User Guide

SpindAx

Variable Speed Digital AC Drive
for three-phse induction motors
3 to 30HP

Part Number:
Issue Number: spxu2

1 Description

1.1 Case styles

Nine SpindAx models cover the range of power ratings. There are two styles and three sizes of case which depend on the power rating of the model. Size 1 and size 2 cases have ingress protection to IP20; size 3 case to IP00.

The model in the size 1 case is cooled by natural convection. The models in sizes 2 and 3 cases are fan cooled.

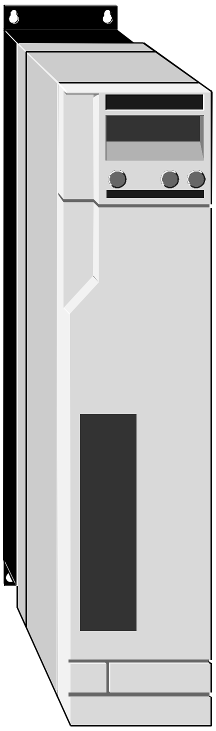


Figure 1–1 Size 1 case used on models DB140, DB220

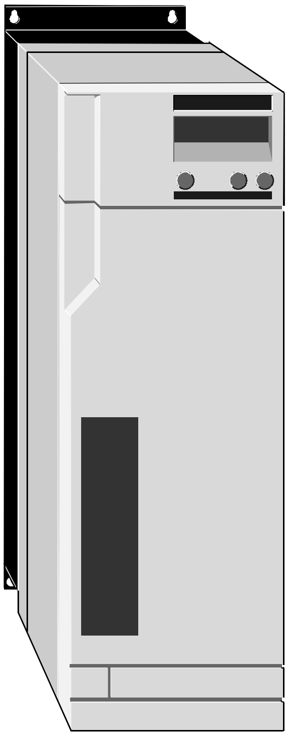


Figure 1–2 Size 2 case used on models DB420, DB600, DB750, DB1100S

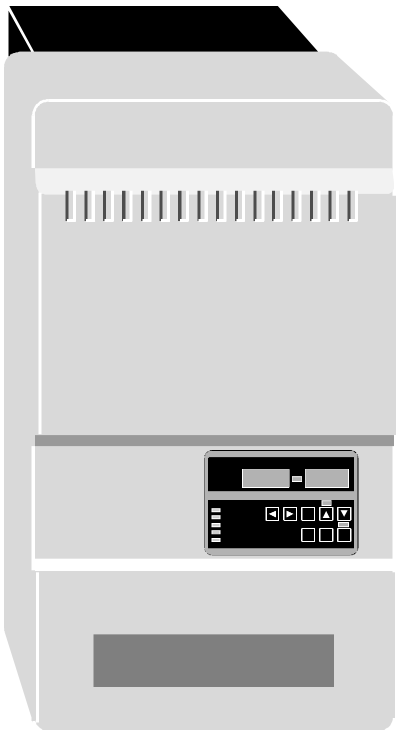


Figure 1–3 Size 3 case used on models DB1500, DB2200

1.2 Method of operation

Power circuits

The AC supply is rectified and smoothed to apply a constant voltage on a DC bus. This DC bus supplies a pulse-width modulated IGBT power stage that delivers AC power at variable frequency and voltage to the motor.

Depending on the model, an external DC choke is required for the DC bus. An external braking resistor can be connected to the DC bus in order to enhance the braking capabilities of the Drive.

When the recommended wiring techniques are used, the Drive retains EMC compatibility.

Controlling the Drive

Operation of the Drive is controlled by programming a number of software parameters. These parameters have default values that enable the Drive to be run without any initial programming.

The Drives have a Control Keypad which is located on the front panel of the case. The Control Keypad is used for the following:

To change parameter values
To stop and start the Drive
To display the operating status of the Drive

An RS485 serial communications port allows the Drive to be controlled remotely using a host PC or plc.

1.3 How best to use this User Guide

This User Guide is arranged logistically: reading from beginning to end will take you in the correct order through the basic steps of installing the Drive and getting it running with a motor.

To make subsequent adjustments to the parameters, refer to Chapter 10, *List of Parameters*.

2 Data

Warning

The voltages present in the Drive are capable of inflicting a severe electric shock and may be lethal. The Stop function of the Drive does not remove dangerous voltages from the Drive or the driven machine.

AC supplies to the Drive must be disconnected at least 15 minutes before any cover is removed or servicing work is performed.

2.1 Model range

Model size	AC supply	Models	Current ratings		Duration of I_{pk}
			I_{nom}	I_{pk}	secs
1	380V to 460V	SA005	5.6	8.4	30
2	380V to 460V	SA010	9.5	14.3	30
		SA016	16	24	30
		SA022	22	33	30
3	380V to 460V	SA038	38	57	30
		SA059	59	88.5	30
4	380V to 460V	SA091	91	136.5	60
		SA110	110	165	60
		SA150	150	225	60

2.2 Ingress protection (IP and NEMA 1)

Model sizes 1 and 2 are rated at IP20. The cooling fans for the heatsink are rated at IP20.

Model sizes 3 and 4 are supplied as a stand-alone unit in a protective case having an enclosure specification which is rated as IP00 (in accordance with the IEC529) or NEMA 1. The cooling fans for the heatsink are rated as IP20.

For Drives supplied in an IP00 case, a DC bus choke (inductor) and an optional braking resistor should be installed externally to the Drive. For Drives supplied in a NEMA 1 case, a DC bus choke and braking resistor are installed internally.

2.3 AC supply

Balanced 3-phase.
50Hz −2Hz to 60Hz +2Hz
380V −10% to 460V +10%

2.4 Drive output

Maximum motor speed: 9000 RPM
Maximum output voltage:
Equal to the AC supply voltage

2.5 Ambient temperature and humidity

Ambient temperature range:

−10°C to +50°C (14°F to 122°F) non-condensing

Local heat sources (such as other equipment) that raise the air temperature above +50°C (122°F) must be removed.

2.6 Vibration

Conformance to the requirements of IEC 68−2−34

2.7 Derating

Maximum altitude without derating is 1000m (3200ft). Derate full load current by 1% for each additional l00m (320ft).

2.8 Starts per hour

Drive

Unlimited

Motor

Refer to motor manufacturer.

2.9 PWM switching frequencies

SA005, SA010, SA016, SA022	8kHz
SA038, SA059	4kHz, 8kHz
SA091, SA110, SA150	4kHz

2.10 Serial communications

RS485 full duplex (RS422 can also be used)

Protocol: ANSI x 3.28–2.5–A4–N, positive logic

Timing

Write to Drive:

25ms at 9600 Baud
15ms at 19.2 kBaud

Read from the Drive:

30ms at 9600 Baud
16ms at 19.2 kBaud

2.11 Resolver specification

Voltage	6V
Frequency	10kHz
Primary	Rotor
Number of poles	2
Transformation ratio	0.28 ±10%
Phase shift	−14° nominal
Primary current	40mA nominal
Power input	120mW
Electrical error	±15 minutes
Impedance ZRO	73 + j129 Ω
Impedance ZSO	116 + j159 Ω
Impedance ZSS	95 + j162 Ω
Excitation winding resistance	28Ω
Stator winding resistance	18Ω
Temperature range	−55°C to 155°C −97°F to 240°F
Inertia	$2.0gm^2 \times 10^{-5}$

2.12 Resolver resolution

14-bit when **Pr99** < 3200 RPM
12 bit when **Pr99** ≥ 3200 RPM

2.13 Response times

Scanning rate for speed loop	512µs
Scanning rate for current loop	128µs
Sampling time of analogue inputs	512µs
Rise time of digital outputs	10µs
Speed loop resolution	0.01%
Current loop resolution	10 bits
Speed loop bandwidth	320Hz
Current loop bandwidth	2kHz
Max delay of STOP input	15ms
Max delay of limit switch input	2ms
Max delay of external trip input	5ms

2.14 Electromagnetic compatibility (EMC)

When all the following conditions are met, the installation can meet the requirements for conducted emissions of EN50081-2:

The specified RFI filter (or ferrite absorber ring and capacitor network) is used
The recommendations for the wiring arrangements are followed
The motor cable passes through a pair of ferrite rings (as specified)

Immunity

In accordance with IEC801 without significant disturbance to operation at the following level:

Part 4 (Transient Burst) Level 3

2.15 Frequency accuracy

Output frequency is within 100ppm of the demanded frequency.

2.16 Weights

The weights of the most powerful model in each size are as follows:

Model size 1: 5.5kg (12lb)
Model size 2: 9.5kg (21lb)
Model size 3: 22.3kg (49lb)
Model size 4: 56kg (123lb)

2.17 Power ratings ????

Note

Power ratings are for typical 3-phase 6-pole 380V AC motors.

Displacement factor (fundamental power factor) at input closely approximates to unity, but is dependent on supply impedance.

400V nominal supply voltage, 150% overload.

Model	Output	Motor Rating	Input			
	100% RMS current		100% RMS current		100% fundamental current	
	A	kW	A	kVA	A	kW
SA005	5.6	2.2	???			
SA010	9.5	4.0				
SA016	16	7.5				
SA022	22	11				???
SA038	38	18.5	38	24	33	22.9
SA059	59	30	58	38	51	35.3
SA091	91	45	90	60	79	54.7
SA110	110	55	109	71	97	67.2
SA150	150	75	144	95	133	92.1

2.18 Losses and efficiency

Note

Figures quoted are at maximum output power.

Model	Total power loss		Efficiency at 460V	
	4kHz (100%)	8kHz (100%)	4kHz	8kHz%
	W	W	%	%
SA005		162		93.1
SA010		248		94.2
SA016		385		95.1
SA022		476		95.8
SA038	523	674	97.3	96.5
SA059	724	913	97.6	97.0
SA091	1106		97.6	
SA110	1322		97.7	
SA150	1897		97.5	

2.19 DC bus choke ratings

DC bus chokes are fitted internally on the SA010, SA016, and SA022 Drives. No DC bus choke is needed for the SA005.

Ripple frequency = 6 × supply frequency

Ratings and values quoted are design minima.

Drive Size	Choke ratings			Weight	
	mH	ARMS	Apk	kg	lb
SA038	1.50	45	85	6.4	14
SA059	0.70	75	143	8.4	19
SA091	0.45	111	224	14.5	32
SA110	0.50	130	251	22.5	50
SA150	0.40	176	352	32.0	71

Dimensions

Refer to the following diagrams.

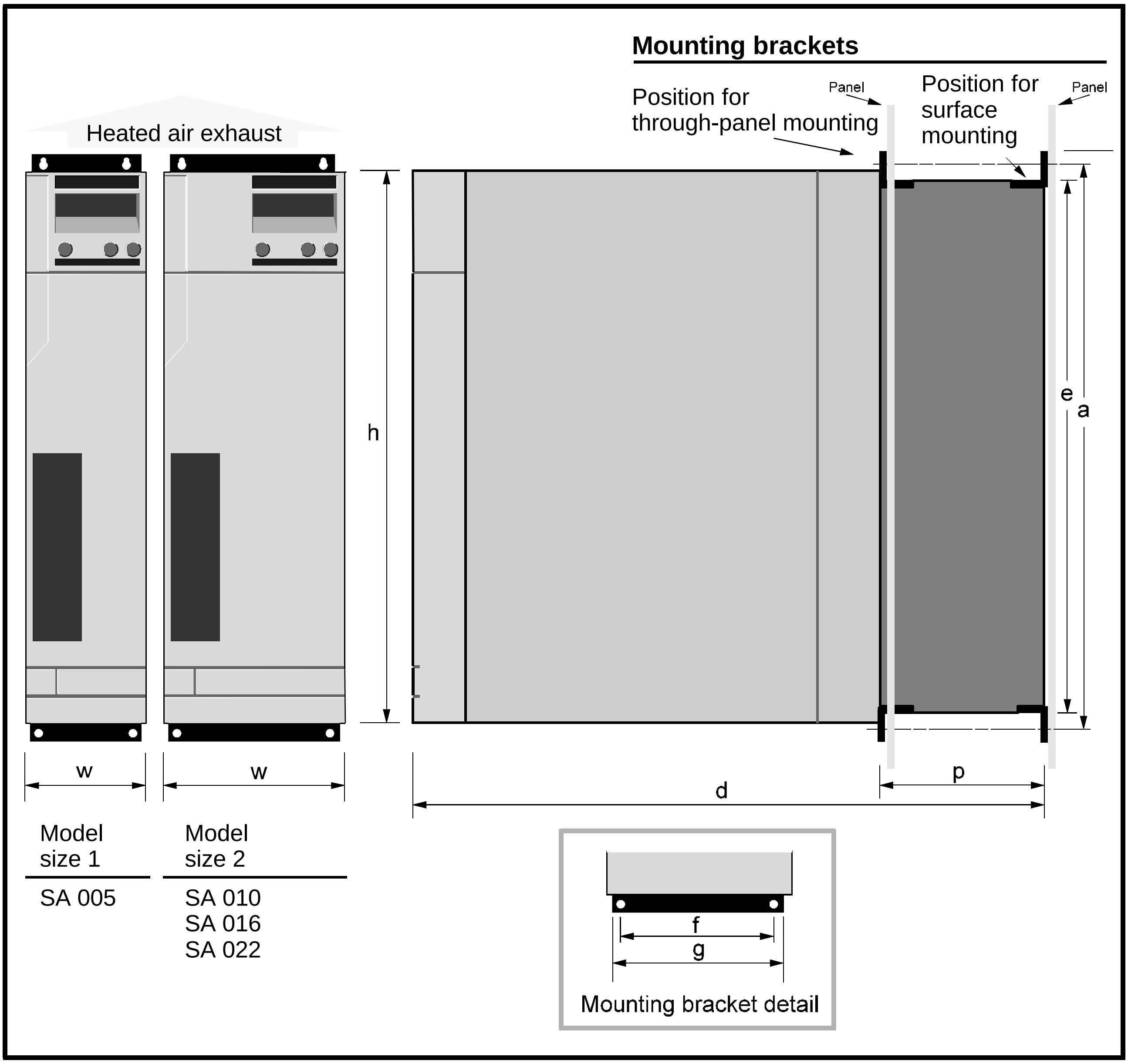


Figure 2–1 Dimensions of model sizes 1 and 2 (See table on opposite page)

Dimension		Model size 1 S005		Model size 2 SA010 SA016 SA022	
		mm	**in**	**mm**	**in**
Height of case	h	352	$13^7/_8$	352	$13^7/_8$
Width of case	w	78.5	$3^1/_{16}$	127	5
Overall depth	d	323.5	$12^3/_4$	328.5	$12^{15}/_{16}$
Depth of heatsink	p	95	$3^7/_8$	100	$3^{15}/_{16}$
Width of heatsink	g	62	$2^7/_{16}$	109	$4^5/_{16}$
Height of heatsink	e	332	$13^1/_{16}$	330	13
Mounting centres top bracket to bottom bracket	a	359.4	$14^1/_8$	359.4	$14^1/_8$
Mounting centres of mounting bracket	f	45	$1^3/_4$	77	$3^1/_{16}$
Height of aperture for through-panel mounting		334	$13^1/_8$	332	$13^1/_{16}$
Width of aperture for through-panel mounting		64	$2^1/_2$	111	$4^3/_8$
Fixing hole diameter		4mm ($^3/_{16}$ins) clear			

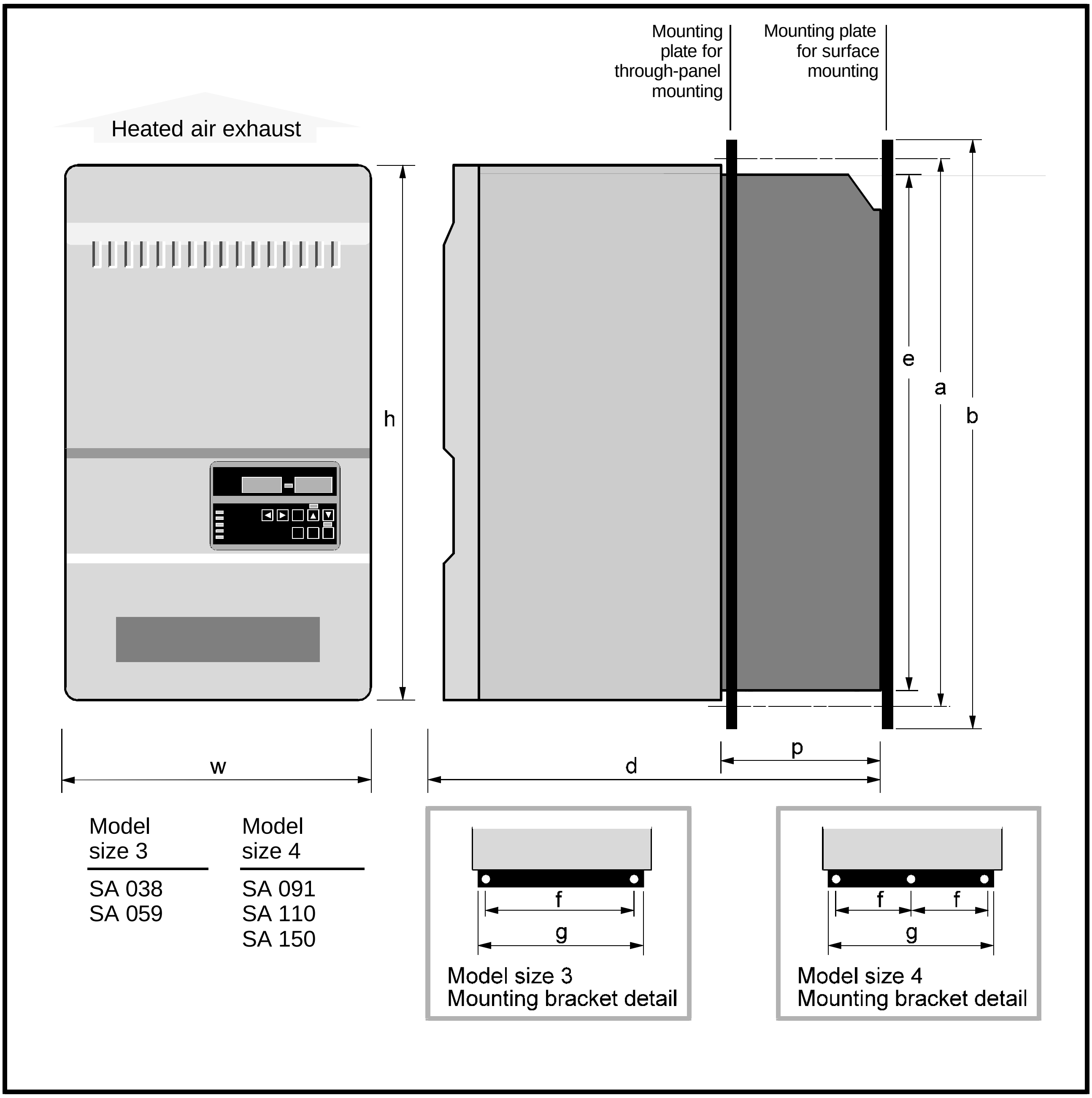


Figure 2–2 Dimensions of model size 3 (See table on opposite page)

Dimension		Model size 3 SA038 SA059		Model size 4 SA091 SA110 SA150	
		mm	in	mm	in
Height of case	h	490	$19^{5}/_{16}$	795	$31^{5}/_{16}$
Width of case	w	330	13	490	$19^{5}/_{16}$
Overall depth	d	283	$11^{3}/_{16}$	305	12
Depth of heatsink	p	139	$5^{1}/_{2}$	135	$5^{5}/_{16}$
Height of heatsink	e	466	$18^{5}/_{16}$	780	$30^{11}/_{16}$
Width of heatsink	g	295	$11^{5}/_{8}$	464.5	$18^{1}/_{4}$
Total height of mounting plates	b	522	$20^{9}/_{16}$	844	$33^{3}/_{16}$
Mounting centres top to bottom	a	502	$19^{3}/_{4}$	815	32
Mounting centres	f	248	$9^{5}/_{16}$	180	$7^{1}/_{16}$
Height of aperture for through-panel mounting		468	$18^{1}/_{2}$	782	$30^{13}/_{16}$
Width of aperture for through-panel mounting		296	$11^{5}/_{8}$	467	$18^{3}/_{8}$
Fixing hole diameter		6mm ($^{1}/_{4}$in) clear		8mm ($^{5}/_{16}$in) clear	

3 Mechanical Installation

Warning

The equipment enclosure is rated at IP20 in accordance with IEC539. It is designed for installation within a protective enclosure which prevents unauthorised access except for trained service personnel, and prevents contamination with conductive dust and condensation.

3.1 EMC wiring recommendations

To minimize radio-frequency emissions, it is necessary to install the Drive in a steel enclosure and pay attention to the arrangement of the wiring inside the enclosure. Figure 3–1 shows recommendations for the layout of the enclosure. Figures 4–4, 4–5 and 4–6 in Chapter 4 *Electrical Installation* show examples of wiring arrangements for minimum radio-frequency emissions. The actual arrangement used will have to be adapted to individual requirements.

When planning the installation, refer to Chapter 4 in addition to this chapter.

The essential requirements are as follows:

RFI filter

- Mount an RFI filter above the Drive at a distance of 125mm (5 in).
- Make the AC power cables from the RFI filter to the Drive as short as possible.
- Use a flat conductor at least 10mm ($^1/_2$in) wide and as short as possible to make the ground connection from the RFI filter to the Drive.

Motor cable

- Use armoured or shielded cable to connect the motor to the Drive. Connect the armour or shield to the Drive and to the motor frame. Make these connections no longer than 50mm (2in).
- If the length of cable used to connect the motor to the Drive exceeds 50m (150 feet), output chokes may be required in order to prevent cable capacitance effects causing over-current trips (**OC**) in the Drive. For difficult cases, consult the supplier of the Drive.

Resolver wiring
Simulated-encoder wiring

- Signal connections from the resolver and from the simulated encoder input of the CNC controller must be connected to the Drive using cable consisting of three twisted-pairs of wire. Each twisted pair must be screened, and the cable must have an overall screen. Connect the screens of the resolver cable only to terminal B18 of the Drive. Connect the screens of the simulated encoder output only to the CNC controller ground terminal.
- When a motor thermistor is to be used, connect it to the Drive using a fourth twisted-pair in the screened cable to the resolver. Connect the screen for this twisted-pair only to terminal B18 on the Drive.

Analog speed reference wiring

- Use shielded twisted-pair cable to connect the analog speed reference to the Drive. It is strongly recommended that a true differential signal source is used in order to maximize immunity to electrical noise. Connect the cable shield only to the ground connection of the CNC controller.
- A single-ended signal source may be used, but electrical noise immunity is reduced. Use shielded twisted-pair cable. Apply the signal to terminal B9 or B10 of the Drive, as required. Connect the 0V common to terminal B11. Connect the unused differential input (terminal B10 or B9) to terminal B11.

