SAFTRONICS

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# VG5

## TECHNICAL MANUAL


REV2 (9/98)
P/N 027-2040

# PREFACE

The VG5 Series of general-purpose Inverters provides V/f Control and Vector Control as standard features along with user-friendly operation.

This manual is designed to ensure correct and suitable application of the VG5 Series Inverters. Read this manual before attempting to install, operate, maintain, or inspect an Inverter and keep it in a safe, convenient location for future reference. Make sure you understand all precautions and safety information before attempting any application.

# PREFACE

## Safety Information

The following conventions are used to indicate precautions in this manual. Failure to follow the precautions provided in this manual can result in serious or possible even fatal injury or damage to the products or to related equipment and systems.

**WARNING** Indicates precautions that, if not followed, could possibly result in loss of life or serious injury.

**CAUTION** Indicates precautions that, if not followed, could result in serious injury, damage to the product, or faulty operation.

The warning symbols for ISO and JIS standards are different, as shown below.

| ISO | JIS |
|---|---|
|  |  |

The ISO symbol is used in this manual. Both of these symbols appear on warning labels on Saftronics products. Please abide by these warning labels regardless of which symbol is used.

## Visual Aids

The following aids are used to indicate certain types of information for easier reference.

**‘ EXAMPLE •** Indicates application examples.

**NOTE:** Indicates important information that should be memorized.

## General Precautions

- The diagrams in this manual may be indicated without covers or safety shields to show details. Be sure to restore covers or shields before operating the units and run the units according to the instructions described in this manual.
- Any illustrations, photographs, or examples used in this manual are provided as examples only and may not apply to all products to which this manual is applicable.
- The products and specifications described in this manual or the content and presentation of the manual may be changed without notice to improve the product and/or the manual.
- When ordering a new copy of the manual due to damage or loss, contact your Saftronics representatives or the nearest Saftronics sales office and provide the manual number shown on the front cover.
- If nameplates become warn or damaged, order new ones from your Saftronics representatives or the nearest Saftronics sales office.

## Safety Precautions

■ **Confirmations upon Delivery**

**⚠ CAUTION**

| | |
|---|---|
| • Never install an Inverter that is damaged or missing components. Doing so can result in injury. | Page 10 |

■ **Installation**

**⚠ CAUTION**

| | |
|---|---|
| | Page |
| • Always hold the case when carrying the Inverter. If the Inverter is held by the front cover, the main body of the Inverter may fall, possibly resulting in injury. | 14 |
| • Attach the Inverter to a metal or other noncombustible material. Fire can result in the Inverter if attached to a combustible material. | 14 |
| • Install a cooling fan or other cooling device when installing more than one Inverter in the same enclosure so that the temperature of the air entering the Inverters is below 45°C. Overheating can result in fires or other accidents. | 14 |

■ **Wiring**

**⚠ WARNING**

| | |
|---|---|
| | Page |
| • Always turn OFF the input power supply before wiring terminals. Otherwise, an electric shock or fire can occur. | 20 |
| • Wiring must be performed by an authorized person qualified in electrical work. Otherwise, an electric shock or fire can occur. | 20 |
| • Be sure to ground the ground terminal. (200 V class: Ground to 100 × or less, 400 V class: Ground to 10 × or less) Otherwise, an electric shock or fire can occur. | 20 |
| • Always check the operation of any emergency stop circuits after they are wired. Otherwise, there is the possibility of injury. (Wiring is the responsibility of the user.) | 20 |
| • Never touch the output terminals directly with your hands or allow the output lines to come into contact with the Inverter case. Never short the output circuits. Otherwise, electrical shock or grounding can occur. | 20 |

**⚠ CAUTION**

| | |
|---|---|
| | Page |
| • Check to be sure that the voltage of the main AC power supply satisfies the rated voltage of the Inverter. Injury or fire can occur if the voltage is not correct. | 20 |
| • Do not perform voltage withstand tests on the Inverter. Otherwise, semiconductor elements and other devices can be damaged. | 20 |
| • Connect braking resistors, Braking Resistor Units, and Braking Units as shown in the I/O wiring examples. Otherwise, a fire can occur. | 20 |
| • Tighten all terminal screws to the specified tightening torque. Otherwise, a fire may occur. | 20 |
| • Do not connect AC power to output Terminal T1, T2, and T3 (U, V, and W). The interior parts of the Inverter will be damaged if voltage is applied to the output terminals. | 20 |

# PREFACE

**CAUTION**

| | Page |
|---|---|
| • Do not connect Power Factor Correction Capacitors or LC/RC noise filters to the output circuits. The Inverter can be damaged or internal parts burnt if these devices are connected. | 20 |
| • Do not connect electromagnetic switches or contactors to the output circuits. If a load is connected while the Inverter is operating, surge current will cause the overcurrent protection circuit inside the Inverter to operate. | 20 |

■ **Setting User Constants**

**CAUTION**

| | Page |
|---|---|
| • Disconnect the load (machine, device) from the motor before Auto-Tuning. The motor may turn, possibly resulting in injury or damage to equipment. Also, motor constants cannot be correctly set with the motor attached to a load. | 81 |

■ **Trial Operation**

**WARNING**

| | Page |
|---|---|
| • Check to be sure that the front cover is attached before turning ON the power supply. Do not remove the front cover during operation. An electric shock may occur. | 86 |
| • Do not come close to the machine when the fault reset function is used. If the alarm is cleared, the machine may start moving suddenly. Also, design the machine so that human safety is ensured even when it is restarted. Injury may occur. | 86 |
| • Provide a separate emergency stop switch; the Digital Operator STOP key is valid only when the function is set. Injury may occur. | 86 |
| • Reset alarms only after confirming that the RUN signal is OFF. If an alarm is reset with the RUN signal turned ON, the machine may suddenly start. Injury may occur. | 86 |

**CAUTION**

| | Page |
|---|---|
| • Do not touch the radiation fins (heat sink), braking resistor, or Braking Resistor Unit. These can become very hot. Otherwise, a burn injury may occur. | 86 |
| • Be sure that the motor and machine is within the applicable ranges before starting operation. Otherwise, an injury may occur. | 86 |
| • Provide a separate holding brake if necessary. Otherwise, an injury may occur. | 86 |
| • Do not check signals while the Inverter is running. Otherwise, the equipment may be damaged. | 86 |
| • Be careful when changing Inverter settings. The Inverter is factory set to suitable settings. Otherwise, the equipment may be damaged. You must, however, you must set the power supply voltage jumper for 400 V class Inverters of 18.5 kW or higher (See *Chapter 5, 5.2.4 Setting Input Voltage*). | 86 |

■ **Maintenance and Inspection**

**WARNING**

| | Page |
|---|---|
| • Do not touch the Inverter terminals. Some of the terminals carry high voltages and are extremely dangerous. Doing so can result in electric shock. | 276 |
| • Always have the protective cover in place when power is being supplied to the Inverter. When attaching the cover, always turn OFF power to the Inverter through the MCCB. Doing so can result in electric shock. | 276 |
| • After turning OFF the main circuit power supply, wait until the CHARGE indicator light goes out before performance maintenance or inspections. The capacitor will remain charged and is dangerous. | 276 |
| • Maintenance, inspection, and replacement of parts must be performed only by authorized personnel. Remove all metal objects, such as watches and rings, before starting work. Always use grounded tools. Failure to heed these warnings can result in electric shock. | 276 |

**CAUTION**

| | Page |
|---|---|
| • A CMOS IC is used in the control board. Handle the control board and CMOS IC carefully. The CMOS IC can be destroyed by static electricity if touched directly. | 276 |
| • Do not change the wiring, or remove connectors or the Digital Operator, during operation. Doing so can result in personal injury. | 276 |

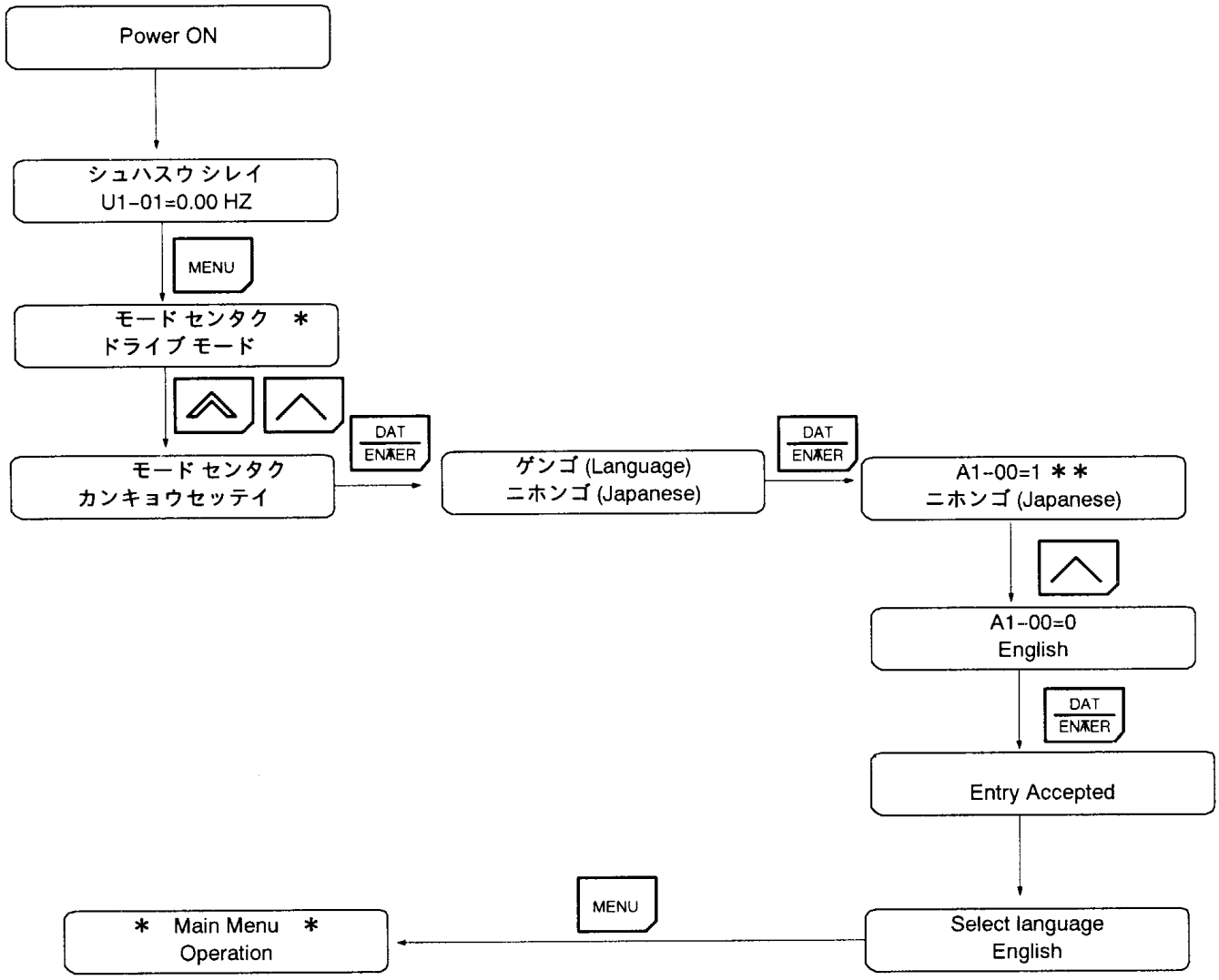
■ **Other**

**WARNING**

- Do not attempt to modify or alter the Inverter. Doing so can result in electrical shock or injury.

## How to Change the Digital Operator Display from Japanese to English

If the Digital Operator displays messages in Japanese, change to the English mode using the following steps. (This manual provides descriptions for the English mode.)



# Table of Contents

# 1

# Introduction

This chapter provides an overview of the VG5 Inverter and describes its functions and components.

# 1.1 Outline and Functions

The VG5 Inverter provides full-current Vector Control based on advanced control logic. An Auto-Tuning function is included for user friendly Vector Control.

The Digital Operator provides a liquid crystal display that is 2 lines by 16 characters in size. User constant settings and monitor items are easily read in interactive operations in either Japanese or English. (The display language can be changed by setting a user constant.)

## 1.1.1 VG5 Inverter Models

VG5 Inverters are available in 200 and 400 V class models. These are listed in the following table. A total of 37 models are available for motor capacities of 0.4 to 300 kW (0.5 ~ 400HP).

Table 1.1 VG5 Inverter Models

| Voltage Class | Maximum Applicable Motor Output (HP) | Maximum Applicable Motor Output (kW) | VG5 | | Inverter Specifications (Specify all required standards when ordering.) | |
|---|---|---|---|---|---|---|
| | | | Output Capacity (kVA) | Model Number | Open Chassis Type (IEC IP 00) VG5❑❑❑❑❑❑ | Enclosed Wall-Mounted Type (IEC IP 20, NEMA 1) VG5❑❑❑❑❑❑ |
| 200 V Class | 0.75 | 0.4 | 1.2 | VG520P4 | Remove the top and bottom covers from the models listed at the right. * | 20P41❑* |
| | 1.5 | 0.75 | 2.3 | VG520P7 | | 20P71❑* |
| | 2 | 1.5 | 3.0 | VG521P5 | | 21P51❑* |
| | 3 | 2.2 | 4.2 | VG522P2 | | 22P21❑* |
| | 5 | 3.7 | 6.7 | VG523P7 | | 23P71❑* |
| | 7.5 | 5.5 | 9.5 | VG525P5 | | 25P51❑* |
| | 10 | 7.5 | 13 | VG527P5 | | 27P51❑* |
| | 15 | 11 | 19 | VG52011 | | 20111❑* |
| | 20 | 15 | 24 | VG52015 | | 20151❑* |
| | 25 | 18.5 | 30 | VG52018 | 20180❑* | 20181❑‡ |
| | 30 | 22 | 37 | VG52022 | 20220❑* | 20221❑‡ |
| | 40 | 30 | 50 | VG52030 | 20300❑† | 20301❑‡ |
| | 50 | 37 | 61 | VG52037 | 20370❑† | 20371❑‡ |
| | 60 | 45 | 70 | VG52045 | 20450❑† | 20451❑‡ |
| | 75 | 55 | 85 | VG52055 | 20550❑† | 20551❑‡ |
| | 100 | 75 | 110 | VG52075 | 20750❑‡ | 20751❑‡ |

* Immediate delivery † Available from factory ‡ Manufactured upon order

| Voltage Class | Maximum Applicable Motor Output (HP) | Maximum Applicable Motor Output (kW) | VG5 | | Inverter Specifications (Specify all required standards when ordering.) | |
|---|---|---|---|---|---|---|
| | | | Output Capacity (kVA) | Model Number | Open Chassis Type (IEC IP 00) VG5❑❑❑❑❑❑ | Enclosed Wall-Mounted Type (IEC IP 20, NEMA 1) VG5❑❑❑❑❑❑ |
| 400 V Class | 1 | 0.4 | 1.4 | VG540P4 | Remove the top and bottom covers from the models listed at the right. * | 40P41❑* |
| | 2 | 0.75 | 2.6 | VG540P7 | | 40P71❑* |
| | 3 | 1.5 | 3.7 | VG541P5 | | 41P51❑* |
| | 4 | 2.2 | 4.7 | VG542P2 | | 42P21❑* |
| | 5 | 3.7 | 6.1 | VG543P7 | | 43P71❑* |
| | 7.5 | 4 | 8.4 | VG544P0 | | 44P01❑* |
| | 10 | 5.5 | 11 | VG545P5 | | 45P51❑* |
| | 15 | 7.5 | 14 | VG547P5 | | 47P51❑* |
| | 20 | 11 | 21 | VG54011 | | 40111❑* |
| | 25 | 15 | 26 | VG54015 | | 40151❑* |
| | 30 | 18.5 | 31 | VG54018 | 40180❑* | 40181❑‡ |
| | 40 | 22 | 37 | VG54022 | 40220❑* | 40221❑‡ |
| | 50 | 30 | 50 | VG54030 | 40300❑* | 40301❑‡ |
| | 60 | 37 | 61 | VG54037 | 40370❑* | 40371❑‡ |
| | 75 | 45 | 73 | VG54045 | 40450❑* | 40451❑‡ |
| | 100 | 55 | 98 | VG54055 | 40550❑† | 40551❑‡ |
| | 125 | 75 | 130 | VG54075 | 40750❑† | 40751❑‡ |
| | 150 | 110 | 170 | VG54110 | 41100❑† | 41101❑‡ |
| | 200 | 160 | 230 | VG54160 | 41600❑† | 41601❑‡ |
| | 250 | 185 | 260 | VG54185 | 41850❑‡ | — |
| | 350 | 220 | 340 | VG54220 | 42200❑‡ | — |
| | 500 | 300 | 460 | VG54300 | 43000❑‡ | — |

* Immediate delivery † Available from factory ‡ Manufactured upon order

### 1.1.2 Outline of Control Methods

The VG5 uses four control methods:

- Open-Loop Vector Control (factory setting)
- Flux Vector Control
- V/f Control without PG
- V/f Control with PG Feedback

**Note:** PG stands for pulse generator (encoder).

Vector Control is a method for removing interference with magnetic flux and torque, and controlling torque according to references.

Current Vector Control independently controls magnetic flux current and torque current by simultaneously controlling the motor primary current and phases. This ensures smooth rotation, high torque, and accurate speed/Torque Control at low speeds.

Vector Control can be replaced by the conventional V/f Control system. If the motor constants required for Vector Control are not known, the motor constants can be automatically set with Auto-Tuning.

The control methods are effective for the following applications:

- Open-Loop Vector Control: General variable-speed drive.
- Flux Vector Control: Simple servo-drive, high-precision speed control/Torque Control.
- V/f Control without PG: Conventional Inverter control mode. Used for multi-drive operation (connecting multiple motors to one Inverter).
- V/f Control with PG Feedback: Simple speed feedback control. (For applications with the PG connected to the machine shaft rather than the motor shaft.)

The control characteristics for each mode are shown in *Table 1.2*.

Table 1.2 Control Method Characteristics

| Characteristic | Vector Control | | V/f Control | |
|---|---|---|---|---|
| | Open-Loop | Flux Vector | Without PG | With PG Feedback |
| Speed Control Range | 1:100 | 1:1000 | 1:40 | 1:40 |
| Speed Control Precision | ±0.2 % | ±0.02 % | ±2 to 3 % | ±0.03 % |
| Initial Drive | 150% at 1 Hz | 150% at 0 r/min | 150% at 3 Hz | |

### 1.1.3 Functions

#### ■ Auto-Tuning

Auto-Tuning is effective for Vector Control. It solves problems in applicable motor restrictions and difficult constant settings. The motor constants are automatically set by entering a value from the motor's rating nameplate.

Auto-Tuning allows Flux Vector Control to operate accurately with virtually any normal AC induction motor, regardless of the supplier.

#### ■ Torque Control

Torque Control is effective for flux vector control with PG. Torque in controlled by taking multi-function analog input signals as torque references. Torque Control accuracy is ±5%. Switching is possible between Torque Control and speed control.

#### ■ V/f Patter Settings

V/f pattern settings are effective for V/f Control. Select V/f pattern according to the application from among the 15 preset V/f patterns. Custom V/f patterns can also be set.

#### ■ Frequency References

The following five types of frequency references can be used to control the output frequency of the Inverter:

- Numeric input from the Digital Operator
- Voltage input within a range from 0 to 10 V
- Voltage input within a range from 0 to ±10 V (With negative voltages, rotation is in the opposite direction from the run command.)
- Current input within the range from 4 to 20 mA
- Input from Output Card

Any of the above frequency references can be used by setting a constant.

A maximum of nine frequency references can be registered with the Inverter. With remote multi-step speed reference inputs, the Inverter can operate in multi-step speed operation with a maximum of nine speed steps.

## PID Control

The Inverter has a PID control loop for easy process control. Process control is an operational method in which the Inverter varies the output frequency to match the feedback value from the sensor to a set target value.

Process control can be applied to a variety of operations, such as those listed below, depending on the variable detected by the sensor.

