# Operations and Monitoring

# 4

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# Introduction

The previous material in Chapter 3 gave a reference listing of all the programmable functions of the inverter. We suggest that you first scan through the listing of inverter functions to gain a general familiarity. This chapter will build on that knowledge in the following ways:

1. **Related functions** – Some parameters interact with or depend on the settings in other functions. This chapter lists “required settings” for a programmable function to serve as a cross-reference and an aid in showing how functions interact.
2. **Intelligent terminals** – Some functions rely on an input signal on a control logic connector terminal, or generate output signals in other cases.
3. **Electrical interfaces** – This chapter shows how to make connections between the inverter and other electrical devices.
4. **Auto-tuning** – The SJ100 inverter has the ability to run a calibration procedure that takes measurements of the motor’s electrical characteristics. This chapter shows how to run the auto-tuning procedure to help the inverter run the motor more smoothly and efficiently.
5. **PID Loop Operation** – The SJ100 has a built-in PID loop that calculates the optimal inverter output frequency to control an external process. This chapter shows the parameters and input/output terminals associated with PID loop operation.
6. **Multiple motors** – A single SJ100 inverter may be used with two or more motors in some types of applications. This chapter shows the electrical connections and inverter parameters involved in multiple-motor applications.

The topics in this chapter can help you decide the features that are important to your application, and how to use them. The basic installation covered in Chapter 2 concluded with the powerup test and running the motor. Now, this chapter starts from that point and shows how to make the inverter part of a larger control or automation system.

## Caution Messages for Operating Procedures

Before continuing, please read the following Caution messages.

**CAUTION:** The heat sink fins will have a high temperature. Be careful not to touch them. Otherwise, there is the danger of getting burned.

**CAUTION:** The operation of the inverter can be easily changed from low speed to high speed. Be sure check the capability and limitations of the motor and machine before operating the inverter. Otherwise, it may cause injury to personnel.

**CAUTION:** If you operate a motor at a frequency higher than the inverter standard default setting (50Hz/60Hz), be sure to check the motor and machine specifications with the respective manufacturer. Only operate the motor at elevated frequencies after getting their approval. Otherwise, there is the danger of equipment damage.

## Warning Messages for Operating Procedures

Before continuing, please read the following Warning messages.

**WARNING:** Be sure to turn ON the input power supply only after closing the front case. While the inverter is energized, be sure not to open the front case. Otherwise, there is the danger of electric shock.

**WARNING:** Be sure not to operate electrical equipment with wet hands. Otherwise, there is the danger of electric shock.

**WARNING:** While the inverter is energized, be sure not to touch the inverter terminals even when the motor is stopped. Otherwise, there is the danger of electric shock.

**WARNING:** If the Retry Mode is selected, the motor may suddenly restart after a trip stop. Be sure to stop the inverter before approaching the machine (be sure to design the machine so that safety for personnel is secure even if it restarts.) Otherwise, it may cause injury to personnel.

**WARNING:** If the power supply is cut OFF for a short period of time, the inverter may restart operation after the power supply recovers if the Run command is active. If a restart may pose danger to personnel, so be sure to use a lock-out circuit so that it will not restart after power recovery. Otherwise, it may cause injury to personnel.

**WARNING:** The Stop Key is effective only when the Stop function is enabled. Be sure to enable the Stop Key separately from the emergency stop. Otherwise, it may cause injury to personnel.

**WARNING:** During a trip event, if the alarm reset is applied and the Run command is present, the inverter will automatically restart. Be sure to apply the alarm reset only after verifying the Run command is OFF. Otherwise, it may cause injury to personnel.

**WARNING:** Be sure not to touch the inside of the energized inverter or to put any conductive object into it. Otherwise, there is a danger of electric shock and/or fire.

**WARNING:** If power is turned ON when the Run command is already active, the motor will automatically start and injury may result. Before turning ON the power, confirm that the RUN command is not present.

**WARNING:** When the Stop key function is disabled, pressing the Stop key does not stop the inverter, nor will it reset a trip alarm.

**WARNING:** Be sure to provide a separate, hard-wired emergency stop switch when the application warrants it.

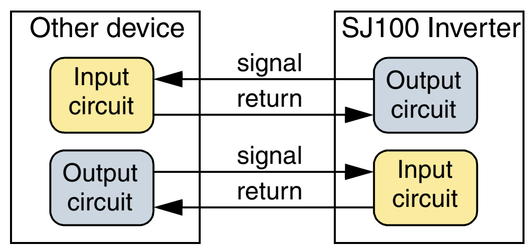
# Connecting to PLCs and Other Devices

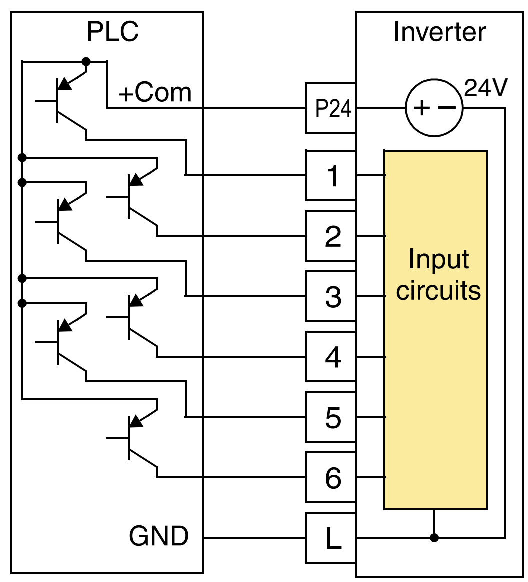
Hitachi inverters (drives) are useful in many types of applications. During installation, the inverter keypad (or other programming device) will facilitate the initial configuration. After installation, the inverter will generally receive its control commands through the control logic connector or serial interface from another controlling device. In a simple application such as single-conveyor speed control, a Run/Stop switch and potentiometer will give the operator all the required control. In a sophisticated application, you may have a *programmable logic controller* (PLC) as the system controller, with several connections to the inverter.

It is not possible to cover all the possible types of application in this manual. It will be necessary for you to know the electrical characteristics of the devices you want to connect to the inverter. Then, this section and the following sections on I/O terminal functions can help you quickly and safely connect those devices to the inverter.

**CAUTION:** It is possible to damage the inverter or other devices if your application exceeds the maximum current or voltage characteristics of a connection point.

The connections between the inverter and other devices rely on the electrical input/output characteristics at both ends of each connection, shown in the diagram to the right. The inverter's inputs require a sourcing output from an external device (such as a PLC). This chapter shows the inverter's internal electrical component(s) at each I/O terminal. In some cases, you will need to insert a power source in the interface wiring.



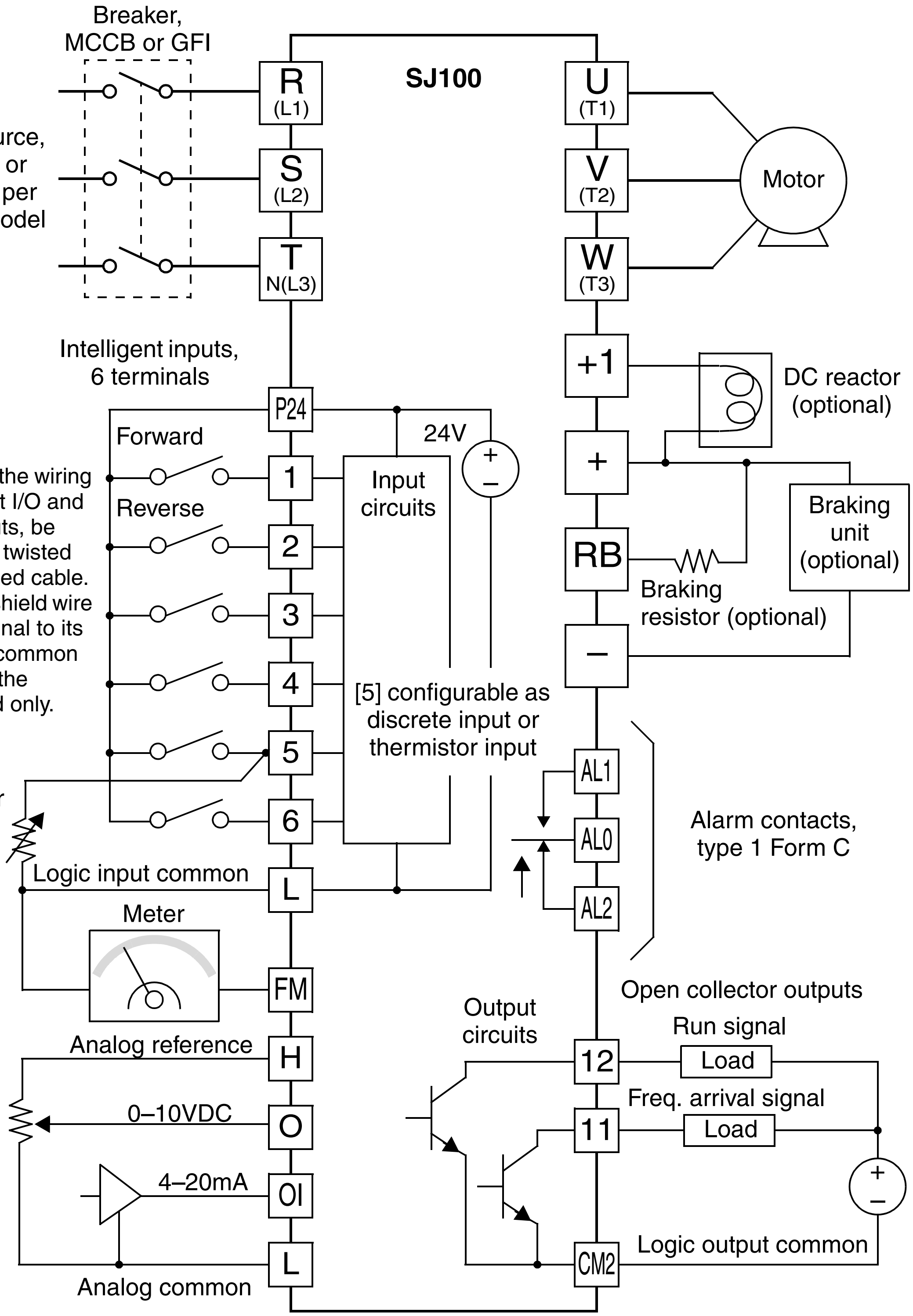

In order to avoid equipment damage and get your application running smoothly, we recommend drawing a schematic of each connection between the inverter and the other device. Include the internal components of each device in the schematic, so that it makes a complete circuit loop.

After making the schematic, then:

1. Verify that the current and voltage for each connection is within the operating limits of each device.
2. Make sure that the logic sense (active high or active low) of any ON/OFF connection is correct.
3. Check the zero and span (curve end points) for analog connections, and be sure the scale factor from input to output is correct.
4. Understand what will happen at the system level if any particular device suddenly loses power, or powers up after other devices.

# Example Wiring Diagram

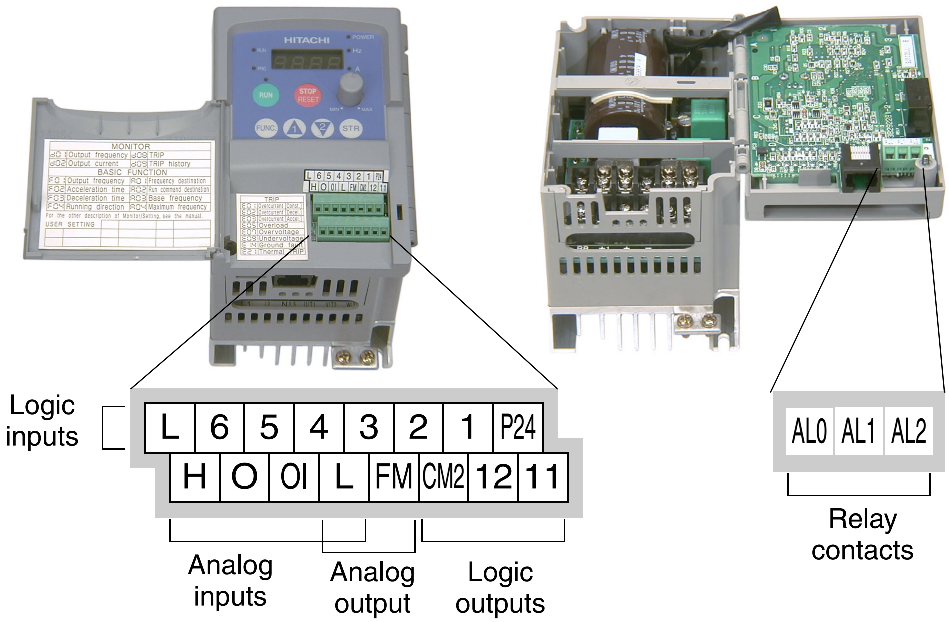
The schematic diagram below provides a general example of logic connector wiring, in addition to basic power and motor wiring covered in Chapter 2. The goal of this chapter is to help you determine the proper connections for the various terminals shown below for your specific application needs.




