Inverter System Accessories

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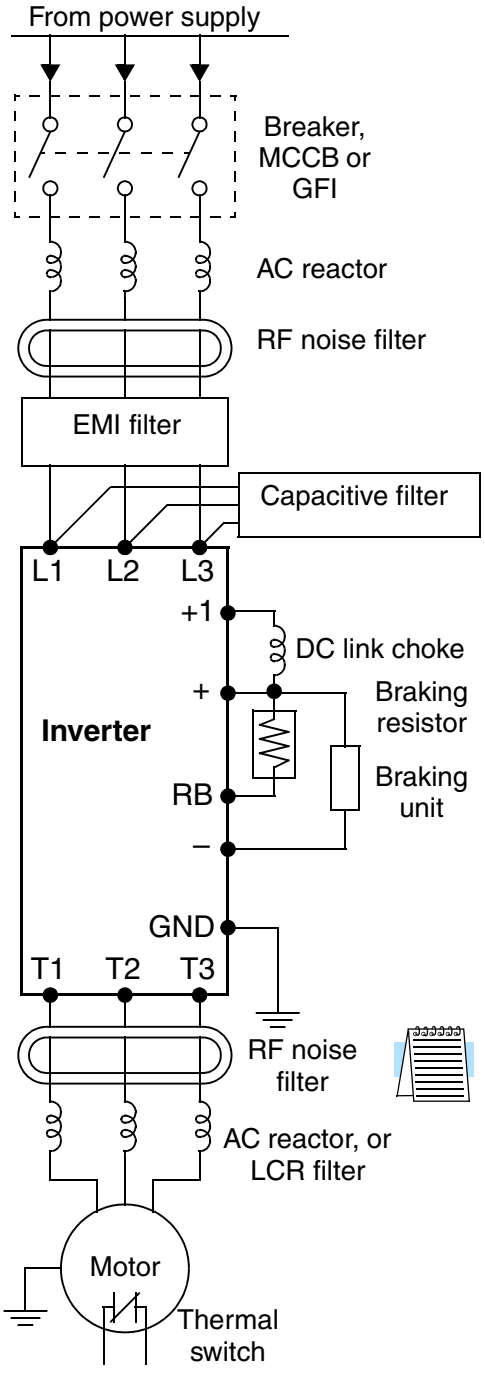
Introduction

A motor control system will obviously include a motor and inverter, as well as fuses for safety. If you are connecting a motor to the inverter on a test bench just to get started, that's all you may need for now. But a fully developed system can also have a variety of additional components. Some can be for noise suppression, while others may enhance the inverter's braking performance. The figure below shows a system with several possible optional components, and the table gives part number information.



Name	Part No. Series		See page
	Europe, Japan	USA	
AC reactor, input side	ALI–xxx2	HRL–x	5–3
RF noise filter, input side	ZCL–xxx	ZCL–xxx	5–4
EMI filter (for CE)	FFL100–xxx	FFL100–xxx	5–4
Capacitive filter	CFI–x	CFI–x	5–4
DC link choke	DCL–x–xx	HDC–xxx	5–4
Braking resistor	JRB–xxx–x SRB–xxx–x	JRB–xxx–x SRB–xxx–x	5–5
Braking resistor, NEMA-rated	—	HRB-x, NSRBx00–x NJRB–xxx	5–5
Resistance braking unit	BRD–xxx	BRD–xxx	5–5
RF noise filter, output side	ZCL–xxx	ZCL–xxx	5–4
AC reactor, output side	ALI–x2–xxx	HRL–xxx	5–3
LCR filter	Combination: ALI–x2–xxx LPF–xxx R–2–xxx	HRL–xxC	5–3

Note: The Hitachi part number series for accessories includes different sizes of each part type, specified by the –x suffix. Hitachi product literature can help match size and rating of your inverter to the proper accessory size.

Each inverter accessory comes with its own printed instruction manual. Please refer to those manuals for complete installation details. This chapter gives only an overview of these optional system devices.

Component Descriptions

AC Reactors, Input Side

This is useful in suppressing harmonics induced on the power supply lines, or when the main power voltage imbalance exceeds 3% (and power source capacity is more than 500 kVA), or to smooth out line fluctuations. It also improves the power factor.

