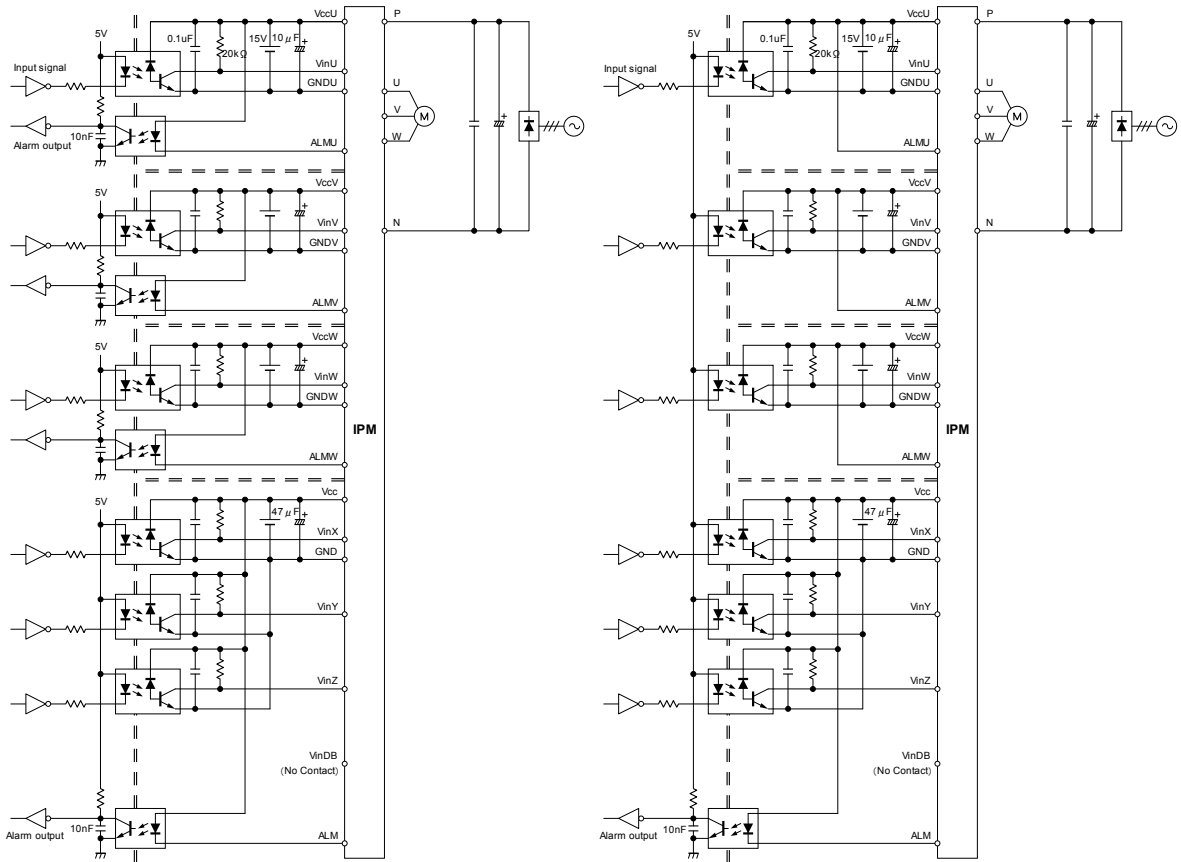


Figure 4-1 Typical application circuits of P629

Figure 4-2 shows typical application circuits of P626.