**NOTE:** For the wiring of intelligent I/O and analog inputs, be sure to use twisted pair / shielded cable. Attach the shield wire for each signal to its respective common terminal at the inverter end only.

## Specifications of Control and Logic Connections

The control logic connectors are located just behind the front panel half-door. The relay contacts are accessible behind the main door. Connector labeling is shown below.




Specifications for the logic connection terminals are in the following table:

| Terminal Name | Description | Ratings |
|---|---|---|
| [P24] | +24V for logic inputs | 24VDC, 30 mA max (do not short to terminal L) |
| [1], [2], [3], [4], [5], [6] | Discrete logic inputs | 27VDC max. (use P24 or an external supply referenced to terminal L) |
| [L] (top row) *1 | GND for logic inputs | sum of input 1-6 currents (return) |
| [11], [12] | Discrete logic outputs | 50mA maximum ON state current,<br>27 VDC maximum OFF state voltage |
| [CM2] | GND for logic outputs | 100 mA: sum of 11 and 12 currents (return) |
| [FM] | PWM (analog/digital) output | 0 to 10VDC, 1 mA, PWM and 50% duty digital |
| [L] (bottom row) *1 | GND for analog inputs | sum of OI, O, and H currents (return) |
| [OI] | Analog input, current | 4 to 19.6 mA range, 20 mA nominal |
| [O] | Analog input, voltage | 0 to 9.6 VDC range, 10VDC nominal,<br>input impedance 10 kΩ |
| [H] | +10V analog reference | 10VDC nominal, 10 mA max |
| [AL0] | Relay common contact | 250 VAC, 2.5A (R load) max.,<br>250 VAC, 0.2A (I load, P.F=0.4) max.<br>100 VAC, 10mA min.<br>30 VDC, 3.0A (R load) max.<br>30 VDC, 0.7A (I load, P.F.=0.4) max.<br>5 VDC, 100mA min. |
| [AL1] | Relay contact, normally closed during RUN | |
| [AL2] | Relay contact, normally open during RUN | |

**Note 1:** The two terminals [L] are electrically connected together inside the inverter.

## Terminal Listing

Use the following tables to locate pages for intelligent input and output material in this chapter.

| Intelligent Inputs | | | |
|---|---|---|---|
| **Symbol** | **Code** | **Name** | **Page** |
| FW | 00 | Forward Run/Stop | 4–9 |
| RV | 01 | Reverse Run/Stop | 4–9 |
| CF1 | 02 | Multi-speed Select, Bit 0 (LSB) | 4–10 |
| CF2 | 03 | Multi-speed Select, Bit 1 | 4–10 |
| CF3 | 04 | Multi-speed Select, Bit 2 | 4–10 |
| CF4 | 05 | Multi-speed Select, Bit 3 | 4–10 |
| JG | 06 | Jogging | 4–12 |
| DB | 07 | External DC Braking | 4–13 |
| SET | 08 | Set Second Motor | 4–14 |
| 2CH | 09 | 2-stage Acceleration and Deceleration | 4–15 |
| FRS | 11 | Free-run Stop | 4–16 |
| EXT | 12 | External Trip | 4–17 |
| USP | 13 | Unattended Start Protection | 4–18 |
| SFT | 15 | Software Lock | 4–19 |
| AT | 16 | Analog Input Voltage/current Select | 4–20 |
| RS | 18 | Reset Inverter | 4–21 |
| TH | 19 | Thermistor Thermal Protection | 4–22 |
| UP | 27 | Remote Control UP Function | 4–23 |
| DWN | 28 | Remote Control DOWN Function | 4–23 |

| Intelligent Outputs | | | |
|---|---|---|---|
| **Symbol** | **Code** | **Name** | **Page** |
| RUN | 00 | Run Signal | 4–25 |
| FA1 | 01 | Frequency Arrival Type 1 – Constant Speed | 4–26 |
| FA2 | 02 | Frequency Arrival Type 2 – Over-frequency | 4–26 |
| OL | 03 | Overload Advance Notice Signal | 4–28 |
| OD | 04 | Output Deviation for PID Control | 4–29 |
| AL | 05 | Alarm Signal | 4–30 |

# Using Intelligent Input Terminals

Terminals [1], [2], [3], [4], [5], and [6] are identical, programmable inputs for general use. The input circuits can use the inverter's internal (isolated) +24V field supply (P24) to power the inputs. The input circuits are internally connected to the power supply ground. As the diagram shows, you can use a switch (or jumper) to activate an input terminal that has been configured.

If you use an external supply, its GND terminal must connect to the [L] terminal on the inverter to complete the input circuit. Current can only flow *into* each input, so they are sinking inputs, whether powered internally or externally.

**NOTE:** We recommend using the top row [L] logic GND for logic input circuits and the [L] GND on the bottom row of terminals for analog I/O circuits.

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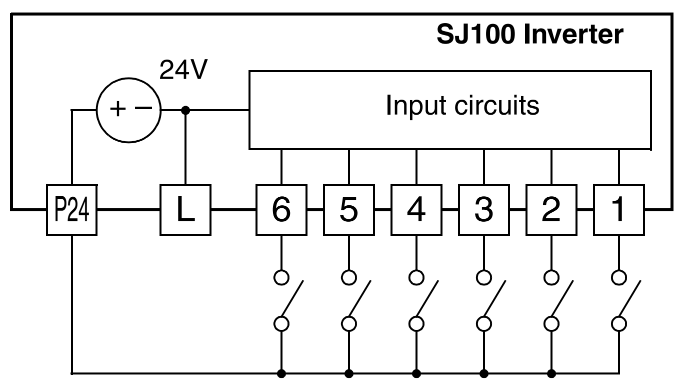
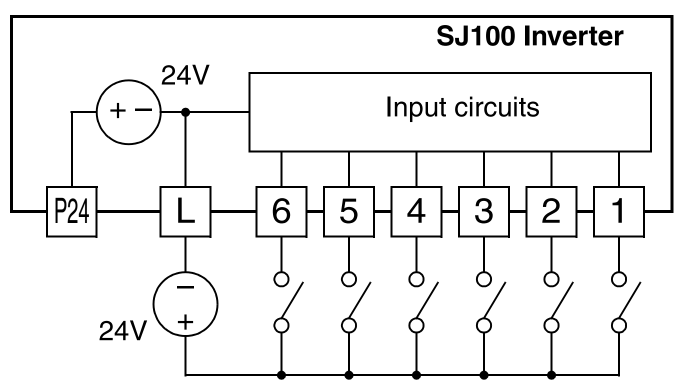
**Sinking inputs, internal supply**




**Sinking inputs, external supply**



## Forward Run/Stop and Reverse Run/Stop Commands:

When you input the Run command via the terminal [FW], the inverter executes the Forward Run command (high) or Stop command (low). When you input the Run command via the terminal [RV], the inverter executes the Reverse Run command (high) or Stop command (low).

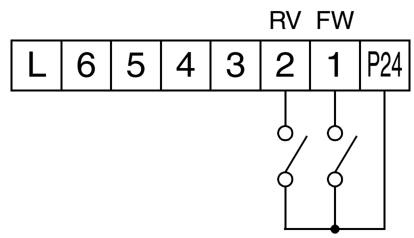
| Option Code | Terminal Symbol | Function Name | State | Description |
|---|---|---|---|---|
| 00 | FW | Forward Run/Stop | ON | Inverter is in Run Mode, motor runs forward |
| | | | OFF | Inverter is in Stop Mode, motor stops |
| 01 | RV | Reverse Run/Stop | ON | Inverter is in Run Mode, motor runs reverse |
| | | | OFF | Inverter is in Stop Mode, motor stops |

| | |
|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 |
| **Required settings:** | A_02 = 01 |

**Notes:**

- When the Forward Run and Reverse Run commands are active at the same time, the inverter enters the Stop Mode.
- When a terminal associated with either [FW] or [RV] function is configured for *normally closed*, the motor starts rotation when that terminal is disconnected or otherwise has no input voltage.

Example (default input configuration shown—see page 3–34):




See I/O specs on page 4–6.

**NOTE:** The parameter F_04, Keypad Run Key Routing, determines whether the single Run key issues a Run FWD command or Run REV command. However, it has no effect on the [FW] and [RV] input terminal operation.

**WARNING:** If the power is turned ON and the Run command is already active, the motor starts rotation and is dangerous! Before turning power ON, confirm that the Run command is not active.

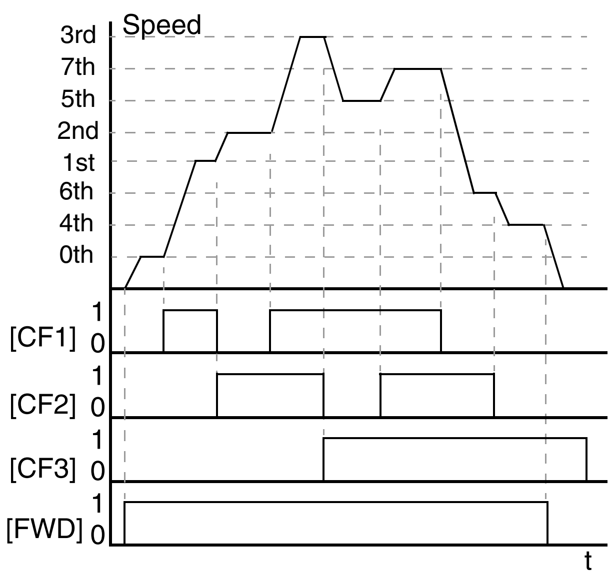
## Multi-Speed Select

The inverter can store up to 16 different target frequencies (speeds) that the motor output uses for steady-state run condition. These speeds are accessible through programming four of the intelligent terminals as binary-encoded inputs CF1 to CF4 per the table to the right. These can be any of the six inputs, and in any order. You can use fewer inputs if you need eight or fewer speeds.

| Multi-speed | Input Function | | | |
|---|---|---|---|---|
| | CF4 | CF3 | CF2 | CF1 |
| Speed 0 | 0 | 0 | 0 | 0 |
| Speed 1 | 0 | 0 | 0 | 1 |
| Speed 2 | 0 | 0 | 1 | 0 |
| Speed 3 | 0 | 0 | 1 | 1 |
| Speed 4 | 0 | 1 | 0 | 0 |
| Speed 5 | 0 | 1 | 0 | 1 |
| Speed 6 | 0 | 1 | 1 | 0 |
| Speed 7 | 0 | 1 | 1 | 1 |
| Speed 8 | 1 | 0 | 0 | 0 |
| Speed 9 | 1 | 0 | 0 | 1 |
| Speed 10 | 1 | 0 | 1 | 0 |
| Speed 11 | 1 | 0 | 1 | 1 |
| Speed 12 | 1 | 1 | 0 | 0 |
| Speed 13 | 1 | 1 | 0 | 1 |
| Speed 14 | 1 | 1 | 1 | 0 |
| Speed 15 | 1 | 1 | 1 | 1 |

**Note:** When choosing a subset of speeds to use, always start at the top of the table, and with the least-significant bit: CF1, CF2, etc.

The example with eight speeds in the figure below shows how input switches configured for CF1–CF3 functions can change the motor speed in real time.