In the following cases for a general-purpose inverter, a large peak current flows on the main power supply side, and is able to destroy the inverter module:

- If the unbalanced factor of the power supply is 3% or higher
- If the power supply capacity is at least 10 times greater than the inverter capacity (the power supply capacity is 500 kVA or more)
- If abrupt power supply changes are expected

Examples of these situations include:

1. Several inverters are connected in parallel, sharing the same power bus
2. A thyristor converter and an inverter are connected in parallel, sharing the same power bus
3. An installed phase-advance (power factor correction) capacitor opens and closes

Where these conditions exist or when the connected equipment must be highly reliable, you MUST install an input-side AC reactor of 3% (at a voltage drop at rated current) with respect to the supply voltage on the power supply side. Also, where the effects of an indirect lightning strike are possible, install a lightning conductor.

Example calculation:

V_{RS} = 205V, V_{ST} = 203V, V_{TR} = 197V,
where V_{RS} is R-S line voltage, V_{ST} is S-T line voltage, V_{TR} is T-R line voltage

$$\text{Unbalance factor of voltage} = \frac{\text{Max. line voltage (min.)} - \text{Mean line voltage}}{\text{Meanline voltage}} \times 100$$

$$= \frac{V_{RS} - (V_{RS} + V_{ST} + V_{TR})/3}{(V_{RS} + V_{ST} + V_{TR})/3} \times 100 = \frac{205 - 202}{202} \times 100 = 1.5\%$$

Please refer to the documentation that comes with the AC reactor for installation instructions.

AC Reactors, Output Side

This reactor reduces the vibrations in the motor caused by the inverter's switching waveforms, by smoothing the waveforms to approximate commercial power quality. It is also useful to reduce the reflected voltage wave phenomenon when wiring from the inverter to the motor is more than 10m in length. Please refer to the documentation that comes with the AC reactor for installation instructions.

Zero-phase Reactor (RF Noise Filter)

The zero-phase reactor helps reduce radiated noise from the inverter wiring. It can be used on the input or output side of the inverter. The example zero-phase reactor shown to the right comes with a mounting bracket. The wiring must go through the opening to reduce the RF component of the electrical noise. Loop the wires three times (four turns) to attain the full RF filtering effect. For larger wire sizes, place multiple zero-phase reactors (up to four) side-by-side for a greater filtering effect.

ZCL–xxx

EMI Filter

The EMI filter reduces the conducted noise on the power supply wiring generated by the inverter. Connect the EMI filter to the inverter primary (input side). The FFL100 series filter is required for compliance to the EMC Class A directive (Europe) and C-TICK (Australia). See “CE–EMC Installation Guidelines” on page C–2.

WARNING: The EMI filter has high internal leakage current from power wiring to the chassis. Therefore, connect the chassis ground of the EMI filter before making the power connections to avoid danger of shock or injury.

FFL100–xxx

RF Noise Filter (Capacitive)

This capacitive filter reduces radiated noise from the main power wires in the inverter input side. This filter is not for achieving CE compliance and is applicable to the input side only of the inverter. It comes in two versions—for 200V class inverters or 400V class inverters. Please refer to the documentation that comes with the radio noise filter for installation instructions.

DC Link Choke

The DC choke (reactor) suppresses harmonics generated by the inverter. It attenuates the high-frequency components on the inverter’s internal DC bus (link). However, note that it does not protect the diode rectifiers in the inverter input circuit.

Dynamic Braking

Introduction

The purpose of dynamic braking is to improve the ability of the inverter to stop (decelerate) the motor and load. This becomes necessary when an application has some or all of the following characteristics:

- High load inertia compared to the available motor torque
- The application requires frequent or sudden changes in speed
- System losses are not great enough to slow the motor as needed

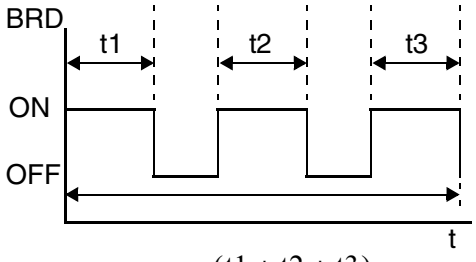
When the inverter reduces its output frequency to decelerate the load, the motor can temporarily become a generator. This occurs when the motor rotation frequency is higher than the inverter output frequency. This condition can cause the inverter DC bus voltage to rise, resulting in an over-voltage trip. In many applications, the over-voltage condition serves as a warning signal that we have exceeded the deceleration capabilities of the system. SJ100 inverters have a built-in braking unit, which sends the regenerative energy from the motor during deceleration to the optional braking resistor(s). External braking units may also be used if higher braking torques and/or duty cycles are required. The dynamic braking resistor serves as a load, developing heat to stop the motor just as brakes on an automobile develop heat during braking.