Ground connections

- Bus-bars must be used to make certain ground connections, as shown in Figure 4–4. These bus-bars must be made of copper bar of the dimensions shown.

Ferrite absorber ring

- When a number of Drives are installed in an enclosure, it is recommended that a ferrite absorber ring is fitted over the AC supply cables to each Drive. (See also *Capacitor network*.)
- Part number: 4200-3608

Capacitor network

- When three or more Drives are installed in an enclosure, a capacitor network may be required. Refer to Figure 4–4. Connect a 0.47μF 500VAC capacitor between each AC supply phase and ground.

3.2 Planning the installation

The following conditions must be met when planning the installation of the Drive or a number of Drives in an enclosure:

- The environment is acceptable
- The maximum permissible ambient temperature is not exceeded
- The EMC requirements are met
- The electrical installation meets safety requirements
- The size of the installation does not exceed the space available

Use the following procedure:

1. Decide how the Drives are to be mounted in the enclosure, as follows:

- Surface-mounted
- Through-panel mounted

Surface mounting gives the following:
Better ingress protection
Heat dissipated inside the enclosure

Through-panel mounting gives the following:
Heat dissipated outside the enclosure
Reduced ingress protection

2. Refer to Figure 3–1 to plan the layout of the equipment in the enclosure.

3. If the Drives are to be surface mounted in the enclosure, refer to either of the following:

If the enclosure is to be sealed, perform the calculations in *Heat dissipation in a sealed enclosure* in order to determine the minimum permissible size of enclosure for heat dissipation.

If the enclosure is to be ventilated, perform the calculation in *Heat dissipation in a ventilated enclosure* in order to determine the required volume of air-flow.

4. If necessary, adjust the size of the enclosure, and re-plan the internal equipment accordingly. Repeat instructions **2** to **4** as many times as required to meet all the requirements.

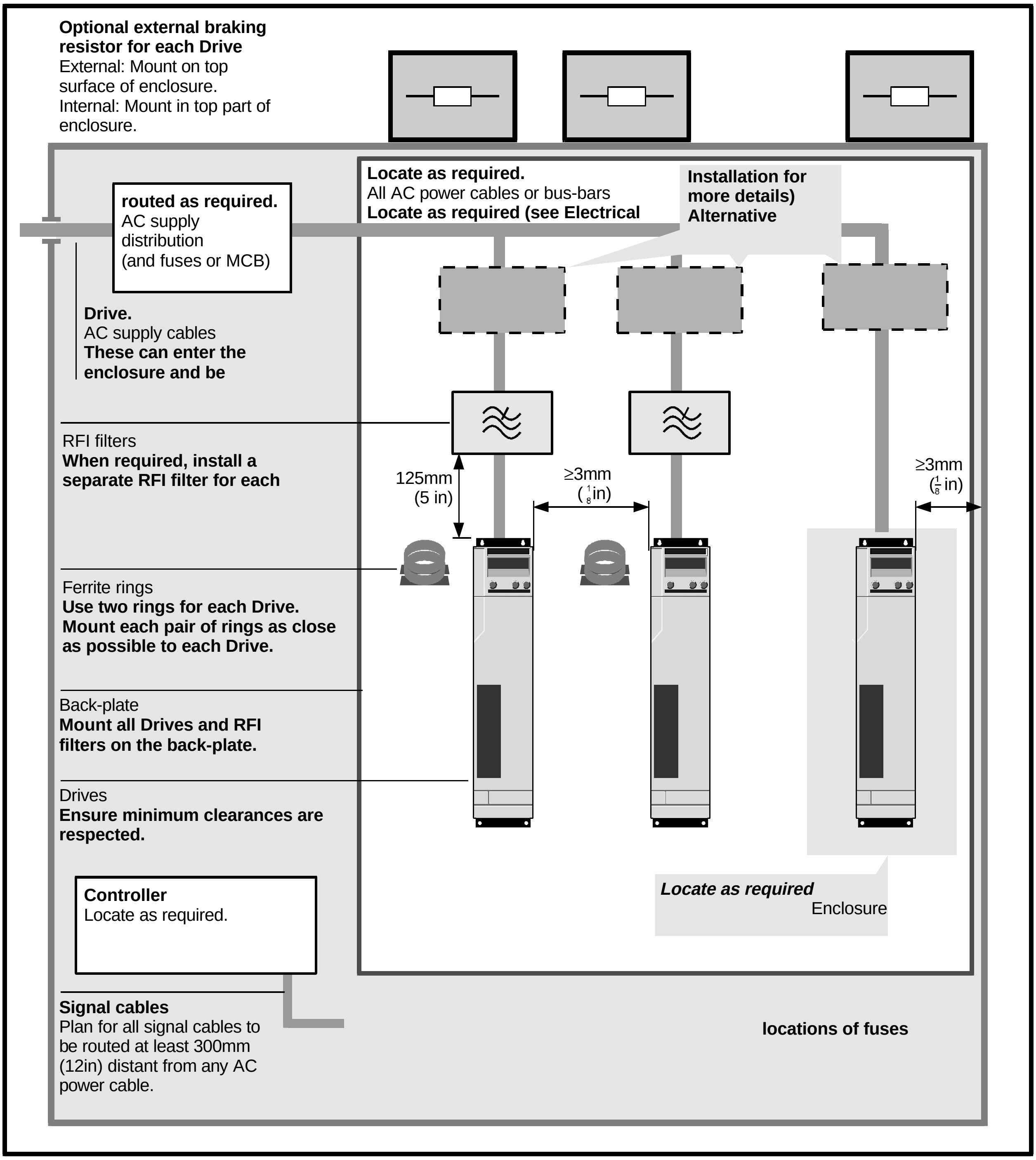


Figure 3–1 Planning the layout of the enclosure

3.3 Environment

1. In accordance with the IP20 rating of the Drive, the Drive must be located in an environment that is free from dust, corrosive vapours, gases and all liquids, including condensation of atmospheric moisture.
2. If condensation is likely to occur when the Drive is not in use, install an anti-condensation heater. This heater must be switched off when the Drive is in use; automatic switching is recommended.
3. Do not locate the Drive in a classified hazardous area, unless the Drive is installed in an approved enclosure and the installation is approved.
4. Install the Drive vertically for best flow of cooling air.
5. Install the Drive as low as possible in the enclosure without contravening EMC requirements.
6. Observe the requirements for ambient temperature if the Drive is to be mounted directly above any heat generating equipment, such as another Drive.
7. If the Drive is to be installed directly beneath other equipment, such as another Drive, ensure the Drive does not cause the ambient temperature requirements of the equipment to be exceeded.
8. Allow at least 100mm (4in) clearance above and below the Drive.
9. Allow at least 3mm ($^1/_8$in) clearance each side of the Drive.

3.4 RFI filters ????

Install the RFI filter specified for the Drive model as follows. Use one RFI filter for each Drive. (Ferrite absorber rings and a capacitor network can be used in place of an RFI filter. See *Ferrite absorber rings* below.) ????

Drive model	**Filter part number**
SA005	4200−4810 ???
SA010	4200−4810
SA016	4200−4810
SA022	4200−4820
SA038	4200−4820
SA059	4200−4830
SA091	4200−1051
SA110	4200−1051
SA150	????

Filter part number	**Filter dimensions**					
	Length		**Width**		**Depth**	
4200−	**mm**	**in**	**mm**	**in**	**mm**	**in**
4810	250	$9^{15}/_{16}$	110	$4^3/_8$	60	$2^3/_8$
4820	270	$10^3/_4$	140	$5^9/_{16}$	60	$2^3/_8$
4830	270	$10^3/_4$	140	$5^9/_{16}$	60	$2^3/_8$
1051	330	13	190	$7^5/_8$	145	$5^{11}/_{16}$

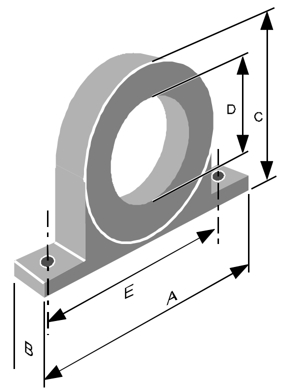
3.5 Ferrite absorber ring ????

A ferrite absorber ring and capacitor network may be used in place of an RFI filter for all models, except for models ???? and ?????. See Figure 4−4.

3.6 Ferrite rings

The three conductors of the motor cable from each Drive must pass twice through two ferrite rings, as shown in Figures 4–5 and 4–6.

Part number: 4200-0000



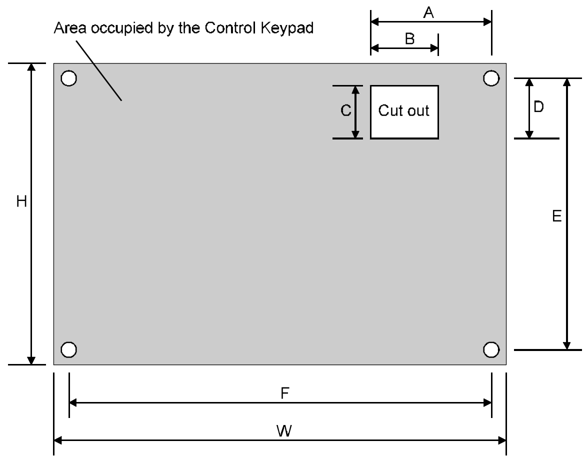
Dimension	mm	in
A	105	$4\frac{3}{16}$
B	24	1
C	62	$2\frac{1}{2}$
D	28.5	$1\frac{1}{8}$
E	90	$3\frac{5}{8}$
Mounting hole diameter	5	$\frac{3}{16}$

Figure 3–2 Dimensions of the ferrite rings

3.7 Control Keypad

The Control Keypad on the bookcase drives (sizes 1 and 2) cannot be located away from the drive.

For model size 3, the Control Keypad is a plug-in unit which can be detached from the Drive for mounting in a panel. Holes are required in the panel for the fixing studs and connector which project from the rear of the Control Keypad housing. Refer to Figure 3–3.



Dimension	mm	in
A	65.0	$2\frac{9}{16}$
B	40.0	$1\frac{9}{16}$
C	26.0	$1\frac{1}{16}$
D	22.0	$\frac{7}{8}$
E	97.0	$3\frac{13}{16}$
F	146.5	$5\frac{3}{4}$
H	167	$6\frac{9}{16}$
W	114	$4\frac{1}{2}$
Mounting hole diameter	M4	$\frac{3}{16}$

Figure 3–3 Mounting screw holes and dimensions of cut-out required for remote mounting of the Control Keypad

The Control Keypad on model sizes 1 and 2 cannot be located remotely from the Drive.

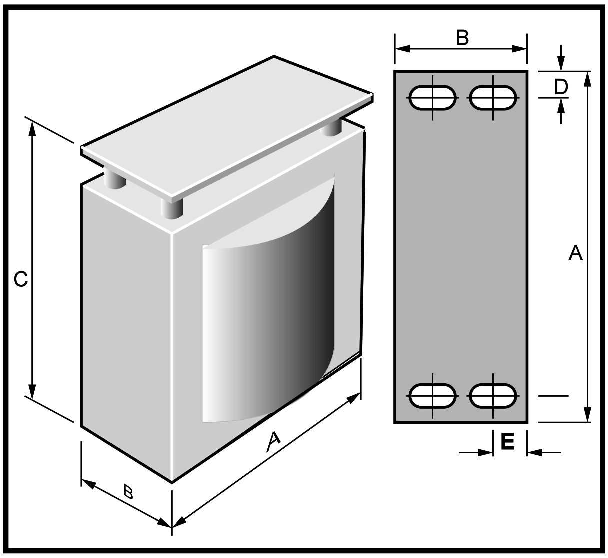
3.8 Mounting a DC bus choke

For model size 3, an external DC bus choke is required. The choke may be mounted in the same enclosure as the Drive.

No external DC bus choke is required for model sizes 1 and 2.

Note

Drives supplied in a NEMA 1 case contain the DC bus choke.



Value	A	B	C	D	E	Terminal size
mH	mm in	mm in	mm in	mm in	mm in	
1.50	137 $5^{7}/_{16}$	84 $3^{5}/_{16}$	175 $6^{7}/_{8}$	24 $^{15}/_{16}$	10 $^{3}/_{8}$	M8
0.70	137 $5^{7}/_{16}$	116 $4^{9}/_{16}$	175 $67/_{8}$	24 $^{15}/_{16}$	10 $^{3}/_{8}$	M8
0.45	167 $6^{5}/_{8}$	119 $4^{11}/_{16}$	197 $7^{3}/_{4}$	39 $1^{9}/_{16}$	8 $^{5}/_{16}$	M8
0.50	195 $7^{11}/_{16}$	138 $5^{7}/_{16}$	230 $9^{1}/_{16}$	46 $1^{13}/_{16}$	11 $^{7}/_{16}$	M10
0.40	215 $8^{7}/_{16}$	166 $6^{9}/_{16}$	254 10	51 $2^{12}/_{16}$	13 $^{1}/_{2}$	M10

Figure 3–4 Dimensions of the DC bus choke

3.9 Heat dissipation in a sealed enclosure

To maintain sufficient cooling of the Drive when it is installed inside a sealed enclosure, heat generated by all the equipment in the enclosure must be taken into account and the enclosure must be of adequate size. To calculate the minimum acceptable size of enclosure, use the following procedure.

Calculate the minimum required surface area $\mathbf{A_e}$ for the enclosure from:

$$\mathbf{A_e} = \frac{\mathbf{P}}{\mathbf{k}(\mathbf{T_i} - \mathbf{T_{amb}})}$$

where:

- $\mathbf{A_e}$ = Unobstructed heat-conducting area in m^2
- **k** = Heat Transmission coefficient of the enclosure material in Watts/m^2/°C
- $\mathbf{T_i}$ = Maximum permissible operating temperature in °C of the Drive
- $\mathbf{T_{amb}}$ = Maximum external ambient temperature in °C
- **P** = Power in Watts dissipated by all heat sources in the enclosure

Example

To calculate the size of an enclosure for one SA038 Drive. The following conditions are assumed:

The installation is to conform to IP54, requiring the Drive to be surface-mounted within a sealed enclosure

Only the top, front and two sides of the enclosure are free to dissipate heat

The enclosure is made of painted 2mm ($^{3}/_{32}$ inch) sheet steel

Maximum external ambient temperature: 25°C (77°F)

Drive PWM frequency: 6kHz

Insert the following values:

- **P** = 674W (from Losses and Efficiency table)
- $\mathbf{T_i}$ = 50°C (122°F)
- $\mathbf{T_{amb}}$ = 25°C (77°F)
- **k** = 5.5 (typical value for painted 2mm ($^{1}/_{16}$ inch) sheet steel)

The minimum required heat conducting area is then:

$$A_e = \frac{674}{5.5(50-25)} = 4.9\text{m}$$

The unobstructed heat-conducting area of the enclosure is:

$$A_e = 2HD + HW + DW$$

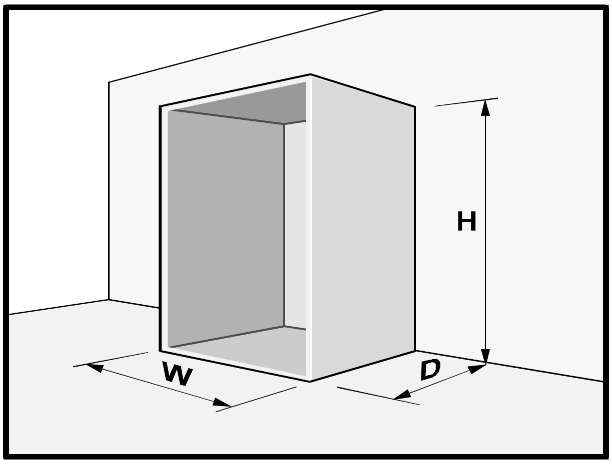


Figure 3–5 Enclosure having top, sides and front surfaces free to dissipate heat

Estimate two of the enclosure dimensions — the height and depth, for instance. Calculate the minimum width from:

$$W = \frac{A_e - 2HD}{H+D}$$

Inserting H = 1.8 metres, D = 0.5 metre, obtain the minimum width:

$$W = \frac{3.2-(2\times1.8\times0.5}{1.8+0.5} = 0.6 \quad \text{metres approx}$$

If possible, locate heat-generating equipment in the lower part of the enclosure to encourage internal convection. Otherwise, increase the height of the enclosure or install 'stirrer' fans.

3.10 Heat dissipation in a ventilated enclosure

If a high ingress factor is not required, a ventilated enclosure may be used. This will be smaller than a sealed enclosure.

To calculate the minimum required volume of ventilating air, use the following formula:

$$V = \frac{3.1\times P}{T_i - T_{amb}}$$

where:

V = Air-flow in m^3/hr
P = Power in Watts dissipated by all heat sources in the enclosure
$\mathbf{T_i}$ = Maximum permissible operating temperature in °C of the Drive
$\mathbf{T_{amb}}$ = Maximum external ambient temperature in °C

Example

To calculate the ventilation requirement for one SA038 Drive:

P = 674W
$\mathbf{T_i}$ = 50°C
$\mathbf{T_{amb}}$ = 25°C

Then...

$$V = \frac{3.1\times 674}{50-25} = 94.7\text{m}^3 / \text{hr}$$

3.11 Motor cooling

When a motor is driven at low speed, its internal cooling fan becomes less effective. If necessary, provide it with additional cooling (such as forced ventilation).

4 Electrical Installation

Warning

The voltages present in the Drive are capable of inflicting a severe electric shock and may be lethal. The Stop function of the Drive does not remove dangerous voltages from the Drive or the driven machine. AC supplies to the Drive must be disconnected using an approved isolation device before any cover is removed or service work is performed.

Warning

Electric shock risk

If the Drive has been energized, the supply must be isolated for at least fifteen minutes. This allows the internal capacitors to discharge fully before work may continue. Refer to *Safety information* on the inside front cover of this user guide.

4.1 Hazardous areas

Approval and certification for hazardous areas should be obtained for the complete installation of the motor and Drive.

4.2 Access to the power connectors

SA005

The main power connector and braking resistor connector are fitted to the top panel of the case.

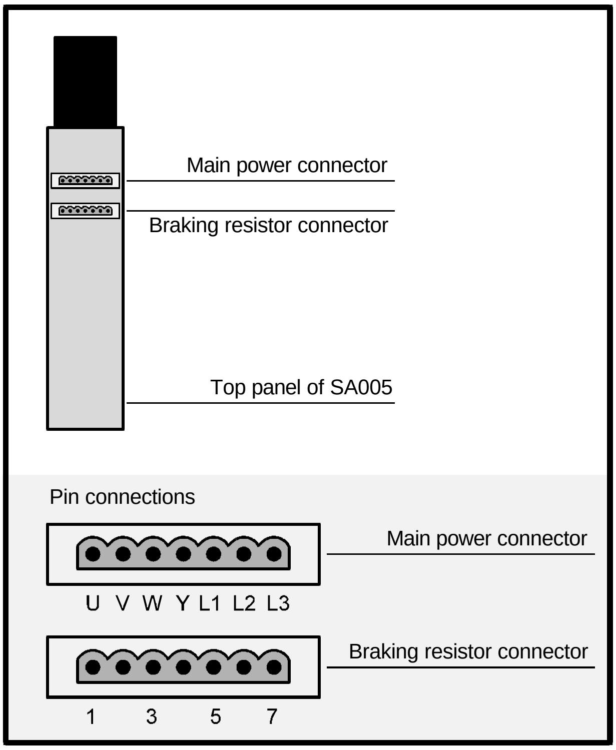


Figure 4–1 Locations of the main power connector and the braking resistor connector on model SA005 (only)

Main power connector

Pin	Function	Type	Notes
U	Phase U	Out	Output to motor
V	Phase V	Out	
W	Phase W	Out	
Y	PE		
L1	Phase L1	In	AC supply
L2	Phase L2	In	
L3	Phase L3	In	

Braking resistor connector

Pin	Function	Type	Notes
1	+DC bus	Out	External braking resistor connection
3	Internal braking resistor	Out	Internal braking resistor connection
5	External/ Internal braking resistor	Out	Controlled output
7	−DC bus	Out	

SA010, SA016, SA022

The power connector is fitted to the top panel of the case.

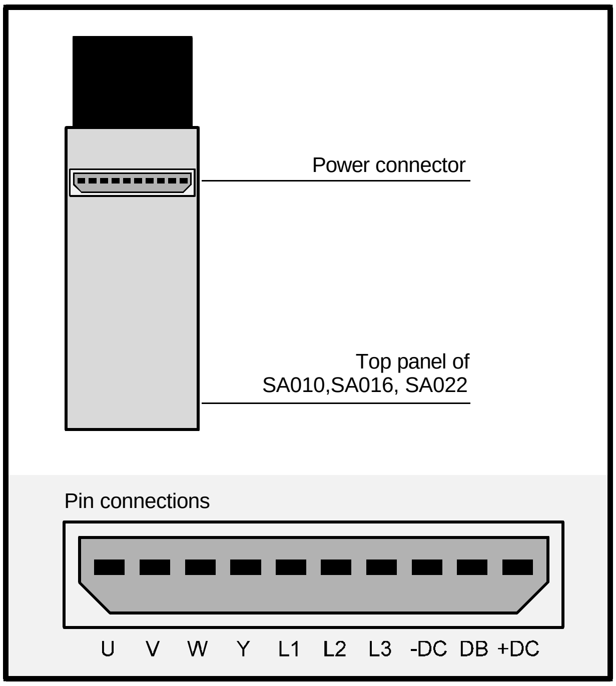


Figure 4–2 Location of the power connector on models SA010, SA016, SA022

Power connectors

Pin	Function	Type	Notes
U	Phase U	Out	Output to motor
V	Phase V	Out	
W	Phase W	Out	
Y	PE		
L1	Phase L1	In	AC supply
L2	Phase L2	In	
L3	Phase L3	In	
−DC	DC bus negative	Out	
BR	External braking resistor	Out	External braking resistor connections
+DC	+DC bus	Out	

SA038, SA059, SA091, SA110, SA150

The power terminals are located along the top and bottom edges of the front panel.