**NOTE:** Speed 0 is set by the A_20 parameter value.

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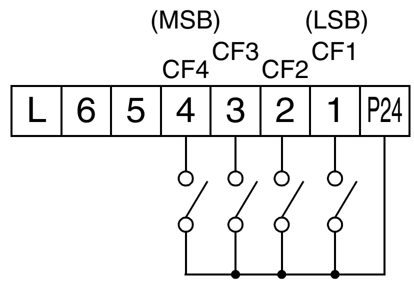
| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 02 | CF1 | Multi-speed Select, Bit 0 (LSB) | ON | Binary encoded speed select, Bit 0, logical 1 |
| | | | OFF | Binary encoded speed select, Bit 0, logical 0 |
| 03 | CF2 | Multi-speed Select, Bit 1 | ON | Binary encoded speed select, Bit 1, logical 1 |
| | | | OFF | Binary encoded speed select, Bit 1, logical 0 |
| 04 | CF3 | Multi-speed Select, Bit 2 | ON | Binary encoded speed select, Bit 2, logical 1 |
| | | | OFF | Binary encoded speed select, Bit 2, logical 0 |

| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 05 | CF4 | Multi-speed Select, Bit 3 (MSB) | ON | Binary encoded speed select, Bit 3, logical 1 |
| | | | OFF | Binary encoded speed select, Bit 3, logical 0 |
| **Valid for inputs:** | | C_01, C_02, C_03, C_04, C_05, C_06 | | Example (some CF inputs require input configuration; some are default inputs—see page 3–34): |
| **Required settings:** | | F_01, A_01 = 02, A_20 to A_35 | | |
| **Notes:**<br>• When programming the multi-speed settings, be sure to press the Store key each time and then set the next multi-speed setting. Note that when the key is not pressed, no data will be set.<br>• When a multi-speed setting more than 50Hz(60Hz) is to be set, it is necessary to program the maximum frequency A_04 high enough to allow that speed. | | | |  See I/O specs on page 4–6. |



While using the multi-speed capability, you can monitor the current frequency with monitor function D_01 during each segment of a multi-speed operation.
There are two ways to program the speeds into the registers A_20 to A_35:

**1.** Standard keypad programming:

**a.** Select each parameter A_20 to A_35.

**b.** Press the (FUNC) key to view the parameter value.

**c.** Use the (1) and (2) keys to edit the value.

**d.** Use the (STR) key to save the data to memory.

**2.** Programming using the CF switches. Set the speed by following these steps:

**a.** Turn the Run command OFF (Stop Mode).

**b.** Turn each switch ON and set it to Multi-speed. Display the value of F_01 on the digital operator.

**c.** Set the desired output frequency by pressing the (1) and (2) keys.

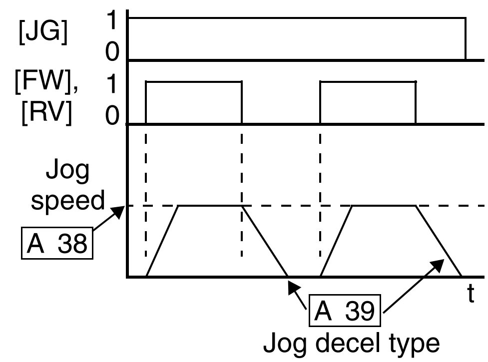
**d.** Press the (STR) key once to store the set frequency. When this occurs, F_01 indicates the output frequency of Multi-speed n.

**e.** Press the (FUNC) key once to confirm that the indication is the same as the set frequency.

**f.** Repeat operations in 2. a) to 2. e) to set the frequency of other Multi-speeds. It can be set also by parameters A_20 to A_35 in the first procedure 1. a) to 1. d).

## Jogging Command

The Jog input [JG] is used to command the motor to rotate slowly in small increments for manual operation. The speed is limited to 10 Hz. The frequency for the jogging operation is set by parameter A_38. Jogging does not use an acceleration ramp, so we recommend setting the jogging frequency A_38 to 5 Hz or less to prevent tripping.




When the terminal [JG] is turned ON and the Run command is issued, the inverter outputs the programmed jog frequency to the motor. To enable the Run key on the digital operator for jog input, set the value 01(terminal mode) in A_02 (Run command source).

The type of deceleration used to end a motor jog operation is selectable by programming function A_39. The options are:

- 00 Free-run stop (coasting)
- 01 Deceleration (normal level) and stop
- 02 Use DC braking and stop

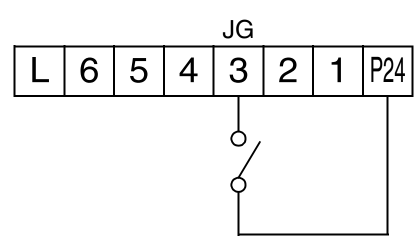
| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 06 | JG | Jogging | ON | Inverter is in Run Mode, output to motor runs at jog parameter frequency |
| | | | OFF | Inverter is in Stop Mode |

| | |
|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 |
| **Required settings:** | A_02= 01, A_38 > B_82, A_38 > 0, A_39 |

**Notes:**

- No jogging operation is performed when the set value of jogging frequency A_38 is smaller than the start frequency B_82, or the value is 0 Hz.
- Be sure to stop the motor when switching the function [JG] ON or OFF.

Example (requires input configuration—see page 3–34):




See I/O specs on page 4–6.

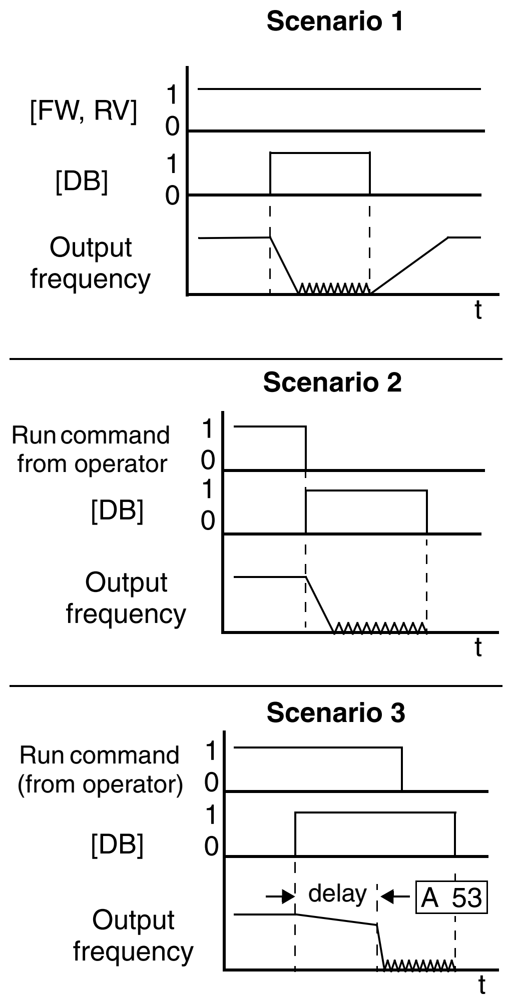
## External Signal for DC Braking

When the terminal [DB] is turned ON, the DC braking feature is enabled. Set the following parameters when the external DC braking terminal [DB] is to be used:

- A_53 – DC braking delay time setting. The range is 0.1 to 5.0 seconds.
- A_54 – DC braking force setting. The range is 0 to 100%.

The scenarios to the right help show how DC braking works in various situations.

1. Scenario 1 – The [FW] or [RV] terminal is ON. When [DB] is ON, DC braking is applied. When [DB] is OFF again, the output frequency ramps to the prior level.
2. Scenario 2 – The Run command is applied from the operator keypad. When the [DB] terminal is ON, DC braking is applied. When the [DB] terminal is OFF again, the inverter output remains OFF.
3. Scenario 3 – The Run command is applied from the operator keypad. When the [DB] terminal is ON, DC braking is applied after the delay time set by A_53 expires. The motor is in a free-running (coasting) condition. When the [DB] terminal is OFF again, the inverter output remains OFF.



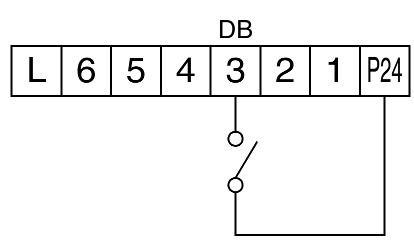

| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 07 | DB | External DC Braking | ON | applies DC injection braking during deceleration |
| | | | OFF | does not apply DC injection braking during deceleration |

| | |
|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 |
| **Required settings:** | A_53, A_54 |

**Notes:**

- Do not use the [DB] input continuously or for a long time when the DC braking force setting A_54 is high (depends on the motor application).
- Do not use the [DB] feature for continuous or high duty cycle as a holding brake. The [DB] input is designed to improve stopping performance. Use a mechanical brake for holding a stop position.

Example (requires input configuration—see page 3–34):




See I/O specs on page 4–6.

## Set Second Motor

If you assign the [SET] function to an intelligent input terminal, you can select between two sets of motor parameters. The second parameters store an alternate set of motor characteristics. When the terminal [SET] is turned ON, the inverter will use the second set of parameters to generate the frequency output to the motor. When changing the state of the [SET] input terminal, the change will not take effect until the inverter is stopped.

When you turn ON the [SET] input, the inverter operates per the second set of parameters. When the terminal is turned OFF, the output function returns to the original settings (first set of motor parameters). Refer to “Configuring the Inverter for Multiple Motors” on page 4–40 for details.

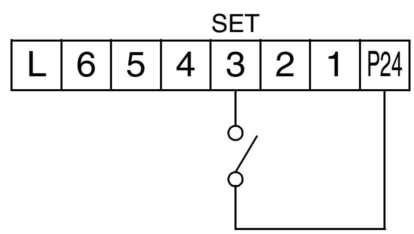
| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 08 | SET | Set (select) 2nd Motor Data | ON | causes the inverter to use the 2nd set of motor parameters for generating the frequency output to motor |
| | | | OFF | causes the inverter to use the 1st (main) set of motor parameters for generating the frequency output to motor |

| | |
|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 |
| **Required settings:** | (none) |

**Notes:**

- If the terminal state is changed while the inverter is running, the inverter continues using the current set of parameters until the inverter is stopped.

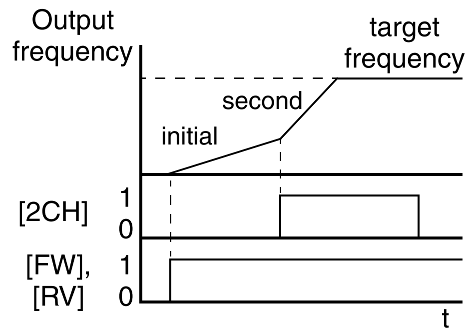
Example (requires input configuration—see page 3–34):




See I/O specs on page 4–6.

## Two-stage Acceleration and Deceleration

When terminal [2CH] is turned ON, the inverter changes the rate of acceleration and deceleration from the initial settings (F_02 and F_03) to use the second set of acceleration/deceleration values. When the terminal is turned OFF, the inverter is returned to the original acceleration and deceleration time (F_02 acceleration time 1, and F_03 deceleration time 1). Use A_92 (acceleration time 2) and A_93 (deceleration time 2) to set the second stage acceleration and deceleration times.



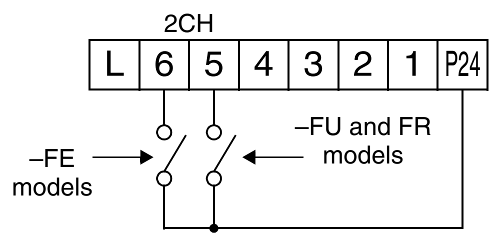

In the graph shown above, the [2CH] becomes active during the initial acceleration. This causes the inverter to switch from using acceleration 1 (F_02) to acceleration 2 (A_92).

| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 09 | 2CH | Two-stage Acceleration and Deceleration | ON | Frequency output uses 2nd-stage acceleration and deceleration values |
| | | | OFF | Frequency output uses the initial acceleration 1 and deceleration 1 values |

| | | |
|---|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 | Example (default input configurations shown—see page 3–34): |
| **Required settings:** | A_92, A_93, A_94=00 | |

**Notes:**

- Function A_94 selects the method for second stage acceleration. It must be set = 00 to select the input terminal method in order for the [2CH] terminal assignment to operate.



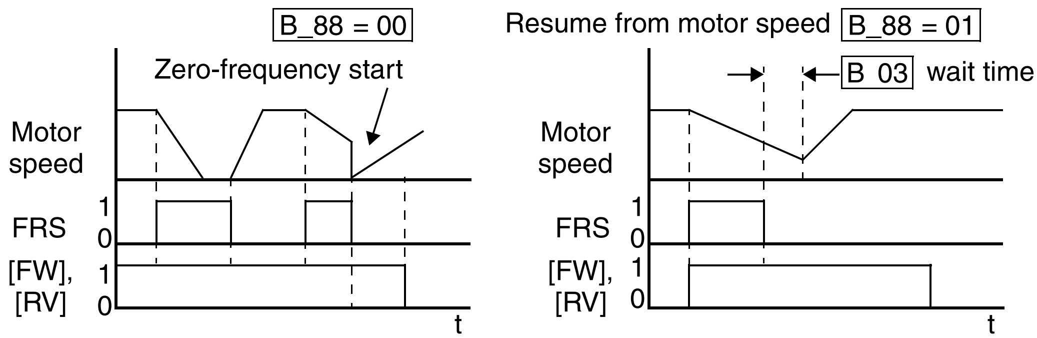

See I/O specs on page 4–6.

## Free-run Stop

When the terminal [FRS] is turned ON, the inverter stops the output and the motor enters the free-run state (coasting). If terminal [FRS] is turned OFF, the output resumes sending power to the motor if the Run command is still active. The free-run stop feature works with other parameters to provide flexibility in stopping and starting motor rotation.

In the figure below, parameter B_88 selects whether the inverter resumes operation from 0 Hz (left graph) or the current motor rotation speed (right graph) when the [FRS] terminal turns OFF. The application determines the best setting.