- Speed Control: With a speed sensor, such as tach generator, the Inverter regulates the rotating speed of the motor regardless of the load on the motor or synchronizes the rotating speed of the motor with that of another motor.
- Pressure Control: With a pressure sensor, the Inverter performs constant pressure control.
- Flow-Rate Control: By sensing the flow-rate of a fluid, the Inverter performs precise flow-rate control.
- Temperature Control: With a temperature sensor, the Inverter performs temperature control by fan speed.

## Zero Servo Control

Zero Servo control is effective with flux vector control. Even at a motor speed of zero (0 Hz), a torque of 150% of the motor's rated torque can be generated and the average servomotor holding power (stopping power) can be obtained.

## Speed Control by Feedback

Speed control using feedback is effective with a PG. An optional PG Speed Option Card can be used to enable feedback control for speeds, thereby improving speed control accuracy.

## Dwell Function

By holding the output frequency for a constant time during acceleration and deceleration, acceleration and deceleration can be performed without stepping out even when driving a motor with a large startup load.

## Low Noise

The output transistor of the Inverter is an IGBT (Insulated Gate Bipolar Transistor). Using sine wave PWM with a high frequency carrier, the motor does not generate metallic noise.

## Monitor Function

The following items can be monitored with the Digital Operator: frequency reference, output frequency, output current, motor speed, output voltage reference, main-circuit DC voltage, output power, torque reference, status of input terminals, status of output terminals, operating status, total operating time, software number, speed deviation value, PID feedback value, fault status, fault history, etc.

All types of data can be monitored even with multi-function analog output.

## Bilingual Digital Operator

The Digital Operator can display either English or Japanese. The Digital Operator's liquid crystal display provides a 16 character by 2-line display area.

Easy-to-read displays allow the advanced functions of the Inverter to be set in interactive operations to input constants, monitoring items, etc. Change the constant setting to select the English display.

## Harmonic Countermeasures (0.4 to 160 kW Models)

The VG5 Inverters up to 160 kW support DC Reactors to easily handle high frequency control guidelines.

- DC Reactors (optional) can be connected to 0.4 to 15 kW models.
- Models from 18.5 to 160 kW have a built-in DC reactor.
- An optional AC reactor can be connected to Inverters from 185 to 300 kW.

## ■ User Constant Structure and Three Access Levels

The VG5 has a number of user constants for setting various functions. These user constants are classified into a hierarchy to make them easier to use.

The levels are as follows from top to bottom: Modes, Groups, Functions, and Constants. The access levels for the user constants are shown in Table 1.3.

Table 1.3 Access Levels for User Constants

| Level | Contents |
|---|---|
| Mode | Classified according to operation<br>Operation: For operating the Inverter. (All kinds of monitoring are possible.)<br>Initialize: For selecting the language displayed at the Digital Operator, setting access levels, initialization, and the control modes.<br>Programming: For setting user constants for operation.<br>Auto-Tuning: For automatic calculation or setting constants. (Only under the Vector Control mode.)<br>Modified Constants: For referencing or monitoring changed constants after shipment. |
| Groups | Classified by application. |
| Functions | Classified by function. (See user constants.) |
| Constants | Individual user constant settings. |

The VG5 allows the following three access levels to be set in order to further simplify setting user constants. (An access level is a range of user constants that can be referenced or set.)

| | |
|---|---|
| Quick-Start | Reads/sets user constants required for trial operation. (factory setting) |
| Basic | Reads/sets user constants that are commonly used. |
| Advanced | Reads/sets all the user constants that can be used. |

In general, press the DATA/ENTER key to move from an upper to a lower level. This varies somewhat, however, according to the access level, as shown in *Figure. 1.1*. For the Quick-Start access level, which has few user constants that can be set, pressing the DATA/ENTER key jumps directly to the user constant level; whereas for the advanced access level, which has many user constants, pressing the DATA/ENTER key first leads to the Group level.

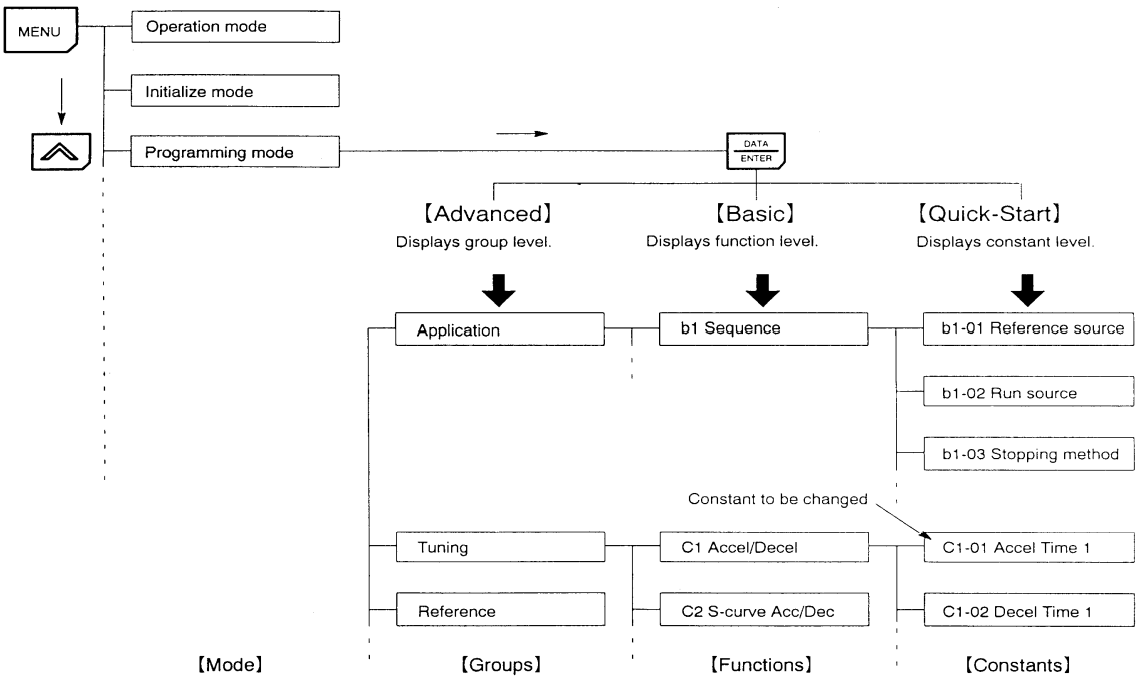



Figure 1.1 Access Level Structure

## 1.2 Nomenclature

This section provides the names of VG5 components, and the components and functions of the Digital Operator.

### 1.2.1 VG5 Components

The appearance of Inverter and the names of its components are shown in *Figure 1.2*.

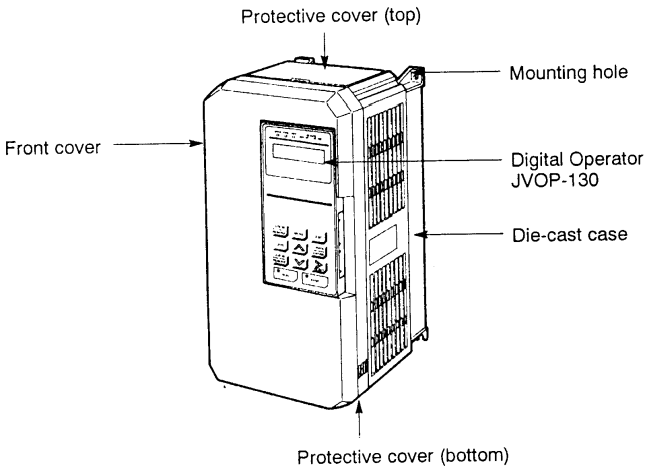



Figure 1.2 Appearance of VG5, Model VG520P4 (200 V, 0.4 kW, 0.5HP)

A 200 V Class Inverter with 0.4 kW Output is shown below with the front cover removed.

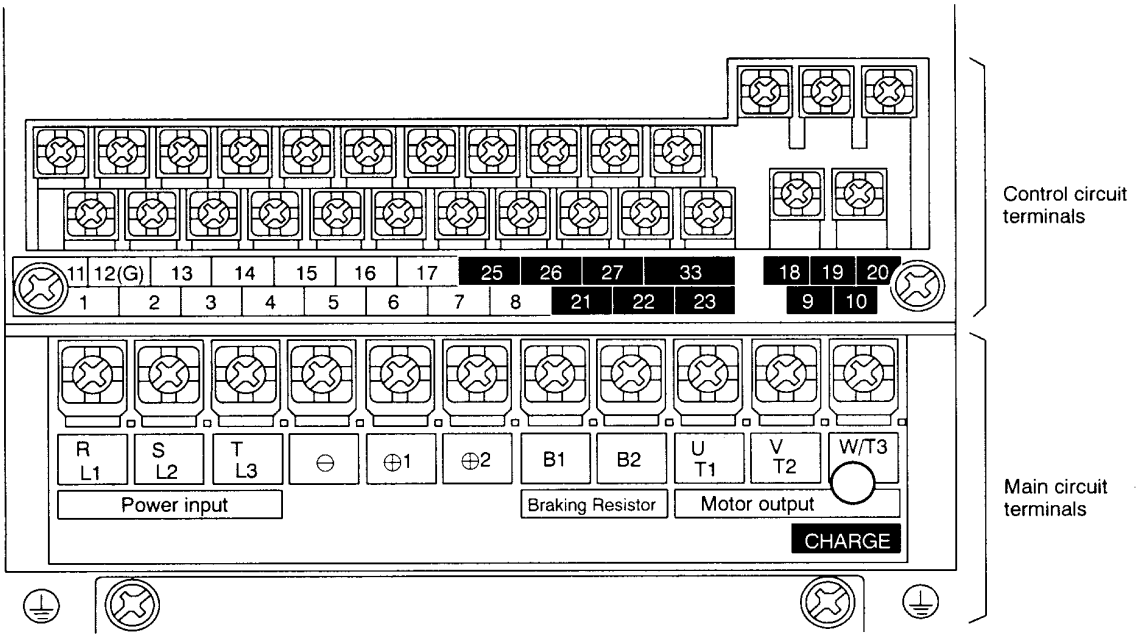
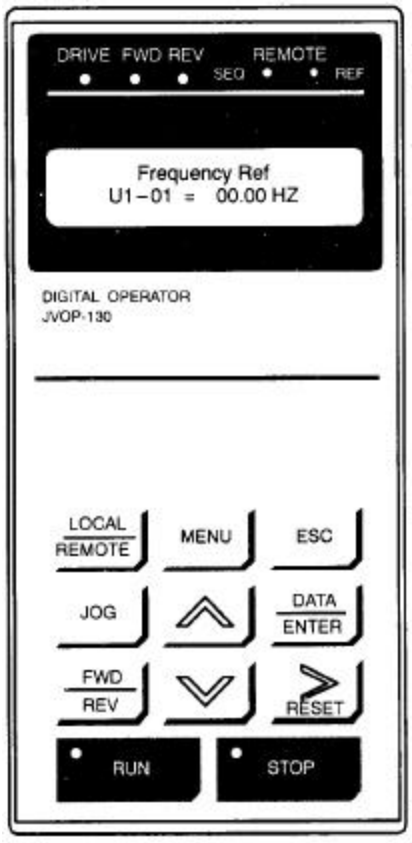



Figure 1.3 Terminal Arrangement

### 1.2.2 Digital Operator Components

This section describes the component names and functions of the Digital Operator. The component names and functions are shown in *Figure 1.4* and key functions are described in *Table 1.4*.




**Operation Mode Indicators**

DRIVE: Lit when in Operation mode.
FWD: Lit when there is a forward run command input.
REV: Lit when there is a reverse run command input.
SEQ: Lit when the run command from the control circuit terminal is enabled.
REF: Lit when the frequency reference from control circuit Terminals 13 and 14 is enabled.

**Data Display**

Two-line LCD that displays data for monitoring, user constants and set values with 16 characters per line.

**Keys**

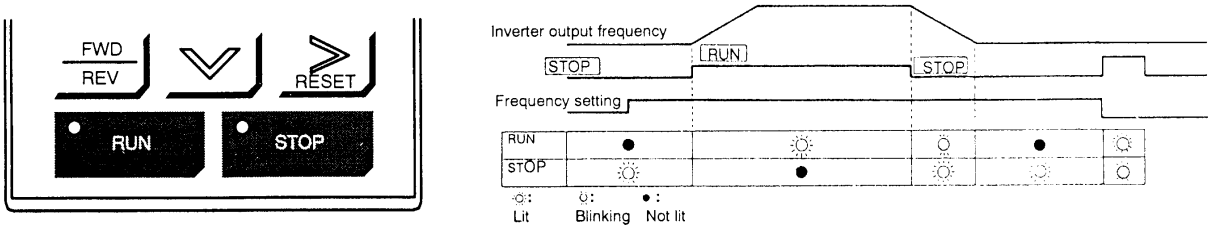
Execute operations such as setting user constants, monitoring, Jog, and Auto-Tuning.

Figure 1.4 Digital Operator Component Names and Functions

Table 1.4 Key Functions

| Key | Name | Function |
|---|---|---|
| LOCAL / REMOTE | LOCAL/REMOTE Key | Switches between (LOCAL) operation via the Digital Operator and control circuit terminal (REMOTE) operation. This key can be enabled or disabled by setting a user constant (o2-01). |
| MENU | MENU Key | Displays menus. |
| ESC | ESC Key | Returns to the status before the DATE/ENTER key was pressed. |
| JOG | JOG Key | Enables jog operation when the VG5 is being operated from the Digital Operator. |
| FWD / REV | FWD/REV Key | Selects the rotation direction of the motor when the VG5 is being operated from the Digital Operator. |
| RESET | RESET Key | Sets the number of digits for user constant settings. Also acts as the reset key when a fault has occurred. |
| ∧ | Increment Key | Selects menu items, groups, functions, and user constant names, and decrements set values. |
| ∨ | Decrement Key | Selects menu items, groups, functions, and user constant names, and decrements set values. |
| DATA / ENTER | DATA/ENTER Key | Enters menu items, functions, constants, and set values after they are set. |
| RUN | RUN Key | Starts the VG5 operation when the VG5 is in operation with the Digital Operator. |
| STOP | STOP Key | Stops VG5 operation. This key can be enabled or disabled by setting a user constant (o2-02) when operating from the control circuit terminal. |

Note: Except in diagrams, keys are referred to using the key names listed in the above table.




The RUN and STOP indicators light and blink to indicate operating status.

Figure 1.5 RUN and STOP Indicators

# 2

# Handling Inverters

This chapter describes the checks required upon receiving a VG5 Inverter and describes installation methods.

## 2.1 Confirmations Upon Delivery

**⚠ CAUTION**

- Never install an Inverter that is damaged or missing components. Doing so can result in injury.

Check the following items as soon as the Inverter is delivered.

Table 2.1 Checks

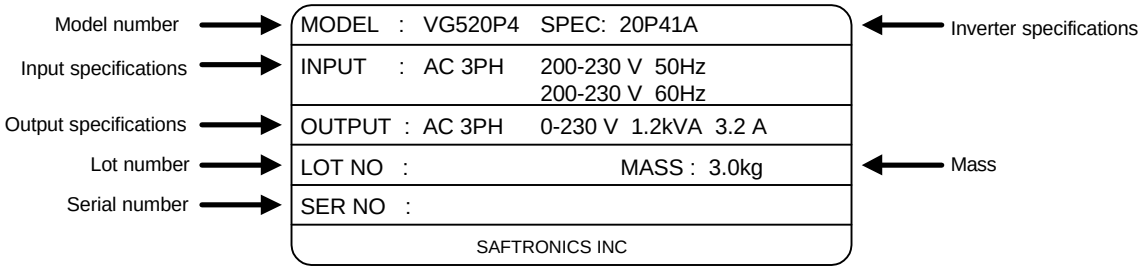
| Item | Method |
|---|---|
| Has the correct model of Inverter been delivered? | Check the model number on the nameplate on the side of the Inverter (See *Nameplate Information 2.1.1).* |
| Is the Inverter damaged in any way? | Inspect the entire exterior of the Inverter to see if there are any scratches or other damage resulting from shipping. |
| Are any screws or other components loose? | Use a screwdriver or other tools to check for tightness. |

If you find any irregularities in the above items, contact the agency from which you purchased the Inverter or your Saftronics representative immediately.

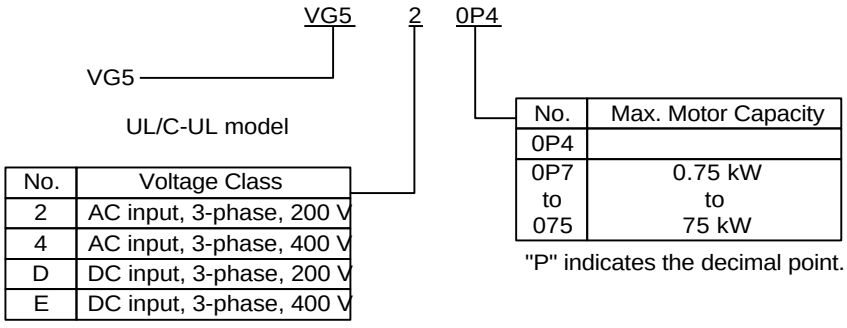
### 2.1.1 Nameplate Information

#### ▪ Example Nameplate

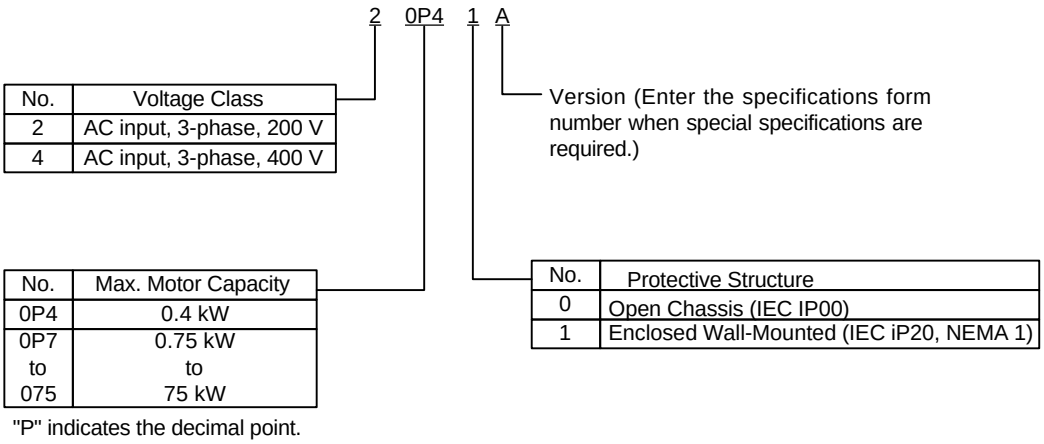
Standard domestic Inverter: 3-phase, 200VAC, 0.4 kW, IEC IP20 and NEMA 1 standards.




#### ▪ Inverter Model Numbers



## ■ Inverter Specifications




| No. | Voltage Class |
|---|---|
| 2 | AC input, 3-phase, 200 V |
| 4 | AC input, 3-phase, 400 V |

| No. | Max. Motor Capacity |
|---|---|
| 0P4 | 0.4 kW |
| 0P7 to 075 | 0.75 kW to 75 kW |

| No. | Protective Structure |
|---|---|
| 0 | Open Chassis (IEC IP00) |
| 1 | Enclosed Wall-Mounted (IEC iP20, NEMA 1) |

"P" indicates the decimal point.

- Open Chassis Type (IEC IP00)

  Protected so that parts of the human body cannot reach electrically charged parts from the front when the Inverter is mounted in a control panel.