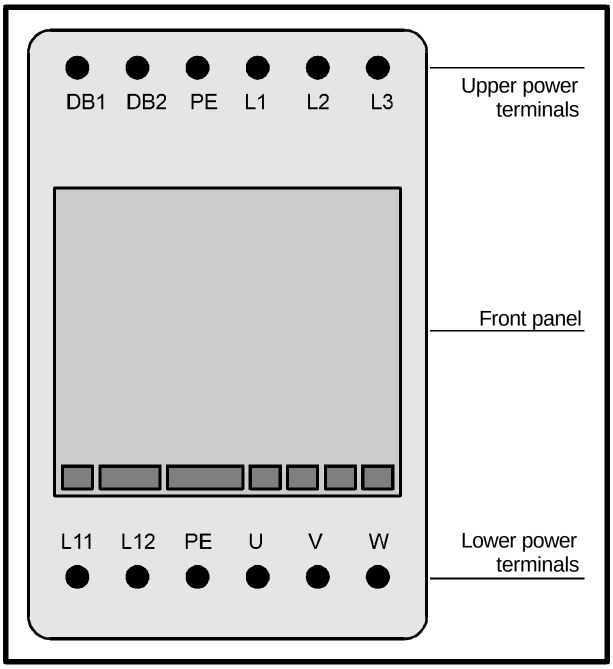


Figure 4–3 Locations of the power terminals on models SA038, SA059, SA091, SA110, SA150

Upper power terminals

Pin	Function	Type	Notes
DB1	External DC braking resistor	Out	+DC bus
DB2			
PE	Ground		
L1	Phase L1	In	AC power
L2	Phase L2	In	
L3	Phase L3	In	

Lower power terminals

Pin	Function	Type	Notes
L11	Choke		−DC bus
L12	Choke		
PE	Ground		
U	Phase U	Out	Output to motor
V	Phase V	Out	
W	Phase W	Out	

4.3 EMC wiring recommendations

Note

Failure to follow the basic recommendations shown in Figure 4–4 may result in vibration in the motor or spurious trips in the Drive.

Using the arrangement shown in Figure 4–4 does not guarantee that the specified standards for conducted and radiated emissions are met. Additional precautions and guidelines need to be considered. These are shown in Figures 4–5 and 4–6.

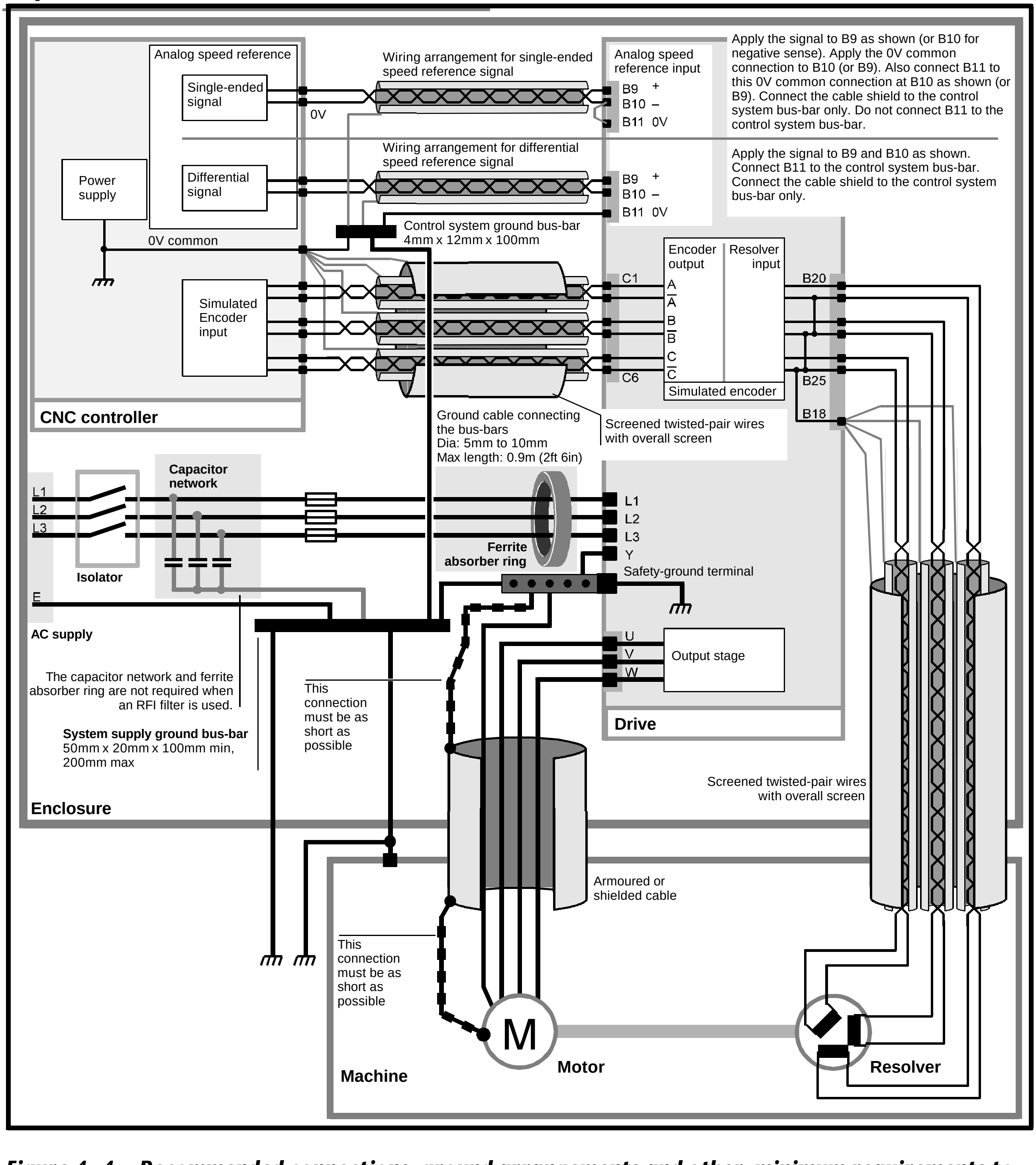


Figure 4–4 Recommended connections, ground arrangements and other minimum requirements to ensure good noise immunity

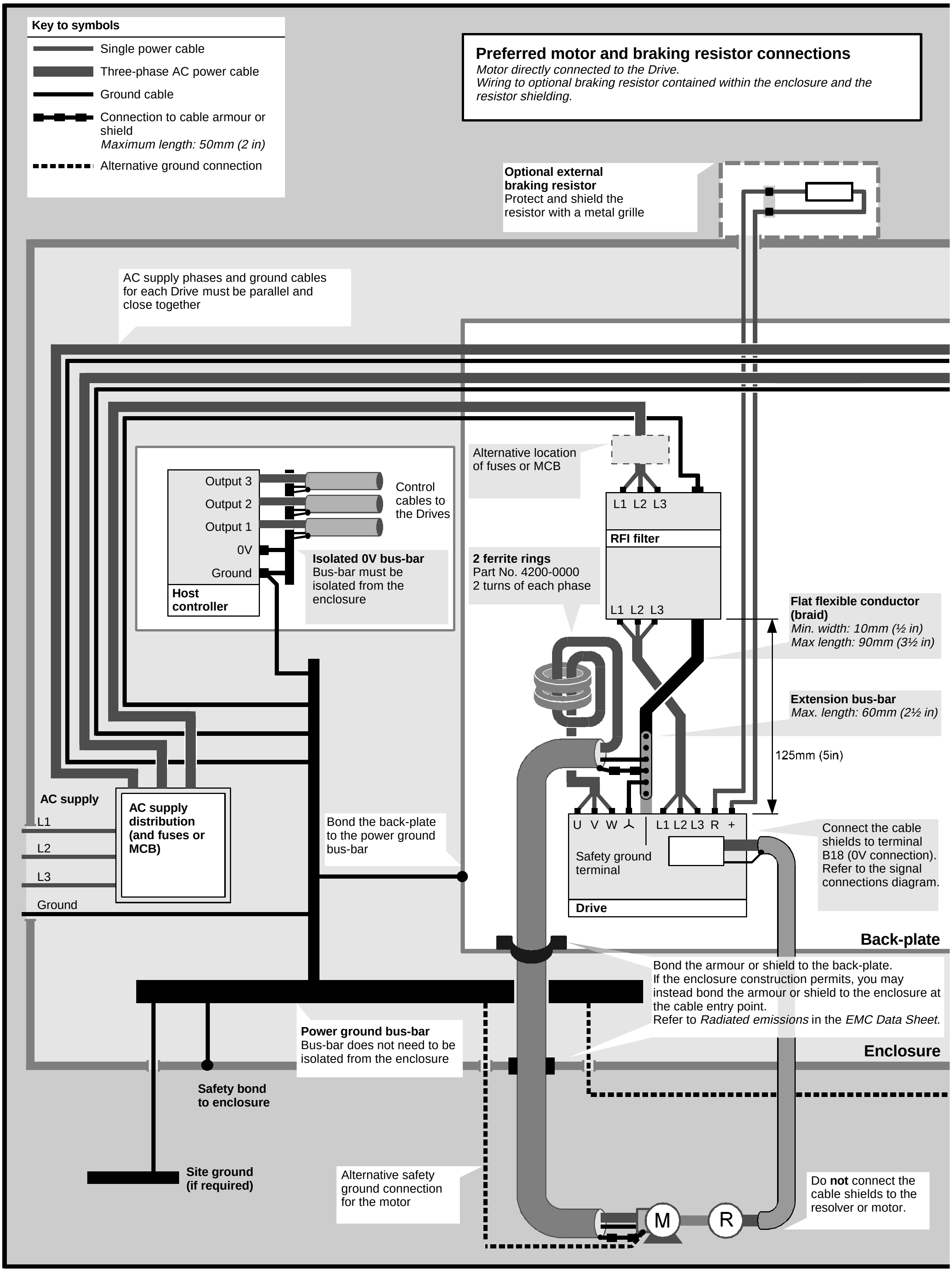
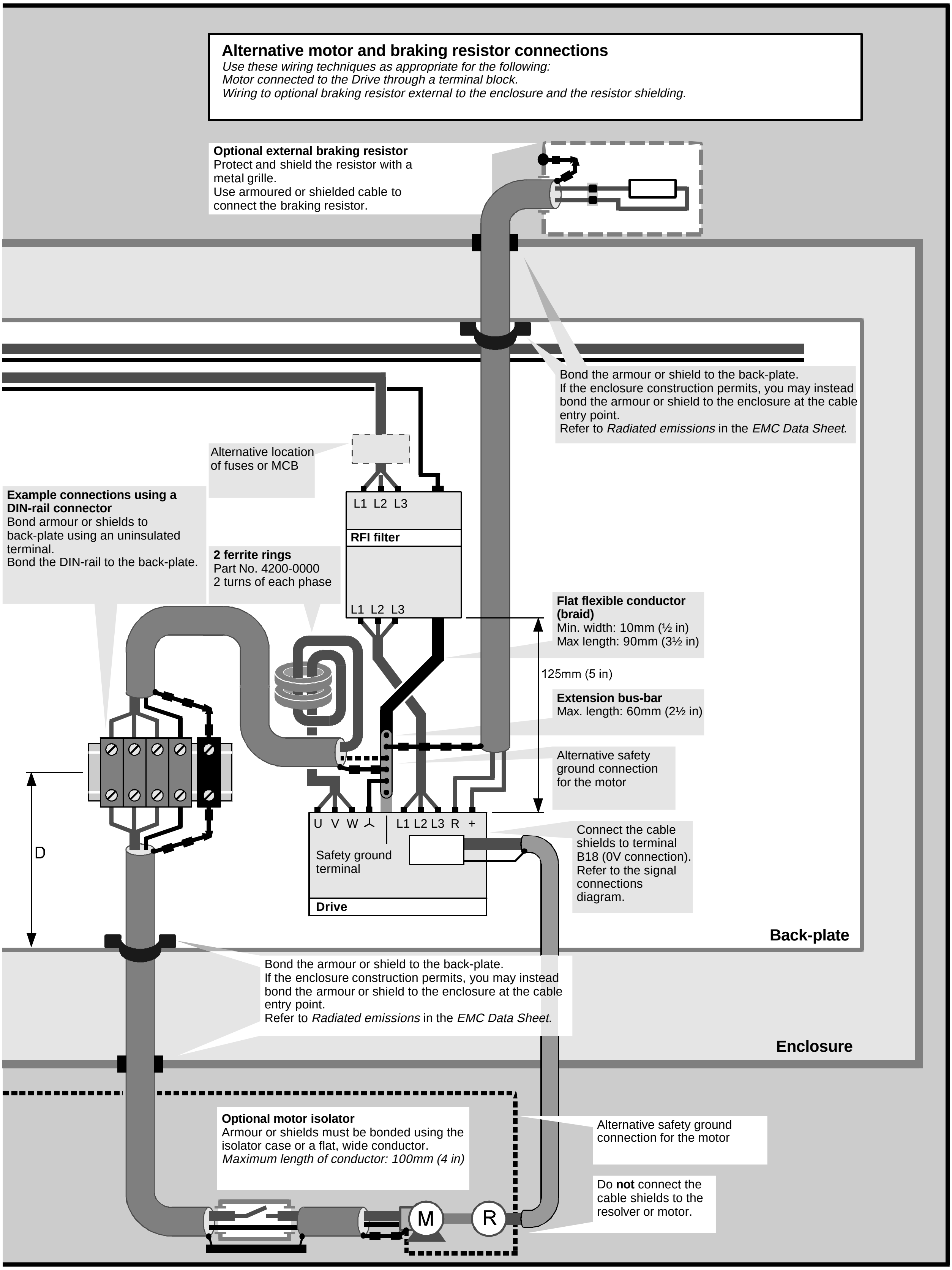


Figure 4–5 Models SA005 to SA022 — Recommended AC power and ground connections



Alternative motor and braking resistor connections
Use these wiring techniques as appropriate for the following:
Motor connected to the Drive through a terminal block.
Wiring to optional braking resistor external to the enclosure and the resistor shielding.
Optional external braking resistor
Protect and shield the resistor with a metal grille.
Use armoured or shielded cable to connect the braking resistor.
Bond the armour or shield to the back-plate.
If the enclosure construction permits, you may instead bond the armour or shield to the enclosure at the cable entry point.
Refer to Radiated emissions in the EMC Data Sheet.
Alternative location of fuses or MCB
L1 L2 L3
RFI filter
L1 L2 L3
Example connections using a DIN-rail connector
Bond armour or shields to back-plate using an uninsulated terminal.
Bond the DIN-rail to the back-plate.
2 ferrite rings
Part No. 4200-0000
2 turns of each phase
Flat flexible conductor (braid)
Min. width: 10mm (½ in)
Max length: 90mm (3½ in)
125mm (5 in)
Extension bus-bar
Max. length: 60mm (2½ in)
Alternative safety ground connection for the motor
U V W ⅄ L1 L2 L3 R +
Safety ground terminal
Drive
Connect the cable shields to terminal B18 (0V connection).
Refer to the signal connections diagram.
D
Back-plate
Bond the armour or shield to the back-plate.
If the enclosure construction permits, you may instead bond the armour or shield to the enclosure at the cable entry point.
Refer to Radiated emissions in the EMC Data Sheet.
Enclosure
Optional motor isolator
Armour or shields must be bonded using the isolator case or a flat, wide conductor.
Maximum length of conductor: 100mm (4 in)
Alternative safety ground connection for the motor
Do not connect the cable shields to the resolver or motor.
M
R

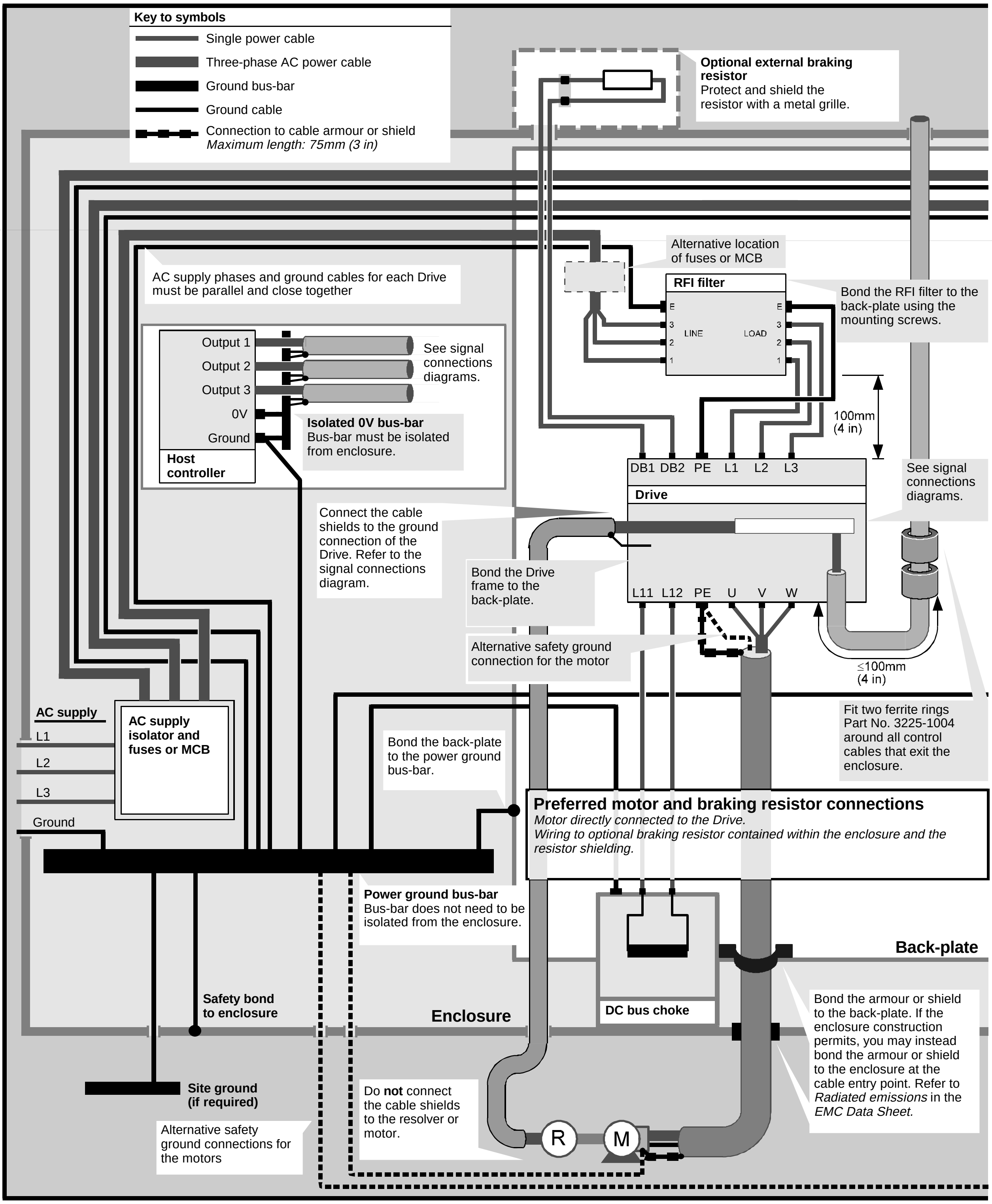
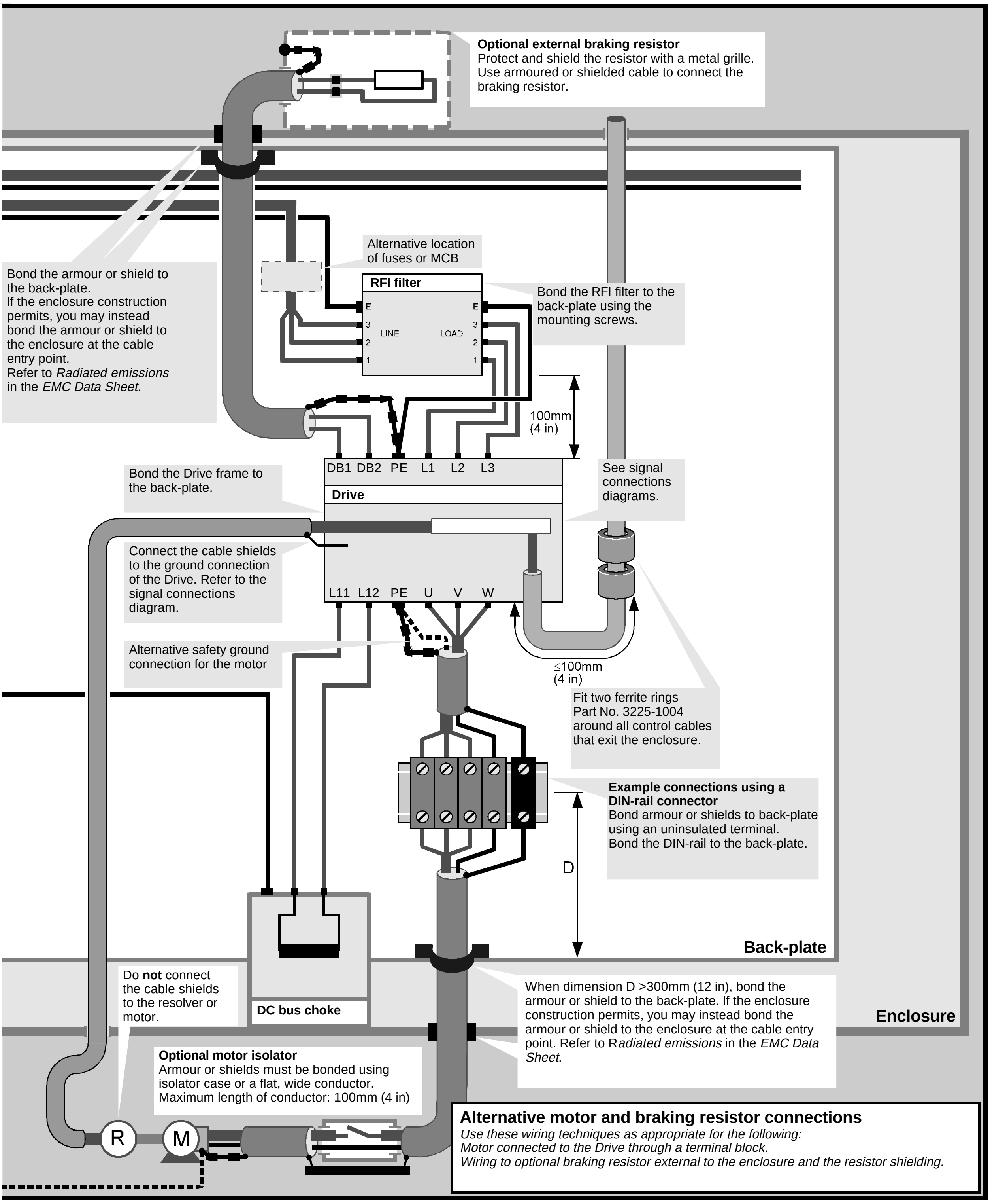


Figure 4–6 Models SA038 to SA150 — Recommended AC power and ground connections



Optional external braking resistor
Protect and shield the resistor with a metal grille. Use armoured or shielded cable to connect the braking resistor.
Alternative location of fuses or MCB
RFI filter
E
3
2
1
LINE
LOAD
Bond the RFI filter to the back-plate using the mounting screws.
Bond the armour or shield to the back-plate. If the enclosure construction permits, you may instead bond the armour or shield to the enclosure at the cable entry point. Refer to Radiated emissions in the EMC Data Sheet.
100mm (4 in)
DB1 DB2 PE L1 L2 L3
Drive
Bond the Drive frame to the back-plate.
See signal connections diagrams.
Connect the cable shields to the ground connection of the Drive. Refer to the signal connections diagram.
L11 L12 PE U V W
Alternative safety ground connection for the motor
≤100mm (4 in)
Fit two ferrite rings Part No. 3225-1004 around all control cables that exit the enclosure.
Example connections using a DIN-rail connector
Bond armour or shields to back-plate using an uninsulated terminal. Bond the DIN-rail to the back-plate.
D
Back-plate
DC bus choke
Do not connect the cable shields to the resolver or motor.
When dimension D >300mm (12 in), bond the armour or shield to the back-plate. If the enclosure construction permits, you may instead bond the armour or shield to the enclosure at the cable entry point. Refer to Radiated emissions in the EMC Data Sheet.
Enclosure
Optional motor isolator
Armour or shields must be bonded using isolator case or a flat, wide conductor. Maximum length of conductor: 100mm (4 in)
R
M
Alternative motor and braking resistor connections
Use these wiring techniques as appropriate for the following:
Motor connected to the Drive through a terminal block.
Wiring to optional braking resistor external to the enclosure and the resistor shielding.