Parameter B_03 specifies a delay time before resuming operation from a free-run stop. To disable this feature, use a zero delay time.

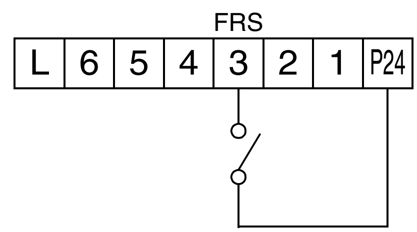



| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 11 | FRS | Free-run Stop | ON | Causes output to turn OFF, allowing motor to free run (coast) to stop |
| | | | OFF | Output operates normally, so controlled deceleration stops motor |

| | | |
|---|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 | Example (requires input configuration—see page 3–34): |
| **Required settings:** | B_03, B_88, C_11 to C_16 | |

**Notes:**

- When you want the [FRS] terminal to be active low (normally closed logic), change the setting (C_11 to C_16) that corresponds to the input (C_01 to C_06) that is assigned the [FRS] function.

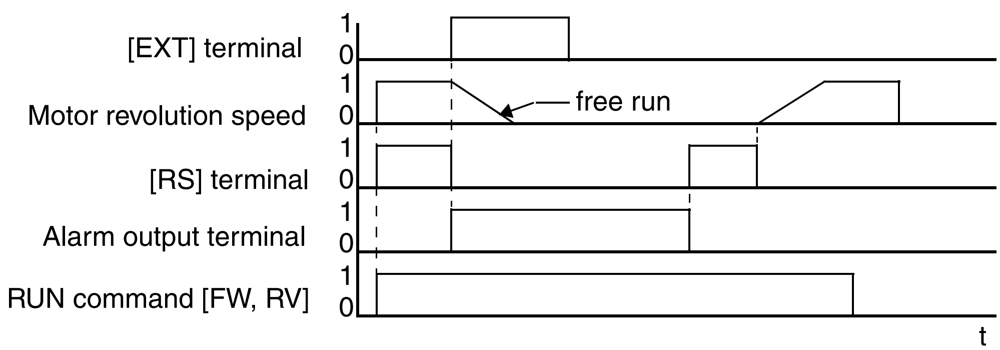



See I/O specs on page 4–6.

## External Trip

When the terminal [EXT] is turned ON, the inverter enters the trip state, indicates error code E12, and stops the output. This is a general purpose interrupt type feature, and the meaning of the error depends on what you connect to the [EXT] terminal. Even if the [EXT] input is turned OFF, the inverter remains in the trip state. You must reset the inverter or cycle power to clear the error, returning the inverter to the Stop Mode.

In the graph below, the [EXT] input turns ON during normal Run Mode operation. The inverter lets the motor free-run to a stop, and the alarm output turns ON immediately. When the operator initiates a Reset command, the alarm and error are cleared. When the Reset is turned OFF, the motor begins rotation since the Run command is already active.

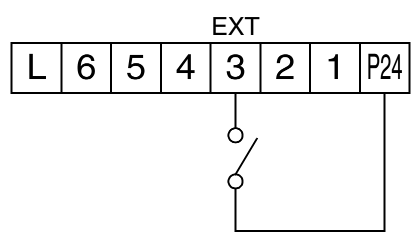



| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 12 | EXT | External Trip | ON | When assigned input transitions OFF to ON, inverter latches trip event and displays E12 |
| | | | OFF | No trip event for ON to OFF, any recorded trip events remain in history until Reset |

| | | |
|---|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 | Example (requires input configuration— see page 3–34): |
| **Required settings:** | (none) | |

**Notes:**

- If the USP (Unattended Start Protection) feature is in use, the inverter will not automatically restart after cancelling the EXT trip event. In that case, it must receive either another Run command (OFF-to-ON transition), a keypad Reset command, or an [RS] intelligent terminal input signal.

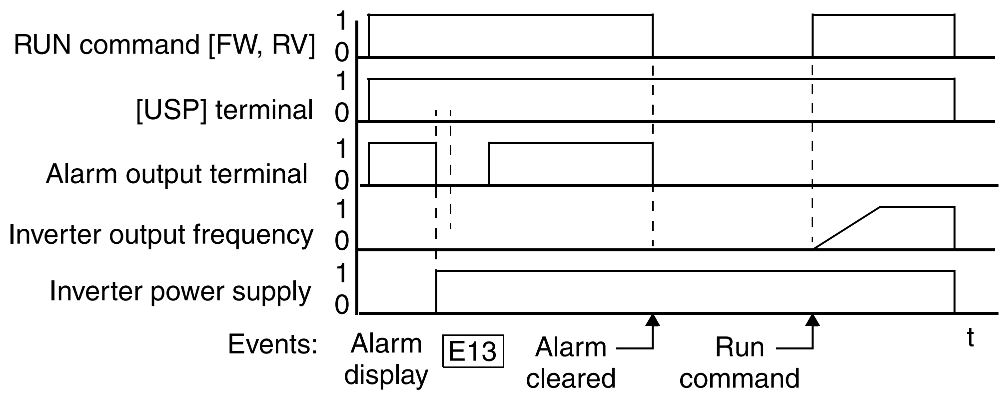



See I/O specs on page 4–6.

## Unattended Start Protection

If the Run command is already set when power is turned ON, the inverter starts running immediately after powerup. The Unattended Start Protection (USP) function prevents that automatic startup, so that the inverter *will not* run without outside intervention. When USP is active and you need to reset an alarm and resume running, either turn the Run command OFF, or perform a reset operation by the terminal [RS] input or the keypad Stop/reset key.

In the figure below, the [UPS] feature is enabled. When the inverter power turns ON, the motor does not start, even though the Run command is already active. Instead, it enters the USP trip state, and displays E13 error code. This requires outside intervention to reset the alarm by turning OFF the Run command per this example (or applying a reset). Then the Run command can turn ON again and start the inverter output.



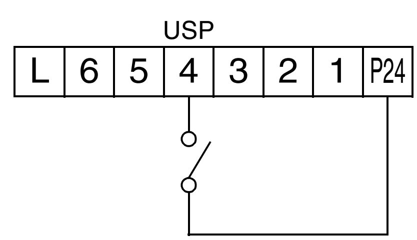

| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 13 | USP | Unattended Start Protection | ON | On powerup, the inverter will not resume a Run command (mostly used in the US) |
| | | | OFF | On powerup, the inverter will resume a Run command that was active before power loss |

| | |
|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 |
| **Required settings:** | (none) |

**Notes:**

- Note that when a USP error occurs and it is canceled by a reset from a [RS] terminal input, the inverter restarts running immediately.
- Even when the trip state is canceled by turning the terminal [RS] ON and OFF after an under voltage protection E09 occurs, the USP function will be performed.
- When the running command is active immediately after the power is turned ON, a USP error will occur. When this function is used, wait for at least three (3) seconds after the powerup to generate a Run command.

Example (default input configuration shown for –FU models; –FE and –FR models require input configuration—see page 3–34):




See I/O specs on page 4–6.

## Software Lock

When the terminal [SFT] is turned ON, the data of all the parameters and functions (except the output frequency, depending on the setting of B_31) is locked (prohibited from editing). When the data is locked, the keypad keys cannot edit inverter parameters. To edit parameters again, turn OFF the [SFT] terminal input.

Use parameter B_31 to select whether the output frequency is excluded from the lock state or is locked as well.

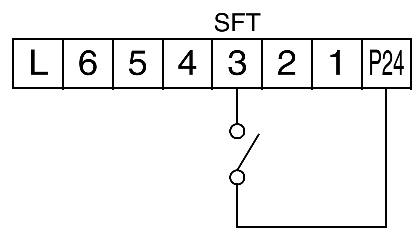
| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 15 | SFT | Software Lock | ON | The keypad and remote programming devices are prevented from changing parameters |
| | | | OFF | The parameters may be edited and stored |

| | |
|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 |
| **Required settings:** | B_31 (excluded from lock) |

**Notes:**

- When the [SFT] terminal is turned ON, only the output frequency can be changed.
- Software lock can include the output frequency by setting B_31.
- Software lock by the operator is also possible without the [SFT] terminal being used (B_31).

Example (requires input configuration—see page 3–34):




See I/O specs on page 4–6.

## Analog Input Current/Voltage Select

The [AT] terminal selects whether the inverter uses the voltage [O] or current [OI] input terminals for external frequency control. When intelligent input [AT] is ON, you can set the output frequency by applying a current input signal at [OI]-[L]. When the [AT] input is OFF, you can apply a voltage input signal at [O]-[L] to set the output frequency. Note that you must also set parameter A_01 = 01 to enable the analog terminal set for controlling the inverter frequency.

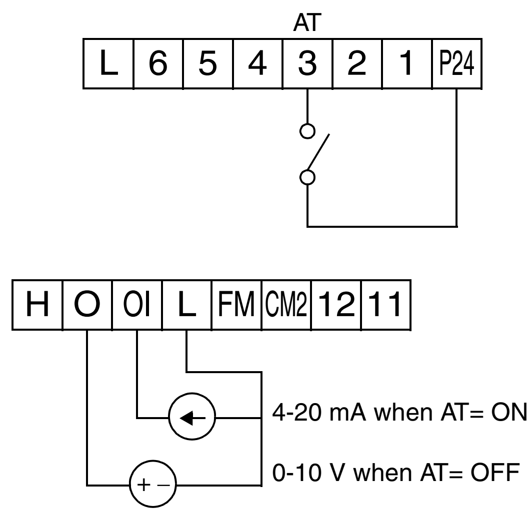
| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 16 | AT | Analog Input Voltage/current Select | ON | Terminal OI is enabled for current input (uses terminal L for power supply return) |
| | | | OFF | Terminal O is enabled for voltage input (uses terminal L for power supply return) |

| | |
|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 |
| **Required settings:** | A_01 = 01 |

**Notes:**

- If the [AT] option is not assigned to any intelligent input terminal, then inverter uses the algebraic sum of both the voltage and current inputs for the frequency command (and A_01=01).
- When using either the analog current and voltage input terminal, make sure that the [AT] function is allocated to an intelligent input terminal.
- Be sure to set the frequency source setting A_01=01 to select the analog input terminals.

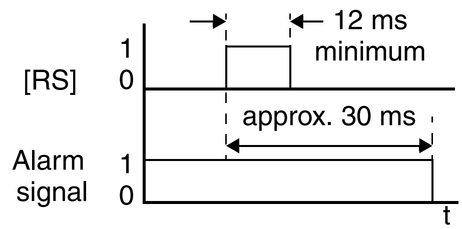
Example (default input configuration shown for –FU models; –FE and –FR models require input configuration—see page 3–34):




See I/O specs on page 4–6.

## Reset Inverter

The [RS] terminal causes the inverter to execute the reset operation. If the inverter is in Trip Mode, the reset cancels the Trip state. When the signal [RS] is turned ON and OFF, the inverter executes the reset operation. The minimum pulse width for [RS] must be 12 ms or greater. The alarm output will be cleared within 30 ms after the onset of the Reset command.

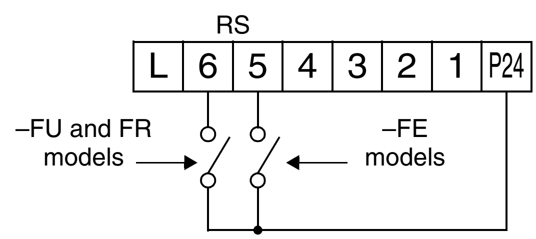



**WARNING:** After the Reset command is given and the alarm reset occurs, the motor will restart suddenly if the Run command is already active. Be sure to set the alarm reset after verifying that the Run command is OFF to prevent injury to personnel.

| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 18 | RS | Reset Inverter | ON | The motor output is turned OFF, the Trip Mode is cleared (if it exists), and powerup reset is applied |
| | | | OFF | Normal power-ON operation |

| | |
|---|---|
| **Valid for inputs:** | C_01, C_02, C_03, C_04, C_05, C_06 |
| **Required settings:** | (none) |

Example (default input configurations shown—see page 3–34):




See I/O specs on page 4–6.

**Notes:**

- When the control terminal [RS] input is already ON at powerup for more than 4 seconds, the remote operator display is “R-ERROR COMM<2>” (the display of the digital operator is – – –. However, the inverter has no error. To clear the digital operator error, turn OFF the terminal [RS] input and press one of the operator keys.
- Pressing the Stop/Reset key of the digital operator can generate a reset operation only when an alarm occurs.
- A terminal configured with the [RS] function can only be configured for normally open operation. The terminal cannot be used in the normally closed contact state.
- When input power is turned ON, the inverter performs the same reset operation as it does when a pulse on the [RS] terminal occurs.
- The Stop/Reset key on the inverter is only operational for a few seconds after inverter powerup when a hand-held remote operator is connected to the inverter.
- If the [RS] terminal is turned ON while the motor is running, the motor will be free running (coasting).