- Enclosed Wall-Mounted Type (IEC IP20, NEMA 1)

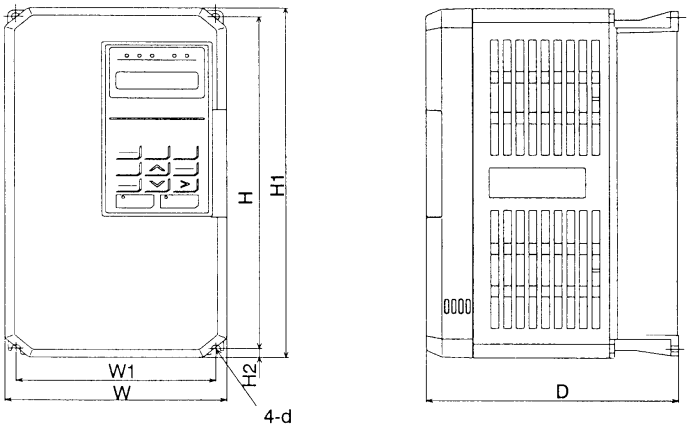
  The Inverter is structured so that the Inverter is shielded from the exterior, and can thus be mounted to the interior wall of a standard building (not necessarily enclosed in a control panel). The protective structure conforms to the standards of NEMA 1 in the USA.

## 2.2 Exterior and Mounting Dimensions

### ■ 200 V/400 V Class Inverters of 15 kW and Lower

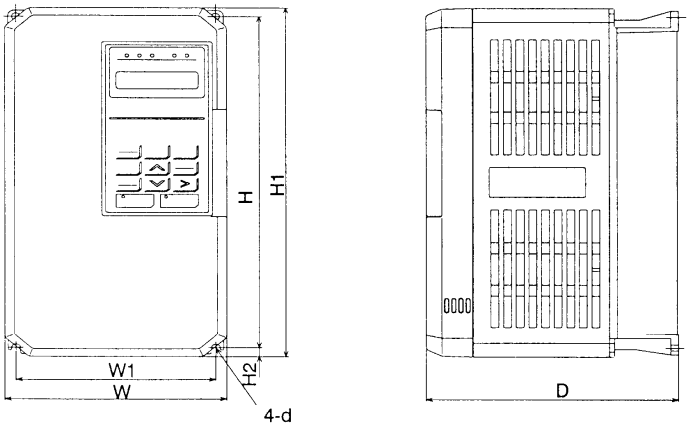
The following diagram shows a 200 V class, 1.5 kW Inverter.

Remove the top and bottom covers when mounting 200 V/400 V class Inverters of 15 kW or lower in a control panel.

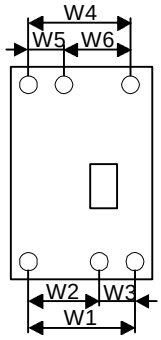



### ■ 200 V/400 V Class Inverters of 18.5 kW and Higher

The following diagram shows a 200 V class, 18.5 kW Inverter.




### ■ Mounting Dimensions for 400 V Class Inverters of 185 to 300 kW




| Max. Applicable Motor Capacity [kW] | W1 | W2 | W3 | W4 | W5 | W6 |
|---|---|---|---|---|---|---|
| 185, 220 | 750 | 440 | 310 | 850 | 285 | 565 |
| 300 | 750 | 440 | 310 | 873 | 298 | 575 |

Table 2.2 VG5 External Dimensions (mm) and Approximate Masses (kg)

| Voltage Class | Max. Applicable Output [kW] | Open Chassis (IP00) | | | | | | | Enclosed Wall-Mounted (NEMA 1) | | | | | | | | DC Reactor *1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | W | H | D | W1 | H1 | H2 | Approx. Mass | W | H | D | W1 | H1 | H2 | Approx. Mass | Mounting Holes d*1 | |
| 200 V Class | 0.4 | 140 | 280 | 160 | 126 | 266 | 7.0 | 3 | 140 | 280 | 160 | 126 | 266 | 7.0 | 3 | M5 | Option |
| | 0.75 | | | | | | | | | | | | | | | | |
| | 1.5 | | | | | | | | | | | | | | | | |
| | 2.2 | 140 | 280 | 180 | 126 | 266 | 7.0 | 4.5 | 140 | 280 | 180 | 126 | 266 | 7.0 | 4.5 | M5 | |
| | 3.7 | | | | | | | | | | | | | | | | |
| | 5.5 | 200 | 300 | 205 | 186 | 285 | 8.0 | 5.5 | 200 | 300 | 205 | 186 | 285 | 8.0 | 5.5 | M6 | |
| | 7.5 | | | | | | | 6 | | | | | | | 6 | | |
| | 11 | 250 | 380 | 225 | 236 | 365 | 7.5 | 11 | 250 | 380 | 225 | 236 | 365 | 7.5 | 11 | M6 | |
| | 15 | | | | | | | | | 400 | | | | 27.5 | | | |
| | 18.5 | 325 | 450 | 285 | 275 | 435 | 7.5 | 28 | 330 | 610 | 285 | 275 | 435 | 87.5 | 32 | M6 | Built-in |
| | 22 | | | | | | | | | 675 | | | | 152.5 | | | |
| | 30 | 425 | 675 | 350 | 320 | 650 | 12.5 | 61 | 430 | 985 | 350 | 320 | 650 | 212.5 | 67 | M10 | |
| | 37 | | | | | | | 62 | | | | | | | 68 | | |
| | 45 | 475 | 800 | 350 | 370 | 775 | 12.5 | 80 | 480 | 1110 | 350 | 370 | 775 | 212.5 | 87 | M10 | |
| | 55 | | | | | | | | | | | | | | | | |
| | 75 | 575 | 925 | 400 | 445 | 895 | 15.0 | 135 | 580 | 1290 | 400 | 445 | 895 | 270 | 145 | M12 | |
| 400 V Class | 0.4 | 140 | 280 | 160 | 126 | 266 | 7.0 | 3 | 140 | 280 | 160 | 126 | 266 | 7.0 | 3 | M5 | Option |
| | 0.75 | | | | | | | | | | | | | | | | |
| | 1.5 | 140 | 280 | 180 | 126 | 266 | 7.0 | 4 | 140 | 280 | 180 | 126 | 266 | 7.0 | 4 | M5 | |
| | 2.2 | | | | | | | 4.5 | | | | | | | 4.5 | | |
| | 3.7 | | | | | | | | | | | | | | | | |
| | 5.5 | 200 | 300 | 205 | 186 | 285 | 8.0 | 6 | 200 | 300 | 205 | 186 | 285 | 8.0 | 6 | M6 | |
| | 7.5 | | | | | | | | | | | | | | | | |
| | 11 | 250 | 380 | 225 | 236 | 365 | 7.5 | 11 | 250 | 380 | 225 | 236 | 365 | 7.5 | 11 | M6 | |
| | 15 | | | | | | | | | | | | | | | | |
| | 18.5 | 325 | 450 | 285 | 275 | 435 | 7.5 | 29 | 330 | 610 | 285 | 275 | 435 | 87.5 | 32 | M6 | Built-in |
| | 22 | | | | | | | 31 | | | | | | | 34 | | |
| | 30 | 325 | 625 | 285 | 275 | 610 | 7.5 | 44 | 330 | 785 | 285 | 275 | 610 | 87.5 | 48 | M6 | |
| | 37 | | | | | | | | | | | | | | | | |
| | 45 | | | | | | | | | 850 | | | | 152.5 | | | |
| | 55 | 455 | 820 | 350 | 350 | 795 | 12.5 | 81 | 460 | 1130 | 350 | 350 | 795 | 212.5 | 87 | M10 | |
| | 75 | | | | | | | 82 | | | | | | | 88 | | |
| | 110 | 575 | 925 | 375 | 445 | 895 | 15.0 | 135 | 580 | 1290 | 375 | 445 | 895 | 270 | 145 | M12 | |
| | 160 | | | 400 | | | | 145 | | | 400 | | | | 155 | | |
| | 185 | 950 | 1450 | 435 | *2 | 1400 | 25 | 360 | — | | | | | | | M12 | – |
| | 220 | | | | | | | | | | | | | | | | |
| | 300 | 960 | 1600 | 455 | *2 | 1550 | 25 | 420 | | | | | | | | | |

*1 Same for open Chassis and enclosed wall-mounted types.

*2 See Page 12 for mounting dimensions.

**NOTE:** An attachment is required to mount the cooling fins (fin section) on the outside of the control panel for 200 V/400 V class Inverters of 15 kW or less. Please ask your Saftronics representative for details. Dimensional drawings for models with externally mounted cooling fins and other special requirements are also available from you Saftronics representative.

## 2.3 Checking and Controlling the Installation Site

**⚠ CAUTION**

- Always hold the case when carrying the Inverter. If the Inverter is held by the front cover, the main body of the Inverter may fall, possibly resulting in injury.
- Attach the Inverter to a metal or other noncombustible material. Fire can result if the Inverter is attached to a combustible material.
- Install a cooling fan or other cooling device when installing more than one Inverter in the same enclosure so that the temperature of the air entering the Inverters is below 45°C. Overheating can result in fire or other accidents.

Install the VG5 in the installation site described below and maintain optimum conditions.

### 2.3.1 Installation Site

Install the Inverter under the following conditions.

| Type | Ambient Operating Temperature | Humidity |
|---|---|---|
| Enclosed wall-mounted | -10 to 40°C | 90% RH or less (no condensation) |
| Open chassis | -10 to 45°C | 90% RH or less (no condensation) |

Protection covers are attached to the top and bottom of the Inverter. Be sure to remove the protection covers before installing a 200 or 400 V class Inverter with an output of 5 kW or less in a panel.

- Install the Inverter in a clean location free from oil mist and dust. It can be installed in a totally enclosed panel that is completely shielded from floating dust.
- When installing or operating the Inverter, always take special care so that metal powder, oil, water, or other foreign matter does not get into the Inverter.
- Do no install the Inverter on combustible material, such as wood.
- Install the Inverter in a location free from radioactive materials and combustible materials.
- Install the Inverter in a location free from harmful gasses and liquids.
- Install the Inverter in a location without excessive oscillation.
- Install the Inverter in a location free from chlorides.
- Install the Inverter in a location not in direct sunlight.

### 2.3.2 Controlling the Ambient Temperature

To enhance the reliability of operation, the Inverter should be installed in an environment free from extreme temperature increases. If the Inverter is installed in an enclosed environment, such as a box, use a cooling fan or air conditioner to maintain the internal air temperature below 45°C.

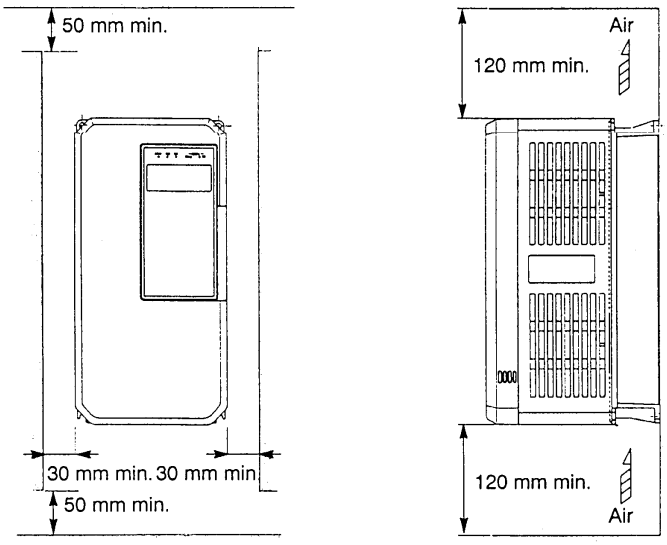
### 2.3.3 Protecting the Inverter from Foreign Matter

Place a cover over the Inverter during installation to shield it from metal power produced by drilling.

Always remove the cover from the Inverter after completing installation. Otherwise, ventilation will be reduced, causing the Inverter to overheat.

## 2.4 Installation Orientation and Space

Install the Inverter on a vertical surface so as not to diminish its coding efficiency. When installing the Inverter, always provide the following installation space to allow normal heat dissipation.




(a) Horizontal Space (b) Vertical Space

Figure 2.1 VG5 Installation Orientation and Space

**NOTE:**

- The same space is required horizontally and vertically for both open chassis (IP00) and enclosed wall-mounted (IP20, NEMA 1) Inverters.
- Always remove the protection covers before installing a 200 or 400 V class Inverter with an output of 15 kW or less in a panel.
- Always provide enough space for suspension eyebolts and the main circuit lines when installing a 200 or 400 V class Inverter with an output of 30 kW or more in a panel.

## 2.5 Removing/Attaching the Digital Operator and Front Cover

Remove the front cover to wire the terminals.

For models of 15 kW or less (both 200 V and 400 V class), do not remove or mount the front cover without first removing the Digital Operator; otherwise, the Digital Operator may malfunction due to imperfect contact. Use the following procedures to remove or attach the front cover.

### 2.5.1 Inverters of 15 kW or Less

#### ■ Removing the Digital Operator

Press the lever on the side of the Digital Operator in the direction of arrow 1 to unlock the Digital Operator. Lift the Digital Operator in the direction of arrow 2 to remove the Digital Operator as shown in the following illustration.

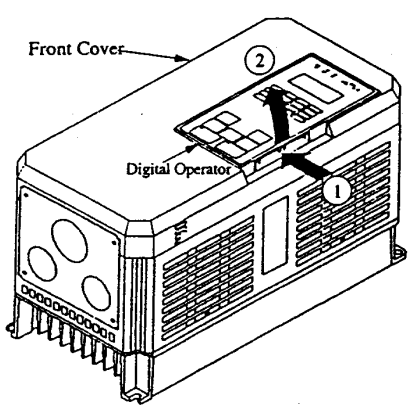



Figure 2.2 Removing the Digital Operator

#### ■ Removing the Front Cover

Press the left and right sides of the front cover in the directions of arrows 1 and lift the bottom of the cover in the direction of arrow 2 to remove the front cover as shown in the following illustration.

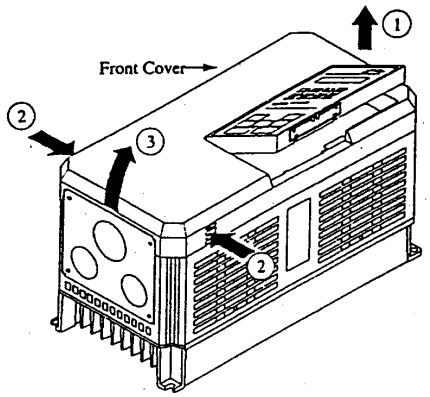



Figure 2.3 Removing the Front Cover

#### ■ Mounting the Front Cover

After wiring the terminals, mount the front cover to the Inverter by performing in reverse order the steps to remove the front cover.

1. Do not mount the front cover with the Digital Operator attached to the front cover; otherwise, the Digital Operator may malfunction due to imperfect contact.
2. Insert the tab of the upper part of the front cover into the groove of the Inverter and press the lower part of the front cover onto the Inverter until the front cover snaps shut.

### ■ Mounting the Digital Operator

1. Hook the Digital Operator at A (two locations) on the front cover in the direction of arrow 1 as shown in the following illustration.
2. Press the Digital Operator in the direction of arrow 2 until it snaps in place at B (two locations).

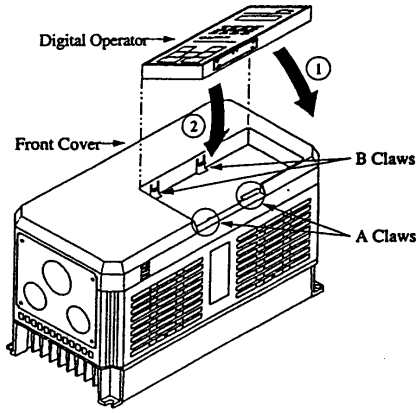



Figure 2.4 Mounting the Digital Operator

**NOTE:**

- Do not remove or attach the Digital Operator or mount or remove the front cover using methods other then those described above, otherwise the Inverter may break or malfunction due to imperfect contact.
- Never attach the front cover to the Inverter with the Digital Operator attached to the front cover. Imperfect contact can result.
- Always attach the front cover to the Inverter itself first, and then attach the Digital Operator to the front cover.

## 2.5.2 Inverters of 18.5 kW or Higher

The front cover can be removed without removing the Digital Operator from the Inverter provided that the Inverter has an output of 18.5 kW or higher.

Loosen the four screws of the front cover and move the front cover slightly upward to remove the front cover.

# 3

# Wiring

This chapter describes wiring terminals, main circuit terminal connections, main circuit terminal wiring specifications, control circuit terminals, and control circuit-wiring specifications.

## ⚠ WARNING

- Always turn OFF the input power supply before wiring terminals. Otherwise, an electric shock or fire can occur.
- Wiring must be performed by an authorized person qualified in electrical work. Otherwise, an electric shock or fire can occur.
- Be sure to ground the ground terminal. (200 V class: Ground to 100 Ω or less, 400 V class: Ground to 10 Ω or less) Otherwise, an electric shock or fire can occur.
- Always check the operation of any emergency stop circuits after they are wired. Otherwise, there is the possibility of injury. (Wiring is the responsibility of the user)
- Never touch the output terminals directly with your hands or allow the output lines to come into contact with the Inverter case. Never short the output circuits. Otherwise, electrical shock or grounding can occur.

## ⚠ CAUTION

- Check to be sure that the voltage of the main AC power supply satisfies the rated voltage of the Inverter. Injury or fire can occur if the voltage is not correct.
- Do not perform voltage withstand tests on the Inverter. Otherwise, semiconductor elements and other devices can be damaged.
- Connect braking resistors, Braking Resistor Units, and Braking Units as shown in the I/O wiring examples. Otherwise, a fire can occur.
- Tighten all terminal screws to the specified tightening torque. Otherwise a fire may occur.
- Do not connect AC power to output Terminals T1, T2, and T3 (U, V, and W). The interior parts of the Inverter will be damaged if voltage is applied to the output terminals.
- Do not connect phase-advancing capacitors or LC/RC noise filters to the output circuits. The Inverter can be damaged or internal parts burnt if these devices are connected.
- Do not connect electromagnetic switches or contactors to the output circuits. If a load is connected while the Inverter is operating, surge current will cause the overcurrent protection circuit inside the Inverter to operate.

## 3.1 Connections to Peripheral Devices

Examples of connections between the VG5 and typical peripheral devices are shown in *Figure 3.1*. Use this illustration to gain an understanding of the overall equipment configuration.

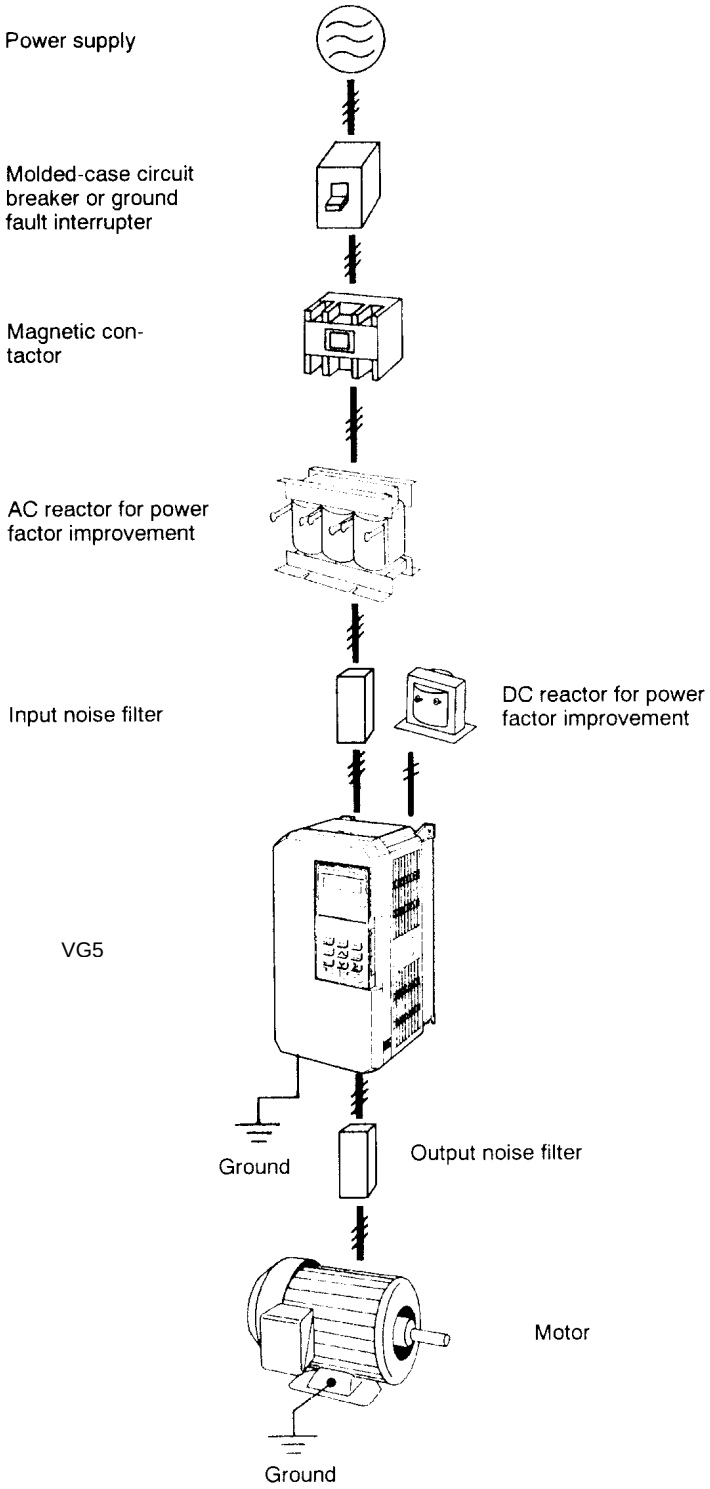



Figure 3.1 Example Connections to Peripheral Devices

## 3.2 Connection Diagram

The connection diagram of the VG5 is shown in *Figure 3.2*.