4.4 AC supply cables and fuses

Warning

The AC supply to the Drive must be fitted with suitable protection against overload and short circuits. The table shows recommended fuse ratings. Failure to observe this recommendation will cause a risk of fire.

Warning

Wiring must be in accordance with local regulations and codes of practice. The table shows typical cable sizes for power input and output wiring. In the event of a conflict, local regulations prevail.

The following table is only a guide to cable sizes. Refer to local wiring regulations for the correct size of cables.

Model	AC supply cables		Motor cables		Fuse rating
	mm²	AWG	mm²	AWG	A
SA005	2.5	14	1.5	16	10
SA010	4.0	10	2.5	14	16
SA016	4.0	10	4.0	10	20
SA022	4.0	10	4.0	10	35
SA038	16	4	16	6	50
SA059	????				70
SA091					100
SA110					125
SA150					160

For the following connections, use 600VAC (1000VDC) 3-core pvc-insulated cable with copper conductors of the size specified in the table:

AC power to the Drive

For the following connections, use 600VAC (1000VDC) 3-core pvc-insulated, shielded or armoured cable with copper conductors of the size specified in the table:

Drive to the motor
Drive to external braking resistor (if used)

Cable sizes must be selected for 100% of the RMS currents.

Unusually long cable runs between the Drive and the motor may give rise to spurious tripping due to the effect of cable capacitance. As a result, an over-current fault would be indicated (OC). In this case, output chokes may be required. In difficult cases, consult the supplier of the Drive.

The AC power should be applied through an isolator and a fuse or circuit-breaker of the specified rating. Since a current surge can occur when AC power is applied to the Drive, the use of slow-blow fuses is recommended. As an alternative to fuses, an MCB or MCCB may be used if equipped with adjustable thermal and magnetic trip devices of a suitable rating.

The AC power should be applied through an isolator and a fuse or circuit-breaker of the specified rating. Since a current surge can occur when AC power is applied to the Drive, the use of slow-blow fuses is recommended. As an alternative to fuses, an MCB or MCCB may be used if equipped with adjustable thermal and magnetic trip devices of a suitable rating.

4.5 Ground connections

The impedance of the ground circuit must conform to the requirements of Health and Safety Regulations that may apply.

The size of external grounding terminals should be appropriate to the size of the grounding cables.

Ground connections on the power input and power output connectors are connected together in the Drive, enabling the following connections to be made through the Drive:

Motor frame ground to system ground
Motor frame ground to the machine ground

The Drives are suitable for grounded-delta installation without alteration.

4.6 DC bus choke

For model size 3, connect the specified DC bus choke to terminals L11 and L12 of the Drive.

An external DC bus choke is not required for model sizes 1 and 2.

4.7 Connecting an external braking resistor

Warning

Electric shock risk

When an external braking resistor is connected, adjustments must be made to the Drive that modify its operation. Make a note on the front of the Drive stating that a modification has been made in order to reduce the risk of a modified Drive being mistaken for a standard Drive.

When an AC motor is decelerated, energy is returned to the Drive from the motor. When a high inertia load is decelerated in a short time, the energy delivered can be too great for the Drive to absorb. The effect is to increase the voltage of the DC bus, with the possibility of the Drive tripping due to overvoltage on the DC bus.

An external DC braking resistor can be connected to the Drive. When the DC bus voltage exceeds a pre-determined level, the resistor is connected to the DC bus by a transistor in order to absorb the excessive energy.

The maximum required braking torque determines the required resistor value. The duty cycle, repetition time and cooling available for the resistor determine the required power rating of the resistor.

A lock-out feature ensures that the braking transistor cannot be turned on when a short-circuit condition exists. In the event of a lock-out, the AC supply must be disconnected and the condition investigated before the Drive is restarted.

It is strongly recommended that a thermal trip is included to trip the AC supply isolator in order to protect the braking resistor if it becomes over-heated.

The maximum DC bus voltage is 750V. The external braking resistor, connecting cables and insulation must be suitable for this operating voltage.

Position the external resistor so that heat generated by it cannot affect the Drive.

Refer to Figure 4–7 for connections for the different models.

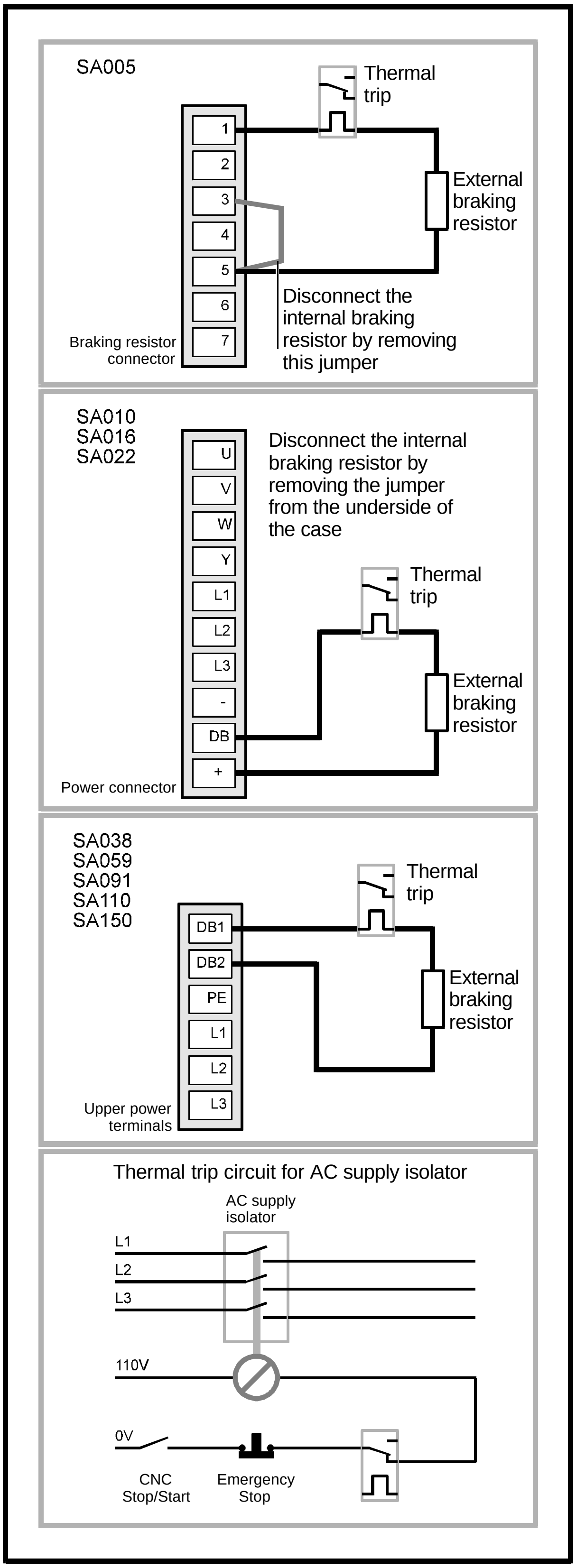


Figure 4–7 Braking resistor and thermal trip connections

Disconnecting the internal braking resistor

Models SA005, SA010, SA016, SA022

When an external braking resistor is used, the internal resistor(s) **must be disconnected**. On the underside of the case is access to a removable jumper. Grip the visible part of the jumper with long-nose pliers and remove the jumper.

4.8 Calculating the braking resistor value

Refer to the following for guidance in selecting a braking resistor. If the internal resistor is inadequate, install an external braking resistor and disconnect the internal resistor. In case of uncertainty, refer to the supplier of the Drive.

The required value and rating of the braking resistor are calculated for the following:

- Amount of energy to be absorbed
- Rate at which the energy (power) is to be absorbed
- Time lapse between successive decelerations

The kinetic energy of the motor and the driven machine is as follow:

$$\varepsilon = 0.5J\varpi^2$$

where:

J = Total moment of inertia (kg.m^2) of the motor and driven machine. If there is gearing between the motor and the driven machine, **J** is the value produced at the motor shaft.

ϖ = Angular velocity $= \frac{2\pi n}{60}$ **rads / sec**

n = motor speed in RPM

Since the energy is proportional to ω^2, most of the energy in the system is concentrated at the higher operating speeds.

The braking resistor should be capable of tolerating thermal shock. *Pulse rated* resistors are recommended.

Example

To calculate the required value and power rating for a braking resistor to decelerate the motor from maximum speed to rest. The conditions are as follows:

Drive rating = 30 kW
Motor rating = 30 kW
Full-load speed of motor (**n**) = 1475 RPM
Nominal torque rating of motor (**a**) = 194 Nm
Repeat cycle time = 30 seconds
System inertia (**J**) = 10 kg.m^2
Resistor operating voltage = 750V

Calculating the minimum permissible deceleration time

Use the following equation to calculate the minimum deceleration time t_b for the maximum possible braking torque M_{bmax}.

$$M_{b\max} = Ja = J\frac{\varpi}{t_b} = J\frac{2\pi n}{60t_b}$$

$$t_b = \frac{J\pi n}{30M_{b\max}}$$

where:

J = System inertia
a = Nominal torque rating of motor
t_b = Deceleration time
n = Full-load speed of motor

Maximum deceleration corresponds to 150% of the nominal torque of the motor. The value of M_{bmax} is then as follows:

$$1.5 \times 194 = 291$$

The *minimum permissible* deceleration time t_b is as follows:

$$t_b = \frac{10 \times \pi \times 1475}{30 \times 291} = 5.31\text{secs}$$

Note

This value is the minimum deceleration time that can be achieved for the stated conditions.

Using a practical deceleration time

A *practical* deceleration time t_d can now be decided. The actual braking torque M_b required to decelerate the load in 7 seconds is calculated as follows:

$$M_b = J\frac{\pi n}{30t_d} = \frac{10 \times \pi \times 1475}{30 \times 7} = 221\text{Nm}$$

Calculating the resistor power rating

The power dissipated in the braking resistor is as follows:

$$P_b = M_b\frac{\pi n}{30 \times 10^3} = \frac{221 \times \pi \times 1475}{30 \times 10^3} = 34.1\text{kW}$$

Since braking occurs intermittently, the resistor can be rated for *intermittent* rather than *continuous* power dissipation. When the intermittent rating is used, the overload factor of the resistor can be used. This factor is derived from *cooling curves* in the resistor data. A typical overload factor is 2.

For deceleration time of 7 seconds and repeat cycle time of 30 seconds, the power rating of the braking resistor can be reduced to the following value:

$$P_r = \frac{P_b}{[\text{Overload factor}]} = \frac{34.1}{2} = 17.1\text{kW}$$

For practical purposes, it can be assumed that 15% to 20% of braking energy is dissipated as follows:

Electrical dissipation in the motor

Electrical dissipation in the Drive

Mechanical losses in the motor and the driven load

The Drive is capable of accepting regeneration current of a value up to 150% of its full load current rating for a period up to 60 seconds (eg. 150% x 30kW = 45 kW). The braking power cannot exceed this power capability of the Drive.

Calculating the resistor value

The maximum value of braking resistor is as follows:

$$R = \frac{V^2}{P_b} = \frac{750^2}{34.1 \times 10^3} = 16.5\Omega$$

In practice, a slightly lower value should be used for the following reasons:

When the duty ratio of the braking transistor is close to 100%, the Drive does not have full control over the DC bus voltage. A lower value of braking resistor will cause more power to be dissipated in a given period of time, allowing the duty ratio to be reduced.

When the required value is not a preferred resistor value, use a resistor having a value close to and lower than the calculated value.

Internal braking resistor ????

The capability of the internal braking resistor is as follows:

Model	Maximum duty cycle for internal braking resistor	Value of internal resistor	Minimum value of external resistor
SA005	1.5kW for 10 secs braking time with 90 secs minimum cooling time.	80Ω	80Ω
SA010	1.5kW for 10 secs braking time with 90 secs minimum cooling time.	????	33Ω
SA016 SA022	3.0kW for 10 secs braking time with 90 secs minimum cooling time.	40Ω	17Ω
SA038 SA059	No internal braking resistor fitted		11Ω
SA091 SA110 SA150	No internal braking resistor fitted		6Ω

4.9 Control Keypad connections

Model size 3

Use screened cable when connecting to a remotely mounted Control Keypad. Connect the cable screen to an external ground terminal which should be as close to the Control Keypad as possible.

The connecting cable should be shielded data cable having a maximum length of 100m (330ft). For lengths of less than 1 metre (3 feet), unscreened twisted-pair wiring may be used. The Control Keypad connector is a 9-pin D-type socket.

Model sizes 1 and 2

The Control Keypad cannot be mounted remotely.

4.10 Signal connections

Note

In the connection diagrams, the programmable inputs and outputs are shown in their default configurations.

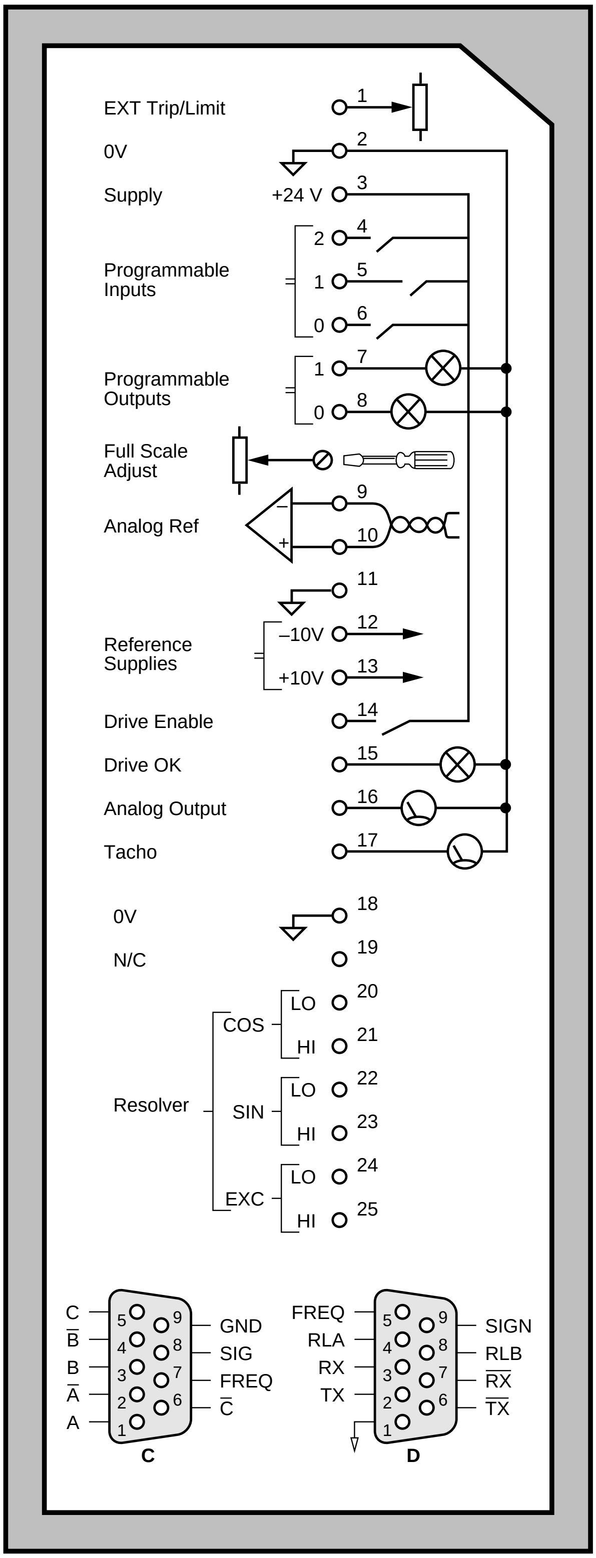


Figure 4–8 Models SA005, SA010, SA016, SA022
Legend printed on the front panel showing locations of the control signal connectors

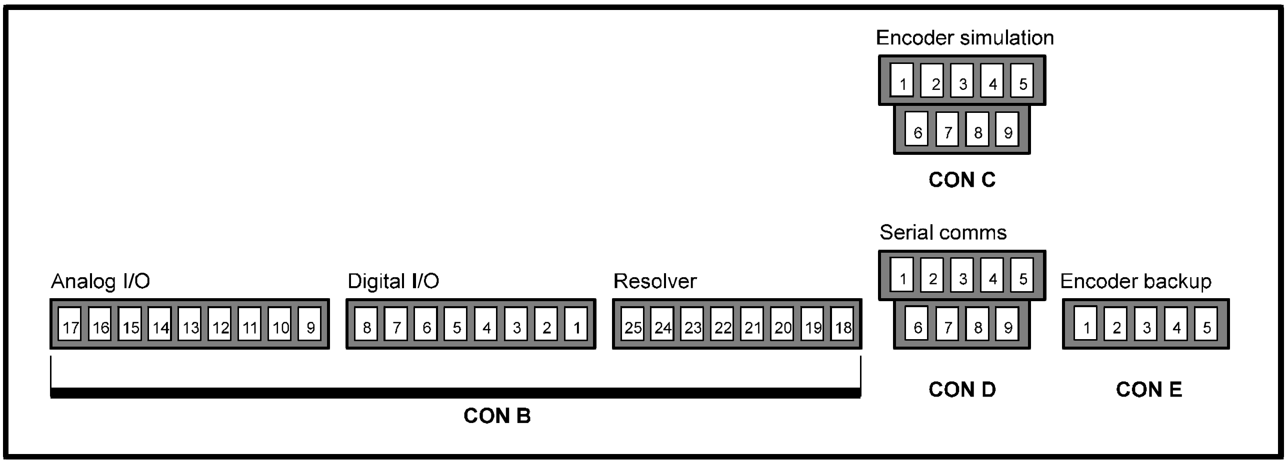


Figure 4–9 Models SA038, SA059, SA091, SA110, SA150 Layout of the control signal connectors on the front panel

CON B – Digital I/O connections

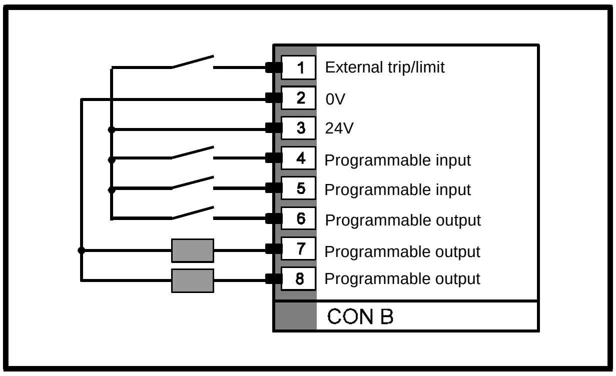
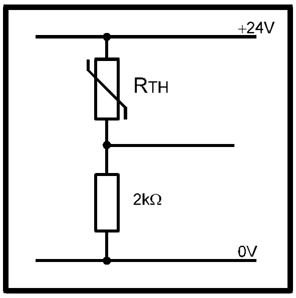


Figure 4–10 Digital I/O connections

Pin	Function	Type	Description
B1	External trip / External current limit	In	When parameter **b56** is set at 0, a signal applied to this input sets the torque limit. When parameter **b56** is set at 1, this input is used as an external trip input. For example, the input can be connected to a PTC motor thermistor as shown below.  Note — The 2kΩ resistor value shown applies to **Dutymax** servomotors. For other motors, the resistor value should be selected so that the input signal at terminal **B1** is less than 5V at the motor trip temperature.
B2	0V		Control signal common
B3	+24V, 100mA	Out	Power supply to external control circuits.
B4	Programmable input 2	In	When parameter **b16** = 0, and **Pr21** = 2, these inputs are used for digital speed selection. The configuration can be read in parameter **Pr18**.
B5	Programmable input 1	In	When **b16** = 1, these inputs are used for limit switch signals. Input impedance: 15kΩ

B4	B5	When b16 = 0 Selects digital speed reference parameter	When b16 = 1 Limit switch inputs
Open-cct	Open-cct	Pr0	Inhibits rotation in both directions
Open-cct	+24V	Pr1	Inhibits reverse (anti-clockwise) rotation
+24V	Open-cct	Pr2	Inhibits forward (clockwise) roatation
+24V	+24V	Pr3	Allows rotation in either direction

Logic 0: <4.5V or open-circuit
Logic 1: >5.5V

Pin	Function	Type	Description
B6	Programmable input 0	In	The function of this input is selected using **b18**, **b53** and **Pr27** as follows: Zero speed Hold Shaft orientation input. Input impedance: 15kΩ

b18	Signal applied to B6	Function
0	Open-circuit	Not stop
1	Any signal level	Stop
X	+24V	Stop

Pin	Function	Type	Description
B7	Programmable output 1	Out	Refer to **Pr30** Open-collector output (PNP), 60mA max.
B8	Programmable output 0	Out	Refer to **Pr31** Open collector output (PNP), 60mA max.