## Thermistor Thermal Protection

Motors that are equipped with a thermistor can be protected from overheating. Input terminal [5] has the unique ability to sense a thermistor resistance. When the resistance value of the thermistor connected to terminal [TH] (5) and [L] is more than 3 k Ohms ±10%, the inverter enters the Trip Mode, turns OFF the output to the motor, and indicates the trip status E35. Use this function to protect the motor from overheating

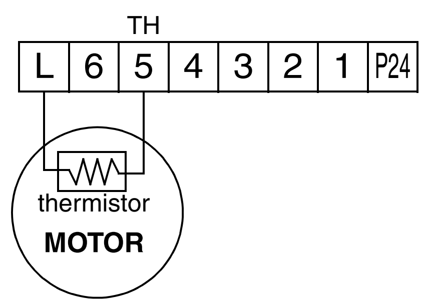
| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 19 | TH | Thermistor Thermal Protection | Sensor | When a thermistor is connected to terminals [5] and [L], the inverter checks for over-temperature and will cause trip (E35) and turn OFF the output to the motor |
| | | | Open | An open circuit in the thermistor causes a trip, and the inverter turns OFF the output |

| | |
|---|---|
| **Valid for inputs:** | C_05 only |
| **Required settings:** | (none) |

**Notes:**

- Be sure the thermistor is connected to terminals [5] and [L]. If the resistance is above the threshold the inverter will trip. When the motor cools down enough, the thermistor resistance will change enough to permit you to clear the error. Press the STOP/Reset key to clear the error.

Example (requires input configuration—see page 3–34):

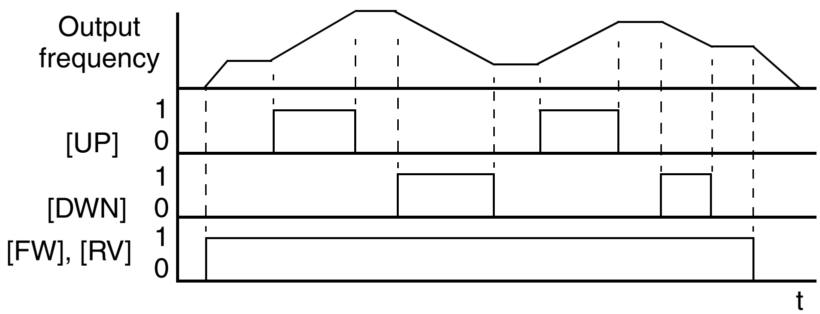


## Remote Control Up and Down Functions

The [UP] [DWN] terminal functions can adjust the output frequency for remote control while the motor is running. The acceleration time and deceleration time of this function is same as normal operation ACC1 and DEC1 (2ACC1,2DEC1). The input terminals operate according to these principles:

- Acceleration - When the [UP] contact is turned ON, the output frequency accelerates from the current value. When it is turned OFF, the output frequency maintains its current value at that moment.
- Deceleration - When the [DWN] contact is turned ON, the output frequency decelerates from the current value. When it is turned OFF, the output frequency maintains its current value at that moment.

In the graph below, the [UP] and [DWN] terminals activate while the Run command remains ON. The output frequency responds to the [UP] and [DWN] commands.

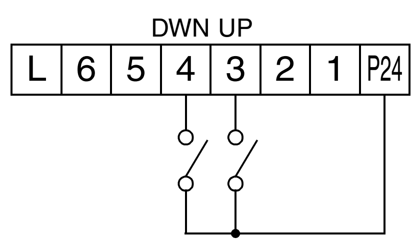



| Option Code | Terminal Symbol | Function Name | Input State | Description |
|---|---|---|---|---|
| 27 | UP | Remote Control UP Function (motorized speed pot.) | ON | Accelerates (increases output frequency) motor from current frequency |
| | | | OFF | Output to motor operates normally |
| 28 | DWN | Remote Control DOWN Function (motorized speed pot.) | ON | Decelerates (decreases output frequency) motor from current frequency |
| | | | OFF | Output to motor operates normally |
| **Valid for inputs:** | | C_01, C_02, C_03, C_04, C_05, C_06 | | |
| **Required settings:** | | A_01 = 02 | | |

**Notes:**

- This feature is available only when the frequency command source is programmed for operator control. Confirm A_01 is set to 02.
- This function is not available when [JG] is in use.
- The range of output frequency is 0 Hz to the value in A_04 (maximum frequency setting).

Example (requires input configuration—see page 3–34):




See I/O specs on page 4–6.

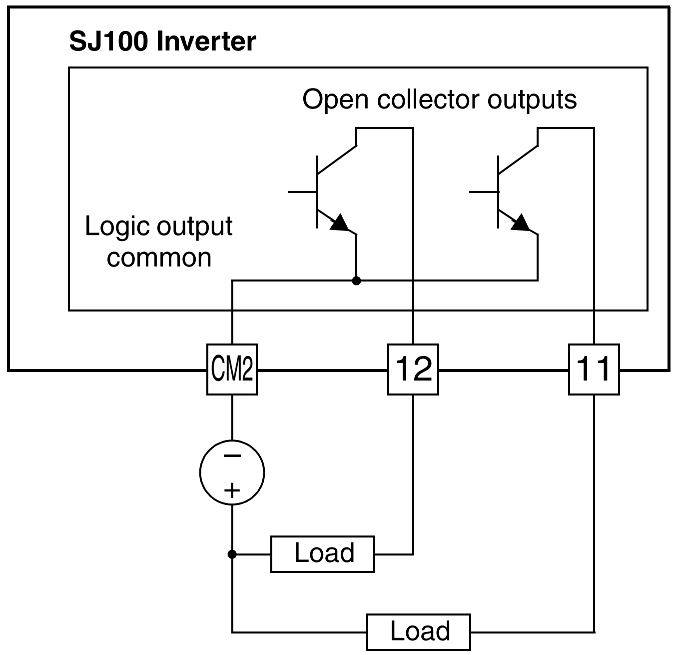
- The minimum ON time of [UP] and [DWN] is 50 ms.
- This setting modifies the inverter speed from using F_01 output frequency setting as a starting point.

# Using Intelligent Output Terminals

The intelligent output terminals are programmable in a similar way to the intelligent input terminals. The inverter has several output functions that you can assign individually to three physical logic outputs. Two of the outputs are open-collector transistors, and the third output is the alarm relay (form C – normally open and normally closed contacts). The relay is assigned the alarm function by default, but you can assign it to any of the functions that the open-collector outputs use.

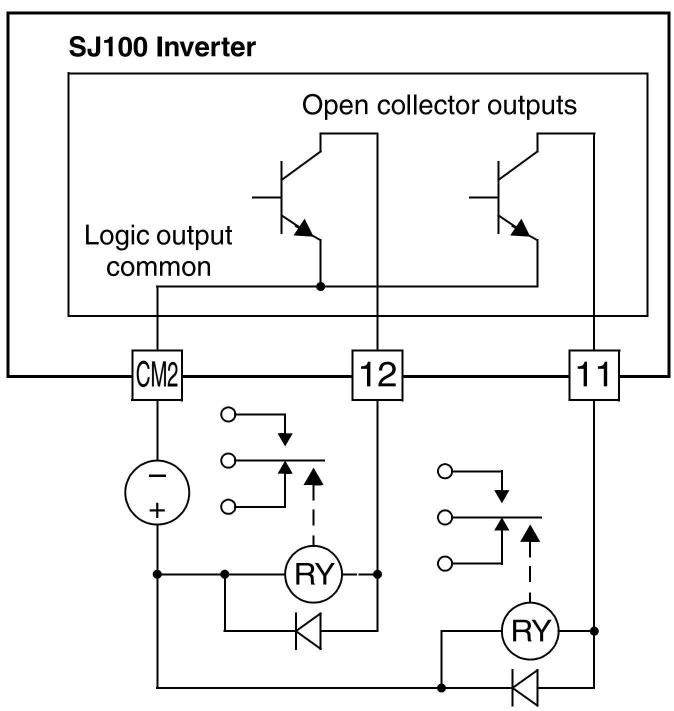
## Sinking Outputs, Open Collector

The open-collector transistor outputs can handle up to 50mA each. We highly recommend that you use an external power source as shown. It must be capable of providing at least 100mA to drive both outputs at full load. To drive loads that require more than 50mA, use external relay circuits as shown below.



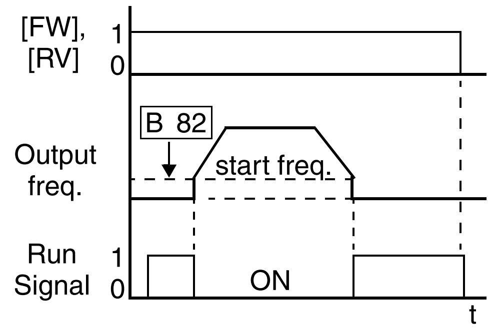

## Sinking Outputs, Open Collector with External Relays

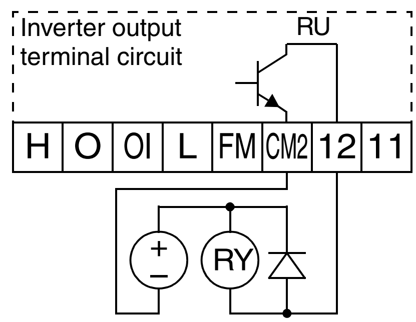
If you need output current greater than 50mA, use the inverter output to drive a small relay. Be sure to use a diode across the coil of the relay as shown (reverse-biased) in order to suppress the turn-off spike, or use a solid-state relay.



## Run Signal

When the [RUN] signal is selected as an intelligent output terminal, the inverter outputs a signal on that terminal when it is in Run Mode. The output logic is active low, and is the open collector type (switch to ground).




| Option Code | Terminal Symbol | Function Name | Output State | Description |
|---|---|---|---|---|
| 00 | RUN | Run Signal | ON | when inverter is in Run Mode |
| | | | OFF | when inverter is in Stop Mode |
| **Valid for outputs:** | | 11, 12, AL0 – AL2 | | Example (default output configuration shown—see page 3–38):  See I/O specs on page 4–6. |
| **Required settings:** | | (none) | | |



**Notes:**

- The inverter outputs the [RUN] signal whenever the inverter output exceeds the start frequency specified by parameter B_82. The start frequency is the initial inverter output frequency when it turns ON.

**NOTE:** The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter's output transistor.

## Frequency Arrival Signals

The *Frequency Arrival* group of outputs help coordinate external systems with the current velocity profile of the inverter. As the name implies, output [FA1] turns ON when the output *frequency arrives* at the standard set frequency (parameter F_01). Output [FA2] relies on programmable accel/ decel thresholds for increased flexibility. For example, you can have an output turn ON at one frequency during acceleration, and have it turn OFF at a different frequency during deceleration. All transitions have hysteresis to avoid output chatter if the output frequency is near one of the thresholds.

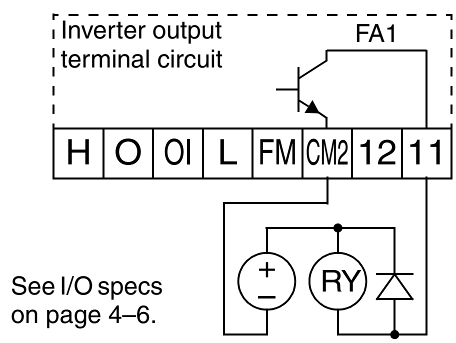
| Option Code | Terminal Symbol | Function Name | Output State | Description |
|---|---|---|---|---|
| 01 | FA1 | Frequency Arrival Type 1 – Constant Speed | ON | when output to motor is at the set frequency |
| | | | OFF | when output to motor is OFF, or in any acceleration or deceleration ramp |
| 02 | FA2 | Frequency Arrival Type 2 – Over-frequency | ON | when output to motor is at or above the set frequency thresholds for, even if in acceleration or deceleration ramps |
| | | | OFF | when output to motor is OFF, or during acceleration or deceleration before the respective thresholds are crossed |

| | |
|---|---|
| **Valid for outputs:** | 11, 12, AL0 – AL2 |
| **Required settings:** | (none) |

**Notes:**

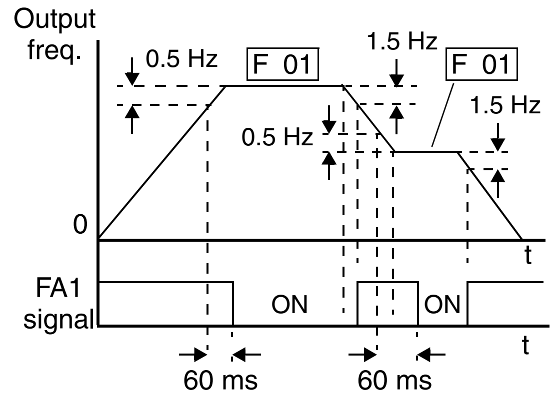
- For most applications you will need to use only one type of frequency arrival outputs (see examples). However, it is possible assign both output terminals to output functions [FA1] and [FA2].
- For each frequency arrival threshold, the output anticipates the threshold (turns ON early) by 1.5Hz.
- The output turns OFF as the output frequency moves away from the threshold, delayed by 0.5Hz.
- The delay time of the output signal is 60 ms (nominal).