Braking Resistor

The braking resistor is the main component of a braking resistor assembly that includes a fuse and thermally activated alarm relay for safety. However, be careful to avoid overheating its resistor. The fuse and thermal relay are safeguards for extreme conditions, but the inverter can maintain braking usage in a safe zone.

Dynamic Braking Usage Ratio

The inverter controls braking via a duty cycle method (percent of the time braking is ON versus total time). Parameter B_90 sets the dynamic braking usage ratio. In the graph to the right, the example shows three uses of dynamic braking in a 100-second period. The inverter calculates the average percentage usage in that time (T%). The percentage of usage is proportional to the heat dissipated. If T% is greater than the B_90 parameter setting, the inverter enters the Trip Mode and turns OFF the frequency output.



B 90 $T\% = \frac{(t1 + t2 + t3)}{100 \text{ seconds}} \times 100$

Please note the following:

- When B_90 is set for 0%, dynamic braking is not performed.
- When the T% value exceeds the limit set by B_90, dynamic braking ends.
- When mounting an external dynamic braking unit, set the usage ratio (B_90) to 0.0 and remove the external resistors.
- The cable from the external resistor to the inverter must not exceed 5 m (16 ft.) length.
- The individual wires from the resistor to the inverter must not be bundled together.

SJ100 Dynamic Braking Selection Tables

The SJ100 series inverter models have internal braking units. Additional stopping torque is available by adding external resistors. The required braking torque depends on your particular application. Other tables in this section will help you choose the proper resistor.

200V Class		Using Internal Resistor		Using External Resistor		Performance at Minimum Resistance			Min. Resistance at 100% Braking Duty Cycle (Ohms)
SJ100 Model Number	HP	Braking Unit	Braking Torque (%)	Resistance (Ohms)	Braking Torque	Min. Resistance (Ohms)	Braking Torque	Max. Braking Duty Cycle (%)	
002NFE/NFU	1/4	Built-in	50	180	150	100	200	10	150
004NFE/NFU	1/2	Built-in	50	180	150	100	200	10	150
005NFE	3/4	Built-in	50	180	150	100	200	10	150
007NFE/NFU	1	Built-in	50	100	150	35	200	10	150
011NFE	1.5	Built-in	50	50	150	35	200	10	150
015NFE/NFU	2	Built-in	50	50	150	35	200	10	100
022NFE/NFU	3	Built-in	20	50	100	35	150	10	100
037LFU	5	Built-in	20	35	100	35	100	10	100
055LFU	7.5	Built-in	20	17	80	17	80	10	50
075LFU	10	Built-in	20	17	80	17	80	10	50

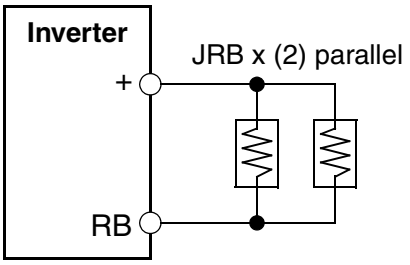
400V Class		Using Internal Resistor		Using External Resistor		Performance at Minimum Resistance			Min. Resistance at 100% Braking Duty Cycle (Ohms)
SJ100 Model Number	HP	Braking Unit	Braking Torque (%)	Resistance (Ohms)	Braking Torque	Min. Resistance (Ohms)	Braking Torque	Max. Braking Duty Cycle (%)	
004HFE/HFU	1/2	Built-in	50	180	150	180	150	10	500
007HFE/HFU	1	Built-in	50	180	150	180	150	10	300
015HFE/HFU	2	Built-in	50	180	150	180	150	10	300
022HFE/HFU	3	Built-in	20	100	100	100	100	10	300
030HFE	4	Built-in	20	100	100	100	100	10	200
040HFE/HFU	5	Built-in	20	100	100	100	100	10	200
055HFE/HFU	7.5	Built-in	20	70	80	70	80	10	200
075HFE/HFU	10	Built-in	20	70	80	70	80	10	150

Selecting Braking Resistors for Internal Braking Units

You can add one or more resistors to your inverter configuration to increase braking torque performance. The tables below lists the resistor types for inverter models with internal braking units. Tables for inverters with external braking units are on the next two pages.