CON B – Analog I/O connections

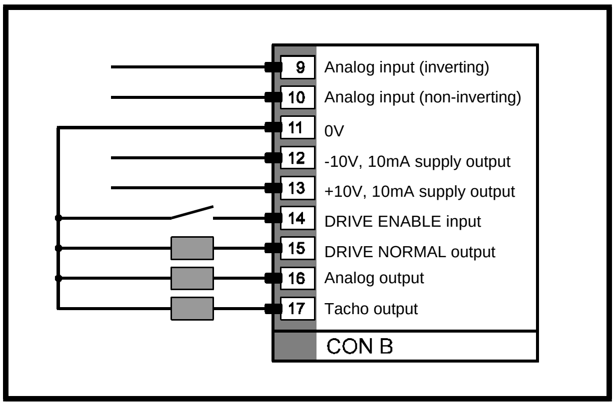


Figure 4–11 Analog inputs and outputs

Pin	Function	Type	Description
B9	Analog inverting input	In	When **b6** = 0, these inputs are used as analog speed reference
B10	Analog non-inverting input	In	When **b6** = 1, these inputs are used as torque reference input Input Impedance: 10kΩ
B11	0V		Control signal common
B12	−10V (10mA)	Out	Voltage reference
B13	+10V (10mA)	Out	Voltage reference
B14	Drive enable	In	Apply +6V to +24V to pin B14, and set parameter **b2** at 1, to enable the Drive.
B15	Drive Normal	Out	Logic output to indicate the Drive is operating normally. Normal state is indicated by: +24V output on B15 **b33** = 1
B16	Programmable analog output	Out	Refer to **b12** and **b13**
B17	Tacho-generator output	Out	

CON B – Resolver connections

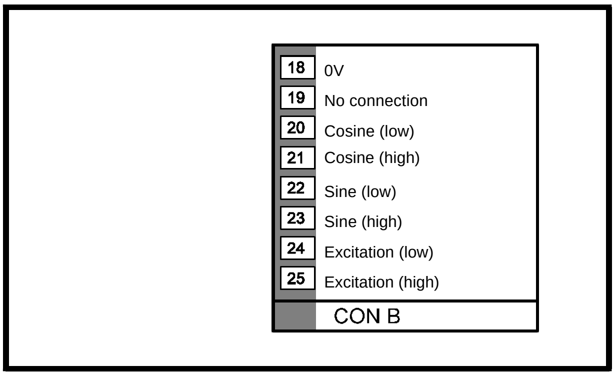


Figure 4–12 Resolver connections

Pin	Function	Type	Description
B18	0V		Ground connection for the resolver wiring screen
B19	Not internally connected		Do not connect
B20	Cosine low	In	Cosine signal from resolver
B21	Cosine high	In	
B22	Sine low	In	Sine signal from resolver
B23	Sine high	In	
B24	Excitation low	Out	
B25	Excitation high	Out	Signal at 7.812 kHz for resolver

CON C – Simulated Encoder connections

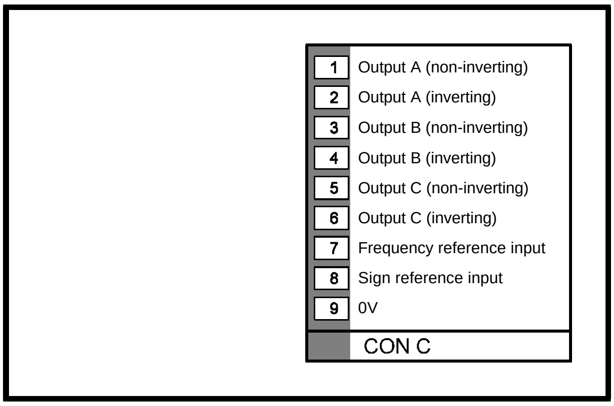


Figure 4–13 Simulated Encoder connections

Pin	Function	Type	Description
C1	A	Out	Simulated encoder, channel A non-inverting output
C2	$\overline{A}$	Out	Simulated encoder, channel A inverting output
C3	B	Out	Simulated encoder, channel B non-inverting output
C4	$\overline{B}$	Out	Simulated encoder, channel B inverting output
C5	C	Out	Simulated encoder, channel C non-inverting output
C6	$\overline{C}$	Out	Simulated encoder, channel C inverting output
C7	Frequency reference input	In	When parameters **b14** = 0 and **b17** = 0, the frequency of a signal applied to this input controls the motor speed. Scale: 2048 pulses = 1 revolution
C8	Sign reference input	In	Used in conjunction with terminal C7 to indicate the required direction of rotation of the motor (See parameter **b15**)
C9	0V		

CON D – Serial Communications connections

The serial communications connector is a 9-way D-type. Full duplex RS485 connections require two shielded twisted-pair wires.

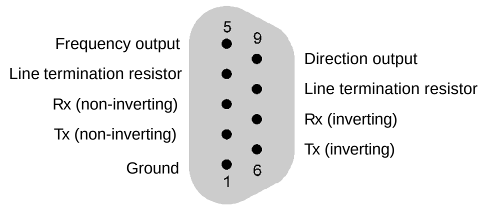


Figure 4–14 Serial Communications connections

Pin	Function	Type	Description
D1	GND		0V
D2	TX	Out	Transmit signal, non-inverted
D3	RX	In	Receive signal, non-inverted
D4	RLA		Network termination resistor
D5	FREQOUT	Out	Frequency output (102.4kHz = 6000 RPM)
D6	$\overline{TX}$	Out	Transmit signal, inverted
D7	$\overline{RX}$	In	Receive signal, inverted
D8	RLB		Network termination resistor
D9	DIROUT	Out	Direction output

CON E – Back-up supply connector

For applications that require serial communications or information on rotor shaft position to be maintained when AC power is lost from the Drive, an external power supply can be connected to connector E which is on the underside of the Drive. This is used to maintain the supplies to the control circuits in the Drive. When AC power is lost, the display on the Drive shows the decimal point moving from left to right. (The serial communications port is not active when the Drive is in this state.)

Pin	Supply
1	+8V
2	+24V
3	0V
4	−24V
5	0V

5 Control Keypad

Two types of Control Keypad are used in SpindAx Drives. The type used depends on the model size.

The Control Keypad can be removed from all the models.

Caution — **Model sizes 1 and 2 only — Before removing the Control Keypad, disconnect the Drive from the AC supply.**

5.1 Model sizes 1 and 2 (SA005, SA010, SA016, SA022)

The Control Keypad on these models has a programmable non-volatile memory. When removed, the Control Keypad retains any stored parameter settings. This allows a programmed Control Keypad to be transferred to another Drive (enabling a Drive to be replaced without the necessity for re-programming).

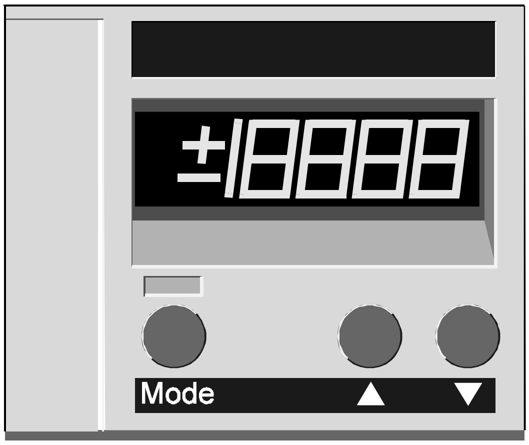


Figure 5–1 Control Keypad used in models SA005, SA010, SA016, SA022

5.2 Model size 3 and 4 SA038, SA059, SA091, SA110, SA150

The Control Keypad on these models has no memory; the parameters are stored in the Drive. Programs cannot be transferred from one Drive to another.

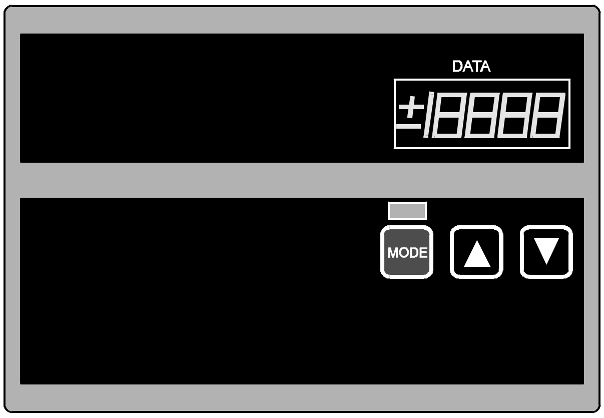


Figure 5–2 Control Keypad used in models SA038, SA059, SA091, SA110, SA150

5.3 Display and controls

Digital display

A $4^1/_2$ digit display is used to show the following:

Status of the Drive
Selected parameter
Value of the selected parameter

At the time AC power is applied, the display shows the following in sequence:

Software version number
CAL during calibration
rdY to indicate that the Drive is ready

When the Drive is running, the display shows the motor speed in rpm.

When a trip has occurred, the display shows a related trip code.

Keypad

The Control Keypad has three keys. These are as follows:

Mode key

The **Mode** key is used to change the type of information shown on the display. A green LED indicator responds to operation of the **Mode** key.

Arrow keys

These are used to scroll the numbers shown on the digital display.

6 Parameters

There are two types of parameters

- Variable parameters, denoted by **Prxx**
- Bit parameters denoted by **bxx**

Variable parameters allow numerical values to be entered. Bit parameters allow digital settings to be made.

Both types of parameter can be as follows:

- Read–write (R–W)
- Read-only (RO)

Read–write parameters are programmable by the user, and the values can be read on the display (or remotely using a serial communications link). Read-only parameters are for information purposes; they cannot be programmed.

Default values

The read–write parameters are programmed during manufacture with default values which are generally valid for the size of Drive and motor.

The default values cannot be erased or changed by the user.

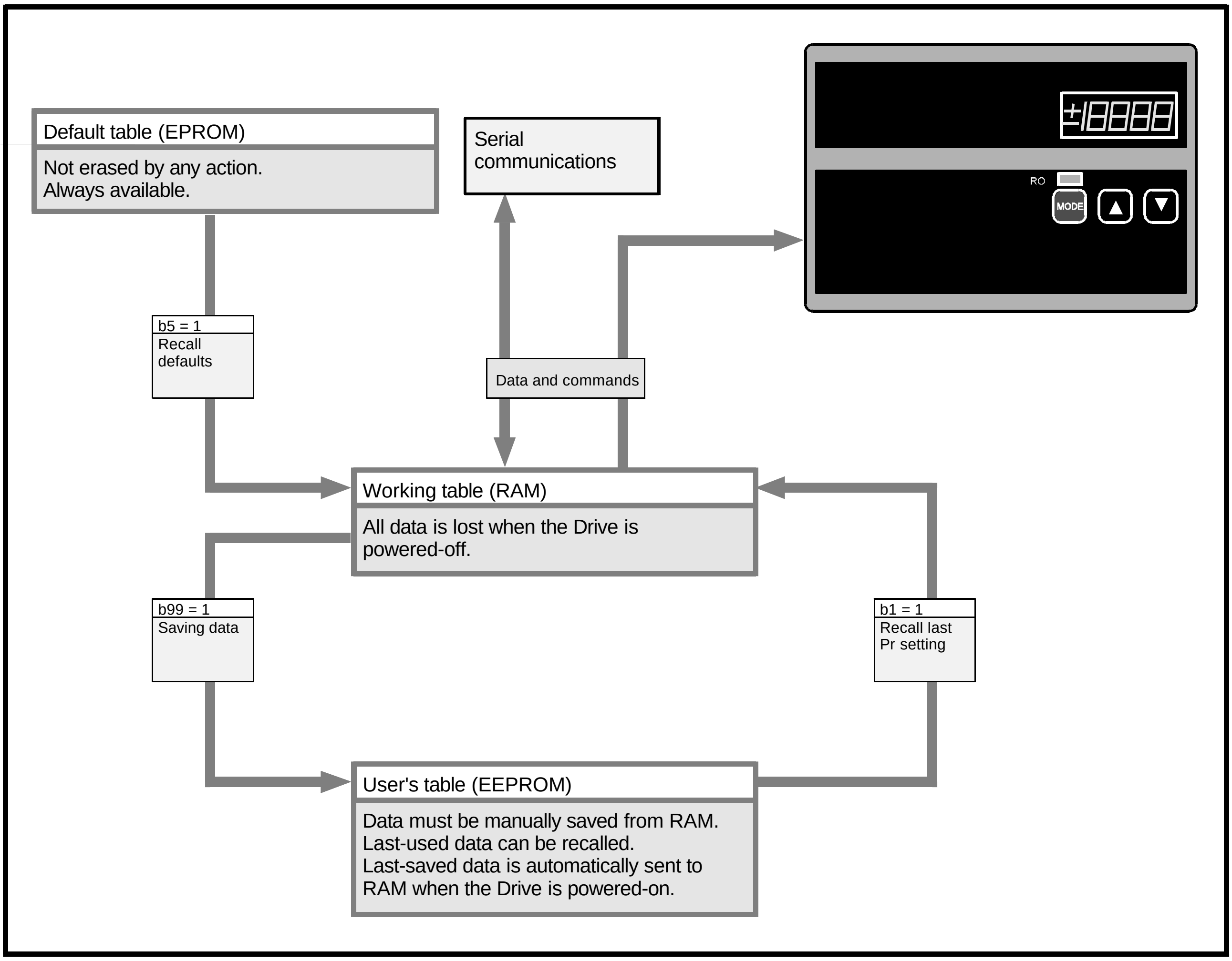


Figure 6–1 How parameter values are stored and changed

Memory Tables

Parameters are held in three Memory Tables (see Figure 6–1). A **Default Table** contains the permanent default settings for the parameters, a **Working Table** holds values that are in use while the Drive is operating, and a **User's Table** holds values set and saved by the user.

Default parameters are all recalled to the Working Table by setting bit parameter **b5** at 1).

The Default Table is held in PROM in the Drive. The Working Table is held in RAM in the Drive and the User's Table is held in EEPROM in the Control Keypad. This arrangement ensures that a Drive is always equipped with its default values, and the user-defined parameter values remain unchanged when the Control Keypad is removed from the Drive.

Note

Setting parameters to their default values includes the value of the security code parameter Pr25. The default value is zero, which allows any parameter to be changed; ie. security is lost when default values are recalled.

At the time AC power is applied, the contents of the User's Table are read into the Working Table. If the Drive has not been programmed by the user, the User's Table contains the default values.

When a parameter value is changed, the new value is held in the Working Table until AC power is removed. The original value is stored in the User's Table and can be recalled by setting bit parameter **b1** at 1. This is useful when experimenting with different values for a parameter when setting up a Drive.

Saving parameter values held in the Working Table stores them in the User's Table. Saving is carried out by setting **b99** at **1**. The contents of the Working Table are lost when AC power is removed.

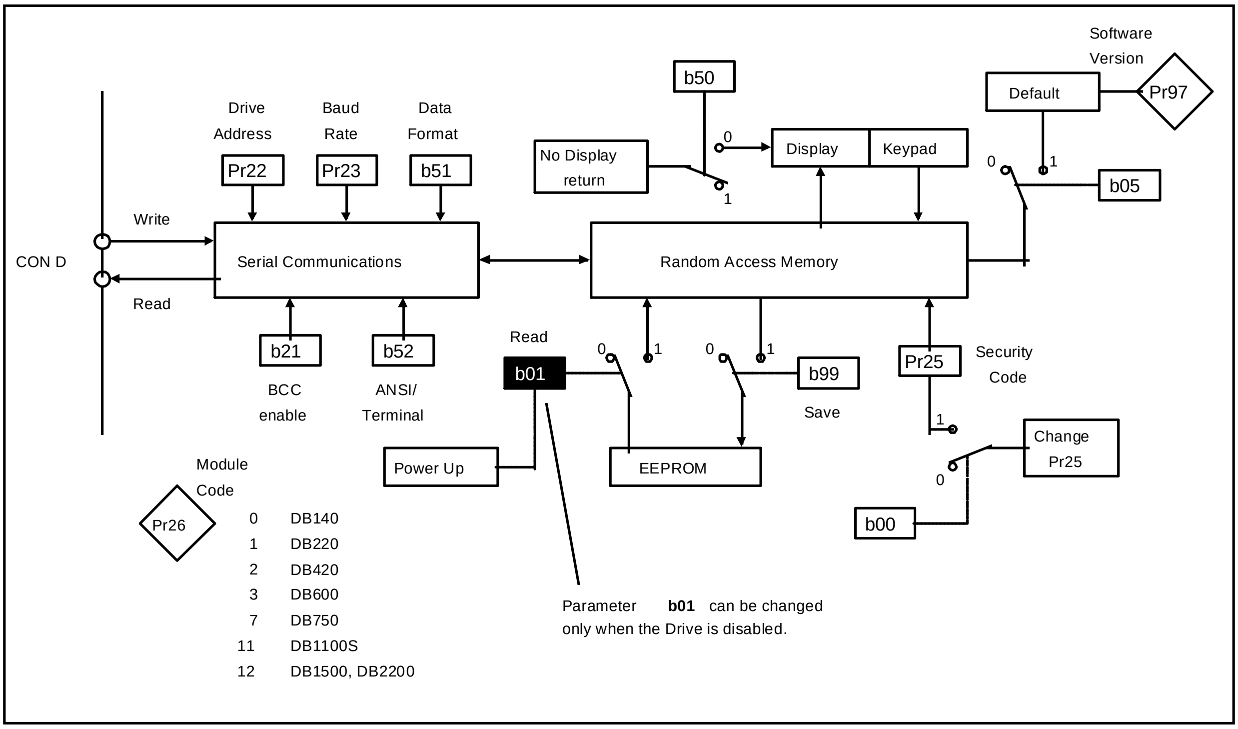


Figure 6–2 Logic diagram showing how parameter values are changed using serial communications

7 Programming Instructions

7.1 Displaying a parameter

Use the following procedure to display a parameter and its value:

1. Press the **Mode** key once. The LED above the **Mode** key illuminates. The display no longer shows the current status (eg. **rdY**); it shows for one second the number of the last accessed parameter in the form of **Pr33** or **b17**. (The display is now in View mode.) The display then alternately shows the parameter number and the parameter value. After 8 seconds, the display returns to showing the current status.

2. To select a different parameter from the one shown, either hold down or press repeatedly one of the arrow keys. The display scrolls through the parameter numbers.

3. Release the key when the number of the required parameter is displayed.

4. Press the **Mode** key. The display shows the value of the parameter; the value remains on display for 8 seconds after a key is last pressed.

7.2 Changing a parameter value

Note

If a new value has been entered in security parameter Pr25, parameter values cannot be edited unless the correct value is first entered in Pr25. Refer to Chapter 8 *Security*.

The values of parameters can be changed when the Drive is stopped or running.

1. Select the parameter to be edited by following the instructions above in *Displaying a parameter*.
2. When the value of the parameter is being displayed hold down or press repeatedly one of the arrow keys to change the displayed value.
3. To enter the value, press the **Mode** key. The LED extinguishes.

7.3 Saving parameter values

Parameters are not saved when AC power is removed. Use the following procedure to save parameters:

1. Follow the procedure in *Displaying a parameter* to display the value of parameter **b99**.

2. Follow the procedure in *Changing a parameter value* to set the value at **1**.

The current parameter values are now saved in the User's Table.

8 Security

8.1 Setting up a security code

The Drive is supplied with no security set up (ie. security code = 0). There is no protection against unauthorized or accidental editing of parameters. Use the following procedure to set up a security code:

1. Set **b0** at 1.
2. Set **Pr25** at the required security code number (0 to 9999).
3. Set **b99** at 1 to save the new security code.

At this stage, the security code is set but only in the User's Table. To make the new security code active, remove AC power for at least 5 seconds.

8.2 Security access

To edit read–write parameters when a security code is in use, first set **Pr25** at the User Security Code number.

8.3 Changing a security code

1. Set **Pr25** at the existing User Security Code number.
2. Follow the procedure in *Setting up a security code*.

9 Getting Started

9.1 Setting parameter values

For the Drive to operate correctly with a motor, appropriate values must be given to certain parameters. Follow the instructions in this chapter to enter values for these parameters in order to get the motor and Drive running. Adjustments can be made later to optimize the system.

The following parameters may be left initially in their default state:

Speed reference	Analog ±10V (**b17** = 0)
Acceleration and deceleration ramps	Disabled (b7 = 0)
Software enable	Enabled (b2 = 1)
Limit switch	Disabled
Analog output **B16**	Indicates clamped current demand (**b12** = 0, **b13** = 0)
Analog output **B17**	Indicates simulated tacho-generator signal
Digital output **B7**	Configured for I^2t limitation (**Pr30** = 0)
Digital output **B8**	Configured for temperature pre-alarm (**Pr31** = 1)
PID parameters **Pr13**, **Pr14**, **Pr15**	Set at typical values

9.2 Motor parameters

Caution

The values of the following parameters affect the protection of the motor and the safety of the system.

Pr28 Motor magnetizing current

Pr29 Motor full load slip

Pr32 Motor base speed

Pr42 Motor maximum current

Pr45 Motor full load current

Pr95 Number of motor poles

To set-up the motor parameters, set b2 at 0. Make sure the values assigned to these parameters are relevant to the motor that is to be used. The default values should not be relied upon.

Keep a note of the values given to the motor parameters, since motor parameters are restored to their default values when parameter b5 is set at 1.

After restoring parameters to their default values, and before starting the Drive, re-enter the appropriate values of the motor parameters.

Note

The motor parameters should be set to within 10% of the required values for the motor. Failure to do this may result in poor response.

Example

A 15kW motor with the following data on the motor rating plate is to be controlled using Drive model SA038. The application requires a maximum of 150% overload.

Full load current = 30A
$\cos\phi = 0.87$
Rated speed = 1455 RPM
Frequency = 50Hz
Required Drive peak current = 57A

Pr45 — Nominal current

From the motor rating plate obtain the value of the full load current (I_{nom}). (This is the vector sum of the magnetizing current and the active (torque-producing) current.) The full load current is the maximum current that the motor can draw continuously without being damaged.

Refer to Chapter 2 *Data* for the value of peak current I_{pk} of the Drive.

Use the following equation to calculate the required value for **Pr45**:

$$Pr45 = \frac{I_{nom}}{I_{pk}} \times 100$$

$$Pr45 = \frac{30}{57} \times 100 = 52.6$$

Enter the value 53 in **Pr45**.

Pr28 — Motor magnetizing current

Obtain the magnetizing current (I_{mag}) of the motor from the manufacturer. Alternatively, obtain its value by measuring the current drawn at no load.

When measuring the current, disconnect the motor spindle from any load, and apply the voltage and frequency stated on the motor rating plate.

A third (less accurate) method of obtaining the magnetizing current is to calculate the following:

$$I_{mag} = I_{nom} \times \sqrt{(1 - \cos^2\phi)}$$

where ϕ is the power factor of the motor.

$$I_{mag} = 30 \times \sqrt{1 - \cos^2 0.87} = 14.8A$$

If an incorrect value is entered, the motor will either be over-excited (wasting energy), or under-excited (full torque will not be produced).

Refer to Chapter 2 *Data* for the value of peak current I_{pk} of the Drive.

Use the following equation to calculate the required value for **Pr28**:

$$Pr28 = \frac{I_{mag}}{I_{pk}} \times 100$$

$$Pr28 = \frac{14.8}{57} \times 100 = 26.0A$$

Enter the value 26 in **Pr28**.

Pr32 — Motor base speed

Motor base speed is the speed at which rated voltage is applied by the Drive to the motor.

Use the following equation to calculate the required value for **Pr32**:

$$Pr32 = \frac{(V_{supply} - 20) \times \text{Base speed in RPM}}{V_{motor}}$$

where:

V_{supply} = AC supply voltage
V_{motor} = Rated voltage of the motor

$$Pr32 = \frac{(415 - 20) \times 1455}{415} = 1385\,RPM$$

Enter thevalue 1385 in **Pr32**.