Example (default output configuration shown—see page 3–38):

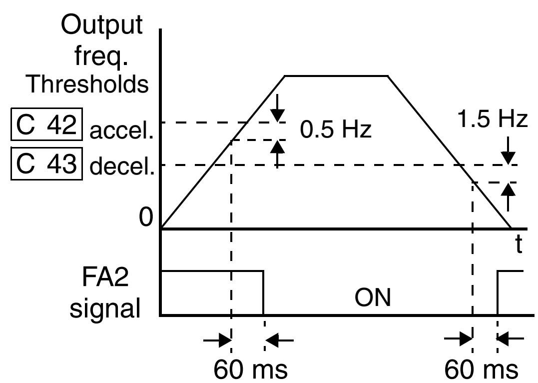



**NOTE:** The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter's output transistor.

Frequency arrival output [FA1] uses the standard output frequency (parameter F_01) as the threshold for switching. In the figure to the right, Frequency Arrival [FA1] turns ON when the output frequency gets within 0.5 Hz below or 1.5 Hz above the target constant frequency. This provides hysteresis that prevents output chatter near the threshold value.The hysteresis effect causes the output to turn ON slightly *early* as the speed approaches the threshold. Then the turn-OFF point is slightly *delayed*. The timing is further modified by a small 60 ms delay. Note the active low nature of the signal, due to the open collector output.

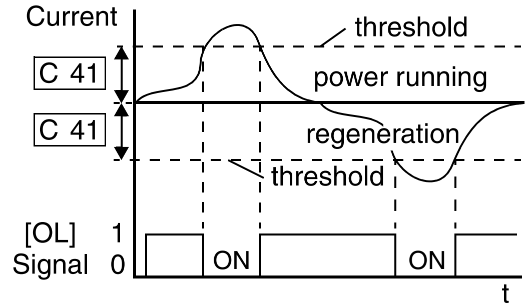



Frequency arrival output [FA2] works the same way; it just uses two separate thresholds as shown in the figure to the right. These provide for separate acceleration and deceleration thresholds to provide more flexibility than for [FA1]. [FA2] uses C_42 during acceleration for the ON threshold, and C_43 during deceleration for the OFF threshold. This signal also is active low and has a 60 ms delay after the frequency thresholds are crossed. Having different accel and decel thresholds provides an asymmetrical output function. However, you can use equal ON and OFF thresholds, if desired.



## Overload Advance Notice Signal

When the output current exceeds a preset value, the [OL] terminal signal turns ON. The parameter C_41 sets the overload threshold. The overload detection circuit operates during powered motor operation and during regenerative braking. The output circuits use open-collector transistors, and are active low.



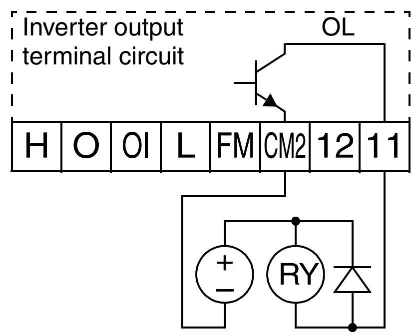

| Option Code | Terminal Symbol | Function Name | Output State | Description |
|---|---|---|---|---|
| 03 | OL | Overload Advance Notice Signal | ON | when output current is more than the set threshold for the overload signal |
| | | | OFF | when output current is less than the set threshold for the overload signal |

| | |
|---|---|
| **Valid for outputs:** | 11, 12, AL0 – AL2 |
| **Required settings:** | C_41 |

**Notes:**

- The default value is 100%. To change the level from the default, set C_41 (overload level).
- The accuracy of this function is the same as the function of the output current monitor on the [FM] terminal (see "Analog and Digital Monitor Output" on page 4–33).

Example (requires output configuration—see page 3–38):

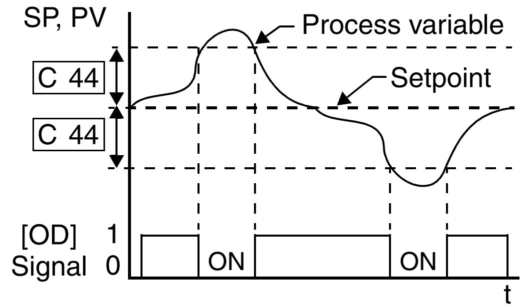



See I/O specs on page 4–6.

**NOTE:** The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter's output transistor.

## Output Deviation for PID Control

The PID loop error is defined as the magnitude (absolute value) of the difference between the Setpoint (target value) and the Process Variable (actual value). When the error magnitude exceeds the preset value for C_44, the [OD] terminal signal turns ON. Refer to “PID Loop Operation” on page 4–39.



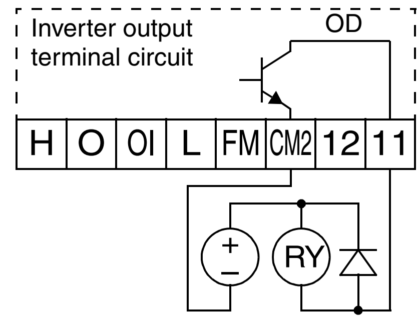

| Option Code | Terminal Symbol | Function Name | Output State | Description |
|---|---|---|---|---|
| 04 | OD | Output Deviation for PID Control | ON | when PID error is more than the set threshold for the deviation signal |
| | | | OFF | when PID error is less than the set threshold for the deviation signal |

| | | |
|---|---|---|
| **Valid for outputs:** | 11, 12, AL0 – AL2 | Example (requires output configuration—see page 3–38): |
| **Required settings:** | C_44 | |

**Notes:**

- The default difference value is set to 3%. To change this value, change parameter C_44 (deviation level).

Example (requires output configuration—see page 3–38):

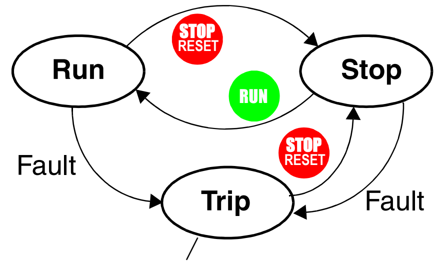



See I/O specs on page 4–6.

**NOTE:** The example circuit in the table above drives a relay coil. Note the use of a diode to prevent the negative-going turn-off spike generated by the coil from damaging the inverter’s output transistor.

## Alarm Signal

The inverter alarm signal is active when a fault has occurred and it is in the Trip Mode (refer to the diagram at right). When the fault is cleared the alarm signal becomes inactive.




We must make a distinction between the alarm *signal* AL and the alarm relay *contacts* [AL0], [AL1] and [AL2]. The signal AL is a logic function, which you can assign to the open collector output terminals [11] or [12] or the relay outputs. The most common (and default) use of the relay is for AL, thus the labeling of its terminals. Use an open collector output (terminal [11] or [12]) for a low-current logic signal interface or to energize a small relay (50 mA maximum). Use the relay output to interface to higher voltage and current devices (10 mA minimum).

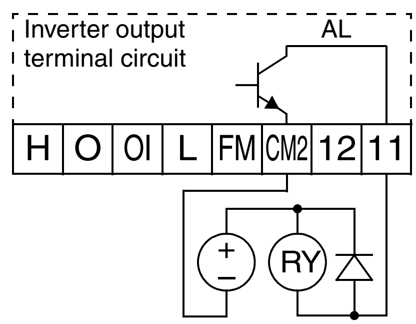
| Option Code | Terminal Symbol | Function Name | Output State | Description |
|---|---|---|---|---|
| 05 | AL | Alarm Signal | ON | when an alarm signal has occurred and has not been cleared |
| | | | OFF | when no alarm has occurred since the last clearing of alarm(s) |

| | |
|---|---|
| **Valid for outputs:** | 11, 12, AL0 – AL2 |
| **Required settings:** | C_24, C_33 |

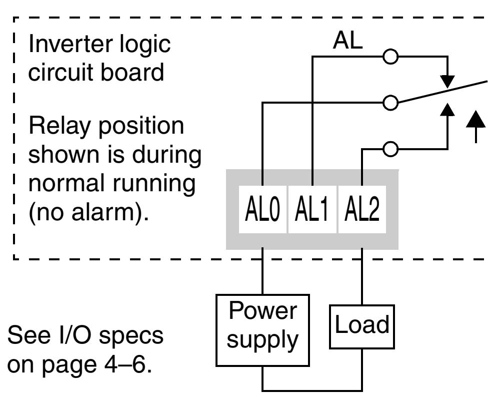
**Notes:**

- When the alarm output is set to normally closed, a time delay of less than 2 seconds occurs until the contact is closed when the power is turned ON.
- Terminals [11] and [12] are open collector outputs, so the electric specifications of [AL] are different from the contact output terminals [AL0], [AL1], [AL2].
- When the inverter power supply is turned OFF, the alarm signal output is valid as long as the external control circuit has power.
- This signal output has the delay time (300 ms nominal) from the fault alarm output.
- The relay contact specifications are in “Specifications of Control and Logic Connections” on page 4–6. The contact diagrams for different conditions are on the next page.

Example for terminal [11] or [12] (requires output configuration—see page 3–38):




Example for terminals [AL0], [AL1], [AL2] (default output configuration shown—see page 3–38):

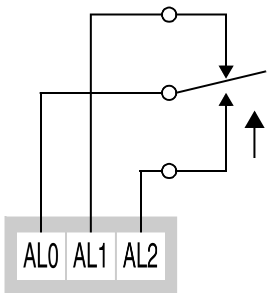



See I/O specs on page 4–6.

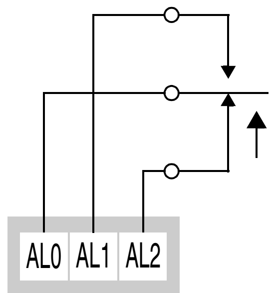
The alarm output terminals are connected as shown below (left) by default. The contact logic can be inverted as shown (below right) by using the parameter setting C_33. The relay contacts normally open (N.O.) and normally closed (N.O.) convention uses “normal” to mean the inverter has power and is in Run or Stop Mode. The relay contacts switch to the opposite position when it is in Trip Mode or when input power is OFF.

**N.C. contacts (after initialization)**

During normal running



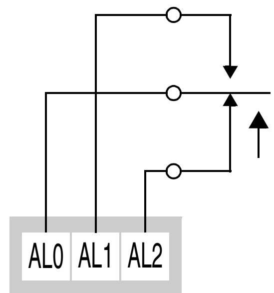

When an alarm occurs or power is turned OFF



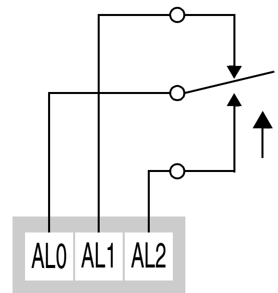

| Contact | Power | Run State | AL0-AL1 | AL0-AL2 |
|---|---|---|---|---|
| N.C. (after initialize, C_33=01) | ON | Normal | Closed | Open |
| | ON | Trip | Open | Closed |
| | OFF | — | Open | Closed |

**N.O. contact (inverted by C_33 setting)**

During normal running or power is turned OFF



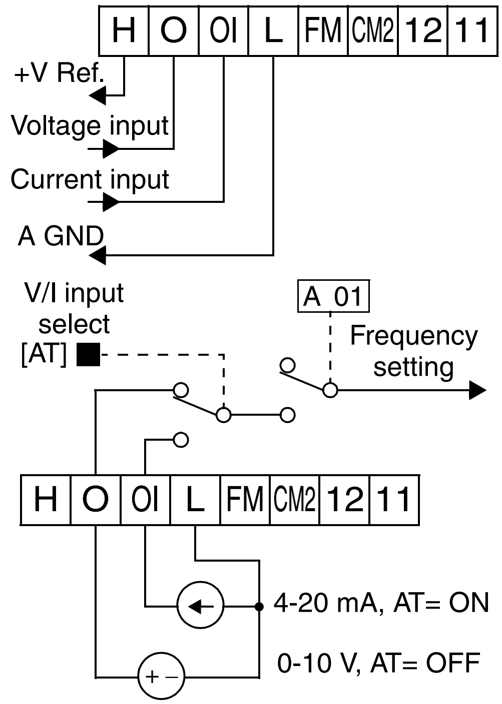

When an alarm occurs




| Contact | Power | Run State | AL0-AL1 | AL0-AL2 |
|---|---|---|---|---|
| N.O. (set C_33=00) | ON | Normal | Open | Closed |
| | ON | Trip | Closed | Open |
| | OFF | — | Open | Closed |

# Analog Input Operation

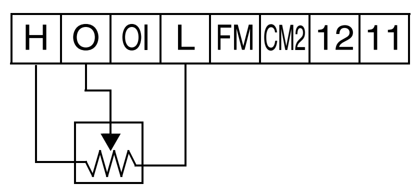
The SJ100 inverters provide for analog input to command the inverter frequency output value. The analog input terminal group includes the [L], [OI], [O], and [H] terminals on the control connector, which provide for Voltage [O] or Current [OI] input. All analog input signals must use the analog ground [L].