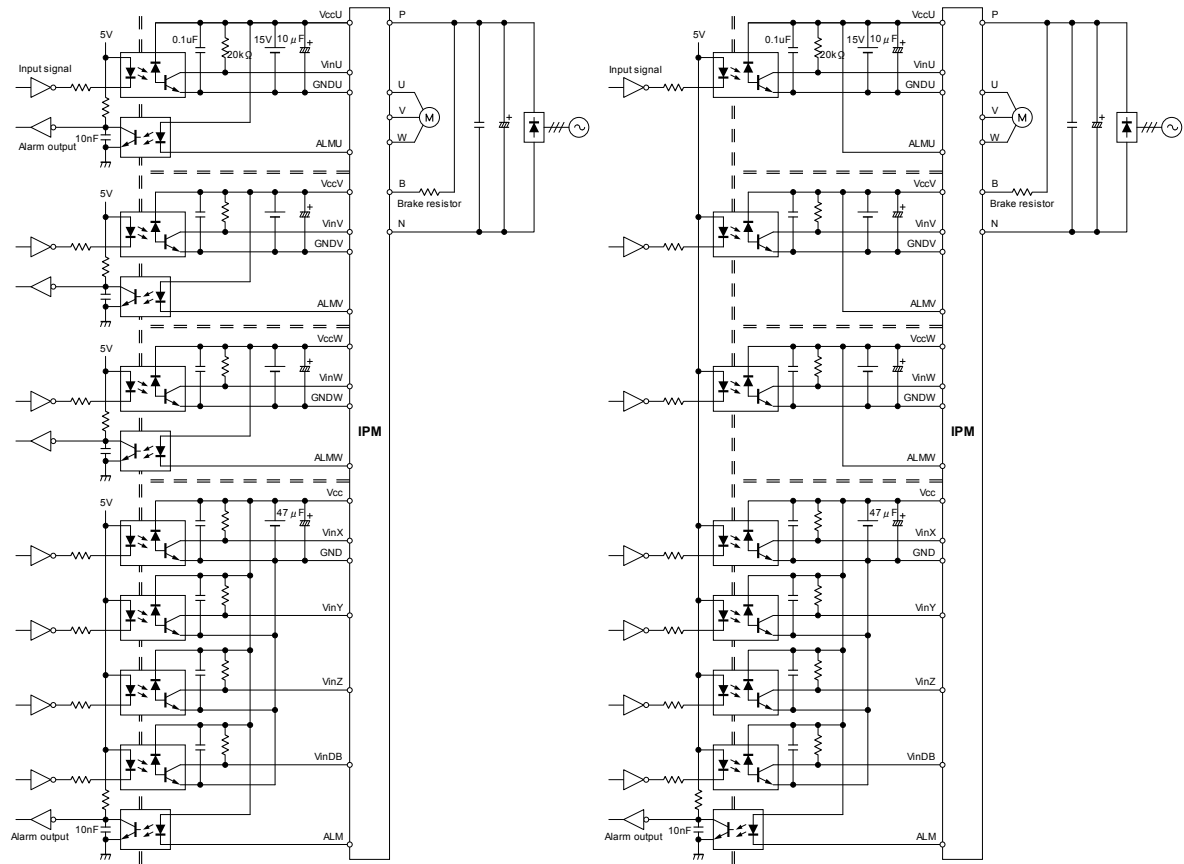


(a) Where upper phase alarm is used

(b) Where upper phase alarm is not used

Figure 4-2 Typical application circuits of P626

Figure 4-3 shows typical application circuits of P630, P631 and P636 with built-in brake type.