When using the Digital Operator, the motor can be operated by wiring only the main circuits.

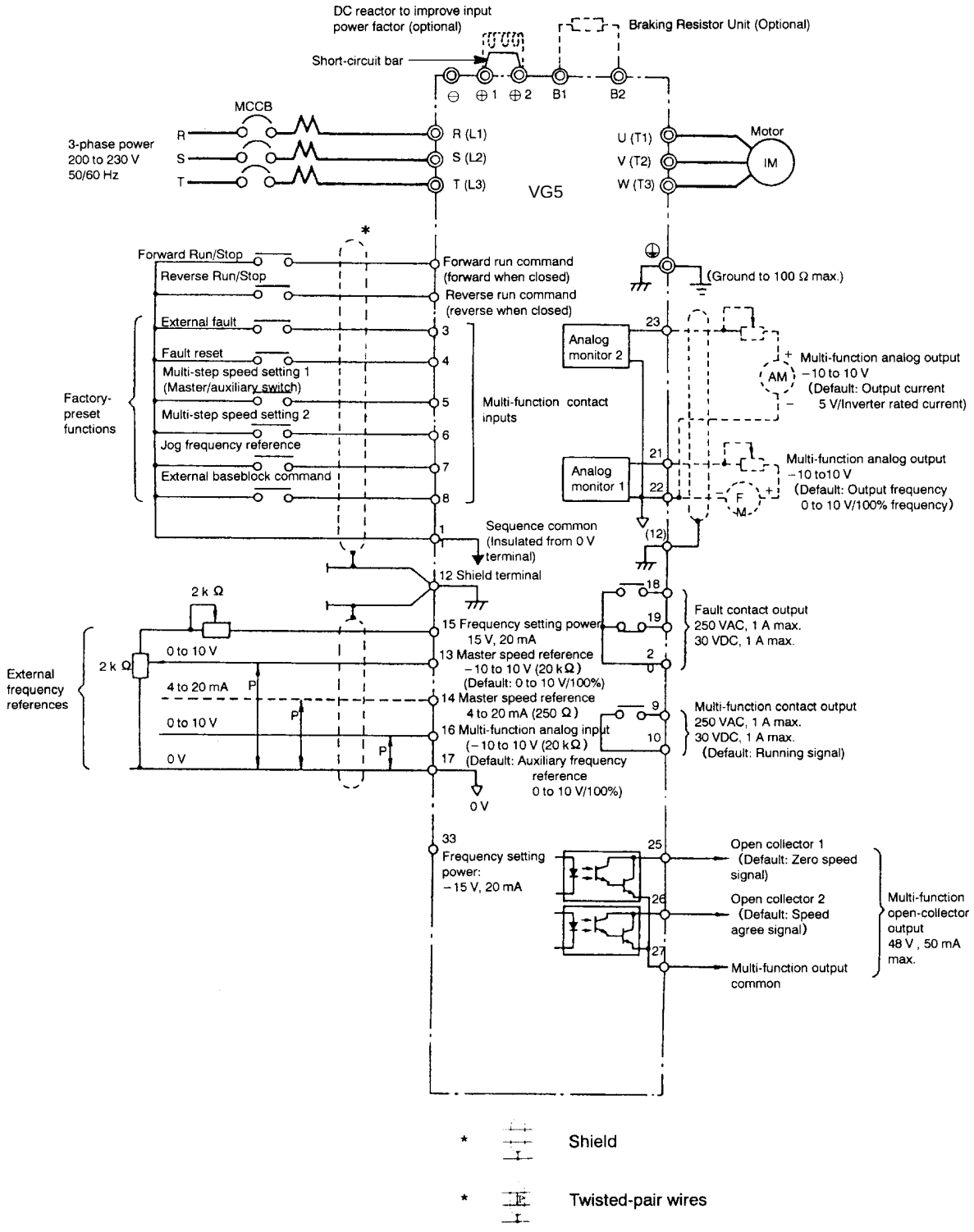



Figure 3.2 Connection Diagram (Model VG527P5 shown above)

**NOTE:**

1. Control circuit Terminals 1 to 33 are not arranged in order of terminal numbers; they are arranged as shown below. Be sure to wire them correctly.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 12(G) | 13 | 14 | 15 | 16 | 17 | 25 | 26 | 27 | 33 | | 18 | 19 | 20 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 21 | 22 | 23 | | | 9 | 10 |

2. Do not use control circuit Terminals 13 and 14 at the same time. (The two signals will be added inside the Inverter if they are input at the same time.
3. The maximum output current capacity of the +15 V/-15 V output from control circuit Terminals 15 and 33 is 20 mA.
4. The multi-function analog output is a dedicated meter output for a frequency meter, ammeter, etc. Do not use this output for Feedback Control or for any other control purpose. Use one of the optional analog monitors (AO-08 or AO-012) for analog outputs to the control system.
5. Disable the Stall Prevention during deceleration (set constant L3-04 to 0) when using a Braking Resistor Unit. If this user constant is not changed to disable Stall Prevention, the system may not stop during deceleration.
6. Enable protection for the internal DB resistor (model ERF) (set constant L8-01 to 1) when using an internal braking resistor. The braking resistor will not be protected unless this setting is changed to enable protection.
7. DC Reactors to improve the input power factor can be connected as an option only to Inverters for 15 kW or less. Remove the short bar from between ⊕1 and ⊕ 2 when connecting a DC Reactor.
8. There is no DC power supply input terminals for 200 V class Inverters of 30 to 75 kW and 400 V class Inverters of 55 to 160 kW, and DC power cannot be input to these Inverters.

## 3.3 Terminal Block Configuration

The terminal block for a 200 V class Inverter with an output of 0.4 kW is shown in *Figure 3.3.*

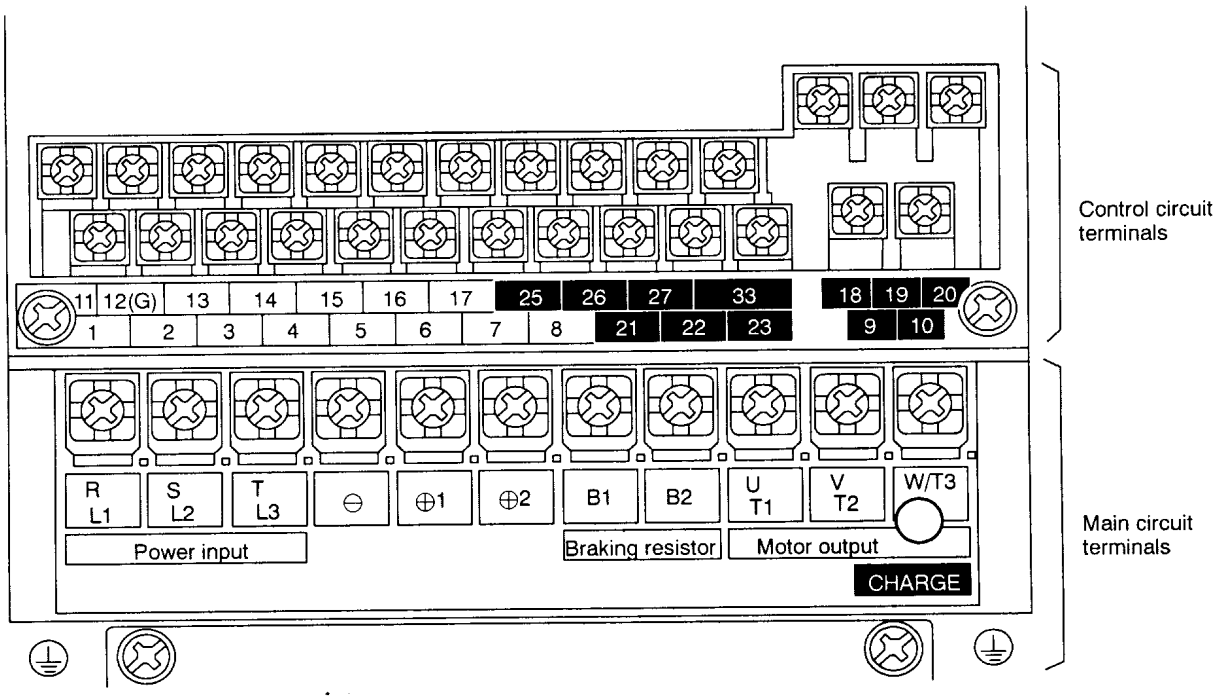



Figure 3.3 Terminal Arrangement

## 3.4 Wiring Main Circuit Terminals

### 3.4.1 Applicable Wire Sizes and Closed-Loop Connectors

Select the appropriate wires and crimp terminals from *Table 3.1* to *Table 3.3.*

Table 3.1 200 V Class Wire Sizes

| Circuit | VG5 Model | Terminal Symbol | Terminal Screws | AWG Sizes | Wire Thickness (see note) $mm^2$ | Wire Type |
|---|---|---|---|---|---|---|
| Main Circuits | VG520P4 | L1, L2, L3, √, — 1,— 2, B1, B2, T1, T2, T3 | M4 | 14-10 | 2-5.5 | Power cables, e.g., 600V vinyl power cables |
| | | ⏚ | | | | |
| | VG520P7 | L1, L2, L3, √, — 1,, — 2, B1, B2, T1, T2, T3 | M4 | 14-10 | 2-5.5 | |
| | | ⏚ | | | | |
| | VG521P5 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 14-10 | 2-5.5 | |
| | | ⏚ | | 12-10 | 3.5-5.5 | |
| | VG522P2 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 12-10 | 3.5-5.5 | |
| | | ⏚ | | | | |
| | VG523P7 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 10 | 5.5 | |
| | | ⏚ | | | | |
| | VG525P5 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M5 | 8 | 8 | |
| | | ⏚ | | 10-8 | 5.5- 8 | |
| | VG527P5 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M5 | 8 | 8 | |
| | | ⏚ | | 10-8 | 5.5-8 | |
| | VG52011 | L1, L2, L3, √, — 1, — 2, — 3, T1, T2, T3 | M6 | 4 | 22 | |
| | | ⏚ | | 8 | 8 | |
| | VG52015 | L1, L2, L3, √, — 1, — 2, — 3, T1, T2, T3 | M8 | 3 | 30 | |
| | | ⏚ | M6 | 8 | 8 | |
| | VG52018 | L1, L2, L3, √, — 1, — 2, — 3, T1, T2, T3 | M8 | 3 | 30 | |
| | | ⏚ | | 6 | 14 | |
| | | r, S | M4 | 20-10 | 0.5-5.5 | |
| | VG52022 | L1, L2, L3, √, — 1, — 2, — 3 T1, T2, T3 | M8 | 2 | 38 | |
| | | ⏚ | | 6 | 14 | |
| | | r, S | M4 | 20-10 | 0.5-5.5 | |
| | VG52030 | L1, L2, L3, √, — 3, T1, T2, T3 | M10 | 4/0 | 38-100 | |
| | | ⏚ | M8 | 4 | 22 | |
| | | r, S | M4 | 20-10 | 0.5-5.5 | |
| | VG52037 | L1, L2, L3, √, — 3, T1, T2, T3 | M10 | 1/0 x 2P | 38- 100 | |
| | | ⏚ | M8 | 4 | 22 | |
| | | r, S | M4 | 20-10 | 0.5-5.5 | |

**NOTE:** The wire thickness is set for copper wires at 75°C.

| Circuit | VG5 Model | Terminal Symbol | Terminal Screws | AWG Sizes | Wire Thickness (see note) $mm^2$ | Wire Type |
|---|---|---|---|---|---|---|
| Main Circuits | VG52045 | L1, L2, L3, √, — 3, T1, T2, T3 | M10 | 1/0 x 2P | 60-100 | Power cables, e.g., 600V vinyl power cables |
| | | ⏚ | M8 | 4 | 22 | |
| | | r, S | M4 | 20-10 | 0.5-5.5 | |
| | VG52055 | L1, L2, L3, √, — 3, T1, T2, T3 | M10 | 1/0 x 2P | 100 | |
| | | ⏚ | M8 | 3 | 30 | |
| | | r, S | M4 | 20-10 | 0.5-5.5 | |
| | VG52075 | L1, L2, L3, √, — 3, T1, T2, T3 | M12 | 4/0 x 2P | 100-200 | |
| | | ⏚ | M8 | 1 | 50 | |
| | | r, S | M4 | 20-10 | 0.5-5.5 | |
| Control Circuits | All models | 1 to 33 | M3.5 | 20-16 | 0.5-2 | Shielded twisted-pair wires |

**NOTE:** The wire thickness is set for copper wires at 75°C.

Table 3.2 400 V Class Wire Sizes

| Circuit | VG5 Model | Terminal Symbol | Terminal Screws | AWG Sizes | Wire Thickness (see note) $mm^2$ | Wire Type |
|---|---|---|---|---|---|---|
| Main Circuits | VG540P4 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 14-10 | 2-5.5 | Power cables, e.g., 600 V vinyl power cables |
| | | ⏚ | | | | |
| | VG540P7 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 14-10 | 2-5.5 | |
| | | ⏚ | | 12-10 | 3.5-5.5 | |
| | VG541P5 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 14-10 | 2-5.5 | |
| | | ⏚ | | 12-10 | 3.5-5.5 | |
| | VG542P2 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 14-10 | 2-5.5 | |
| | | ⏚ | | 12-10 | 3.5-5.5 | |
| | VG543P7 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 14-10 | 2-5.5 | |
| | | ⏚ | | 12-10 | 3.5-5.5 | |
| | VG44P0 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 12-10 | 3.5-5.5 | |
| | | ⏚ | | | | |
| | VG545P5 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M4 | 12-10 | 3.5-5.5 | |
| | | ⏚ | | | | |
| | VG547P5 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M5 | 8-6 | 8-14 | |
| | | ⏚ | | | | |
| | VG54011 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M5 | 8-6 | 8-14 | |
| | | ⏚ | M6 | 8 | 88 | |
| | VG54015 | L1, L2, L3, √, — 1, — 2, B1, B2, T1, T2, T3 | M5 | 8-6 | 8-14 | |
| | | ⏚ | M6 | 8 | 8 | |
| | VG54018 | L1, L2, L3, √, — 1, — 2, — 3, T1, T2, T3 | M6 | 6 | 14 | |
| | | ⏚ | M8 | 8 | 8 | |
| | | r, $ | M4 | 20-10 | 0.5-5.5 | |
| | VG54022 | L1, L2, L3, √, — 1, — 2, — 3, T1, T2, T3 | M6 | 4 | 22 | |
| | | ⏚ | M8 | 8 | 8 | |
| | | r, $ | M4 | 20-10 | 0.5-5.5 | |
| | VG54030 | L1, L2, L3, √, — 1, — 2, — 3, T1, T2, T3 | M8 | 4 | 22 | |
| | | ⏚ | | 8 | 8 | |
| | | r, $ | M4 | 20-10 | 0.5-5.5 | |
| | VG54037 | L1, L2, L3, √, — 1, — 2, — 3, T1, T2, T3 | M8 | 3 | 30 | |
| | | ⏚ | | 6 | 14 | |
| | | r, $ | M4 | 20-10 | 0.5-5.5 | |
| | VG54045 | L1, L2, L3, √, — 1, — 2, — 3, T1, T2, T3 | M8 | 1 | 50 | |
| | | ⏚ | | 6 | 14 | |
| | | r, $ | M4 | 20-10 | 0.5-5.5 | |
| | VG54055 | L1, L2, L3, √, — 3, T1, T2, T3 | M10 | 4/0 | 38-100 | |
| | | ⏚ | M8 | 4 | 22 | |
| | | r, $ 200, $ 400 | M4 | 20-10 | 0.5-5.5 | |

**NOTE:** The wire thickness is set for copper wires at 75°C.

| Circuit | VG5 Model | Terminal Symbol | Terminal Screws | AWG Sizes | Wire Thickness (see note) $mm^2$ | Wire Type |
|---|---|---|---|---|---|---|
| Main Circuits | VG54075 | L1, L2, L3, √, — 3, T1, T2, T3 | M10 | 1/0 x 2P | 100 | Power cables, e.g., 600 V vinyl power cables |
| | | ⏚ | M8 | 4 | 22 | |
| | | r, $ 200, $ 400 | M4 | 20-10 | 0.5-5.5 | |
| | VG54110 | L1, L2, L3, √, — 3, T1, T2, T3 | M10 | 1/0 x 2P | 60-100 | |
| | | ⏚ | M8 | 3 | 30 | |
| | | r, $ 200, $ 400 | M4 | 20-10 | 0.5-5.5 | |
| | VG54160 | L1, L2, L3, √, — 3, T1, T2, T3 | M12 | 4/0 x 2P | 100 x 2P | |
| | | ⏚ | M8 | 1 | 50 | |
| | | r, $ 200, $ 400 | M4 | 20-10 | 0.5-5.5 | |
| | VG54185 | L1, L2, L3, √, — 1, — 3, T1, T2, T3 | M16 | 650MCM x 2P | 325 X 2p | |
| | | ⏚ | M8 | 1 | 50 | |
| | | r, $ 200, $ 400 | M4 | 20-10 | 0.5-5.5 | |
| | VG54220 | L1, L2, L3, √, — 1, — 3, T1, T2, T3 | M16 | 650MCM x 2P | 325 | |
| | | ⏚ | M8 | 1/0 | 60 | |
| | | r, $ 200, $ 400 | M4 | 20-10 | 0.5-5.5 | |
| | VG54300 | L1, L2, L3, √, — 1, — 3, T1, T2, T3 | M16 | 650MCM x 2P | 325 x 2P | |
| | | ⏚ | M8 | 1/0 | 60 | |
| | | r, $ 200, $ 400 | M4 | 20-10 | 0.5- 5.5 | |
| Control Circuits | All models | 1 to 33 | M3.5 | 20-16 | 0.5-2 | Shielded twisted-pair wires |
| | | G | M3.5 | 20-14 | 0.5-2 | |

**NOTE:** The wire thickness is set for copper wires at 75°C.

Table 3.3 Closed-Loop Connector Sizes (JIS C 2805) (For 200 V and 400 V Classes)

| AWG Sizes | Wire Thickness $mm^2$ | Terminal Screws | Size |
|---|---|---|---|
| 20 | 0.5 | M3.5 | 1.25-3.5 |
| | | M4 | 1.25-4 |
| 18 | 0.75 | M3.5 | 1.25-3.5 |
| | | M4 | 1.25-4 |
| 16 | 1.25 | M3.5 | 1.25-3.5 |
| | | M4 | 1.25-4 |
| 14 | M8 | M3.5 | 2-3.5 |
| | | M4 | 2-4 |
| | | M5 | 2-5 |
| | | M6 | 2-6 |
| | | M8 | 2-8 |
| 12-10 | 3.5/5.5 | M4 | 5.5-4 |
| | | M5 | 5.5-5 |
| | | M6 | 5.5-6 |
| | | M8 | 5.5-8 |
| 8 | 8 | M5 | 8-5 |
| | | M6 | 8-6 |
| | | M8 | 8-8 |
| 6 | 14 | M6 | 14-6 |
| | | M8 | 14-8 |
| 4 | 22 | M6 | 22-6 |
| | | M8 | 22-8 |
| 3-2 | 30/38 | M8 | 38-8 |
| 1-1/0 | 50/60 | M8 | 60-8 |
| | | M10 | 60-10 |
| 3/0 | 80 | M10 | 80-10 |
| 4/0 | 100 | | 100-10 |
| 4/0 | 100 | M12 | 100-12 |
| 300MCM | 150 | | 150-12 |
| 400MCM | 200 | | 200-12 |
| 650MCM | 325 | M12 X 2 | 325-12 |
| | | M16 | 325-16 |

**NOTE:** Determine the wire size for the main circuit so that line voltage drop is within 2% of the rated voltage. Line voltage drop is calculated as follows (if there is the possibility or excessive voltage drop, use a larger wire suitable to the required length.