Pr29 — Full-load slip

Obtain the value of the full-load slip from the motor rating plate. Alternatively, obtain the value by measuring the motor speed at no-load and full-load.

Enter full-load slip as a value of RPM, as follows:

$$Pr29 = N_O - N_R$$

where:

N_0 = Motor speed in RPM at no load

N_R = motor speed in RPM at full load

$$Pr29 = 1500 - 1455 = 45\,RPM$$

Enter the value 45 in **Pr29**.

Pr95 — Number of motor poles

Enter 2, 4 or 8 in **Pr95** according to the construction of the motor. (Default setting: 4)

If this parameter is changed, the following procedure must be performed to make the change take effect:

1. Save the parameter values (by setting **b99** at 1).
2. Remove AC power from the Drive.
3. Wait 10 seconds, then re-apply AC power to the Drive.

9.3 Protection parameters

Pr42 — Maximum current

It is common in spindle applications for the motor to be required to tolerate a short-term current I_{max} in excess of the continuous full-load current, I_{nom}.

The value of I_{max} may be lower than the rated maximum current of the Drive, I_{pk}. **Pr42** can then be used to limit the maximum current that can be delivered by the Drive so that I_{max} for the motor is not exceeded.

Calculate the following:

$$Pr42 = \frac{I_{max}}{I_{pk}} \times 100$$

where:

I_{pk} = Rated current of the Drive
I_{max} = Maximum motor current

When 150% overload is required, the maximum current must be equal to 150% of the nominal current, (ie. I_{max} = 45A).

$$Pr42 = \frac{45}{57} \times 100 = 78.9$$

Enter the value 80 in **Pr42**.

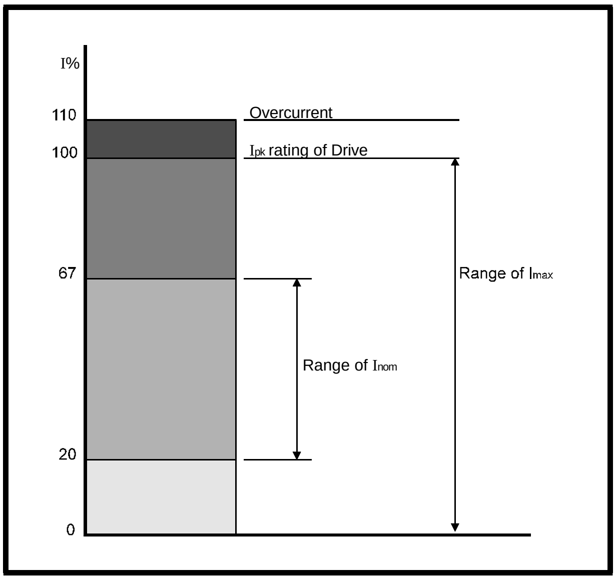


Figure 9–1 Relationship between maximum current (Pr42) and nominal current (Pr45)

The default value of **Pr42** is 100, which makes I_{max} equal to I_{pk}.

Pr45 — Nominal current

This is the maximum continuous current that can flow in the motor without overheating and possibly permanently damaging the motor. This value is entered in **Pr45**, and is calculated as the percentage of I_{pk}.

Pr80 — I^2t protection

The effect of the values of **Pr42** and **Pr45** on the operation of the Drive are important. When the motor current exceeds the value of $I_{nom,}$ (**Pr45**) the Drive starts integrating the current with respect to the time constant set in **Pr55**. This integrated value is displayed in **Pr80**. The Drive trips when the value of **Pr80** reaches 100%.

If the motor current drops below the value set in **Pr45**, the integrator starts to count down towards 0. This allows for short periods of high over-load to be tolerated, particularly during acceleration and deceleration cycles.

Current in excess of 110% of I_{pk} (which would indicate an abnormal condition such as a short-circuit or a ground fault in the motor circuit) activates a hardware trip circuit. Over-current trip **OC** is produced and the Drive output is disabled.

Analysis of the effective current

When the specifications of the mechanical system and of the duty cycle are known, it is possible to evaluate the effective current I_{eff} to verify whether it exceeds $\mathbf{I_{nom}}$ at any part of the cycle. It is possible then to calculate the amount of time spent in the overload region during a particular cycle, and determine when possible [Ixt] limiting will occur.

Taking the example operating cycle shown below:

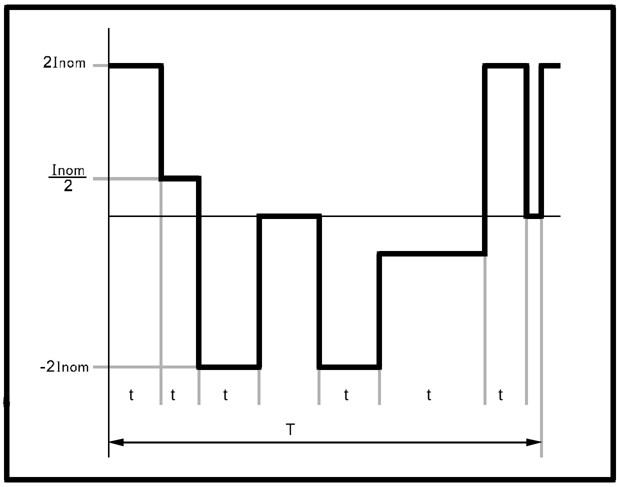


Figure 9–2 Example operating cycle

The effective current is given by:

$$\mathbf{Ieff} = \sqrt{\left(\frac{\mathbf{I_1^2 t_1 + I_2^2 t_2 + \ldots + I_6^2 t_6}}{\mathbf{T}}\right)}$$

where $\mathbf{I_1}$ to $\mathbf{I_6}$ are the current levels during time periods $\mathbf{t_1}$ to $\mathbf{t_6}$.

To ensure that short-term overload does not cause the $\mathbf{I^2t}$ integration to reach 100%, the calculated value of I_{eff} must not exceed the value of I_{nom}.

9.4 Methods of speed control

Any of the following three methods can be used as a speed reference:

- Analog input signal
- Digital input signal
- Frequency input signal

> **Caution**
> **Before changing the method of speed control, set parameter b2 at 0 to disable the Drive. The Drive can subsequently be enabled by setting b2 at 1.**

Using an analog speed reference

The speed of the motor is controlled by applying an analog speed reference voltage having a maximum range of ±10V to terminals B9 and B10. This voltage can be either a single-ended or differential signal. The maximum speed is set by the value of **Pr99**, but this can be trimmed using the full-scale speed potentiometer. This has a ±20% window of adjustment around **Pr99**.

Use the following procedure to set up the Drive for analog speed control:

1. Set parameter **b6** at 0.

2. Set parameter **b14** at 1.

3. Set parameter **b17** at 0.

Using a digital speed reference

The speed of the motor can be controlled by values in **Pr0**, **Pr1**, **Pr2** and **Pr3**. This allows for up to four pre-set speed settings. These values can be selected using any of the following methods:

- **Direct selection** using **Pr20**
- **Sequential selection** using **Pr19**
- **Digital input control** using terminals **B4** and **B5**

The permissible range of values is determined by the value programmed in **Pr99** as follows:

Value of Pr99	Maximum value of reference parameters
200 to 3000	3000
>3000	6000

Direct selection

1. Set **b6** at 0.

2. Set **b16** at 0.

3. Set **b17** at 1.

4. Set **Pr21** at 0.

Enter the required pre-set speed parameter in **Pr20** (eg. to select **Pr2**, enter 2 in **Pr20**) using serial communications or directly using the Control Keypad.

Sequential selection

1. Set **b6** at 0.

2. Set **b16** at 0.

3. Set **b17** at 1.

4. Set **Pr21** at 1.

The pre-set speeds are selected in sequence at intervals defined by **Pr19**.

Digital input control

1. Set **b6** at 0.

2. Set **b16** at 0.

3. Set **b17** at 1.

4. Set **Pr21** at 2.

The required parameter is selected by applying signals to the digital inputs as follows:

Parameter	Terminal	
	b4	b5
Pr0	0V	0V
Pr1	0V	+24V
Pr2	+24V	0V
Pr3	+24V	+24V

Using a frequency speed reference

The speed and direction of the motor are controlled by applying a pulse reference to terminal C7 and a direction signal to terminal C8. The speed of the motor is directly controlled by the frequency of the pulse reference signal.

Scaling is as follows:

When **Pr99** ≤3000,
409.6kHz gives 3000 RPM
When **Pr99** >3000,
409.6kHz gives 6000 RPM

Reliable operation at 409.6kHz occurs when the step height of the frequency input pulse train is ≥15V.

Make the following settings for frequency reference control:

1. Set **b14** at 0.
2. Set **b15** at 0.
3. Set **b17** at 0.

Ramps can be selected by setting **b7** at 1. When selected, all three methods of speed control will be subject to the ramps during changes in speed. All ramps (acceleration and deceleration in forward and reverse) are independently controlled, and can be set in terms of milliseconds per 1000 RPM in **Pr9**, **Pr10**, **Pr11** and **Pr12**.

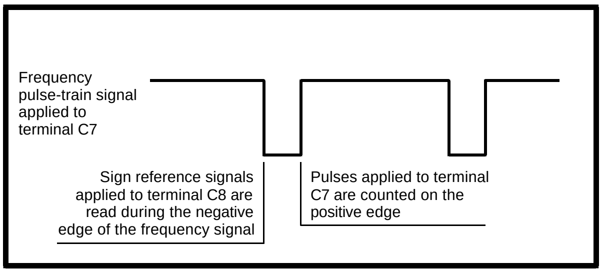


Figure 9–3 Interpretation of pulses using frequency reference control

9.5 Methods of torque control

Any of the following three methods can be used to run the Drive in torque control:

- Analog input signal
- Digital input signal
- Speed control with external torque limit

Warning

Before selecting torque control, set parameter b2 at 0 to disable the Drive, and ensure the motor is at standstill. The Drive can subsequently be enabled by setting b2 at 1.

Analog torque control

This mode of operation allows the shaft torque from the motor to be controlled using an analog reference applied to terminals B9 and B10. This input can also be used for master/slave applications where the motors or their loads are coupled together in some way to allow load sharing. The master Drive would be in speed control, and the current demand output from the master would be used as the torque reference for the slave.

Protection against excessive motor speed is given by the Drive tripping on trip **OS** if the speed set in **Pr58** is exceeded.

Use the following procedure to set the Drive in analog torque reference control:

1. Set **b2** at 0 to disable the Drive
2. Ensure the motor is stopped.
3. Set **b6** at 1 to select torque control.
4. Set **b8** at 0 to select analog torque reference

Digital torque control

The torque reference for the Drive is controlled by parameter **Pr8**, and is set as the percentage of I_{max}. The range of **Pr8** is –100 to +100; the maximum corresponds to the value of maximum current. (See **Pr42** in Chapter 10 *List of Parameters*). This allows the torque output to be controlled using serial communications.

Protection against excessive motor speed is given by the Drive tripping on trip **OS** if the speed set in **Pr58** is exceeded.

Use the following procedure to set the Drive for digital torque reference control:

1. Set **b2** at 0 to disable the Drive.
2. Ensure the motor is stopped.
3. Set **b6** at 1 to select torque control.
4. Set **b8** at 1 to select digital torque reference.

Speed control with external torque limit

Speed control with external torque limit allows the maximum speed to be controlled while the Drive is in torque control.

When the motor is under load, the Drive tries to run the motor at the speed set by the speed reference. It is prevented from doing so while the output current (torque) is limited by the value set by the torque input signal. When the load reduces sufficiently to reduce the output current to below the value set by the torque input signal, the motor speed attains the value set by the speed reference.

When parameter **b11** is set at 1, terminal B1 becomes an analog speed reference input, and controls parameter **Pr41**. This sets the value of current limit which in effect applies torque control to the motor.

Use the following procedure:

1. Set **b6** at 0 to select speed control. (See **Methods of speed control** for setting up the Drive for the required speed reference).
2. Set **b11** at 1 to select external torque limit.
3. Set **b56** at 0 to disable the external trip function of terminal B1.
4. Apply the required signal to terminal B1 (±10V gives torque limited to ±100% of I_{pk}). (See **Pr42**).

The instantaneous values of current limit are given as percentages of **Pr41**, and are shown in the following read-only parameters:

Pr39 Value of the analog current limit signal on terminal B1.

Pr40 Value of the analog current reference; this can be made available at terminal B16 as the Clamped Current Demand.

Pr41 Clamped Current Reference threshold, corresponding to the lowest of the values among **Pr42**, **Pr43**, and **Pr39**.

Pr80 Shows the value of the **I^2t** computation. **I^2t** limitation will occur when **Pr80** reaches 100.

9.6 Spindle orientation

This function allows the Drive to be stopped at a pre-defined position when under analog or digital speed reference control. The orientation position for the shaft is set in **Pr27**. The range of **Pr27** is 0 to 2047, giving a resolution of 0.176°. Spindle orientation can be initiated in either of two ways as follows:

Set **b53** and **b18** at 1 (Stop, orientate and hold with ramps) using serial communications.

Set **b53** at 1, and apply a Stop signal to terminal B6.

When a Stop signal is received, the motor decelerates to the orientation speed set in **Pr54**. The motor continues rotating in the same direction until the orientation position is reached.

Parameter **b41** (Shaft orientation) is set at 1 under the following condition:

Pr53 ≥ **Pr27** – **Pr83**

During orientation, the value of **Pr37** is used for the position loop gain.

9.7 Methods of stopping

Normal stop-and-hold

When a Stop signal is applied to terminal B6 (terminal B6 can alternatively be controlled by **b88**), or **b18** is set at 1, the Drive brings the motor to standstill, but the Drive does not become disabled. The motor can be stopped without deceleration ramp (stopping under current limit), or ramps can be included to make the stop smoother. This keeps the motor under torque control, and consequently holds the motor at the stopped position. The motor stops at a random position unless some external control loop is used.

Ramps are selected by setting **b22** at 1. When a Stop signal is received, the Drive decelerates the motor at the rate given in **Pr11** or **Pr12**. Selection of ramps for stop-and-hold mode is independent of whether ramps are selected to act on the speed reference.

Use the following procedure to select Stop-and-hold mode:

1. Configure terminal B6 as follows for the voltage sense of the Stop signal:

b88 setting	Stop signal
0	+24V
1	0V

2. Set **b22** at 1 for stopping with ramps.

3. Set **Pr11** and **Pr12** for deceleration rate in milliseconds per 1000 RPM.

Limit switch stop-and-hold

When a limit-switch is triggered, the Drive inhibits rotation in that direction, and stops the motor. The motor can be stopped without deceleration ramp (stopping under current limit), or ramps can be included to make the stop smoother. When the motor has stopped, the Drive will keep the motor in torque to prevent the mechanical system from moving past the end-stop.

Ramps are selected by setting **b23** at 1. When the limit-switch is activated, the Drive decelerates the motor at the rate set in **Pr11** or **Pr12**. Selection of ramps for the limit-switch stop-and-hold mode is independent of whether or not ramps are selected to act on the speed reference.

Use the following proceudre to configure the limit-switch stop functions:

1. Set **b16** at 1.
2. Set **b23** at 1 to select ramps.
3. Apply the limit-switch signals as follows:

Limit-switch	**Terminal**	
	B4	**B5**
Forward	X	0
Reverse	0	X

0 = logic 0 = 0V = Stop
(X = don't care)

Stop, hold and orientate

See *Spindle orientation* earlier in this chapter.

9.8 Quick reference

Note

A maximum speed limit is programmable in Pr58. The Drive is disabled if the motor speed exceeds the programmed value.

Speed control

Make the following settings:

Type of speed reference	b6	b14	b15	b17
Analog	0	1	X	0
Digital	0	X	X	1
Frequency	0	0	0	0

Ramps can be applied to all types of speed reference by setting **b7** at 1.

Torque control

Make the following settings:

Type of torque reference	b6	b8	b11	b56
Analog	1	0	0	1
Digital	1	1	0	1
Speed control with external torque limit	0	X	1	0

9.9 Programmable outputs

Programmable digital outputs

The digital outputs on terminals B7 and B8 can be configured to show the state of a bit parameter. These signals can then be used to indicate the present status of the Drive.

Terminal B7 is selected using **Pr30**.

Terminal B8 is selected using **Pr31**.

The following parameters can be selected for terminals B7 and B8:

Pr30 Pr31	**Parameter**	**Indication**
0	**b89**	I^2t integrating (alarm)
1	**b91**	Over-temperature (pre-alarm)
2	**b84**	Over-current (alarm)
3	**b38**	Direction of motor rotation
4	**b41**	Motor status (running/stopped)
5	**b42**	At-speed status
6	**b48**	Speed loop saturation status

Programmable analog output

The analog output on terminal B16 can be configured to produce an analog signal proportional to one of the following:

- Motor current
- Clamped current demand
- Post-ramp speed reference

Make the following settings to select the required indication:

b12	**b13**	**Parameter**	**Indication**
1	X		Motor current. Scaling: 16V pk−pk = $I_{peak\text{-}peak}$
0	0	Pr40	Clamped current demand. This output can be used as the torque reference for a slave Drive (See Methods of torque control). Scaling: ±10V = ±100% of I_{max}
0	1		Post-ramp speed reference. Scaling: ±5V = ±6000 RPM

The output from terminal B17 is the analog tachogenerator signal.

9.10 Speed calibration

The Drive requires a 10V input signal for maximum speed. Some motion controllers produce an output signal of 8V to 9V for maximum speed demand, reserving a margin of 1V to 2V to cover tracking errors. The scaling of the input speed reference is set in **Pr99** in steps of 200 or 400 RPM. The full-scale speed calibration potentiometer allows the full-scale speed to be adjusted to produce the correct speed for a specified speed reference input signal.

Setting the scaling in Pr99

To find the required value of **Pr99**, use the following equation:

$$Pr99 = \frac{V_{ref} \times n_{max}}{V_{out}}$$

where:

V_{ref} = Maximum speed reference signal of the Drive

n_{max} = Required maximum speed (2400 RPM)

V_{out} = Output of the controller corresponding to maximum speed.

Taking the case of a controller which produces an 8V reference signal for a required speed of 2400 RPM, the equation becomes as follows:

$$Pr99 = \frac{10 \times 2400}{8} = 3000$$

After the value has been entered in **Pr99**, set the controller output at maximum to apply the maximum speed reference signal to the Drive. Trim the speed to the exact value using the full-scale speed potentiometer.

Pr6 — Zero-speed offset

An offset in the speed reference signal will cause the motor to rotate slowly when zero speed is demanded. To compensate for this offset, enter the resulting motor speed in **Pr6** to the nearest 0.1 RPM.

9.11 Resolver phasing

Motor and resolver assemblies are supplied with correct phasing. Use the following procedure only when you are unsure of the phasing of a motor and resolver.

Warning

Disconnect the motor shaft from the driven load before using this procedure. During this procedure, the Drive will apply rated current to the motor. It is essential that Pr45 is set correctly, or the Drive may damage the motor.

1. Set parameter **b2** at 0.
2. Apply +24V to terminal B14.
3. Set parameter **b49** at 1. The motor shaft rotates at approximately 60 RPM.
4. If the motor shaft rotates anticlockwise when viewed from the shaft end of the motor, remove AC power from the Drive. Reverse any two motor phase connections. Repeat the procedure.
5. Check that the value of **Pr83** increases while the motor rotates. If this is not the case, remove AC power from the Drive. Check the resolver connctions. Repeat the procedure.

The resolver signal is now in phase with the motor.

9.12 Commissioning

Use the following procedure:

1. Remove the connections from terminals B9 through B17.
2. Apply AC power to the Drive. Check the display first shows **02.xx**, then **CAL**, then **rdY**.
3. If the Drive is being controlled by serial communications, check the correct transmission format is being used.
4. Unless the **Hold zero speed** function is required, disconnect terminal **B6** and check the value of **b18** (digital stop selector) is **0** (default value).
5. Replace the connections that were removed in step **1**. Make sure that all terminals are fully tightened on the Drive, motor and resolver.
6. Connect the motor to the load. Perform typical working cycles for a period of at least 15 minutes. Check the following:

   If the value of **b33** = 0, at least one alarm condition exists. Investigate as necessary.
   If the value of **b89** = 1, the Drive has entered the **I^2t** region. The value of **I^2t** is displayed in **Pr80** as a percentage (fully-integrated value = 100). It may be necessary to change the setting of **Pr45**, or reduce the duty cycle to reduce the effective current I_{eff}.

9.13 PID-loop calibration

In most cases, only small changes will be needed to the values of the PID and speed-loop parameters to optimize the system for the application. If a large change is necessary (for example, due to a load inertia greater than three-times the motor inertia), use the following procedure:

Warning

During calibration, the motor is required to Drive the load. Take care to ensure the following:

- **It is safe for the machinery to be operating**
- **The limit switches are not over-ridden**

The default values of the dynamic parameters (PID) are valid for typical spindle applications. It is recommended that the PID functions should not be disturbed until the Drive is commissioned and its behaviour during a normal duty cycle has been observed. The PID parameters are as follows:

Parameter	Default value	Function
Pr13	100	Proportional gain Range 0 to 255 Resolution 1
Pr14	0	Derivative gain Range 0 to 128 Resolution 1
Pr15	5	Integral gain Range 0 to 255 Resolution 1
Pr7	2	Speed-loop bandwidth limit Range 1 to 7 (320Hz to 5Hz)

Procedure

Preliminary settings

1. Connect the motor to the load.
2. Set **b7** at 0 (no ramps).
3. Set **b18** at 0.
4. Set **Pr58** at maximum speed + 10%.
5. Ensure that **Pr99** is set for the full-scale speed of the motor.

Digital reference settings

1. Set **b17** at 1.
2. Set **Pr0** at 0.
3. Set **Pr1** at **Pr58** ÷ 5.
4. Set **Pr2** at 0.
5. Set **Pr3** at − (**Pr58** ÷ 5).
6. Set **Pr19** at 2.5 (0.2Hz).

   Note that this setting depends on the transmission ratio and the mechanical limitations of the system.
7. Set **Pr21** at 1.

Analog reference settings

1. Set **bl7** = 0.

Connecting the terminals

1. Disconnect terminal B6 (programmable input).
2. Disconnect terminals B9 and B10 (analog reference input).
3. Link terminal B9 to terminal B11 (zero volts).
4. Set up a signal generator to deliver the following output:

   Square-wave

   Amplitude: −2V to +2V

   Frequency: 0.2Hz
   (See step 6 of *Digital reference settings*)
5. Connect the non-inverted output of the signal generator to terminal B10, and the common to terminal B11.
6. Set up an oscilloscope as follows:

   Both channels at 1V per division

   Timebase at 20ms per division

   Channel B trigger
7. Attach probe **A** of the oscilloscope to terminal B16, and probe **B** to the signal generator output. Attach the ground clips of the probes to terminal B11 or B18 (0V common)

Note

During the next stage, the Drive will cause the motor shaft to oscillate. Adjustment may be made as follows:

Using an analog reference signal

If the amplitude of oscillation is excessive, increase the signal generator frequency. If the speed is too high, reduce the signal generator output voltage to not less than ±1V.