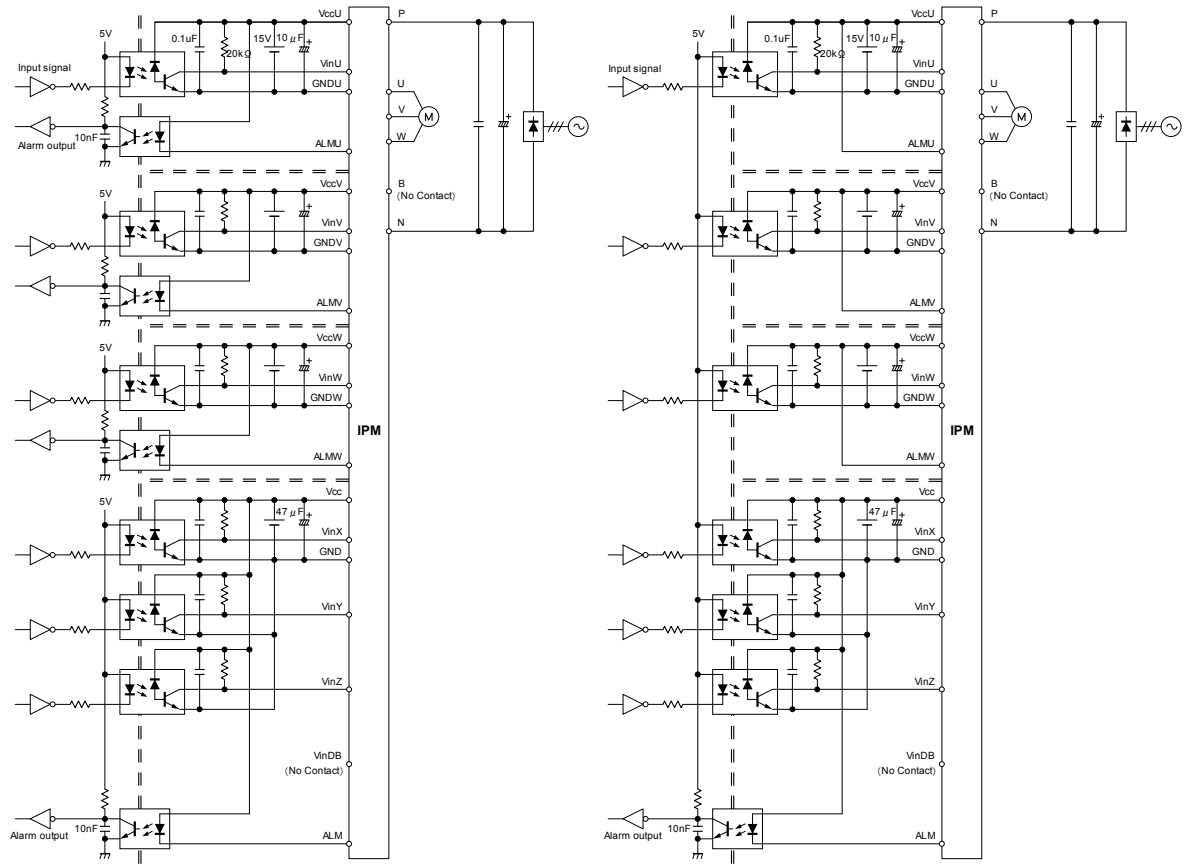


(a) Where upper phase alarm is used

(b) Where upper phase alarm is not used

Figure 4-3 Typical application circuits of P630, P631 and P636 with brake circuit

Figure 4-4 shows typical application circuits of P630, P631 and P636 of no brake type.



(a) Where upper phase alarm is used

(b) Where upper phase alarm is not used

Figure 4-4 Typical application circuits of P630, P631 and P636 without brake circuit

## **2 Important remarks**

### **2.1 Control power supply units**

Four isolated power supply units; three for the upper arm and one for the lower arm are needed as shown in the application circuit examples. If a readymade power supply unit is used, do not connect the output GND terminals of the power supply unit. If the GND of the output side is connected to the + or – terminals, it may cause a failure of the system because each power supply unit is connected to the ground of input side of the power supply unit. Furthermore, reduce stray capacitance (floating capacitance) between the power supply units and the Earth ground as much as possible.

Furthermore, please use a power supply unit which has enough capability to supply  $I_{CC}$  with low output power fluctuation.

### **2.2 Structural insulation between four power supply units (input portion connector and PCB)**

The four power units and the main power supply unit have to be insulated from each other. A sufficient insulation air gap distance is required (2 mm or longer is recommended) because a high  $dv/dt$  is applied to the insulation distance during IGBT switching.