Line voltage drop (V) = /3 x wire resistance (Ω/km) x wire length (m) x current (A) x $10^{-3}$

### 3.4.2 Main Circuit Terminal Functions

Main circuit terminal functions are summarized according to terminal symbols in *Table 3.4* and *Table 3.5.* Wire the terminals correctly for the desired purposes.

Table 3.4 200 V Class Main Circuit Terminal Functions

| Purpose | Terminal Symbol | Model: VG5 |
|---|---|---|
| Main circuit power input | L1, L2, L3 (R, S, T) | 20P4 to 2075 |
| Inverter outputs | T1, T2, T3 (U, V, W) | 20P4 to 2075, D030 to D075 (all models) |
| DC power input | — 1- √ | 20P4 to 2022, D030 to D075 |
| Braking Resistor Unit Connection | B1, B2 | 20P4 to 27P5 |
| DC Reactor connection | — 1- —2 | 20P4 to 2015 |
| Braking Unit connection | — 3- √ | 2011 to 2075, D030 to D075 |
| Cooling fan power input | r, § | 2018 to 2022 |
| Cooling fan power input (control power input) | r, § | 2030 to 2075, D030 to D075 |
| Ground | ⏚ | 20P4 to 2075, D030 to D075 (all models) |

**NOTE:** Models VG52030 to 2075 do not support DC power input.

Table 3.5 400 V Class Main Circuit Terminal Functions

| Purpose | Terminal Symbol | Model: VG5 |
|---|---|---|
| Main circuit power input | L1, L2, L3 (R, S, T) | 40P4 to 4300 |
| Inverter outputs | T1, T2, T3 (U, V, W) | 40P4 to 4300 |
| DC power input | — 1- √ | 40P4 to 4045, 4185 to 4300 |
| Braking Resistor Unit Connection | B1, B2 | 40P4 to 4015 |
| DC reactor connection | — 1- —2 | 40P4 to 4015 |
| Braking Unit connection | — 3- √ | 4018 to 4300 |
| Cooling fan power input | r, § 200: 200 to 230 VAC input<br>r, § 400: 380 to 460 VAC input | 4018 to 4045 |
| Cooling fan power input (control power input) | r, § | 4055 to 4300 |
| Ground | ⏚ | 40P4 to 4300 |

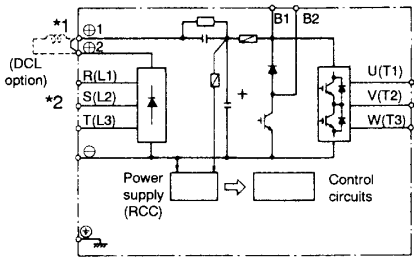
**NOTE:** Models VG54055 to 4160 do not support DC power input.

### 3.4.3 Main Circuit Configurations

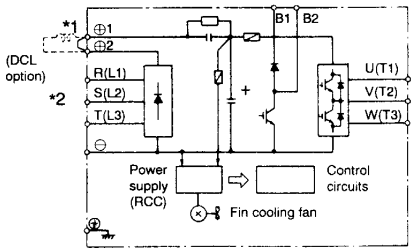
The main circuit configurations are shown in *Figure 3.4 and Figure 3.5.*

#### ■ 200 V Class

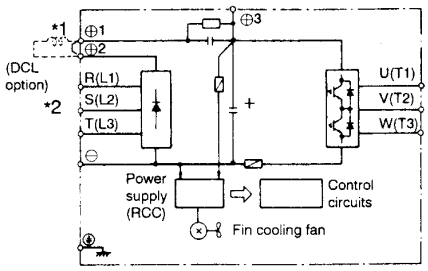
VG520P4 to 21P5 (0.4kW to 1.5kW)



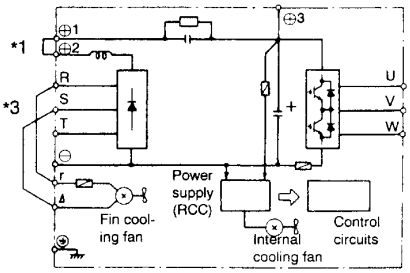

VG522P2 TO 27P5 (0.75 kW to 5.5 kW)



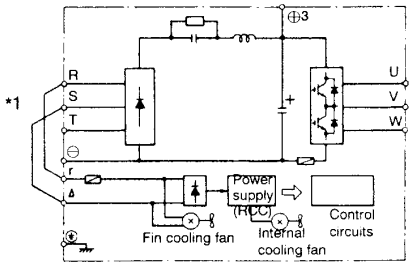

VG52011 to 2015 (11, 15 kW)



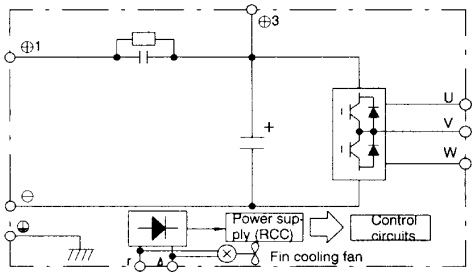

VG52018 to 2022 (18.5, 22 kW)




VG52030 to 2075 (30 to 75 kW)




VG5D030 to D075 (30 to 75 kW)




*1 Prewired at the factory.

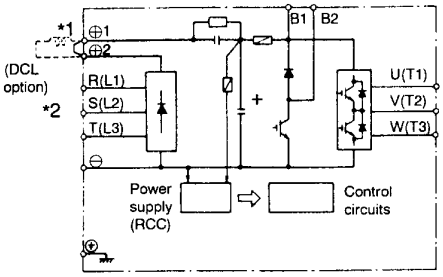
*2 Remove the short-circuit bar from between ⊕ 1 and ⊕ 2 when connecting a DC reactor to Inverters of 15 kW or less.

*3 Prewired at the factory. When supplying power to the main circuits from the DC power supply, remove the wiring from R-r and S- S.

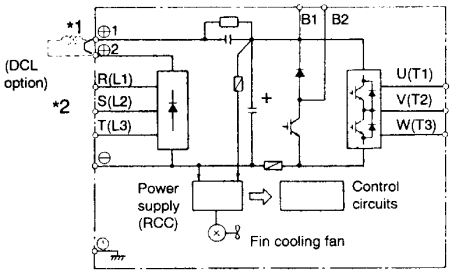
Figure 3.4 200 V Class Inverter Main Circuit Configurations

## ■ 400 V Class

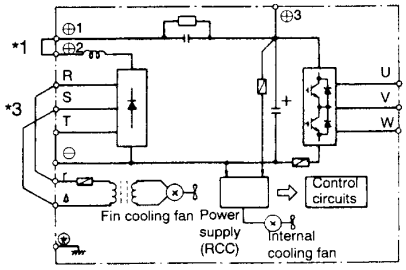
VG540P4 to 41P5 (0.4 to 1.5 kW)



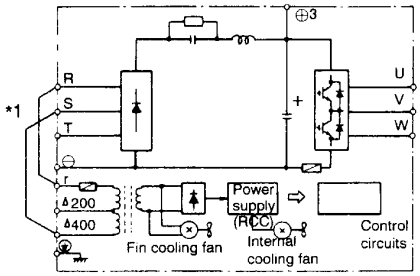

VG542P2 to 4015 (2.2 kW to 15 kW)



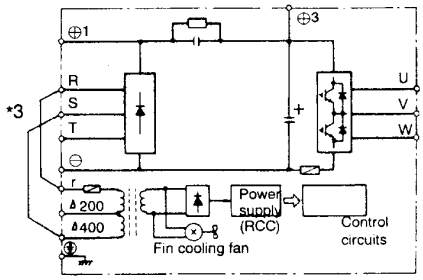

VG54018 to 4045 (18.5, 45 kW)




VG54055 to 4160 (55 to 160 kW)




VG54185 to 4300 (185 to 300 kW)




* 1 Prewired at the factory.

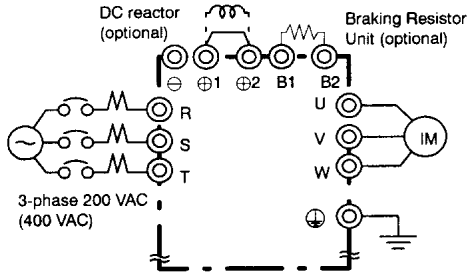
* 2 Remove the short-circuit bar from between ⊕ 1 and ⊕ 2 when connecting a DC reactor to Inverters of 15 kW or less.

* 3 Prewired at the factory. When supplying power to the main circuits from the DC power supply, remove the wiring from R-r and S-S.

Figure 3.5 400 V Class Inverter Main Circuit Configurations

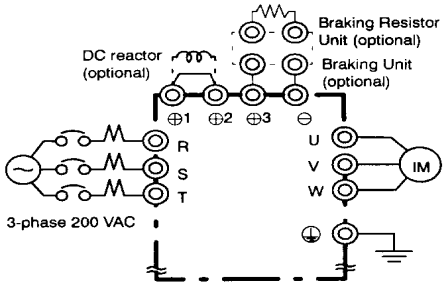
### 3.4.4 Standard Connection Diagrams

VG520P4 to 27P5, 40P4 to 4015



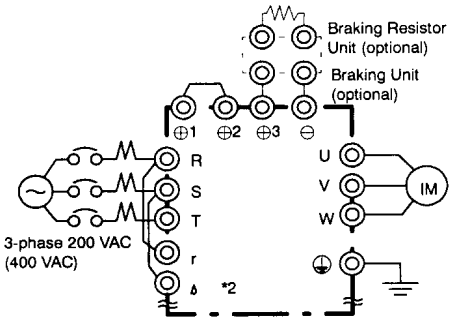

Be sure to remove the short-circuit bar before connecting a DC Reactor.

VG52011, 2015



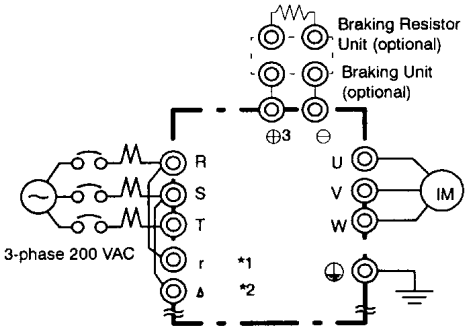

Be sure to remove the short-circuit bar before connecting a DC Reactor.

VG52018, 2022, 4018 to 4045



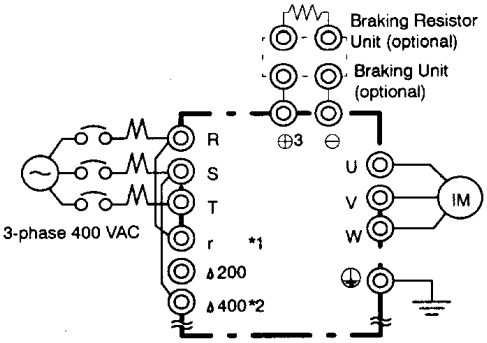

The DC Reactor is built in.

VG52030 to 2075



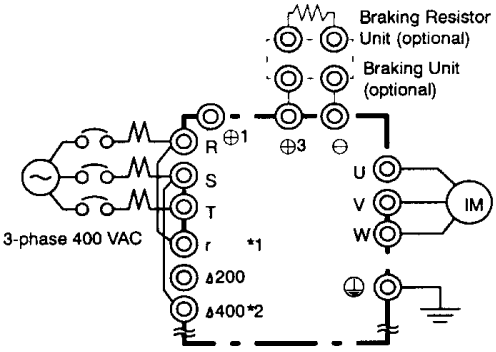

The DC Reactor is built in.

VG54055 to 4160




The DC Reactor is built in.

VG54185 to 4300




The DC Reactor is built in.

* 1 Input the control circuit power supply from r- S for 200 V class Inverters of 30 to 75 kW and from r- S 400 for 400 V class Inverters of 55 to 300 kW. (For other models, the control power supply is supplied internally from the main circuit DC power supply.)

* 2 The r-R, S (S 400)-S terminals are short-circuited for shipping. Remove the short wiring from the 2018, 2022, 4018 to 4045 and 4185 to 4300 when supplying power to the main circuits from the DC power supply.

Figure 3.6 Main Circuit Terminal Connections

### 3.4.5 Wiring the Main Circuits

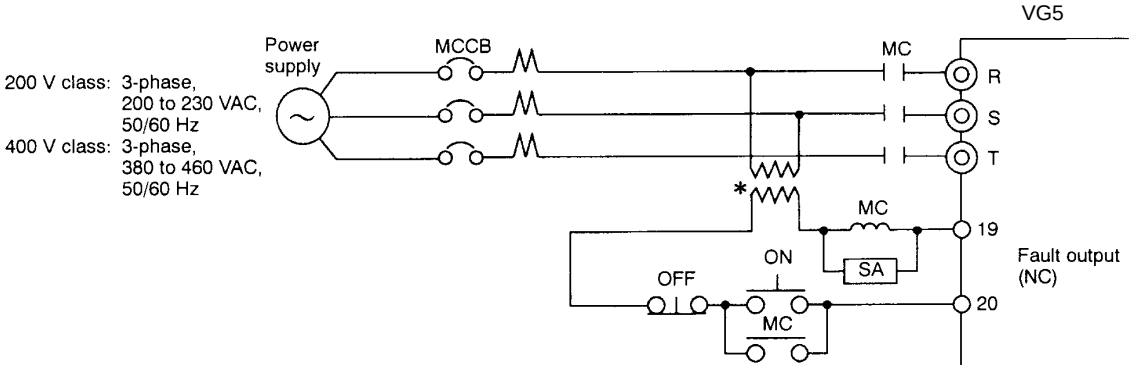
This section describes wiring connections for the main circuit inputs and outputs

## ■ Wiring Main Circuit Inputs

**Installing a Molded Case Circuit Breaker**

Always connect the power input Terminals L1, L2, and L3 (R, S, and T) and power supply via a Molded Case Circuit Breaker (MCCB) suitable for the Inverter.

- Choose an MCCB with a capacity of 1.5 to 2 times the Inverter's rated current.
- For the MCCB's time characteristics, be sure to consider the Inverter's overload protection (one minute at 150% of the rated output current).
- If the same MCCB is to be used for more than one Inverter, or other devices, set up a sequence so that the power supply will be turned OFF by a fault output, as shown in *Figure 3.7.*




* For 400V class Inverters, connect a 400/200 V transformer.

Figure 3.7 MCCB Installation

**Installing a Ground Fault Interrupter**

Inverter outputs use high speed switching, so high-frequency leakage current is generated. Therefore, at the Inverter primary side, use a ground fault interrupter that detects only the leakage current in the frequency range that is hazardous to humans and excludes high-frequency leakage current.

- For the special purpose ground fault interrupter for Inverters, choose a ground fault interrupter with a sensitivity amperage of at least 30 mA per Inverter.
- When using a general ground fault interrupter, choose a ground fault interrupter with a sensitivity amperage of 200 mA or more per Inverter and with an operating time of 0.1secondsor more.

**Installing a Magnetic Contactor**

If the power supply for the main circuit is to be shut off during a sequence, a Magnetic Contactor can be used instead of an MCCB.

When a Magnetic Contactor is installed on the primary side of the main circuit to forcibly stop the Inverter, however, the regenerative braking does not work and the Inverter will coast to a stop.

- The Inverter can be started and stopped by opening and closing the Magnetic Contactor on the primary side. Frequently opening and closing the Magnetic Contactor, however, may cause the Inverter to break down.
- When the Inverter is operated with the Digital Operator, automatic operation cannot be performed after recovery from a power interruption.
- If the Braking Resistor Unit is used, program the sequence so that the Magnetic Contactor is turned OFF by the contact of the unit's Thermal Overload Relay.

**Connecting Input Power Supply to the Terminal Block**

Input power supply can be connected to other Terminals L1, L2, and L3 (R, S or T) on the terminal block; the phase sequence of input power supply is irrelevant to the phase sequence.

**Installing an AC Reactor**

If the Inverter is connected to a large capacity power transformer (600 kW or more) or the Power Factor Correction Capacitor is switched, an excessive peak current may flow through the input power circuit, causing the converter unit to break down.

To prevent this, install an optional AC Reactor on the input side of the Inverter or a DC reactor to the DC reactor connection terminals.

This also improves the power factor on the power supply side.

**Installing a Surge Absorber**

Always use a surge absorber or diode for inductive loads near the Inverter. These inductive loads include Magnetic Contactors, electromagnetic relays, solenoid valves, solenoids, and magnetic brakes.

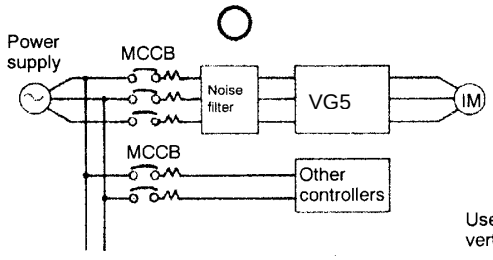
**Wiring the Power Terminals of Inverters with 18.5 to 300 kW Outputs**

- For 200 V class Inverters of 18.5 to 75 kW or 400 V class Inverters of 18.5 to 45 kW, connect the r and S terminals to the R and S terminals respectively. (These are shorted by a short-circuit bar for shipping.)
- For 400 V class, 55 to 300 kW, connect the r and S 400 terminals to the R and S terminals respectively. (These are shorted by a short-circuit bar for shipping.)

**Installing a Noise Filter on Power Supply Side**

Install a noise filter to eliminate noise transmitted between the power line and the Inverter.

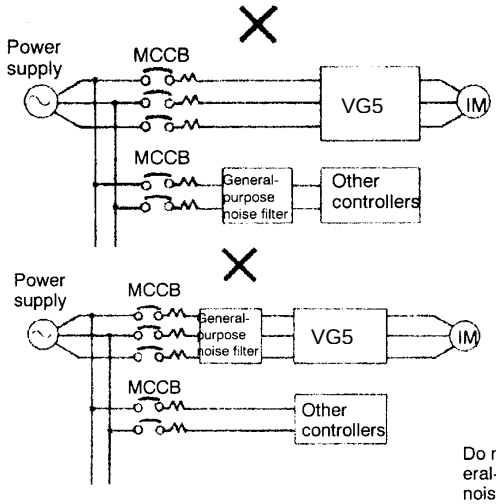
- Wiring Example 1




Use a special-purpose noise filter for Inverters.

Figure 3.8 Correct Power Supply Noise Filter Installation

- Wiring Example 2




Do not use general-purpose noise filters. No general-purpose noise filter can effectively suppress noise generated from the Inverter.