Using a digital reference

If the speed is excessive, decrease the values of **Pr0**, **Pr1**, **Pr2**, **Pr3**. Decrease the value of **Pr19** to reduce the scan time.

Setting the PID gains

1. Apply +24V to terminal B14 and set **b2** at **1** to enable the Drive.

Check the waveform on the oscilloscope. If the waveform is similar to that shown in Figure 9–4 the proportional gain is too low.

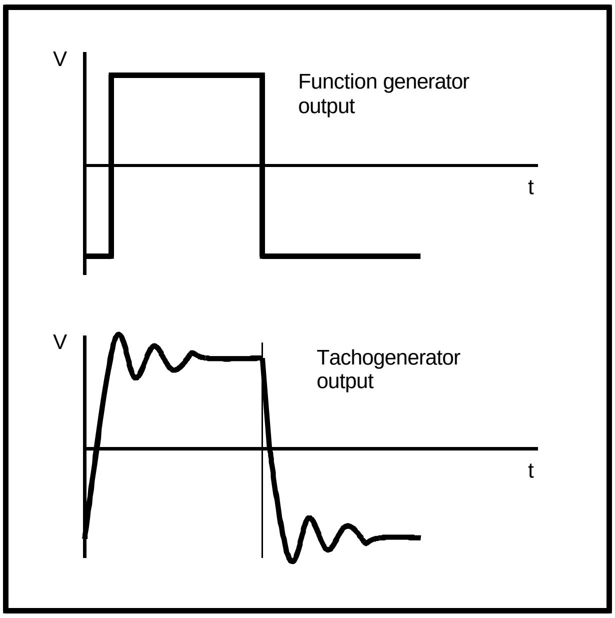


Figure 9–4 Waveform resulting from proportional gain being too low

Increasing the value of **Pr13** (proportional gain) will achieve a waveform similar to that shown in Figure 9–5, which shows low derivative gain.

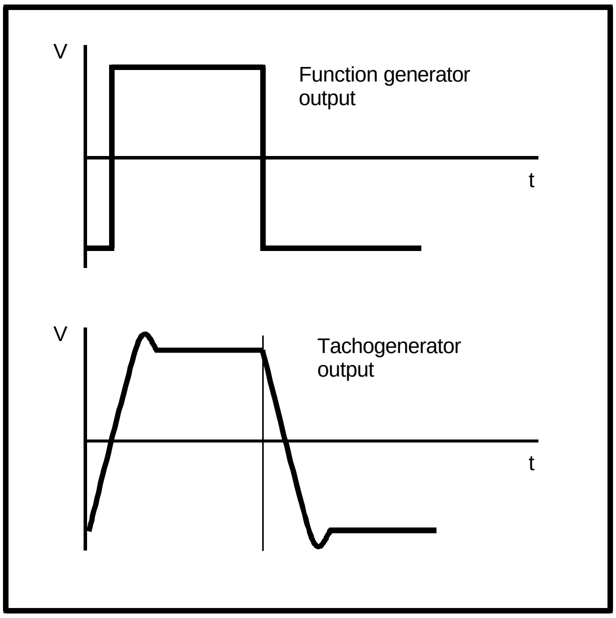


Figure 9–5 Waveform resulting from derivative gain being too low

Increasing the value of **Pr14** (derivative gain) will reduce overshoot at the expense of increased current and possibly increased heating of the motor. An ideal response can be achieved as shown in Figure 9–6.

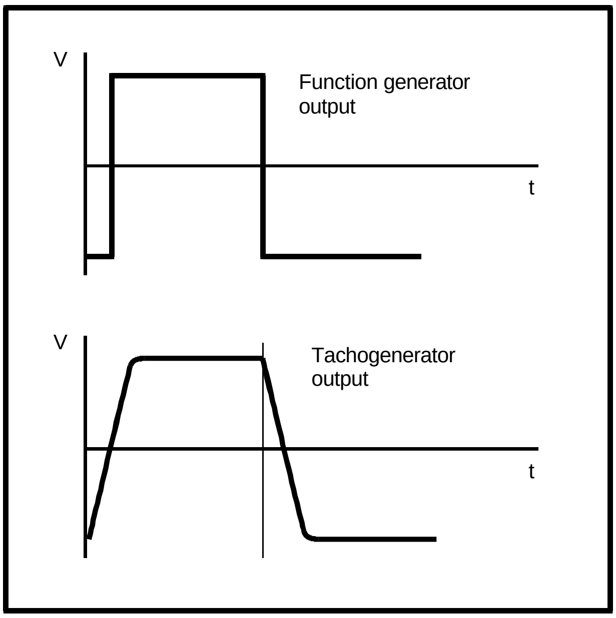


Figure 9–6 Waveform showing ideal response

Excessive derivative gain can have the following effects:

Excessive heating of the motor due to extra current

Motor shaft oscillation $\mathbf{I_{2t}}$ current limiting

Reduced speed of response as shown in Figure 9–7

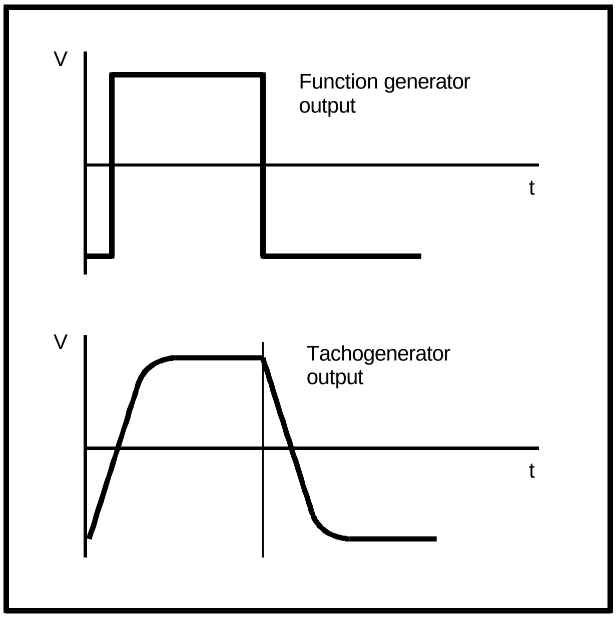


Figure 9–7 Reduced speed of response caused by excessive derivative gain

Pr15 (integral gain) is not likely to require adjustment. If adjustment is required, the value must not exceed 250. If stability of position control or anomalous responses to stop signals persist, check the operation of the position controller.

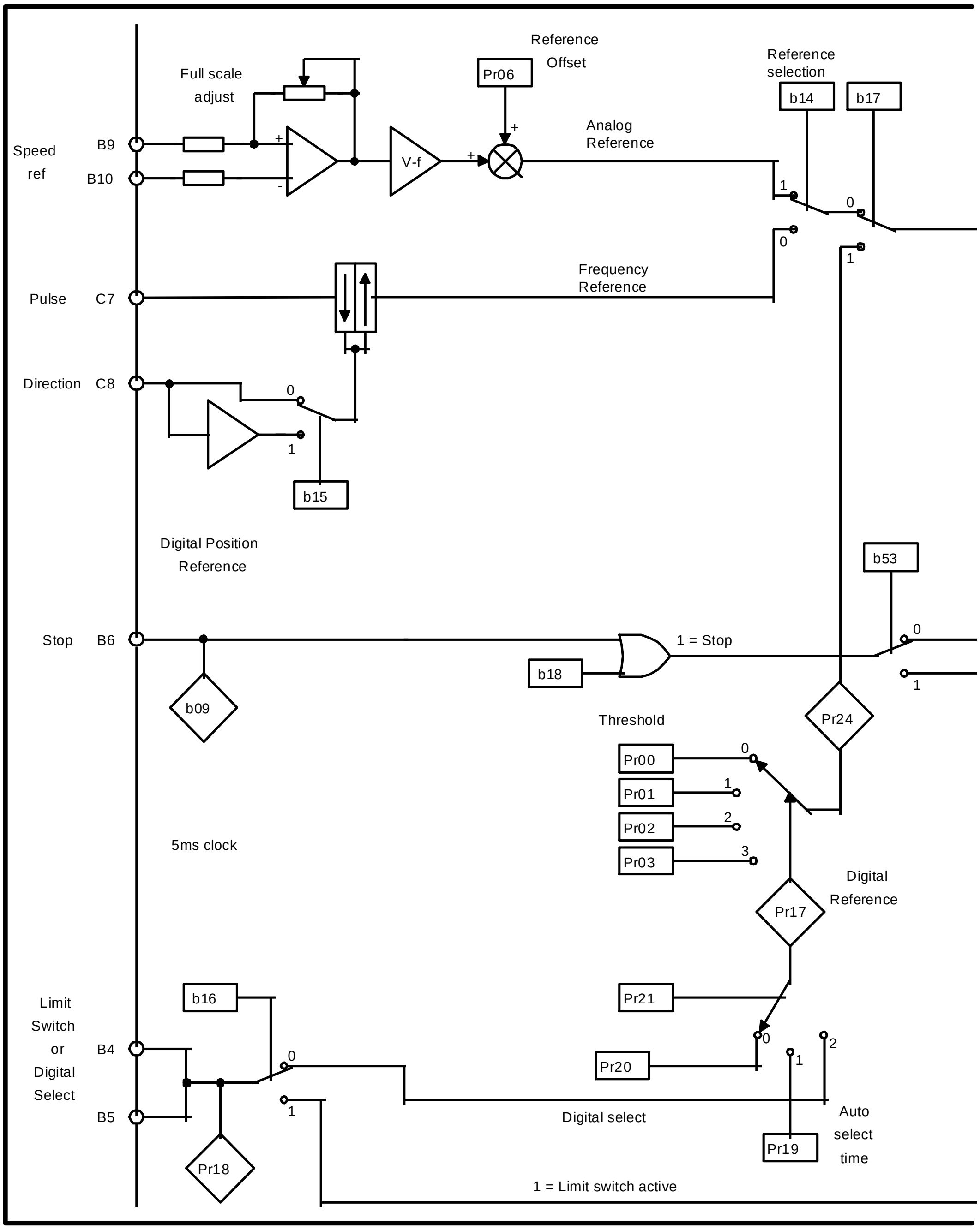
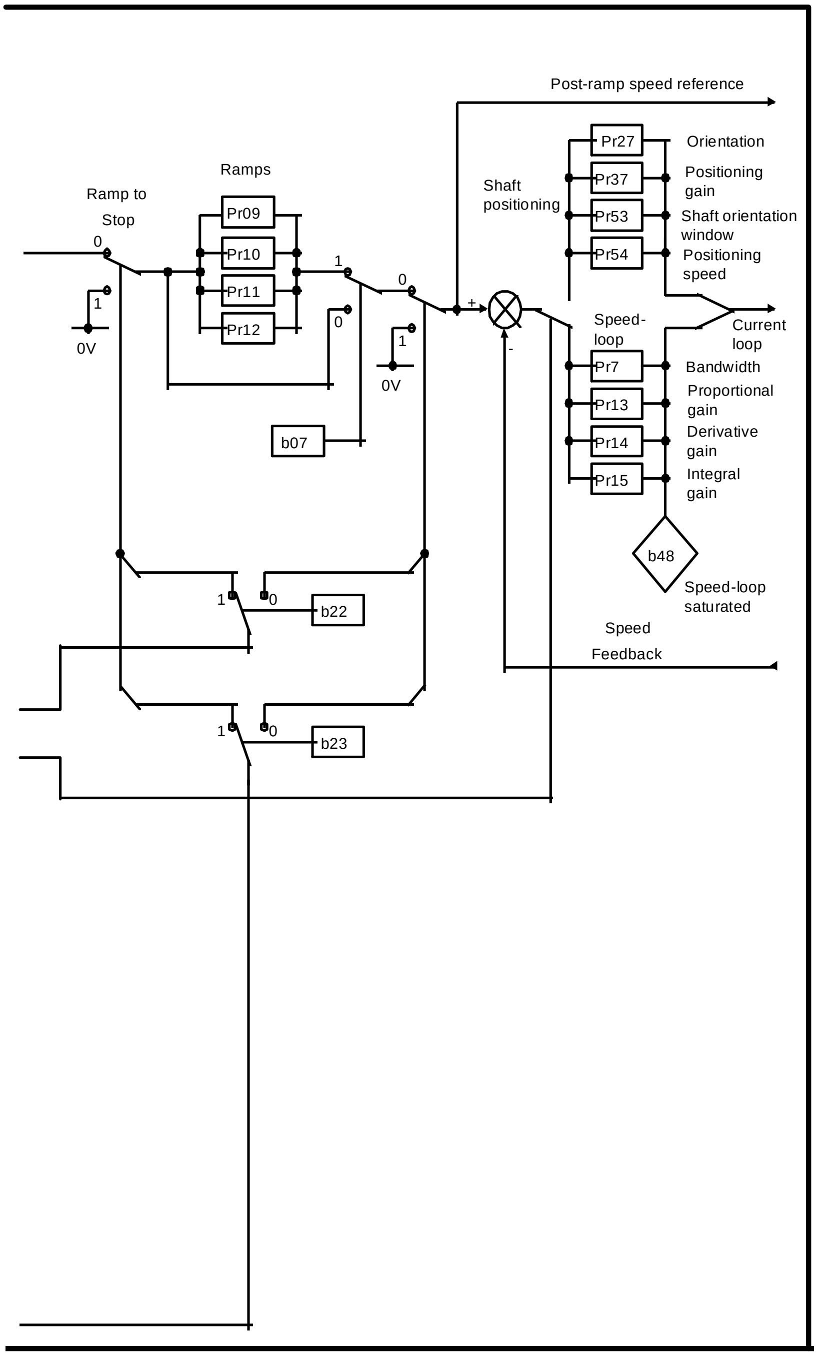


Figure 9–8 Logic diagram showing speed reference selection and position control


Post-ramp speed reference
Ramps
Ramp to
Stop
0
1
0V
Pr09
Pr10
Pr11
Pr12
1
0
0
1
0V
b07
Shaft
positioning
Pr27
Pr37
Pr53
Pr54
Orientation
Positioning
gain
Shaft orientation
window
Positioning
speed
+
-
Speed-
loop
Current
loop
Pr7
Pr13
Pr14
Pr15
Bandwidth
Proportional
gain
Derivative
gain
Integral
gain
b48
Speed-loop
saturated
1
0
b22
Speed
Feedback
1
0
b23

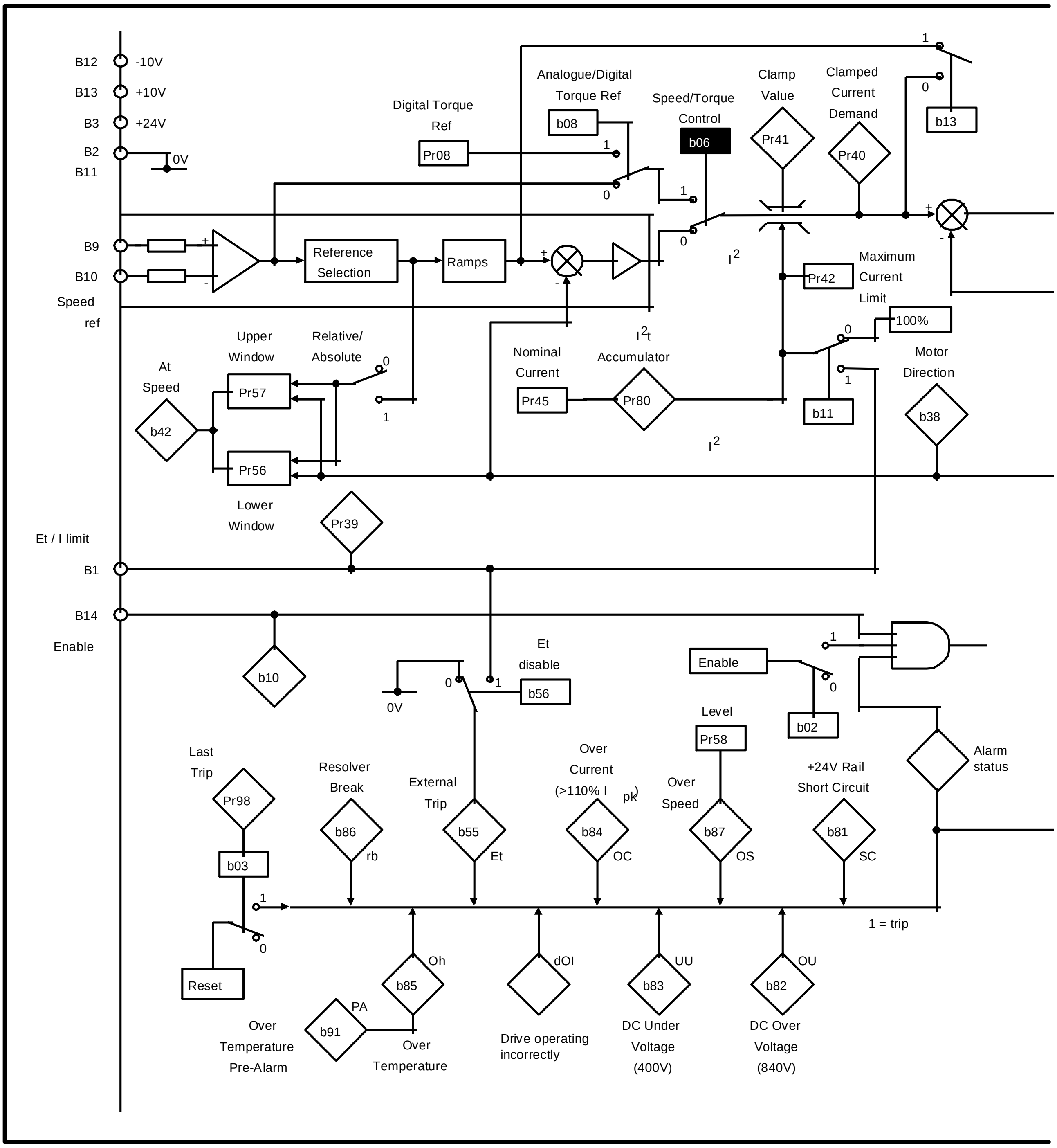
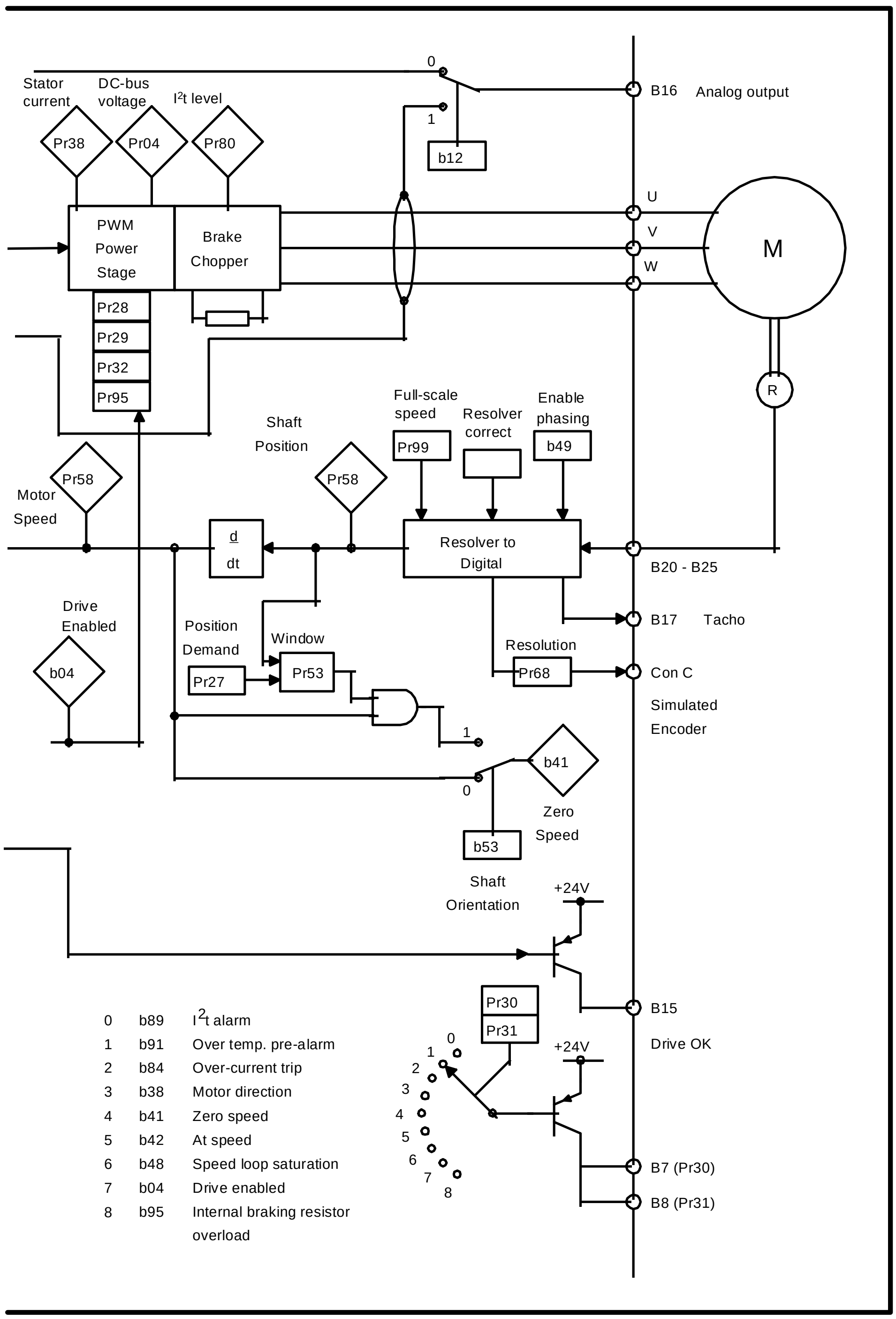


Figure 9–9 Logic diagram showing the torque loop, trip logic and I/O



Stator current
DC-bus voltage
I2t level
Pr38
Pr04
Pr80
0
1
b12
B16
Analog output
PWM Power Stage
Brake Chopper
U
V
W
M
Pr28
Pr29
Pr32
Pr95
R
Full-scale speed
Resolver correct
Enable phasing
Pr99
b49
Shaft Position
Pr58
Motor Speed
Pr58
d
dt
Resolver to Digital
B20 - B25
B17
Tacho
Drive Enabled
Position Demand
Window
Pr27
Pr53
Resolution
Pr68
Con C
Simulated Encoder
b04
1
0
b41
Zero Speed
b53
Shaft Orientation
+24V
B15
Drive OK
Pr30
Pr31
+24V
B7 (Pr30)
B8 (Pr31)
0 b89 I2t alarm
1 b91 Over temp. pre-alarm
2 b84 Over-current trip
3 b38 Motor direction
4 b41 Zero speed
5 b42 At speed
6 b48 Speed loop saturation
7 b04 Drive enabled
8 b95 Internal braking resistor overload