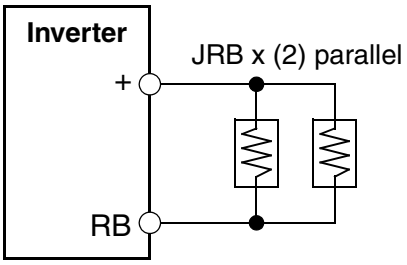
- Total Ohms – lists the resistance value of the resistor or, if using multiple resistors, their combined resistance
- Total Watts – lists the power dissipation of the resistor or, if using multiple resistors, their combined power dissipation
- Maximum Duty Cycle – the maximum allowable percentage of braking time over any 100-second interval to avoid overheating the resistor(s)
- Maximum Braking Torque – the maximum braking torque that the inverter / resistor combination can deliver

The table below lists 200V-class inverter models with built-in braking units. Depending on the desired braking torque or on the inverter model, the resistor selection specifies multiple resistors in a parallel or series combination. The example diagram shows a parallel configuration. Please refer to the braking resistor documentation for detailed wiring diagrams.



200V Class		Dynamic Braking Resistor Selection											
		JRB Series				SRB/NSRB Series				HRB Series			
SJ100 Model Number	HP	Type & (Qty)	Total Ohms	Total Watts	Max. Duty Cycle (%)	Type & (Qty)	Total Ohms	Total Watts	Max. Duty Cycle (%)	Type & (Qty)	Total Ohms	Total Watts	Max. Duty Cycle (%)
002NFE/NFU	1/4	120–1	180	120	5.0	200–1	180	200	10.0				
004NFE/NFU	1/2	120–1	180	120	5.0	200–1	180	200	10.0				
005NFE	3/4	120–1	180	120	5.0	200–1	180	200	10.0				
007NFE/NFU	1	120–2	100	120	2.5	200–2	100	200	7.5				
011NFE	1.5	120–2	100	120	2.5	200–2	100	200	7.5				
015NFE/NFU	2	120–3	50	120	1.5	300–1	50	300	7.5				
022NFE/NFU	3	120–3	50	120	1.5	300–1	50	300	7.5				
037LFU	5	120–4	35	120	1.0	400–1	35	400	7.5				
055LFU	7.5	120–4 x (2) in parallel	17.5	240	1.0	400–1 x (2) in parallel	17.5	800	7.5	HRB3	17	1200	10.0
075LFU	10		17.5	240	1.0		17.5	800	7.5	HRB3	17	1200	10.0

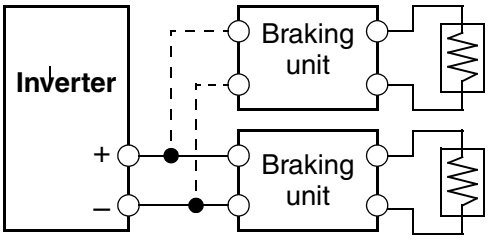
The table below lists 400V-class inverter models with built-in braking units. Depending on the desired braking torque or on the inverter model, the resistor selection specifies multiple resistors in a parallel or series combination. The example diagram shows a parallel configuration. Please refer to the braking resistor documentation for detailed wiring diagrams.



400V Class		Dynamic Braking Resistor Selection											
		JRB Series				SRB/NSRB Series				HRB Series			
SJ100 Model Number	HP	Type & (Qty)	Total Ohms	Total Watts	Max. Duty Cycle (%)	Type & (Qty)	Total Ohms	Total Watts	Max. Duty Cycle (%)	Type & (Qty)	Total Ohms	Total Watts	Max. Duty Cycle (%)
004HFE/HFU	1/2	120–1	180	120	2.0	200–1	180	200	4.0				
007HFE/HFU	1	120–1	180	120	2.0	200–1	180	200	4.0				
015HFE/HFU	2	120–1	180	120	2.0	200–1	180	200	4.0				
022HFE/HFU	3	120–2	100	120	1.5	200–2	100	200	3.0				
030HFE	4	120–2	100	120	1.5	200–2	100	200	3.0				
040HFE/HFU	5	120–2	100	120	1.5	200–2	100	200	3.0				
055HFE/HFU	7.5	120–4 x (2) in series	70	240	1.0	400–1 x (2) in series	70	800	7.5	RB2 x (2) in series	70	1200	10.0
075HFE/HFU	10		70	240	1.0		70	800	7.5		70	1200	10.0

Selecting Braking Resistors for External Braking Units

200V Class Inverters – The following tables specify the braking options for 200V class SJ100 inverters and the braking torque for each option. You can connect a single braking unit to the inverter, or two braking units for additional stopping torque.



Use one BRD–E2 braking unit for the braking torque listed in the following table.