Figure 3.9 Incorrect Power Supply Noise Filter Installation

## Wiring on the Output Side of Main Circuit

### Connecting the Inverter and Motor

Connect output Terminals T1, T2, and T3 (U, V and W) to motor lead wires T1, T2, and T3, respectively.

Check that the motor rotates forward with the forward RUN command. Switch over any two of the output terminals to each other and reconnect if the motor rotates in reverse with the forward RUN command.

### Never Connect a Power Supply to Output Terminals

Never connect a power supply to output Terminals T1, T2, and T3 (U, V and W). If voltage is applied to the output terminals, the internal circuits of the Inverter will be damaged.

### Never Short or Ground Output Terminals

If the output terminals are touched with bare hands or the output wires come into contact with the Inverter casing, an electric shock or grounding will occur. This is extremely hazardous. Do not short the output wires.

### Do Not Use a Power Factor Correction Capacitor or Noise Filter

Never connect a Power Factor Correction Capacitor or LC/RC noise filter to an output circuit. Doing so may result in damage to the Inverter or cause other parts to burn.

### Do Not Use an Electromagnetic Switch or Magnetic Contactor

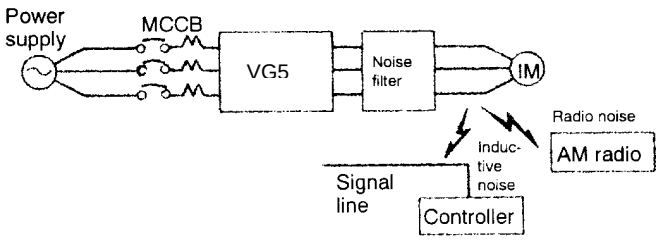
Do not connect an electromagnetic switch or Magnetic Contactor to an output circuit. If a load is connected to the Inverter during operation, a surge current will actuate the overcurrent protective circuit in the Inverter.

### Installing a Thermal Overload Relay

This Inverter has an electronic thermal protection function to protect the motor from overheating. If, however, more than one motor is operated with one Inverter or a multi-polar motor is used, always install a Thermal Overload Relay between the Inverter and the motor and set L1-01 to 0 (no motor protection).

Set the Thermal Overload Relay to the value on the motor nameplate when operating at 40 Hz and to 1.1 times the value on the nameplate when operating at 60 Hz. The sequence should be designed so that the contacts of the Thermal Overload Relay turn OFF the Magnetic Contactor on the main circuit inputs.

### Installing a Noise Filter on Output Side




Connect a noise filter to the output side of the Inverter to reduce radio noise and inductive noise.

Inductive Noise: Electromagnetic induction generates noise on the signal line, causing the controller to malfunction.
Radio Noise: Electromagnetic waves from the Inverter and cables cause the broadcasting radio receiver to make noise.

Figure 3.10 Installing a Noise Filter on the Output Side

### Countermeasures Against Inductive Noise

As described previously, a noise filter can be used to prevent inductive noise from being generated on the output side. Alternatively, cables can be routed through a grounded metal pipe to prevent inductive noise. Keeping the metal pipe at least 30 cm away from the signal line considerably reduces inductive noise.

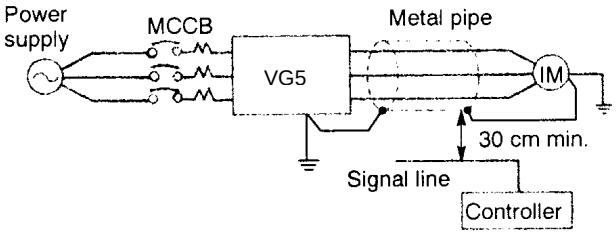



Figure 3.11 Countermeasures Against Inductive Noise

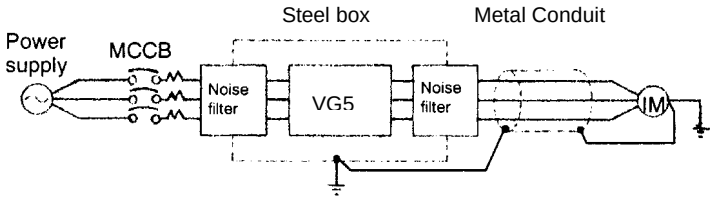
**Countermeasures Against Radio Interference**

Radio noise is generated from the Inverter as well as from the input and output lines. To reduce noise, install noise filters on both input and output sides, and also install the Inverter in a totally enclosed steel box.

The cable between the Inverter and the motor should be as short as possible.

Figure 3.12 Countermeasures Against Radio Interference

**Cable Length Between Inverter and Motor**




If the cable between the Inverter and the motor is long, the high-frequency leakage current will increase, causing the Inverter output current to increase as well. This may affect peripheral devices. To prevent this, adjust the carrier frequency (set in C6-01 to C6-03) as shown in *Table 3.6*. (For details, refer to the user constant settings.)

Table 3.6 Cable Length between Inverter and Motor

| Cable Length | 50 m max | 100 m max. | More than 100 m |
|---|---|---|---|
| Carrier Frequency | 15 kHz max. | 10 kHz max | 5 kHz max. |
| (Set value: C6-01) | (15.0) | (10.0) | (5.0) |
| (Set value: C6-02) | (15.0) | (10.0) | (5.0) |
| (Set value: C6-03) | (0) | (0) | (0) |

## Ground Wiring

- Always use the ground terminal of the 200 V Inverter with a ground resistance of less than 100 Ω and that of the 400 V Inverter with a ground resistance of less than 10 Ω.
- Do not share the ground wire with other devices, such as welding machines or power tools.
- Always use a ground wire that complies with technical standards on electrical equipment and minimize the length of the ground wire.

  Leakage current flows through the Inverter. Therefore, if the distance between the ground electrode and the ground terminal is too long, potential on the ground terminal of the Inverter will become unstable.
- When using more than one Inverter, be careful not to loop the ground wire.

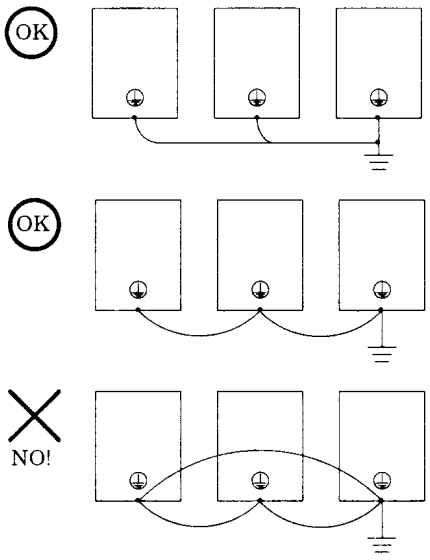
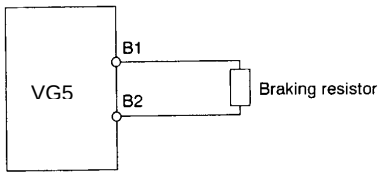



Figure 3.13 Ground Wiring

## Connecting the Braking Resistor (ERF)

Connect the braking resistor as shown in *Figure 3.14*. When using a Braking Resistor Unit, set L8-01 to "1" (protect selection for DB resistor) and set L3-04 to "0" (no Stall Prevention during deceleration).




The braking resistor connection terminals are B1 and B2. Do not connect to any other terminals. Connecting to any terminals other than B1 or B2 can cause the resistor to overheat, resulting in damage to the equipment.

Figure 3.14 Connecting the Braking Resistor

## Connecting the Braking Resistor Unit and Braking Unit

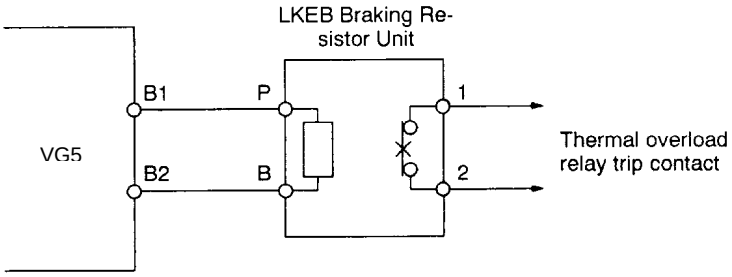
Connect the Braking Resistor Unit and Braking Unit to the Inverter as shown in *Figure 3.15*. Set L8-01 to "0" (protect selection for DB resistor) and L3-04 to "0" (no Stall Prevention during deceleration) before using the Inverter with the Braking Resistor Unit connected.

Set L8-01 to "1" before operating the Inverter with the braking resistor without Thermal Overload Relay trip contacts.

The Braking Resistor Unit cannot be used and the deceleration time cannot be shortened by the Inverter if L3-04 is set to "1" (i.e., if Stall Prevention is enabled for deceleration).

To prevent the unit from overheating, design the sequence to turn OFF the power supply for the Thermal Overload Relay trip contacts of the Unit as shown in *Figure 3.15*.

**200 V Class Inverters with 3.7 to 7.5 kW Output and**
**400 V Class Inverters with 3.7 to 15 kW Output**




**200 V Class Inverters with 11 kW or higher Output and**
**400 V Class Inverters with 18.5 kW or higher Output**

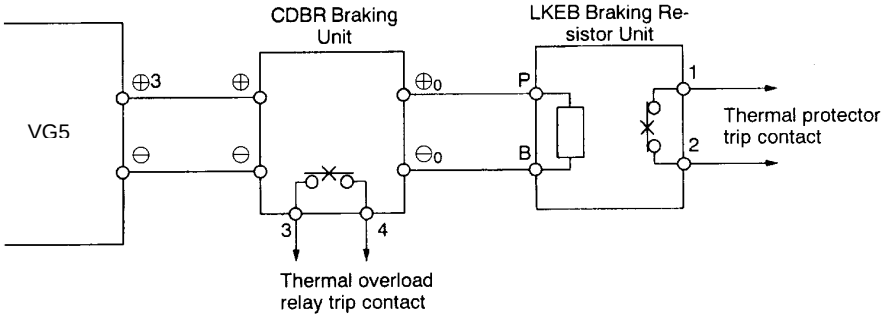



Figure 3.15 Connecting the Braking Resistor Unit and Braking Unit

**Connecting Braking Units in Parallel**

When connecting two or more Braking Units in parallel, use the wiring and connectors shown in *Figure 3.16*. There are connectors for selecting whether each Braking Unit is to be a Master or Slave. Select "Master" for the first Braking Unit only, and select "Slave" for all other Braking Units (i.e., from the second Unit onwards).

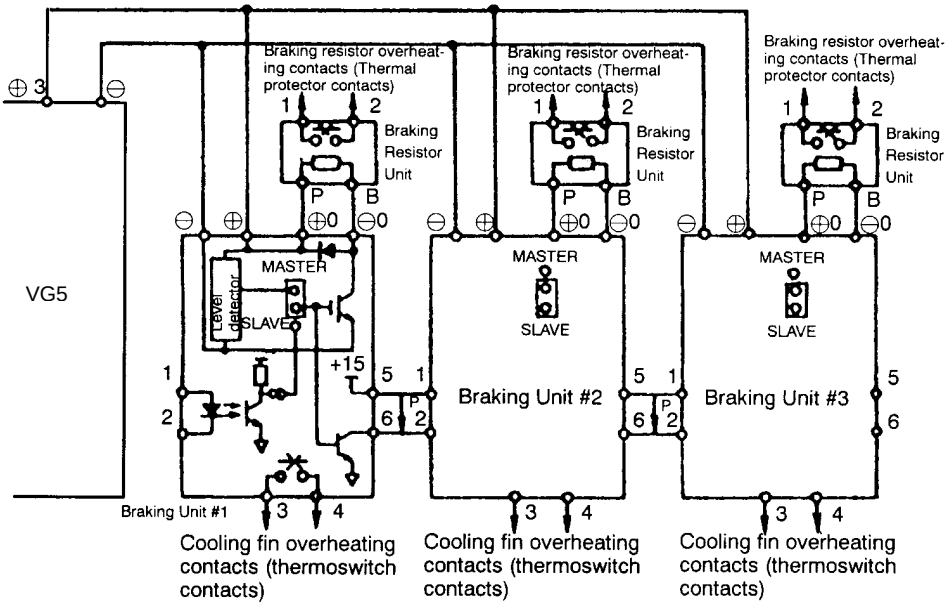



Figure 3.16 Connecting Braking Units in Parallel

**Power Supply Sequence**

* Use a transformer with 200 and 400 V outputs for the power supply of the 400 V Inverter

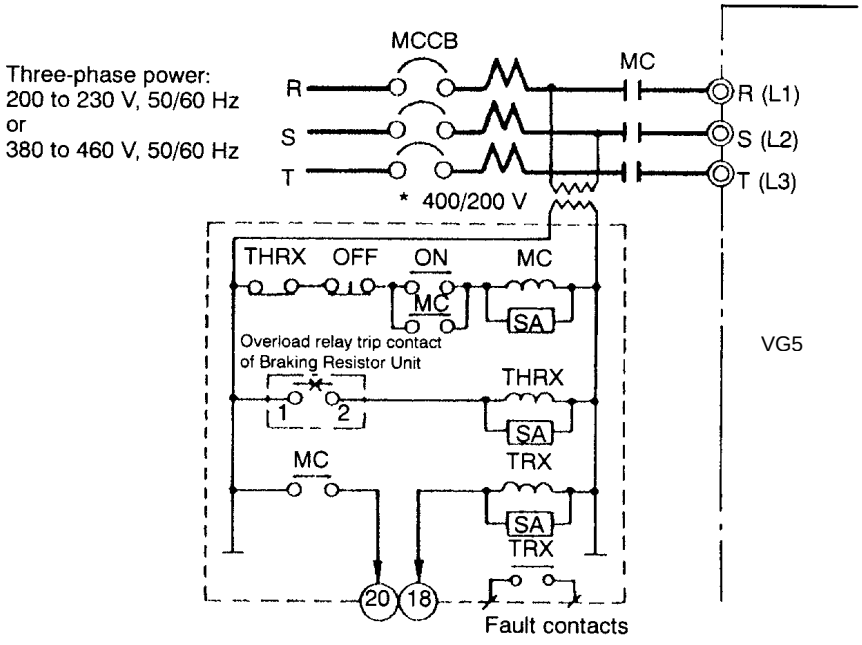



Figure 3.17 Power Supply Sequence

## 3.5 Wiring Control Circuit Terminals

A control signal line must not be longer than 50 meters (164 feet) and must be separated from power lines. The frequency reference must be input to the Inverter through twisted-pair wires.

### 3.5.1 Wire Sizes and Closed-Loop Connectors

Terminal numbers and wire sizes are shown in *Table 3.7*.

Table 3.7 Terminal Numbers and Wire Sizes (Same for all Models)

| Terminals | Terminal Screws | AWG Sizes | Wire Thickness ($mm^2$) | Wire Type |
|---|---|---|---|---|
| 1 to 11, 13 to 33 | M3.5 | 20-16 | Stranded wire: 0.5 to 1.25<br>Single wire: 0.5 to 1.25 | • Shielded, twisted-pair wire |
| 12 (G) | M3.5 | 20-14 | 0.5 to 2 | • Shielded, polyethylene-covered, vinyl sheath cable |

The closed-loop connectors and tightening torques for various wire sizes are shown in *Table 3.8*.

Table 3.8 Closed-Loop Connectors for Ground Terminal

| Terminals | Terminal Screws | Crimp Size | Tightening Torque (n - m) |
|---|---|---|---|
| 0.5 | M3.5 | 1.25 to 3.5 | 0.8 |
| 0.75 | | 1.25 to 3.5 | |
| 1.25 | | 1.25 to 3. | |
| 2 | | 2 to 3.5 | |

### 3.5.2 Control Circuit Terminal Functions

The functions of the control circuit terminals are shown in *Table 3.9*. Use the appropriate terminals for the correct purposes.

Table 3.9 Control Circuit Terminals

| Type | No. | Signal Name | Function | | Signal Level |
|---|---|---|---|---|---|
| Sequence input signals | 1 | Forward run/stop command | Forward run when CLOSED; stopped when OPEN. | | 24 VDC, 8 mA Photocoupler isolation |
| | 2 | Reverse run/stop command | Reverse run when CLOSED; stopped when OPEN. | | |
| | 3 | External fault input | Fault when CLOSED; normal when OPEN | Multi-function contact inputs (Command signals can be selected by Setting H1-01 to H1-06.) | |
| | 4 | Fault Reset | Reset when CLOSED. | | |
| | 5 | Multi-step speed reference 1 (Master/auxiliary switch) | Auxiliary frequency reference when CLOSED. | | |
| | 6 | Multi-step speed reference 2 | Multi-step Setting 2 when CLOSED. | | |
| | 7 | Jog frequency reference | Jog run when CLOSED. | | |
| | 8 | External baseblock | Inverter output stopped when CLOSED. | | |
| | 11 | Sequence input common | — | | |
| Analog input signals | 15 | 15 V power output | 15 V power supply for analog reference | | 15 V (Maximum current: 20 mA) |
| | 33 | – 15 V power output | – 15 V power supply for analog references | | – 15 V (Maximum current: 20 mA) |
| | 13 | Master speed frequence reference | – 10 to 10 V/–100% to 100%<br>0 to 10 V/100% | | –10 to 10 V (20 kΩ),<br>0 to 10 V (20 kΩ) |
| | | | 4 to 20 mA/100%, –10 to +10 V/–100% to 100%<br>0 to +10 V/100% | | 4 to 20 mA (250 Ω) |
| | 16 | Multi-function analog input | – 10 to 10 V/–100% to 100%<br>0 to 10 V/100% | Auxiliary analog input (H3-05) | –10 to 10 V (20 kΩ),<br>0 to 10 V (20 kΩ) |
| | 17 | Control common | — | | — |
| | 12 | Shield wire, optional ground line connection point | — | | — |
| Sequence output signals | 9 | Running signal (1 NO contact) | Operating when CLOSED | Multi-function outputs | Dry contacts<br>Contact capacity:<br>1 A maximum at 250 VAC<br>1 A maximum at 30 VDC |
| | 10 | | | | |
| | 25 | Zero Speed detection | Zero level (b2-01) or below when CLOSED | | |
| | 26 | Speed agree detection | Within ±2 Hz of set frequency when CLOSED | | Open-collector output<br>50 mA maximum at 48 V* |
| | 27 | Open-collector output common | — | | |
| | 18 | Fault output signal (SPDT) | Fault when CLOSED across 18 and 20<br>Fault when OPEN across 19 and 20 | | Dry contacts<br>Contact capacity:<br>1 A maximum at 250 VAC<br>1 A maximum at 30 VDC |
| | 19 | | | | |
| | 20 | | | | |
| Analog output signals | 21 | Frequency output | 0 to 10 V/100% frequency | Multi-function analog monitor 1 (H4-01, H4-02) | 0 to ±10 V maximum ±5%<br>2 mA maximum |
| | 22 | Common | — | | |
| | 23 | Current monitor | 5 V/Inverter's rated current | Multi-function analog monitor 2 (H4-04m H4-05) | |

* When driving an inductive load, such as a relay coil, always insert a flywheel diode as shown in *Figure 3.18*.