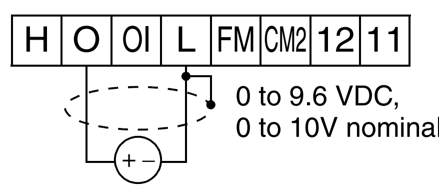

If you use either the voltage or current analog input, you must select one of them using the logic input terminal function [AT] analog type. If terminal [AT] is OFF, the voltage input [O] can command the inverter output frequency. If terminal [AT] is ON, the current input [OI] can command the inverter output frequency. The [AT] terminal function is covered in“Analog Input Current/Voltage Select” on page 4–20. Remember that you must also set A_01 = 01 to select analog input as the frequency source.

**NOTE:** If no logic input terminal is configured for the [AT] function, then inverter sums the voltage and current input to determine the desired input value.

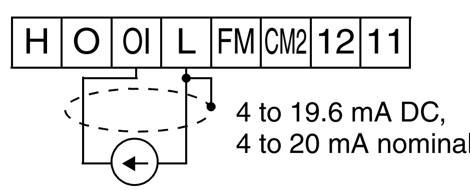
Using an external potentiometer is a common way to control the inverter output frequency (and a good way to learn how to use the analog inputs). The potentiometer uses the built-in 10V reference [H] and the analog ground [L] for excitation, and the voltage input [O] for the signal. By default, the [AT] terminal selects the voltage input when it is OFF. Take care to use the proper resistance for the potentiometer, which is 1 to 2 k Ohms, 2 Watts.




**Voltage Input** – The voltage input circuit uses terminals [L] and [O]. Attach the signal cable’s shield wire only to terminal [L] on the inverter. Maintain the voltage within specifications (do not apply negative voltage).




**Current Input** – The current input circuit uses terminals [OI] and [L]. The current comes from a *sourcing* type transmitter; a *sinking* type will not work! This means the current must flow into terminal [OI], and terminal [L] is the return back to the transmitter. The input impedance from [OI] to [L] is 250 Ohms. Attach the cable shield wire only to terminal [L] on the inverter.

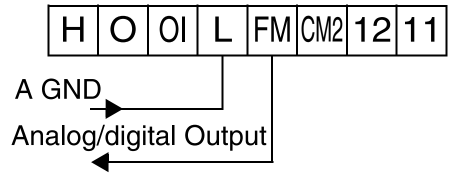



See I/O specs on page 4–6.

# Analog and Digital Monitor Output

In the system design for inverter applications it is useful to monitor the inverter operation from a remote location. In some cases, this requires only a panel-mounted analog meter (moving-coil type). In other cases, a controller device such as a PLC may command the inverter frequency and other functions. Sometimes it is useful to have the inverter transmit the (real-time) output frequency value back to the controller to confirm actual operation. The monitor output function [FM] serves these purposes.

The inverter provides an analog/digital output primarily for frequency monitoring on terminal [FM] (frequency monitor). It uses terminal [L] as analog GND reference. You can configure terminal [FM] to transmit the inverter current output or frequency output in *pulse-width modulated* format (PWM). You can also configure terminal [FM] to output the frequency value in a *frequency-modulated* (FM) format.



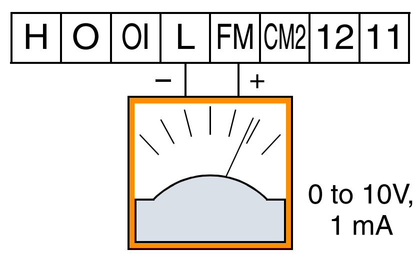

See I/O specs on page 4–6.

The following table lists terminal [FM] configurations. Use function C_23 to configure.

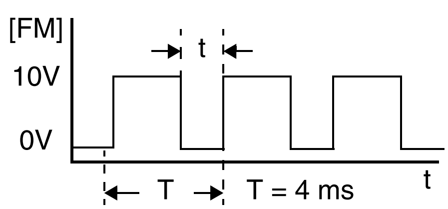
| Func. | Code | Description | Waveform | Full Scale value |
|---|---|---|---|---|
| C_23 | 00 | Output frequency | PWM | 0 – Max. frequency (Hz) |
| | 01 | Output current | PWM | 0 – 200% |
| | 02 | Output frequency | FM | 0 – Max. frequency (Hz) |

## PWM Signal Type

The pulse-width modulated signal at terminal [FM] is primarily designed for driving a moving-coil meter. The PWM signal is automatically averaged by the inertia of the moving-coil mechanism—converting the PWM signal to an analog representation. Be sure to use a 10V full-scale DC voltmeter.




The signal characteristics of terminal [FM] in PWM configuration is shown below:




$$[FM]\ Output = \frac{t}{T}$$

C_23 = 00 Inverter output frequency

C_23 = 01 Inverter output current

B 81 PWM scale factor

To calibrate the meter reading, generate a full-scale output (always ON) at terminal [FM]. Then use parameter B_81(gain setting from 0 to 255) to adjust the corresponding full-scale reading of the meter. For example, when the inverter output frequency is 60 Hz, change the value of B_81 so that the meter reads 60 Hz.

**TIP:** When using the analog meter for monitoring, adjust the meter so it has a zero reading when the [FM] output is zero. Then use scale factor B_81 to adjust the [FM] output so the maximum frequency in the inverter corresponds to a full-scale reading on the meter.

The following accuracy notes apply for PWM monitor outputs:

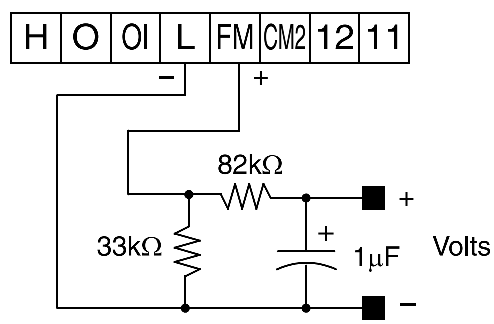
- The monitor accuracy for frequency monitoring after adjustment is about ±5%. Depending on the motor, the accuracy may exceed this value.
- The monitor display accuracy for current (normally ± 20%, depending on the connected motor's characteristics) can be improved by adjusting parameter B_32.
- The accuracy of the current reading is given by the equation:

$$\frac{Imc - Im}{Ir} \times 100 \;\leq\; \pm 20\%$$

Im = Inverter output current (measured)
Imc = Monitor display current
Ir = Inverter rated current

- If precise current measurement is necessary, use the moving-coil type ammeter between the inverter and the motor.

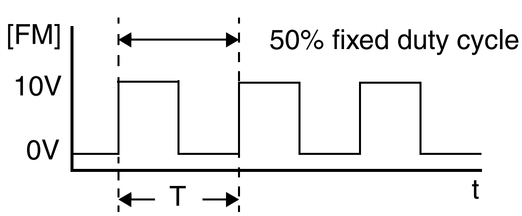
**PWM Smoothing Circuit** – You may also wish to smooth the PWM signal at the [FM] terminal and convert it to an analog signal. The [FM] terminal will then generate a relatively stable DC analog voltage that represents the output value. To do this, use the circuit shown to the right. Note the output impedance of the circuit is at least 82kΩ, so the monitoring device needs an input impedance of 1MΩ or greater. Otherwise, the impedance of the smoothing circuit will cause a non-linearity in the reading.




See I/O specs on page 4–6.

## FM Signal Type

The *frequency-modulated* output at terminal [FM] varies its frequency with the inverter output frequency (C_23=03). The multiplier is 10, such that the maximum [FM] signal frequency is 10 x 360 = 3.6 kHz, or 10 times the inverter's maximum output frequency. The signal at [FM] uses the parameter A_04 *Maximum frequency setting*. For example, if A_04 = 60 Hz, then the maximum signal value at [FM] will be 10 x 60 = 600 Hz. This frequency is digitally controlled for accuracy, and does not use the B_81 gain setting when C_23=03 (frequency modulation selection).




$$T = \frac{1}{[FM]\ \text{Output value} \times 10}$$

$$[FM]\ \text{Output value} = \frac{1}{T \times 10}$$

C_23 = 02 Selects FM type output

# Auto-tuning for Sensorless Vector Control

The SJ100 inverter has a built-in auto-tuning algorithm. Its purpose is to detect and record the motor parameters to use in sensorless vector control. As you may recall from Chapter 3, sensorless vector control (SLV) is the more sophisticated control algorithm the SJ100 inverter can use to deliver higher torque levels at different speeds. Using parameter A_44, you can select from the following:

- 00 = Variable frequency with constant torque
- 01 = Variable frequency with reduced torque
- 02 = Sensorless vector control (SLV)

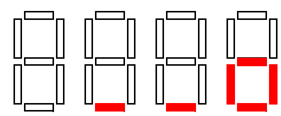
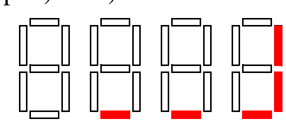
**NOTE:** Although "auto-tuning" is often associated with PID loops, the PID loop in the SJ100 inverter is not directly affected by the auto-tuning procedure or parameters.

Most of the "H" Group parameters are dedicated to storing SLV parameters. The inverter comes from the factory with default settings for these parameters. To benefit fully from SLV control, you must use A_44 to select SLV control, and initiate the auto-tuning calibration procedure as described below for your motor. During the procedure, the inverter will write new values for the "H" Group settings related to SLV control. The settings have a second set of parameters for a second motor. The factory default configuration will apply auto-tuning to the first motor.

**WARNING:** You may need to disconnect the load from the motor before performing auto-tuning. The inverter runs the motor forward and backward for several seconds without regard to load movement limits.

Follow the steps below to auto-tune the inverter (table continued on next page):

| Step | Parameter | | Parameter Setting or Action | Notes |
|---|---|---|---|---|
| | Code | Name | | |
| 1 | F_02 | Acceleration (1) | Set to a time greater than 10 seconds | Parameters F_02 and F_03 must be equal in order for the moment of inertia data to be correct. Increase the time if over-current or over-voltage trip event occurs. |
| 2 | F_03 | Deceleration (1) | Set the same as setting F_02 | |
| 3 | H_03 | Motor capacity | Varies with inverter (default value will be correct) | Setting is in kW |
| 4 | H_04 | Motor poles setting | Set the poles 2 / 4 / 6 / 8 to match motor | Refer to the motor specifications label |
| 5 | A_01 | Frequency source setting | Set = 02 (selects parameter F_01 as source of output frequency) | The auto-tuning procedure will automatically control the speed |
| 6 | A_03 | Base frequency setting | Set = 50 or 60 for your motor | Default= 50 (Europe) / 60(US) |
| 7 | A_20 | Multi-speed frequency setting | Set A_20 > 0 | If A_20 = 0, auto-tuning is not performed |

| Step | Parameter | | Parameter Setting or Action | Notes |
|---|---|---|---|---|
| | Code | Name | | |
| 8 | A_82 | AVR voltage select | Select output voltage for motor<br>200V class: 200/220/230/240<br>400V class: 380/400/415/440/460 | Voltage setting cannot be greater than input voltage |
| 9 | A_51 | DC braking enable | Set = 00 to disable DC braking | Default = 00 (disabled) |
| 10 | H_01 | Auto-tuning Setting | Set = 01 (full auto-tuning<br>Set = 02 (partial auto-tuning – measures resistance and inductance only) | Try using H_01 = 01, if possible. If application or load interferes with or prohibits motor rotation, then use H_01 = 02. |
| 11 | — | — | Press the RUN key on the keypad and wait for the test to complete | The inverter actions are:<br>A) .. AC excitation (no rotation)<br>B)... DC excitation (no rotation)<br>C)... Motor accelerates to 80% of base frequency, then stops.<br>D) Motor accelerates to A20 setting frequency, then stops. |
| 12 | — | — | Interpret results by reading the display pattern | Auto-tuning process completed steps A) to D)<br><br>Auto-tuning failed at step A) or B)<br> |
| 13 | — | — | Reset Inverter by pressing the Stop/Reset Key | Inverter will display alternating pattern on the display and return to parameter menu. Auto-tuning will be OFF. Make any corrections and start again at step 10. |

**NOTE:** During step 11, the motor will make a slight humming sound during the AC and DC excitation (A and B) steps of the auto-tuning process. This sound is normal.