### **2.3 GND connection**

Do not connect the control terminal GND U to the main terminals U, control terminal GND V to main terminals V, control terminal GND W to main terminal W, control terminal GND to main terminal N (N1 and N2 in case of P631). If these terminals are connected, it might cause a malfunction.

### **2.4 External capacitors for control power supply**

Capacitors of 10  $\mu\text{F}$  (47  $\mu\text{F}$ ) and 0.1  $\mu\text{F}$ , which are connected to each power supply unit shown in typical application circuits are not used for smoothing the output voltage of the control power supply units but are used for reduction of the wiring impedance from the power supply unit to the IPM. Additional capacitors for smoothing the voltage are required.

Furthermore, these external capacitors should be connected to the IPM terminals or optocoupler terminals as short as possible because transient variation occurs by the wiring impedance between the capacitors and control circuits.

Also, an electrolytic capacitor which has a low impedance and good frequency characteristics is recommended. In addition, it is recommended to connect a film capacitor which has good frequency characteristics in parallel.

## 2.5 Alarm circuit

The alarm terminal has a 1.3 k $\Omega$  internal resistor in series, so that an optocoupler can be connected to the terminal directly without an external resistor. The wiring distance between the optocoupler and the IPM should be as short as possible. Also the pattern layout should be designed to minimize the floating capacitance between the primary side and the secondary side of the optocoupler. Because of the potential of the secondary side of the optocoupler it may fluctuate due to high dv/dt. It is recommended that a 10nF capacitor is connected to the output terminal of the secondary side of the optocoupler as shown in Figure 4-4.

Furthermore, if upper side alarm outputs are not used, please connect the alarm output terminal to Vcc as shown in Figure 4-4 (b).

## 2.6 Pull-up of signal input terminal

Connect the control signal input terminals to Vcc through a 20 k $\Omega$  pull-up resistor. Furthermore, unused input terminals also have to be pulled up through a 20 k $\Omega$  resistor. If these terminals are not pulled up, an under voltage protection is activated during the starting up so that no ON operation is possible.

## 2.7 Connection in case there is an unused phase

If there is an unused phase such as the case when a 6in1 IPM (no brake type) is used in single phase or a 7in1 IPM (brake built-in type) is used without using B-phase, please supply a control voltage to these unused phase and connect the input/alarm terminals of the phase to Vcc so that it will stabilize the potential of these terminals.

## 2.8 Handling of unconnected terminals (no contact terminals)

Unconnected terminals (no contact terminals) are not connected to the internal of the IPM. These terminals are insulated from other terminals. There is no need of special treatment such as potential stabilization.

Furthermore, guide pins should also not be connected to the internal of the IPM.

## 2.9 Snubbers

Connect snubber circuits between P and N terminals directly and as short as possible.