Note the column meanings in the tables:

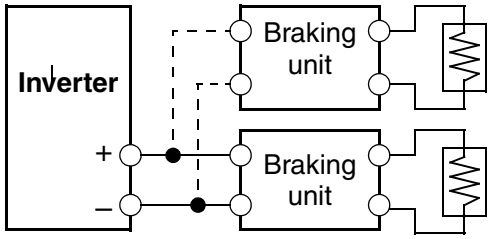
- Column “A” = Average braking torque from 60 Hz to 3 Hz.
- Column “B” = Average braking torque from 120 Hz to 3 Hz.

SJ100 Inverter 200V Models			Braking Torque with BRD–E2 Braking Unit							
Model Number	HP	Braking torque without braking unit	Using built-in resistor only		External resistor added					
					HRB1		HRB2		HRB3	
			A	B	A	B	A	B	A	B
002NFE/NFU	1/4	50%	150%	120%						
004NFE/NFU	1/2	50%	150%	120%						
005NFE	3/4	50%	100%	80%	150%	120%				
007NFE/NFU	1	50%	100%	80%	150%	120%				
011NFE	1.5	50%	60%	60%	100%	80%				
015NFE/NFU	2	50%	50%	50%	100%	80%				
022NFE/NFU	3	20%	50%	50%	100%	80%				
037LFU	5	20%	40%	40%	60%	60%	100%	80%	150%	120%
055LFU	7.5	20%	30%	30%	50%	50%	80%	60%	100%	80%
075LFU	10	20%	20%	20%	40%	40%	60%	60%	80%	80%

Connect a second braking unit in parallel for additional braking torque listed in the following table.

SJ100 Inverter 200V Models			Braking Torque with TWO (2) BRD–E2 Braking Units							
Model Number	HP	Braking torque without braking unit	Using built-in resistor only		External resistor added					
					HRB1		HRB2		HRB3	
			A	B	A	B	A	B	A	B
002NFE/NFU	1/4	50%	150%	150%						
004NFE/NFU	1/2	50%	150%	150%						
005NFE	3/4	50%	150%	150%						
007NFE/NFU	1	50%	150%	120%						
011NFE	1.5	50%	100%	80%						
015NFE/NFU	2	50%	70%	70%	150%	120%				
022NFE/NFU	3	20%	70%	70%	150%	120%				
037LFU	5	20%	50%	50%	110%	90%				
055LFU	7.5	20%	30%	30%	80%	80%	90%	90%	100%	80%
075LFU	10	20%	30%	30%	60%	60%	80%	80%	100%	80%

400V Class Inverters –The following tables specify the braking options for 400V class SJ100 inverters and the braking torque for each option. You can connect a single braking unit to the inverter, or two braking units for additional braking torque.



Use one BRD–E2 braking unit for the braking torque listed in the following table.

SJ100 Inverter 400V Models			Braking Torque with BRD–EZ2 Braking Unit							
Model Number	HP	Braking torque without braking unit	Using built-in resistor only		External resistor added					
					HRB1		HRB2		HRB3	
			A	B	A	B	A	B	A	B
004HFE/HFU	1/2	50%	150%	120%						
007HFE/HFU	1	50%	100%	80%	150%	120%				
015HFE/HFU	2	50%	60%	60%	100%	80%	120%	100%	150%	120%
022HFE/HFU	3	20%	50%	50%	100%	80%	120%	100%	150%	120%
030HFE	4	20%	40%	40%	80%	60%	100%	80%	150%	120%
040HFE/HFU	5	20%	40%	40%	60%	60%	80%	60%	150%	120%
055HFE/HFU	7.5	20%	30%	30%	50%	50%	80%	60%	100%	80%
075HFE/HFU	10	20%	20%	20%	40%	40%	60%	40%	80%	80%

Connect a second braking unit in parallel for additional braking torque listed in the following table.

SJ100 Inverter 400V Models			Braking Torque with TWO (2) BRD–EZ2 Braking Units							
Model Number	HP	Braking torque without braking unit	Using built-in resistor only		External resistor added					
					HRB1		HRB2		HRB3	
			A	B	A	B	A	B	A	B
004HFE/HFU	1/2	50%	150%	120%						
007HFE/HFU	1	50%	150%	120%						
015HFE/HFU	2	50%	100%	80%						
022HFE/HFU	3	20%	70%	70%	150%	120%				
030HFE	4	20%	50%	50%	110%	90%				
040HFE/HFU	5	20%	50%	50%	110%	90%				
055HFE/HFU	7.5	20%	30%	30%	80%	80%	90%	90%	100%	100%
075HFE/HFU	10	20%	30%	30%	60%	60%	80%	80%	100%	100%