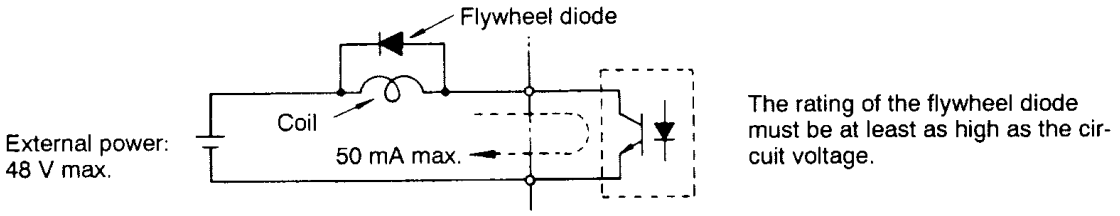



Figure 3.18 Flywheel Diode Connection

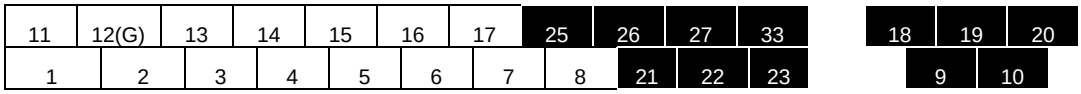
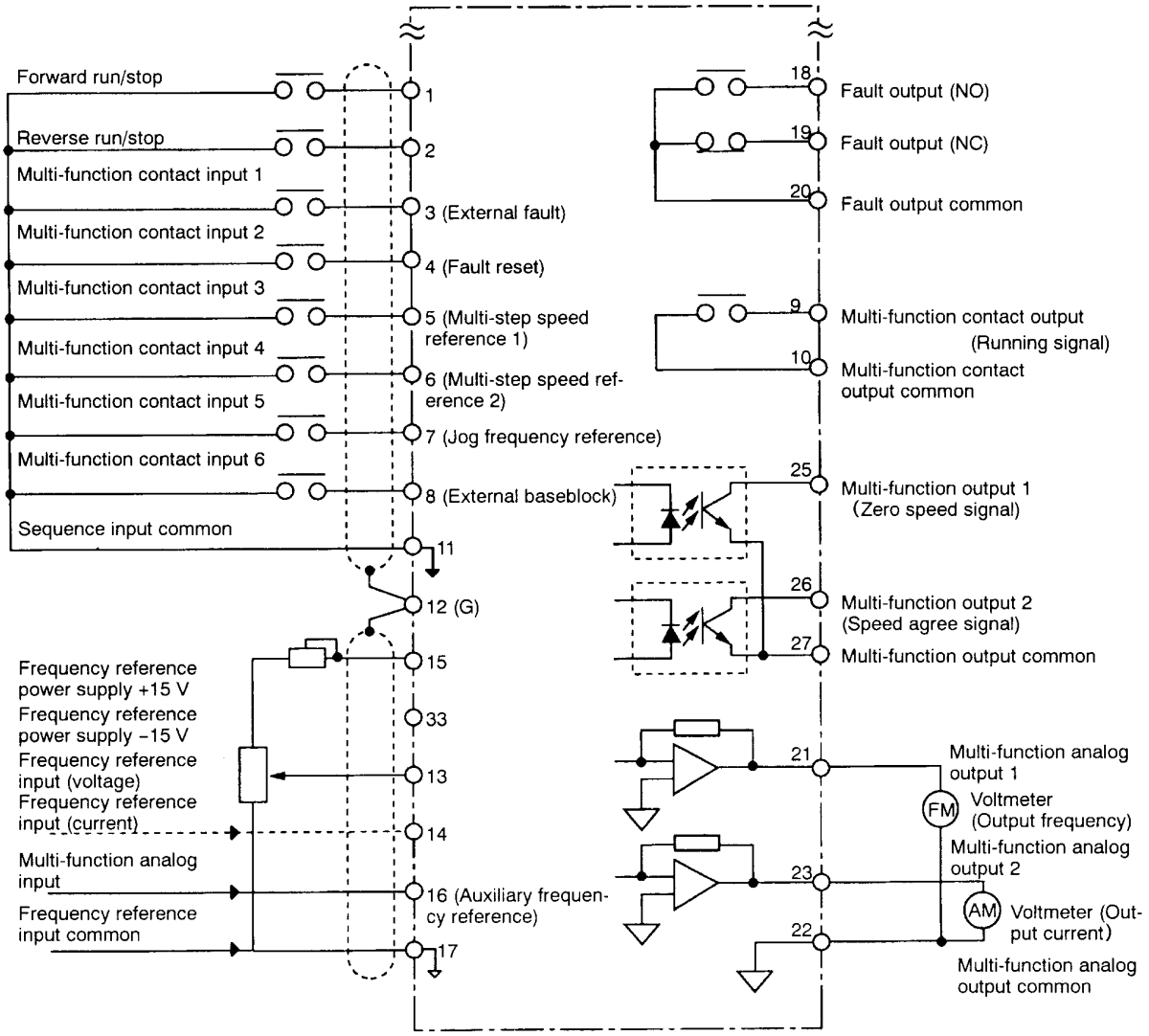



Figure 3.19 Control Circuit Terminal Arrangement

### 3.5.3 Control Circuit Terminal Connections (All Models)

Connections to VG5 control circuit terminals are shown in *Figure 3.20*.




Factory presets are shown in parentheses. When driving an inductive load, such as a relay coil, always insert a flywheel diode as shown in *Figure 3.18*.

Figure 3.20 Control Circuit Terminal Connections

### 3.5.4 Control Circuit Wiring Precautions

- Separate control circuit wiring (Terminals 1 to 33) from main circuit wiring (Terminals L1, L2, and L3 (R, and S, and T), B1, B2 , T1, T2, and T3 (U, V, and W), √, ⊕ 1, ⊕ 2, and ⊕ 3 and other high-power lines.
- Separate wiring for control circuit Terminals 9, 10, 18, 19, and 20 (contact outputs) from wiring for Terminals 1 to 8, 21, 22, 23, 25, 26, 27, 33 and 11 to 17.
- Use twisted-pair or shielded twisted-pair cables for control circuits to prevent operating faults. Process cable ends as shown in *Figure 3.21*.
- Connect the shield wire to Terminal 12(G).
- Insulate the shield with tape to prevent contact with other signal lines and equipment.

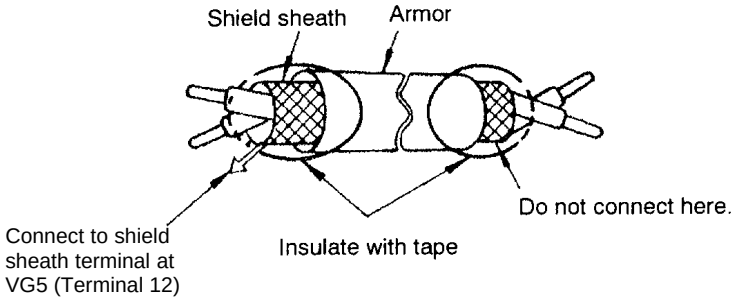



Figure 3.21 Processing the Ends of Twisted-Pair Cables

## 3.6 Wiring Check

Check all of the wiring after wiring has been completed. Do not perform a megger check on control circuits.

- Is all wiring correct?
- Have any wire clippings, screws, or other foreign material been left?
- Are all screws tight?
- Are any wire ends contacting other terminals?

## 3.7 Installing and Wiring PG Speed Option Cards

PG Speed Option Cards are used for executing Speed Control using a PG. There are four types of PG Speed Controls, as shown below. Select the type that fits the application and control method.

| | Part No. | |
|---|---|---|
| PG-A2 | 031-4005 | A-Phase (single) pulse input for open collector output or complementary outputs, for V/f Control |
| PG-B2 | 031-4006 | A/B-Phase pulse input for open collector output or complementary outputs, for Vector Control |
| PG-D2 | 031-4007 | A-Phase (single) pulse input for line driver input, for V/f Control |
| PG-X2 | E001063-28 | A/B/Z-Phase pulse input for line driver input, for Vector Control |

### 3.7.1 Installing a PG Speed Option Card

Use the following procedure to install a PG Speed Option Card:

1. Turn OFF the main-circuit power supply.
2. Leave it OFF for at least one minute before removing the front cover of the Inverter (or at least three minutes for Inverters of 30 kW or more). Check to be sure that the CHARGE indicator is OFF.
3. Insert the spacer (which is provided) into the spacer hole in the Inverter's mounting base.

   For Inverters of 3.7 kW or lower, there are two adjacent holes. Insert the spacer into the 7CN hole. The spacer cannot be easily removed if inserted into the wrong hole. Be very careful to insert the spacer into the correct hole, and in the proper direction.
4. Referring to the enlarged illustration in the following diagram, align the PG Speed Option Card with the catch position as shown by (a) and (b) and fit it precisely to the Option-A connector. Insert (a) first.
5. Pass the spacer through the spacer hole at the card. (Refer to A in the illustration.) Check to be sure that it is precisely aligned with the 4CN position, and snap it into the proper position. Be sure to press it in firmly until you hear it snap into place.

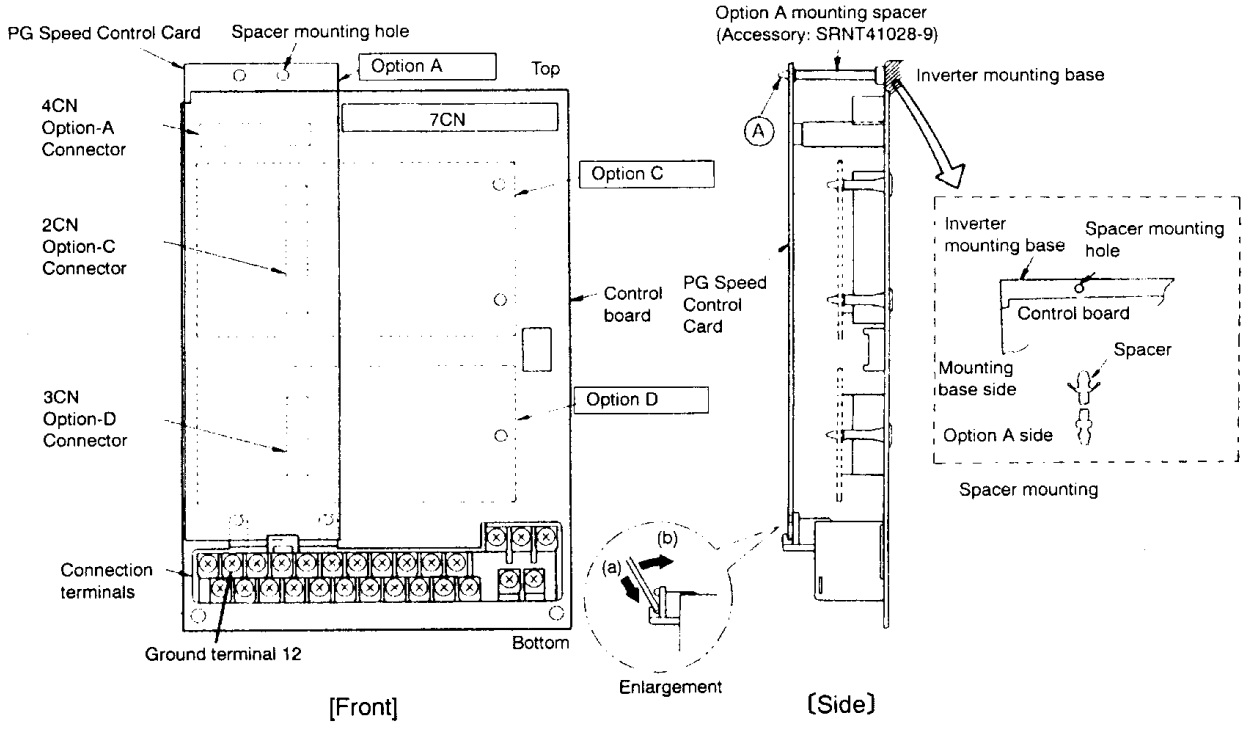



Figure 3.22 Installing a PG Speed Option Card

### 3.7.2 PG Speed Option Card Terminal Blocks

The terminal specifications for each PG Speed Option Card are given in the following tables:

#### ■ PG-A2 (For V/f with PG Feedback Mode Only)

Table 3.10 PG-A2 Terminal Specifications

| Terminal | No. | Contents | Specifications |
|---|---|---|---|
| TA1 | 1 | Power Supply for pulse generator | 12 VDC(±5%), 200 mA maximum |
| | 2 | | 0 VDC (GND for power supply) |
| | 3 | +12 V/open collector switching terminal | Terminal for switching between 12 V voltage input and open collector input. For open collector input, short across 3 and 4 |
| | 4 | | |
| | 5 | Pulse input terminal | H: +4 to 12 V; L: +1 V maximum. (maximum response frequency: 30 kHz) |
| | 6 | | Pulse input common |
| | 7 | Pulse motor output terminal | 12 VDC (+10%), 20 mA maximum |
| | 8 | | Pulse monitor output common |
| TA2 | (E) | Shield connection terminal | — |

#### ■ PG-B2 (For Flux Vector Control Mode Only)

Table 3.11 PG-B2 Terminal Specifications

| Terminal | No. | Contents | Specifications |
|---|---|---|---|
| TA1 | 1 | Power Supply for pulse generator | 12 VDC(±5%), 200 mA maximum |
| | 2 | | 0 VDC (GND for power supply) |
| | 3 | A-Phase pulse input terminal | H: +8 to 12 V<br>L: +1 V maximum<br>(maximum response frequency: 30 kHz) |
| | 4 | | Pulse input common |
| | 5 | B-Phase pulse input terminal | H: +8 to 12 V<br>L: +1 V maximum<br>(maximum response frequency: 30 kHz) |
| | 6 | | Pulse input common |
| TA2 | 1 | A-Phase monitor output terminal | Open collector output, 24 VDC, 30 mA maximum |
| | 2 | | A-Phase monitor output common |
| | 3 | B-Phase monitor output terminal | Open collector output, 24 VDC, 30 mA maximum |
| | 4 | | B-Phase monitor output common |
| TA3 | (E) | Shield connection terminal | — |

#### ■ PG-D2 (For V/f with PG Feedback Mode Only)

Table 3.12 PG-D2 Terminal Specifications

| Terminal | No. | Contents | Specifications |
|---|---|---|---|
| TA1 | 1 | Power Supply for pulse generator | 12 VDC(±5%), 200 mA maximum (see note) |
| | 2 | | 0 VDC (GND for power supply) |
| | 3 | | 5 VDC ((±5%), 200 mA maximum (see note) |
| | 4 | Pulse input + terminal | Line driver input (RS-422 level input)<br>Maximum response frequency: 300 kHz |
| | 5 | Pulse input – terminal | |
| | 6 | Common terminal | — |
| | 7 | Pulse monitor output + terminal | Line driver output (RS-422 level output) |
| | 8 | Pulse monitor output – terminal | |
| TA2 | (E) | Shield connection terminal | — |

**NOTE:** 5 VDC and 12 VDC cannot be used at the same time.

### ■ PG-X2 (For Flux Vector Control Mode Only)

Table 3.13 PG-X2 Terminal Specifications

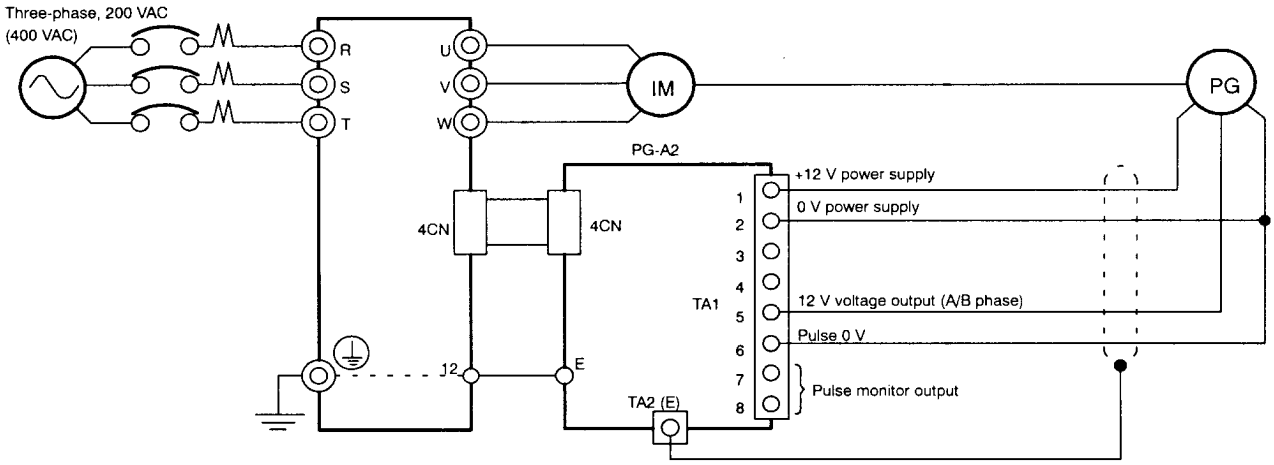
| Terminal | No. | Contents | Specifications |
|---|---|---|---|
| TA1 | 1 | Power Supply for pulse generator | 12 VDC(±5%), 200 mA maximum (see note) |
| | 2 | | 0 VDC (GND for power supply) |
| | 3 | | 5 VDC ((±5%), 200 mA maximum (see note) |
| | 4 | A-Phase + input terminal | Line driver input (RS-422 level input) (maximum response frequency: 300 kHz) |
| | 5 | A-Phase – input terminal | |
| | 6 | B-Phase + input terminal | |
| | 7 | B-Phase – input terminal | |
| | 8 | Z-Phase + input terminal | |
| | 9 | Z-Phase – input terminal | |
| | 10 | Common terminal | 0 VDC (GND for power supply) |
| TA2 | 1 | A-Phase + output terminal | Line driver output (RS-422 level output) |
| | 2 | A-Phase – output terminal | |
| | 3 | B-Phase + output terminal | |
| | 4 | B-Phase – output terminal | |
| | 5 | Z-Phase + input terminal | |
| | 6 | Z-Phase – input terminal | |
| | 7 | Control circuit common | Control circuit GND |
| TA3 | (E) | Shield connection terminal | — |

**NOTE:** 5 VDC and 12 VDC cannot be used at the same time.

## 3.7.3 Wiring a PG Speed Option Card

Wiring examples are provided in the following illustrations for the PG Speed Option Cards.

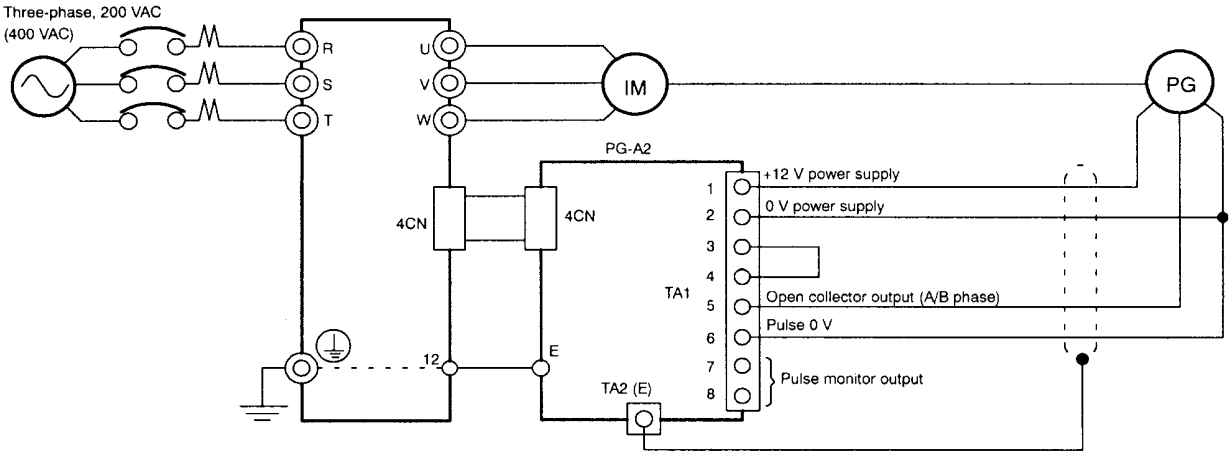
### ■ PG-A2 (For V/f with PG Feedback Mode Only)




**12 V Voltage Input**

Figure 3.23 Wiring a 12 V Voltage Input

### Open Collector Input




- Shielded twisted-pair wires must be used for signal lines.
- Do not use the PG's power supply for anything other than the PG. Using it for another purpose can cause malfunctions due to noise.
- The length of the PG's wiring must not be more than 100 meters (328 feet).