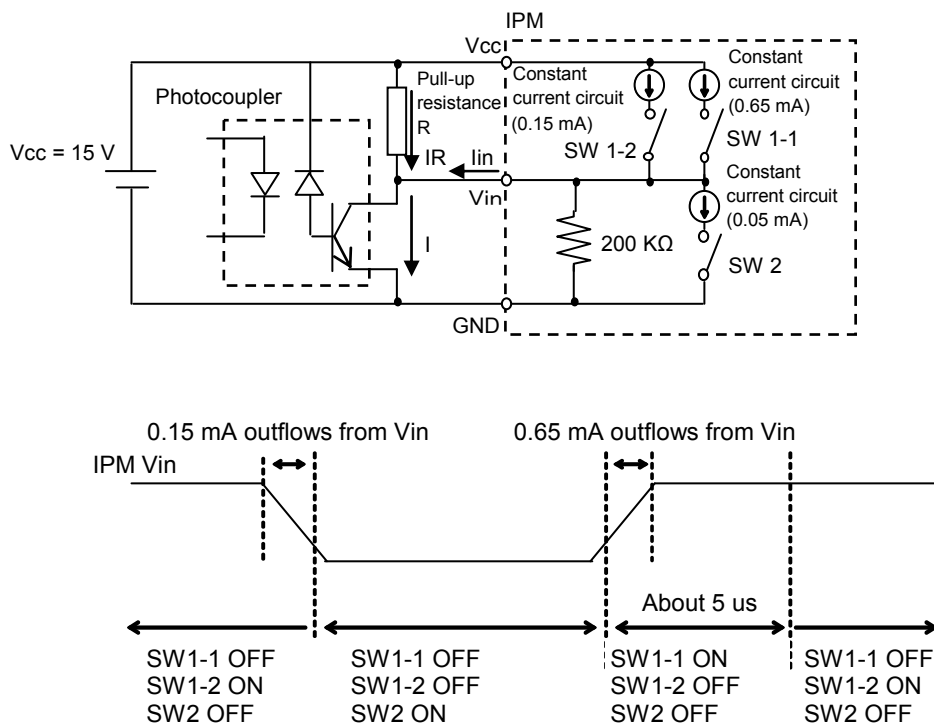
For P631 package which has two P/N terminals, it is effective for surge voltage reduction to connect snubber circuits to the P1-N1 and P2-N2 terminals. Do not connect snubber circuits across the two terminals such as P1-N2 and P2-N1 because it may cause a malfunction.

## 2.10 Grounding capacitor

Please connect about 4500 pF capacitors between each AC input line and Earth ground to prevent a noise from the AC input line to the system.

## 2.11 Input circuit of IPM

There is a constant current circuit in the input part of the IPM as shown in Figure 4-5 and constant current of  $I_{in} = 0.15 \text{ mA}$  or  $I_{in} = 0.65 \text{ mA}$  flows at that timing shown in Figure 4-5. The current of the secondary side of optocoupler is the sum of the constant current  $I_{in}$  and the current through a pull-up resistor  $I_R$ . Therefore it is necessary to decide the current of primary side of optocoupler  $I_F$  so that enough current flows in the secondary side of optocoupler. If the  $I_F$  is insufficient, there is a possibility that a malfunction arises on the secondary side.



\* The operation duration of constant current circuit (0.65 mA) is the length of time until  $V_{in}$  reaches  $V_{CC}$ , and the maximum length about 5  $\mu\text{s}$ .

Figure 4-5 IPM input circuit and constant current operation timing



### **3 Optocoupler peripheral circuits**

#### **3.1 Control input Optocoupler**

##### **3.1.1 Optocoupler rating**

Use an optocoupler that satisfies the characteristics indicated below:

- $CMH = CML > 15 \text{ kV}/\mu\text{s}$  or  $10 \text{ kV}/\mu\text{s}$
- $tpHL = tpLH < 0.8 \mu\text{s}$
- $tpLH - tpHL = -0.4$  to  $0.9 \mu\text{s}$
- $CTR > 15\%$

Example: HCPL-4504 made by Avago Technologies

TLP759 (IGM) made by Toshiba

Pay attention to safety standards such as UL and VDE.

The reliability and characteristics of these optocouplers are not guaranteed by Fuji Electric.

##### **3.1.2 Primary side limit resistance**

The current limiting resistor on the primary side should be selected to have an ability to flow a sufficient current on the secondary side. Also, an age-related deterioration of CTR of the optocoupler should be considered in the design of the current limiting resistor.

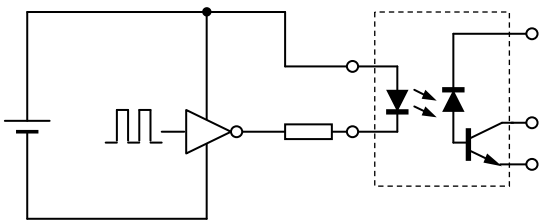
##### **3.1.3 Wiring between optocoupler and IPM**

The wiring distance between the optocoupler and the IPM should be short as much as possible to reduce the impedance of the line. The primary line and secondary line of the optocoupler should be kept away from each other to reduce the floating capacitance. High  $dv/dt$  is applied between the primary side and the secondary side.