**NOTE:** When the SLV control method is selected with A_44 (F-04), set the carrier frequency to 2.1 kHz or higher with B_83.

If the inverter drives a motor/load with a small inertia, the motor may exhibit “hunting” during running. If this occurs, take the following corrective steps:

1. Adjust the stabilization constant H_06/H206.
2. Decrease the carrier frequency B_83, but not below 2.1 kHz.
3. Set the Automatic Voltage Regulation (AVR) function A_81 to the OFF setting (disabled = 01).

If the desired characteristic cannot be obtained in sensorless vector controlled operation with standard (factory default) or auto-tuning data, adjust the motor constant(s) according to the observed symptoms shown below.

| Operation Status | Symptom | Adjustment | Parameter |
|---|---|---|---|
| Powered running (status with an accelerating torque) | When low frequency (a few Hz) torque is insufficient | Increase the motor speed constant R1 in relation to auto-tuning data, step by step, within 1 to 1.2 times R2. | H_20 / H_30 / H220/ H230 |
| | When the speed fluctuation coefficient becomes negative | Increase the motor constant R2 in relation to auto-tuning data, step by step, within 1 to 1.2 times R2. | H_21 / H_32 / H221 / H231 |
| | When the speed fluctuation coefficient becomes positive | Decrease the motor constant R2 in relation to auto-tuning data, step by step, within 0.8 to 1 times R2. | H_21 / H_32 / H221 / H231 |
| Regeneration (status with a decelerating torque) | When low frequency (a few Hz) torque is insufficient | Increase the motor speed constant R1 in relation to auto-tuning data, step by step, within 1 to 1.2 times R1. | H_20 / H_30 / H220/ H230 |
| | | Increase the motor constant R2 in relation to auto-tuning data, step by step, within 1 to 1.2 times R2. | H_21 / H_32 / H221 / H231 |
| | | Decrease the carrier frequency set value. | B_83 |

**Note 1:** If the inverter is using sensorless vector control and the motor is more than one frame size smaller than the maximum applicable motor, then the motor characteristic values may not be satisfactory.

**Note 2:** No sensorless vector control operation is possible if two or more motors are connected (parallel operation).

**Note 3:** When the auto-tuning function is executed in the state that the DC braking is set, the motor constants will not be accurately set. Therefore, disable DC braking and then start the auto-tuning procedure again.

**Note 4:** When accelerating or speeding up is not to be performed in the auto-tuning step for accelerating up to 80% of the base frequency, lower the set value of manual torque boost.

**Note 5:** Be sure the motor is stopped before you carry out an auto-tuning procedure. Auto-tuning data that is derived while the motor is still running may not be correct.

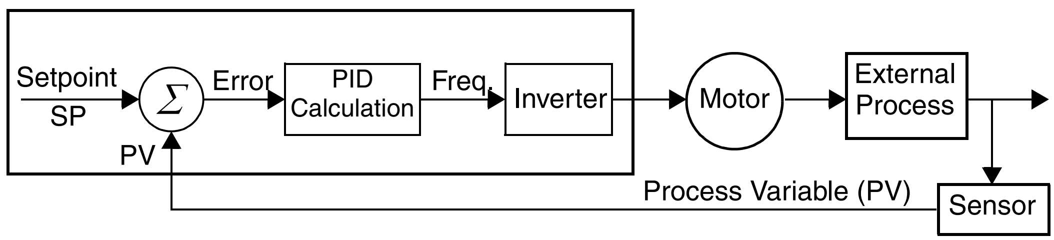
**Note 6:** Do not interrupt an auto-tuning procedure by removing power or by using the Stop command, unless it is emergency. If this does occur, initialize the inverter's parameters to the factory default settings (see "Restoring Factory Default Settings" on page 6–8). Then reprogram the parameters unique to your application, and initiate the auto-tuning procedure again.

**NOTE:** When the data of the H Group parameters does not match that of the motor, satisfactory characteristics may not be obtained during sensorless vector operation. Also, the stabilization adjustment (H_06) is effective for V/f settings (00 and 01). The full performance may not be achieved if the rating of a motor used is more than one frame size smaller than the maximum applicable rating when the sensorless vector function is used. You must disable sensorless vector operation when two or more motors are connected. For the motor stabilization, set this data properly for the H_03 (H203) parameter according to the motor used if its rating is not the same as the maximum applicable rating in V/f operation.

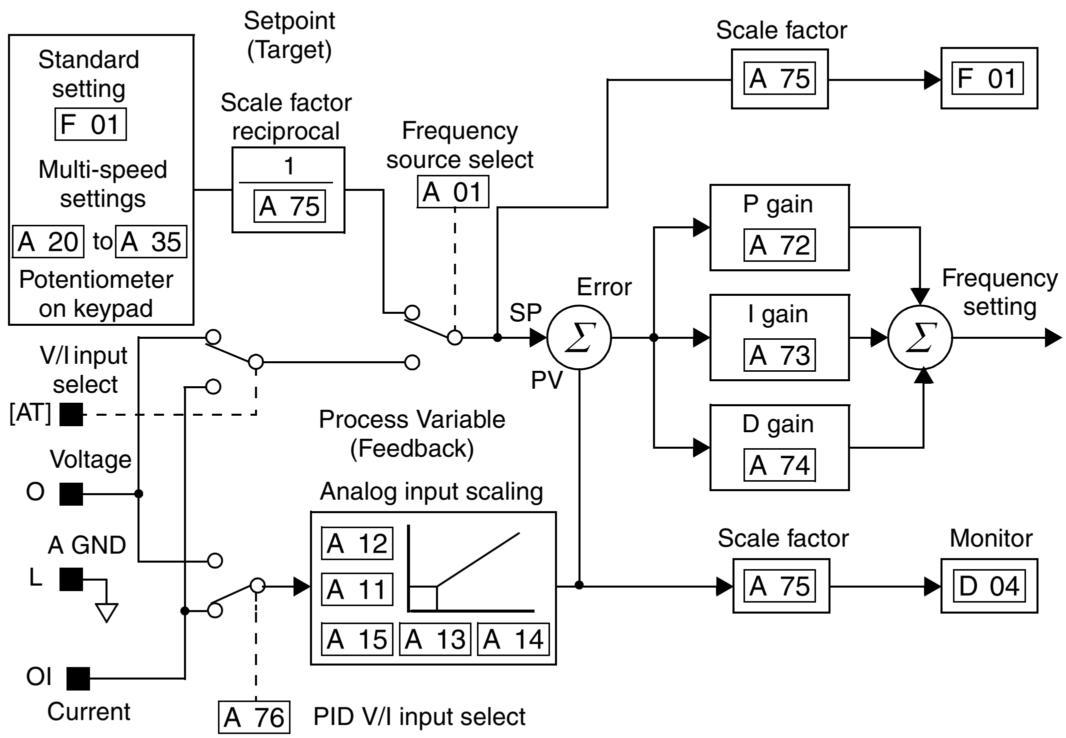
# PID Loop Operation

In standard operation, the inverter uses a reference source selected by parameter A_01 for the output frequency, which may be a fixed value (F_01), a variable set by the front panel potentiometer, or value from an analog input (voltage or current). To enable PID operation, set A_71 = 01. This causes the inverter to *calculate* the target frequency, or setpoint.

A calculated target frequency can have a lot of advantages. It lets the inverter adjust the motor speed to optimize some other process of interest, potentially saving energy as well. Refer to the figure below. The motor acts upon the external process. To control that external process, the inverter must monitor the process variable. This requires wiring a sensor to either the analog input terminal [O] (voltage) or terminal [OI] (current).



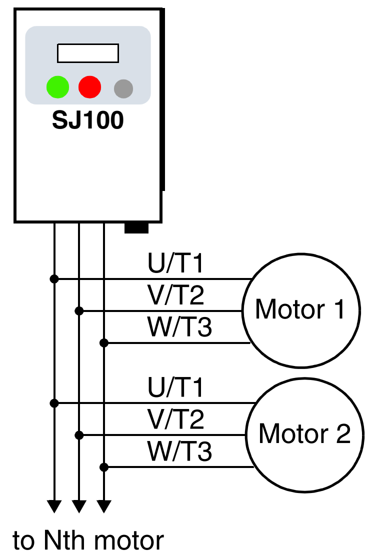

When enabled, the PID loop calculates the ideal output frequency to minimize the loop error. This means we no longer command the inverter to run at a particular frequency, but we specify the ideal value for the process variable. That ideal value is called the *setpoint*, and is specified in the units of the external process variable. For a pump application it may be gallons/minute, or it could be air velocity or temperature for an HVAC unit. Parameter A_75 is a scale factor that relates the external process variable units to motor frequency. The figure below is a more detailed diagram of the PID function.



# Configuring the Inverter for Multiple Motors

## Simultaneous Connections

For some applications, you may need to connect two or more motors (wired in parallel) to a single inverter's output. For example, this is common in conveyor applications where two separate conveyors need to have approximately the same speed. The use of two motors may be less expensive than making the mechanical link for one motor to drive multiple conveyors.




Some of the characteristics of using multiple motors with one drive are:

- Use only V/f (voltage-frequency) control; do not use SLV (sensorless vector control).
- The inverter output must be rated to handle the sum of the currents from the motors.
- You must use separate thermal protection switches or devices to protect each motor. Locate the device for each motor inside the motor housing or as close to it as possible.
- The wiring for the motors must be permanently connected in parallel (do not remove one motor from the circuit during operation).

**NOTE:** The motor speeds are identical only in theory. That is because slight differences in their loads will cause one motor to slip a little more than another, even if the motors are identical. Therefore, do not use this technique for multi-axis machinery that must maintain a fixed position reference between its axes.



## Inverter Configuration for Two Motor Types

Some equipment manufacturers may have a single type of machine that has to support two different motor types—and only one motor will be connected at a time. For example, an OEM may sell basically the same machine to the US market and the European market. Some reasons why the OEM needs two motor profiles are:

- The inverter power input voltage is different for these markets.
- The required motor type is also different for each destination.

In other cases, the inverter needs two profiles because the machine characteristics vary according to these situations:

- Sometimes the motor load is very light and can move fast. Other times the motor load is heavy and must move slower. Using two profiles allows the motor speed, acceleration and deceleration to be optimal for the load and avoid inverter trip (fault) events.
- Sometimes the slower version of the machine does not have special braking options, but a higher performance version does have braking features.

Having two motor profiles lets you store two "personalities" for motors in one inverter's memory. The inverter allows the final selection between the two motor types to be made in the field through the use of an intelligent input terminal function [SET]. This provides an extra level of flexibility needed in particular situations. See the following table.

Parameters for the second motor have a function code of the form x2xx. They appear immediately after the first motor's parameter in the menu listing order. The following table lists the parameters that have the second parameter register for programming.

| Function Name | Parameter Codes | |
|---|---|---|
| | 1st motor | 2nd motor |
| Multi-speed frequency setting | A_20 | A220 |
| Acceleration (1) time setting | F_02 | F202 |
| Deceleration (1) time setting | F_03 | F203 |
| Acceleration (2) time setting | A_92 | A292 |
| Deceleration (2) time setting | A_93 | A293 |
| Select method to use Acc2/Dec2 | A_94 | A294 |
| Acc1 to Acc2 frequency transition point | A_95 | A295 |
| Dec1 to Dec2 frequency transition point | A_96 | A296 |
| Level of electronic thermal setting | B_12 | B212 |
| Electronic thermal characteristic | B_13 | B213 |
| Torque boost method selection | A_41 | A241 |
| Manual torque boost value | A_42 | A242 |
| Manual torque boost frequency adjustment | A_43 | A243 |
| V/f characteristic curve selection | A_44 | A244 |
| Base frequency setting | A_03 | A203 |
| Maximum frequency setting | A_04 | A204 |
| Motor data selection | H_02 | H202 |
| Motor capacity | H_03 | H203 |
| Motor poles setting | H_04 | H204 |
| Motor constant R1 | H_20/H_30 | H220/H230 |
| Motor constant R2 | H_21/H_31 | H221/H231 |
| Motor constant L | H_22/H_32 | H222/H232 |
| Motor constant $I_o$ | H_23/H_33 | H223/H233 |
| Motor constant J | H_24/H_34 | H224/H234 |
| Motor speed constant | H_05 | H205 |
| Motor stabilization constant | H_06 | H206 |