Figure 3.24 Wiring an Open-Collector Input

### I/O Circuit Configuration

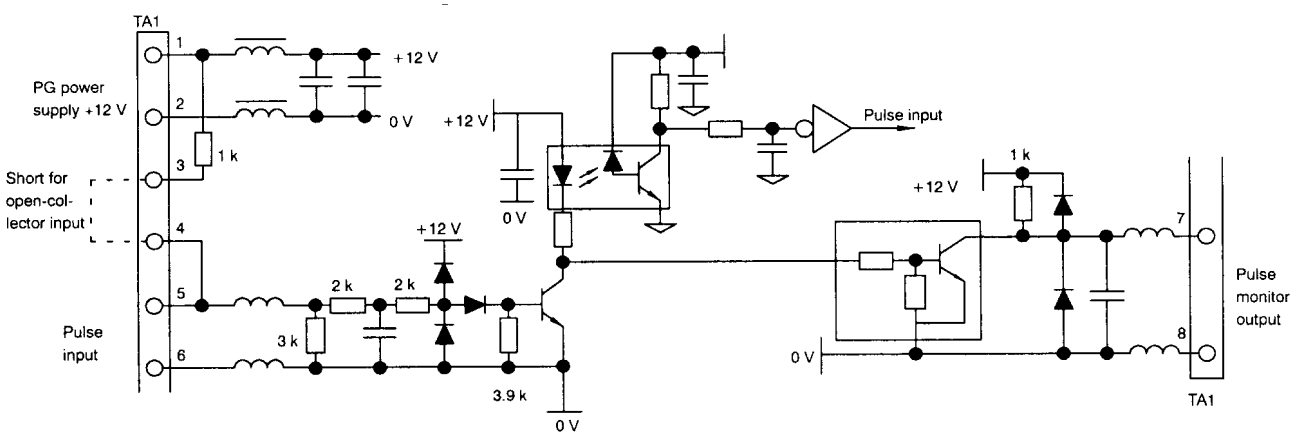
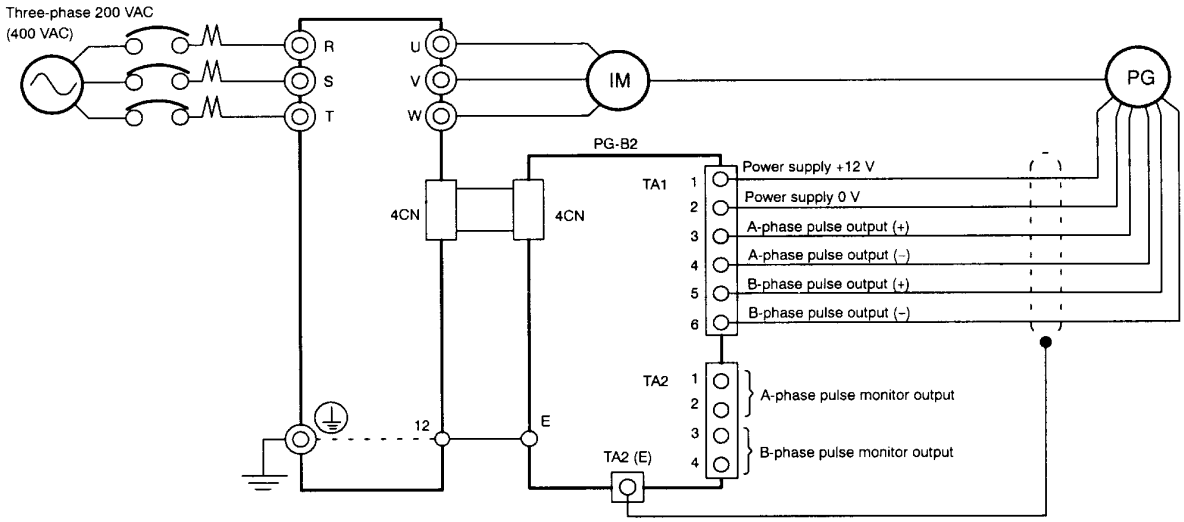



Figure 3.25 I/O Circuit Configuration of the PG-A2

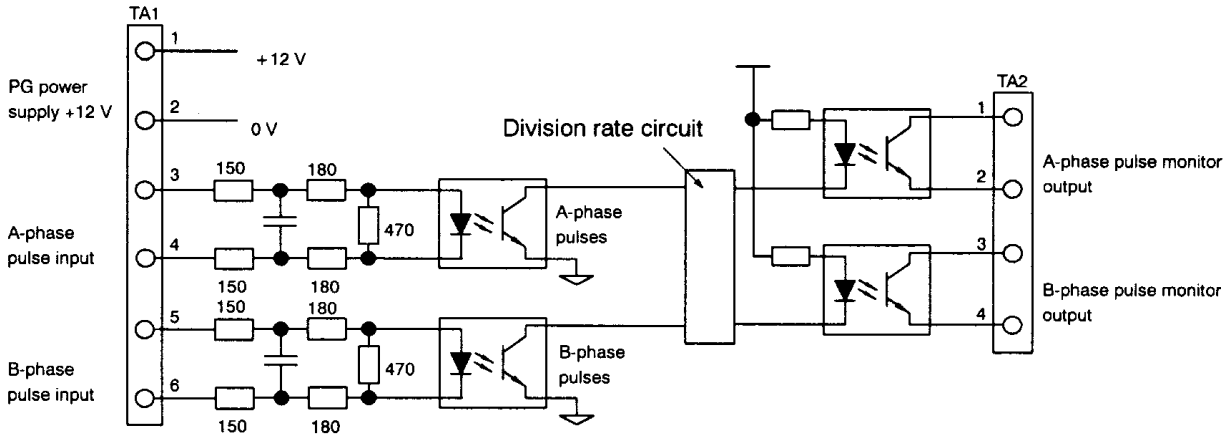
## ■ PG-B2 (For Flux Vector Control Mode Only)




- Shielded twisted-pair wires must be used for signal lines.
- Do not use the PG's power supply for anything other than the PG. Using it for another purpose can cause malfunctions due to noise.
- The length of the PG's wiring must not be more than 100 meters (328 feet).
- The direction of rotation of the Inverter can be set in user constant F1-05. The factory preset if for forward rotation, A-Phase advancement.

Figure 3.26 PG-B2 Wiring

### I/O Circuit Configuration




- When connecting to a voltage-output-type PG, select a PG that has an output impedance with a current of at least 12 mA to the input circuit photocoupler (diode).

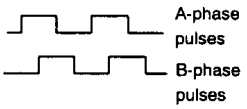
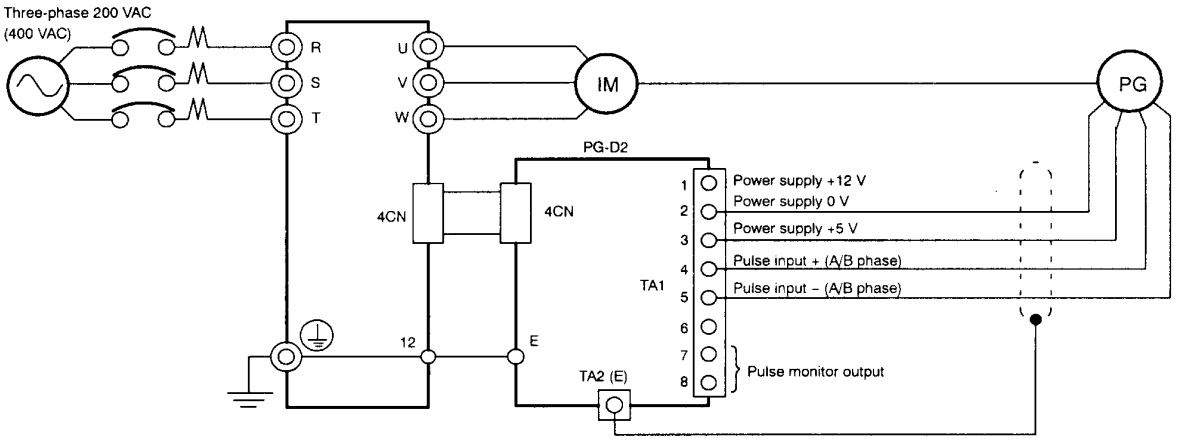



Figure 3.27 I/O Circuit Configuration of the PG-B2

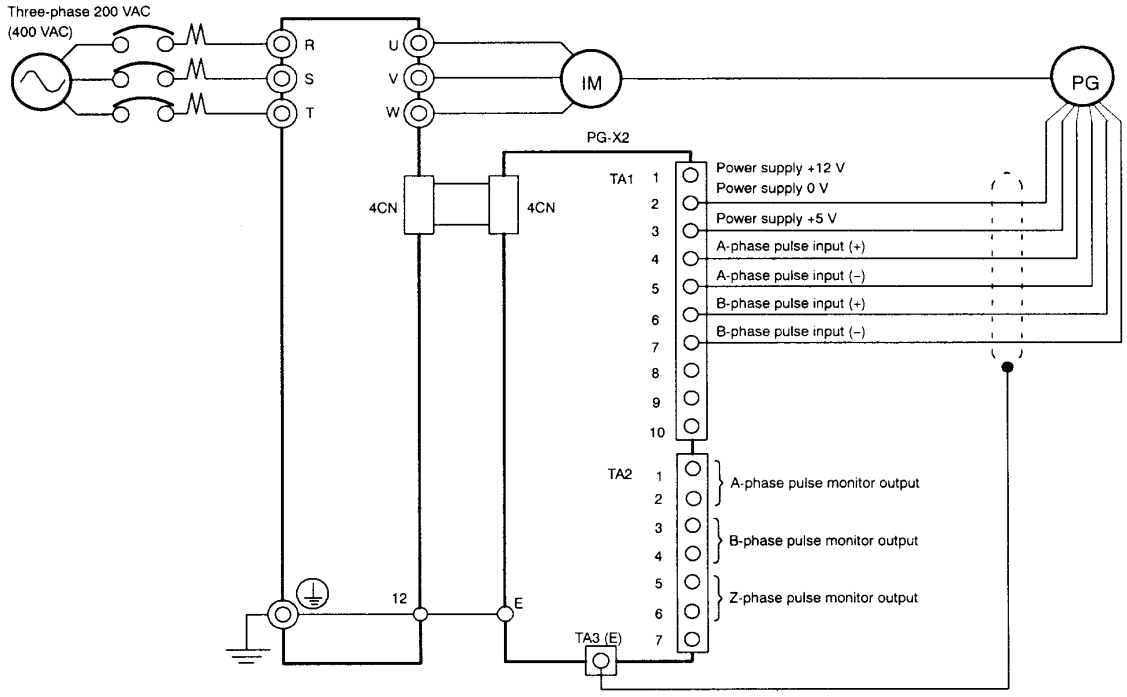
## ■ PG-D2 (For V/f with PG Feedback Mode Only)




- Shielded twisted-pair wires must be used for signal lines.
- Do not use the PG's power supply for anything other than the PG. Using it for another purpose can cause malfunctions due to noise.
- The length of the PG's wiring must not be more than 100 meters (328 feet).

Figure 3.28 PG-D2 Wiring

## ■ PG-X2 (For Flux Vector Control Mode Only)




- Shielded twisted-pair wires must be used for signal lines.
- Do not use the PG's power supply for anything other than the PG. Using it for another purpose can cause malfunctions due to noise.
- The length of the PG's wiring must not be more than 100 meters (328 feet).
- The direction of rotation of the Inverter can be set in user constant F1-05. The factory preset if for forward rotation, A-Phase advancement.

Figure 3.29 PG-X2 Wiring

### 3.7.4 Wiring PG Speed Option Card Terminal Blocks

Use no more than 100 meters (328 feet) of wiring for PG signal lines, and keep them separate from power lines.

Use shielded, twisted-pair wires for pulse inputs and pulse output monitor wires, and connect the shield to the shield connection terminal.

#### ■ Wire Sizes (Same for All Models)

Terminal wire sizes are shown in *Table 3.14.*

Table 3.14 Wire Sizes

| Terminal | Terminal Screws | Wire Thickness ($mm^2$) | AWG Sizes | Wire Type |
|---|---|---|---|---|
| PG power supply<br>Pulse input terminal<br>Pulse monitor output terminal | — | Stranded wire: 0.5 to 1.25<br>Single wire: 0.5 to 1.25 | 20-16 | • Shielded, twisted-pair wire<br>• Shielded, polyethylene-covered, vinyl sheath cable |
| Shield connection terminal | M3.5 | 0.5 to 2 | 20-14 | |

#### ■ Solderless Terminals for Control Circuit Terminals

The use of solderless terminals for the control circuit terminals is recommended because solderless terminals are easy to connect securely.

Table 3.15 Straight Solderless Terminal Sizes

| Wire Thickness ($mm^2$) | AWG Sizes | Model | d1 | d2 | Manufacturer |
|---|---|---|---|---|---|
| 0.5 | 20 | A1 0.5-8 WH | 1.00 | 2.60 | Phoenix Contact |
| 0.75 | 18 | A1 0.75-8 GY | 1.20 | 2.80 | |
| 1 | 16 | A1 1-8 RD | 1.40 | 3.00 | |
| 1.5 | 14 | A1 1.5-8 BK | 1.70 | 3.50 | |

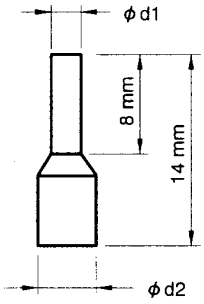



Figure 3.30 Straight Solderless Terminal Sizes

**NOTE:** Do not solder wires with the control circuit terminal if wires are used instead of solderless terminals. Wires many not contact well with the control circuit terminals or the wires may be disconnected from the control circuit terminals due to oscillation if the wires are soldered.

## Closed-Loop Connector Sizes and Tightening Torque

The closed-loop connectors and tightening torques for various wire sizes are shown in *Table 3.16.*

Table 3.16 Closed-Loop Connectors and Tightening Torques

| Wire Thickness ($mm^2$) | AWG Sizes | Terminal Screws | Crimp Terminal Size ($mm^2$) | Tightening Torque (N · m) |
|---|---|---|---|---|
| 0.5 | 20 | M3.5 | 1.25 to 3.5 | 0.8 |
| 0.75 | 18 | | 1.25 to 3.5 | |
| 1.25 | 16 | | 1.25 to 3.5 | |
| 2 | 14 | | 2 to 3.5 | |

## Wiring Method

Use the following procedure to connect wires to the terminal block:

1. Loosen the terminal screws with a thin-slot screwdriver.
2. Insert the wires from underneath the terminal block.
3. Tighten the terminal screws firmly.

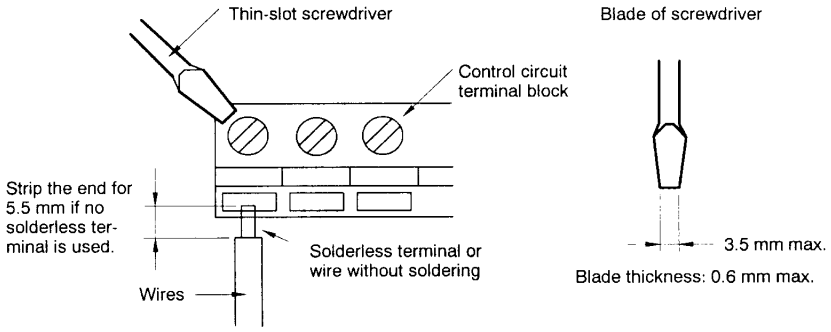



Figure 3.31 Connecting Wires to Terminal Block

**NOTE:** Wiring Precautions

1. Separate PG Speed Option Card control circuit wiring (Terminals TA1 and TA2) from main circuit wiring and other high-power lines.
2. Use twisted-pair or shielded twisted-pair cables to connect the PG to prevent operating faults. Process cable ends as shown in *Figure 3.32*. The maximum cable length is 100 meters (328 feet).

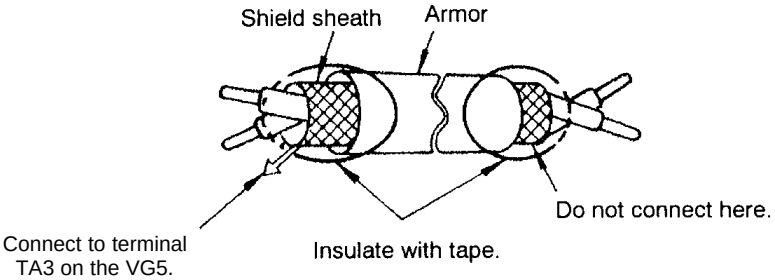



Figure 3.3 Processing the Ends of Twisted-pair Cables

3. Connect the shield to the ground terminal.
4. Do not solder the wires to the control circuit terminals. The wires may not contact well with the control circuit terminals if the wires are soldered.
5. The end of each wire connected to the control circuit terminals must be stripped for approximately 5.5 mm (0.22 inches).

### 3.7.5 Selecting the Number of PG Pulses

#### ■ PG-A2/PG-B2

The maximum response frequency is 32,767 Hz. Use a PG that outputs a maximum frequency of approximately 20 kHz for the rotational speed of the motor.

$$\frac{\text{Motor speed at maximum frequency output (r/min)}}{60} \text{ X PG rating (p/rev)} = 20{,}000 \text{ Hz}$$

Some examples of PG output frequency (number of pulses) for the maximum frequency output are shown in *Table 3.17.*

Table 3.17 PG Pulse Selection Examples

| Motor's Maximum Speed (r/min) | PG Rating (p/rev) | PG Output Frequency for Maximum Frequency Output (Hz) |
|---|---|---|
| 1800 | 600 | 18,000 |
| 1500 | 800 | 20,000 |
| 1200 | 1000 | 20,000 |
| 900 | 1200 | 18,000 |

**NOTE:** 1. The motor speed at maximum frequency output is expressed as the sync rotation speed.

2. The PG power supply is 12 V.

3. A separate power supply is required if the PG power supply capacity is greater than 200 mA. (If momentary power loss must be handled, use a backup capacitor or other method.)

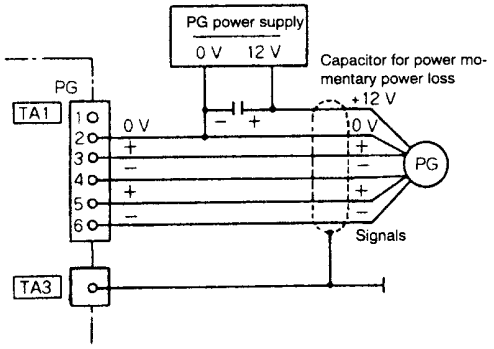



Figure 3.33 PG-B2 Connection Example

#### ■ PG-D2/PG-X2

The maximum response frequency is 300 kHz.

Use the following equation to compute the output frequency of the PG (fPG):

$$f_{PG}\,(\text{Hz}) = \frac{\text{Motor speed at maximum frequency output (r/min)}}{60} \text{ X PG rating (p/rev)}$$

A separate power supply is required if the PG power supply capacity is greater than 200 mA. (If momentary power loss must be handled, use a backup capacitor or other method.)

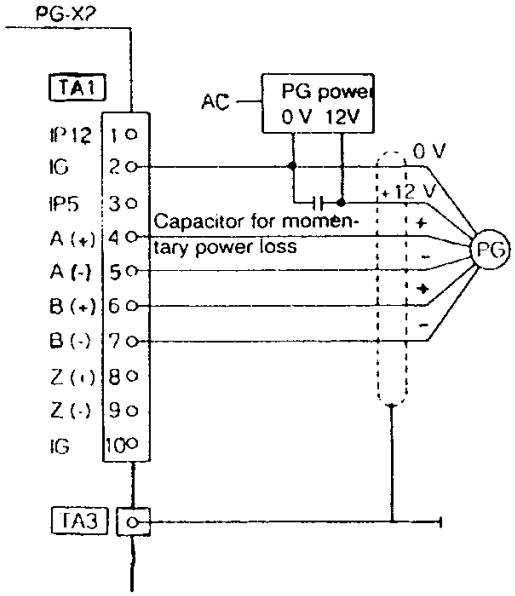



Figure 3.34 PG-X2 Connection Example