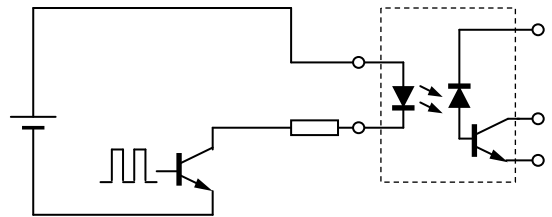
### 3.1.4 Optocoupler drive circuit

A noise current flows through the floating capacitance between the primary side and the secondary side of the optocoupler due to the high  $dv/dt$  that is generated inside or outside of the IPM. The  $dv/dt$  tolerance also varies by the optocoupler drive circuit. Good/bad examples of the optocoupler driving circuits are shown in Figures 4-6. As the optocoupler input is connected in low impedance in these good examples, malfunction caused by noise current hardly occurs. Please contact to the optocoupler manufacturer regarding details of the optocouplers.

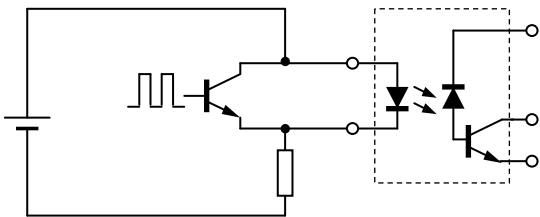
Good example: Totem pole output IC  
Current limit resistance on cathode side of photodiode



Bad example: Open collector



Good example: Diodes A and K are shorted  
between transistors C and E  
(Case that is particularly strong against photocoupler off)



Bad example: Current limit resistance on anode side  
of photodiode

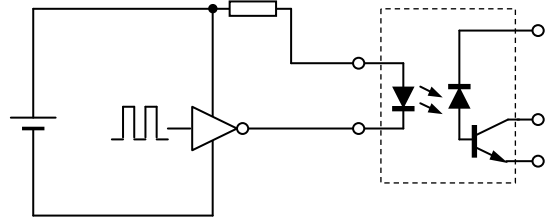


Figure 4-6 Optocoupler input circuits

## 3.2 Alarm output optocoupler

### 3.2.1 Optocoupler ratings

A general-purpose optocoupler can be used but an optocoupler of the following characteristics is recommended:

- $100\% < \text{CTR} < 300\%$
- Single channel type

Example: TLP781-1-GR rank or TLP785-1-GR rank made by Toshiba

Pay attention to safety standards such as UL and VDE also.

The reliability and characteristics of the optocouplers indicated above are not guaranteed by Fuji Electric.

### 3.2.2 Input current limiting resistance

A current limiting resistor for input side diode of optocoupler is built in the IPM. The resistance  $R_{\text{ALM}} = 1.3 \text{ k}\Omega$ , and  $I_{\text{F}}$  is about 10 mA when the optocoupler is connected to  $V_{\text{CC}} = 15 \text{ V}$ . An external current limiting resistor is not required.

If large current  $I_{\text{out}} > 10 \text{ mA}$  is required for the optocoupler output side, it is necessary to increase the optocoupler's CTR value to achieve the required level.

### 3.2.3 Wiring between optocoupler and IPM

Note that high  $dv/dt$  is applied to the optocoupler for alarm output, please take care as same as to Section 3.1.3.

## 4 Connector

Connectors that conform to the shape of control terminals of V-IPM are available on the market.

For P630: MA49-19S-2.54DSA and MA49-19S-2.54DSA (01) made by Hirose Electric

For P631: MDF7-25S-2.54DSA made by Hirose Electric

Furthermore, please contact the connector manufacturer for the details of reliability and use of these connectors.

Please note that the reliability and the characteristics of these connectors are not guaranteed by Fuji Electric.