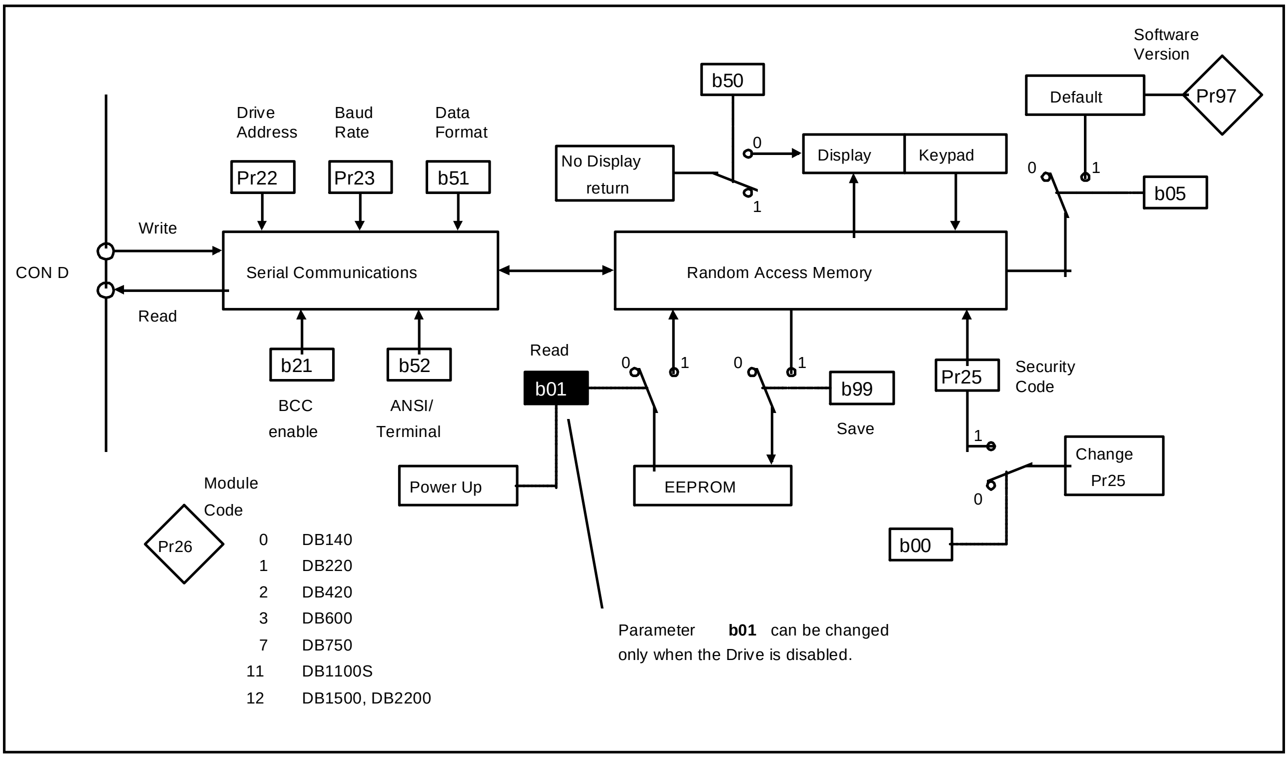


Figure 9–10 Select pulse offset control switching, or limit-switch function

10 List of Parameters

10.1 Variable parameters

Note

R–W = Read–write parameter
RO = Read-only parameter

Selection of **Pr0**, **Pr1**, **Pr2**, and **Pr3** is controlled by **Pr17**, which receives its coding from the values of **Pr18**, **Pr19** and **Pr20**, as selected by **b16** and **Pr21**. Refer to **Pr17**, **Pr18**, **Pr19**, **Pr20**, **Pr21** and **b16**.

Pr0	**Programmable digital speed reference**					R–W
(Range: see below)	RPM	Def. val.	0	Res.	1	

−3000 to 3000 RPM when **Pr99** = 200 to 3000
−9000 to 9000 RPM when **Pr99** = 3600 to 9000

Pr1	**Programmable digital speed reference**					R–W
(Range: see below)	RPM	Def. val.	0	Res.	1	

−3000 to 3000 RPM when **Pr99** = 200 to 3000
−9000 to 9000 RPM when **Pr99** = 3600 to 9000

Pr2	**Programmable digital speed reference**					R–W
(Range: see below)	RPM	Def. val.	0	Res.	1	

−3000 to 3000 RPM when **Pr99** = 200 to 3000
−9000 to 9000 RPM when **Pr99** = 3600 to 9000

Pr3	**Programmable digital speed reference**					R–W
(Range: see below)	RPM	Def. val.	0	Res.	1	

−3000 to 3000 RPM when **Pr99** = 200 to 3000
−9000 to 9000 RPM when **Pr99** = 3600 to 9000

Pr4	**Voltage level of DC bus**					RO
0 to 1024	V	Def. val.		Res.	4	

Pr6	**Analog reference input offset**					R–W
−50.0 to +50.0	RPM	Def. val.	0	Res.	0.1	

Adjustment of **Pr6** permits the user to apply a correction to offset in the analog speed reference which would cause slow rotation of the motor when zero speed is intended.

Pr7	**Speed loop bandwidth limit**					R–W
1 to 7	RPM	Def. val.	2	Res.	1	

Used in conjunction with **Pr13**, **Pr14**, **Pr15** to minimize instability of the speed loop caused by resonance in the mechanical transmission, or by high inertia of the driven load.

Value of Pr7	Bandwidth limit
1	320Hz
2	160Hz
3	80Hz
4	40Hz
5	20Hz
6	10Hz
7	5Hz

Pr8	**Digital current reference**					R–W
± 100	%	Def. val.	0	Res.	1	

User-programmable current reference, entered as a percentage of I_{pk}. The polarity indicates the direction of motor rotation.

Pr9	**Acceleration ramp – forward**					R–W
1 to 3000	ms	Def. val.	200	Res.	1	

Slope in milliseconds per 1000 RPM.

Pr10	**Acceleration ramp – reverse**					R–W
1 to 3000	ms	Def. val.	200	Res.	1	

Slope in milliseconds per 1000 RPM.

Pr11	**Deceleration ramp – forward**					R–W
1 to 3000	ms	Def. val.	200	Res.	1	

Slope in milliseconds per 1000 RPM.

Pr12	Deceleration ramp — reverse				R–W
1 to 3000 ms	Def. val.	200	Res.	1	

Slope in milliseconds per 1000 RPM.

Pr13	Proportional gain				R–W
0 to 255	Def. val.	100	Res.	1	

Pr14	Derivative gain				R–W
0 to 128	Def. val.	0	Res.	1	

Pr15	Integral gain				R–W
0 to 255	Def. val.	5	Res.	1	

Pr17	Digital reference				RO
0 to 3	Def. val.		Res.		

Indicates the reference selected by **Pr21**.

Pr18	Digital input configuration (terminals B4 and B5)				RO
0 to 3	Def. val.		Res.		

Indicates the signal levels on terminals B4 and B5.

Terminal		Pr18
B4	B5	
0V	0V	0
0V	+24V	1
+24V	0V	2
+24V	+24V	3

Pr19	Digital reference scan time				R–W
0.1 to 600.0s	Def. val.	10.0s	Res.	0.1	

Pr20	Digital reference selector				R–W
0 to 3	Def. val.	0	Res.	1	

Directs **Pr17** to select from **Pr0**, **Pr1**, **Pr2**, or **Pr3**.

Pr20	Selected reference parameter
0	Pr0
1	Pr1
2	Pr2
3	Pr3

Pr21	Digital reference selector enable				R–W
0, 1 or 2	Def. val.	0	Res.	1	

Pr21	Enables...
0	Digital selector **Pr20**
1	Time selector **Pr19**
2	Digital inputs (when **b16** = 0)

Pr22	Drive address				R–W
1 to 32	Def. val.	1	Res.	1	

Required when serial communications are used.

Pr23	Baud rate				R–W
300 to 19200	Def. val.	9600	Res.		

This parameter can be set only at the control keypad, not by using serial communications.

Available values are as follows:

300, 600 1200, 2400, 4800, 9600, 19200

The host computer must be set at the same Baud rate as the Drive.

Pr24	Digital run reference				RO
±9000 RPM	Def. val.		Res.	1	

Indicates the value of the selected digital reference in RPM at the start of the speed loop.

Pr25	Security code				R–W
1 to 9999		Def. val.	0	Res.	1

Write protection of parameters. Refer to Setting up a security code in Chapter 8 *Security*.

Pr26	Drive model code				RO
0, 1, 2, 3, 7, 11, 12, 13		Def. val.		Res.	

SA005 = 1
SA010 = 2
SA016 = 7
SA022 = 11
SA038 to SA059 = 12
SA091 to SA150 = 13

Pr27	Shaft orientation function in resolver steps				R–W
0 to 2047	stops	Def. val.	0	Res.	1

Determines the shaft orientation as directed by either **b18** or the reference input applied to terminal B6 when **b53** = 1. See **Pr37**, **Pr53**, **Pr54**, **Pr83**, **b41**.

Pr28	Motor magnetizing current				R–W
10% to 60	%	Def. val.	26%	Res.	1

Determines the value of magnetizing current for the motor, as a percentage of I_{pk}.

Pr29	Full load slip				R–W
0 to 500	RPM	Def. val.	100	Res.	1

The motor slip at rated speed and rated load. This can be expressed as **Pr29** = $N_0 - N_r$

where:

N_0 = the no load motor speed (in RPM)
N_r = the full load motor speed (in RPM)

Pr30	Digital output selector 1				R–W
0 to 6		Def. val.	0	Res.	1

Selects the parameter value presented at terminal B7.

Pr30	Selects...
0	I^2t alarm (**b89**)
1	Temperature pre-alarm (**b91**)
2	Current limit alarm (**b84**)
3	Indication of present direction (**b38**)
4	Indication of motor stopped (**b41**)
5	Indication of At Speed (**b42**)
6	Indication of speed loop saturation (**b48**)

Pr31	Digital output selector 0				R–W
0 to 6		Def. val.	1	Res.	1

Selects the parameter value presented at terminal B8.

Pr31	Selects...
0	I^2t alarm (**b89**)
1	Temperature pre-alarm (**b91**)
2	Current limit alarm (**b84**)
3	Indication of present direction (**b38**)
4	indication of motor stopped (**b41**)
5	Indication of motor at-speed (**b42**)
6	Indication of speed loop saturation (**b48**)

Pr32	Motor base speed				R–W
100 to 10000	RPM	Def. val.	1500	Res.	1

Motor speed when rated voltage is applied. This determines the voltage/frequency characteristic below base speed.

Pr37	Orientation (position) loop gain				R–W
0 to 50		Def. val.	12	Res.	1

When the orientation function is selected (Normal stop while **b53** = 1), the Drive automatically sets the orientation loop gain.

Pr38	Stator current				RO
		Def. val.		Res.	

Indicates the value of motor current when the motor speed is not greater than base speed. Value is always positive as % of I_{pk}.

Pr39	Analog current input				RO
		Def. val.		Res.	

Indicates the value of the reference voltage on analog input terminal B1. −100% to +100% represents −10V to +10V.

Pr40	Clamped current demand				RO
−100 to +100	%	Def. val.		Res.	1

Indicates the value of the current after limiting by **Pr41**.

Pr41	Current limitation value				RO
0 to +100	%	Def. val.		Res.	1

Indicates the lowest value set in the following parameters:

- I^2t limit (**Pr43**)
- Analog limit (rectified) (**Pr39**) when **b11** = 1
- Digital limit **Pr42**

0 is shown when the Drive is disabled

Pr42	Maximum current limit				R−W
0 to 100	%	Def. val.	100	Res.	1

Sets the maximum peak motor current (I_{max}) available from the Drive, as a percentage of I_{pk}.

Pr43	I^2t limit				RO
0 to 100	%	Def. val.		Res.	1

When **Pr43** = 100, this indicates current is not in I^2t region

When **Pr43** shows the percentage of I_{pk}, the current is in the I^2t region

Pr44	TPRC (Test Point Requested Current) value				RO
		Def. val.		Res.	

Indicates the value of the TPRC when the motor is operating at nominal torque output.

Pr45	Nominal current				R−W
20% to 67	%	Def. val.	50	Res.	1

Sets the maximum continuous motor current (I_{nom}) available from the Drive, as a percentage of I_{pk}.

Pr53	Shaft orientation window				R−W
0 to 100	stops	Def. val.	10	Res.	1

Defines a window either side of the value programmed in **Pr27** within which it is assumed that the motor shaft is correctly orientated when stop is selected while **b53** = 1. See **Pr27**.

Pr54	Speed reference during orientation				R−W
10 to 200	RPM	Def. val.	150	Res.	1

Speed in RPM adopted during shaft orientation. See **Pr27**.

Pr56	Motor At-speed window — lower limit				R−W
±9000	RPM	Def. val.	−5	Res.	1

Refer also to **Pr57**, **b42** and **b96**.

Pr57	Motor At-Speed window — upper limit				R−W
±9000	RPM	Def. val.	5	Res.	1

Refer also to **Pr56**, **b42** and **b96**.

Pr58	Maximum speed limit				R−W
0 to 12000	RPM	Def. val.	3200	Res.	1

If the motor exceeds this limit, an over-speed trip occurs. See **b87**.

Pr59	Motor speed				RO
±12000 RPM		Def. val.		Res.	1

Pr68	Simulated encoder output resolution				R–W
0 to 3		Def. val.	1	Res.	

Pr68	Pulses per revolution
0	256
1	512
2	1024
3	2048

Note

Maximum speed is 3000 RPM.

Pr80	I²t level				RO
0 to 100 %		Def. val.		Res.	0.1

Displays values corresponding to the percentage set in **Pr42**. I²t limiting is activated at 100%.

Pr83	Rotor position				RO
0 to 2047		Def. val.		Res.	1

See **Pr27**.

Pr95	Number of motor poles				R–W
		Def. val.	4	Res.	

Enter the number of motor poles from 2, 4, or 8.

Pr97	Software version number				RO
		Def. val.		Res.	

This manual applies to V2.XX.XX software

Pr98	Last alarm store				RO
		Def. val.		Res.	

Displays the cause of the last trip. **Pr98** is set at zero when the Drive is reset (**b3** set at 1). When **Pr98** is interrogated using serial communications, a number representing the trip is sent to the host computer. The numbers are as follows:

Pr98	Trip
0	Drive normal
1	Overvoltage
2	Undervoltage
3	Overcurrent
4	Overtemperature
5	Resolver circuit break
6	I²t Integrating
7	Temp pre-alarm
8	Overspeed
9	Short Circuit
10	External trip
11	Internal fault

Pr99	Speed — full scale				R–W
200 to 3000 RPM 3000 to 9000		Def. val.	3000	Res.	200 600

10.2 Bit parameters

b0	Enable change of security code				R–W
0 or 1		Def. val.	0	Res.	

Enables the security code to be changed to any valid number. Refer to **Pr25**.

b1	Recall last parameter settings from EEPROM				R–W
0 or 1		Def. val.	0	Res.	

Return to the last-written parameter values. Set **b2** at 0 to enable this parameter. The display will show **rEAd** while the parameters are recalled. Related to **b5** and **b99**.

b2	Drive enable				R–W
0 or 1		Def. val.	1	Res.	

b2	Drive state
0	Disabled
1	Enabled

Refer to terminal B14.

b3	Alarm reset				R–W
0 or 1		Def. val.	0	Res.	

Accepts and cancels any alarm or trip, and resets the last alarm store. Refer to **Pr98**.

Note

Before resetting the alarm, set **b2** at 0 or apply 0V to terminal B14 to disable the Drive.

b4	Drive enable status				RO
		Def. val.		Res.	

b4	Indicates...
0	Drive is disabled by one of the following: b2 set at 0 Alarm trip 0V applied to terminal B14)
1	Drive is enabled

b5	Recall default values from PROM				R–W
0 or 1		Def. val.	0	Res.	

Recalls the default values of all parameters from PROM and enters them in RAM for immediate application. Display will show **dEf** while defaults are restored. Related to **b1** and **b99**.

b6	Reference selector				R–W
0 or 1		Def. val.	0	Res.	

b6	Reference selected
0	Speed loop output
1	Analog or digital current reference

Refer to **b8**.

Warning

Change the value of **b6** only when the Drive is disabled by setting **b2** at 0, and the motor is stopped.

b7	Enable accel/decel ramps				R–W
0 or 1		Def. val.	0	Res.	

Change speed with or without ramps.

b7	Selects...
0	Ramps are disabled
1	Ramps are enabled

b8	Current reference mode selector				R–W
0 or 1		Def. val.	0	Res.	

b9	Digital stop function status				RO
		Def. val.		Res.	

Indicates the logic level present on terminal B6.

Terminal B6	Parameter b53	Parameter b22	Stop function
0V	X	X	Select using software only Refer to **b18**
+24V	1	X	Stop in position
+24V	0	0	Hold zero speed without ramps
+24V	0	1	Hold zero speed with ramps

Refer to **b18**.

b10	Digital enable state				RO
		Def. val.		Res.	

Indicates the logic state at input terminal B14.

Logic state at terminal B14	Parameter b10	Drive state
0	0	Not enabled
1	1	Enabled

b11 Current limit selector (R–W)

0 or 1	Def. val.	0	Res.	

Selects the current limit.

b11	Selects...
0	Current limit is I_{max}
1	Current limit is determined by the signal applied to terminal B1

b12 Analog output selector (R–W)

0 or 1	Def. val.	0	Res.	

Selects the analog output signal to be produced at terminal B16.

b12	Selects...
0	(Refer to b13)
1	Output signal represents the motor current (16V pk-pk ≡ I_{peak})

b13 Analog Output Selector (R–W)

0 or 1	Def. val.	0	Res.	

Selects the signal source when **b12** is set at 0.

b13	Selects...
0	Clamped current demand **Pr40** (±10V ≡ ±100%)
1	Post-ramp speed reference (5V ≡ 6000 RPM demand)

b14 Reference selector (R–W)

0 or 1	Def. val.	1	Res.	

Selects the speed reference.

b17	b14	Selects...
0	1	Analog speed reference (±10V) (terminals B9 and B10)
1	0	Frequency reference (terminal C7) Frequency scaling: 409.6 kHz at terminal C7 ≡ full scale speed (**Pr99**).

b15 Reverse polarity of sign signal (R–W)

0 or 1	Def. val.	0	Res.	

Reverses the polarity of the sign input signal at terminal C8.

b15	Selects...
0	Logic 1 produces forward rotation
1	Logic 1 produces reverse rotation

b16 Digital speed reference or limit switch function selector (R–W)

0 or 1	Def. val.	0	Res.	

Selects the functions of terminals B4 and B5.

b16	Pr21	Selects...
0	2	Digital speed reference input
1	X	Limit switch inputs

b17 Speed reference input selector (R–W)

0 or 1	Def. val.	0	Res.	

Selects the speed reference at terminals B9 and B10.

b17	Selects...
0	Analog speed reference
1	Digital speed reference (**b14** has no effect)

b18 Digital stop selector (R–W)

0 or 1	Def. val.	0	Res.	

Selects the stop function.

b18	b53	b22	Stop function
0	X	X	Controlled by applying a signal to terminal B6
1	1	X	Stop in position with ramp and hold
1	0	0	Stop without ramps and hold
1	0	1	Stop with ramps and hold

Refer also to **b7**, **b9**, **b23**.

b21	BCC enable				R–W
0 or 1		Def. val.	1	Res.	

When **b21** is set at 0, BCC is disabled.
When **b21** is set at 1, BCC is enabled.

b22	Ramp function for Normal stop				R–W
0 or 1		Def. val.	1	Res.	

Selects with or without ramps for stop-and-hold.

When **b22** is set at 0, *without* ramps is selected.
When **b22** is set at 1, *with* ramps is selected.

Note

Stopping with orientation always uses ramps irrespective of the setting in b22 (see b53).

b23	Limit switch ramp function				R–W
0 or 1		Def. val.	1	Res.	

Selects with or without ramps for limit switch stop.

When **b23** is set at 0, *without* ramps is selected.
When **b23** is set at 1, *with* ramps is selected.

b33	Alarm status				RO
		Def. val.		Res.	

When **b33** is set at 0, at least one alarm is active.
When **b33** is set at 1, no alarm is active.

The state of this parameter is indicated as a logic signal on terminal B15.

b38	Direction of motor rotation				RO
		Def. val.		Res.	

Motor direction is described when looking at the shaft end of the motor.

When **b38** is set at 0, reverse (anti-clockwise) is selected.
When **b38** is set at 1, forward (clockwise) is selected.

b41	Zero speed or shaft orientation status				RO
		Def. val.		Res.	

b53	b41	Indicates...
0	0	Motor not at zero speed
1	0	Shaft not orientated
0	1	Motor at zero speed
1	1	Shaft orientated (see **Pr27**)

b42	At-speed status				RO
		Def. val.		Res.	

b42 = 0 indicates motor is not at speed; motor speed is outside the range defined by **Pr56** and **Pr57**.
b42 = 1 indicates motor is at speed; motor speed is within the range defined by **Pr56** and **Pr57**.

Refer also to **Pr56**, **Pr57** and **b96**.

b48	Speed loop saturation status				RO
		Def. val.		Res.	

b48 = 0 indicates the speed loop is in linear operation.
b48 = 1 indicates the speed loop is saturated.

b49	Resolver phasing				R–W
0 or 1		Def. val.	0	Res.	

When **b49** is set at 0, resolver phasing is inactive.
When **b49** is set at 1, resolver phasing is enabled.

b50	Display return function				R–W
0 or 1		Def. val.	0	Res.	

When **b50** is set at 0, the control keypad display returns to display **rdY** or the speed value after 8 seconds without a key stroke.
When **b50** is set at 1, the display continues to show the value of the last parameter to have been selected.

b51	Serial link data format				R–W
0 or 1		Def. val.	0	Res.	

When **b51** is set at 0, 8-bit no parity format is selected.

When **b51** is set at 1, 7 bit even parity format is selected.

Note

This parameter can be adjusted only at the control keypad, not by using serial communications.

b52	Serial link mode				R–W
0 or 1		Def. val.	0	Res.	

When **b52** is set at 0, ANSI standard is selected.

When **b52** is set at 1, Terminal mode is selected.

b53	Digital stop mode selector				R–W
0 or 1		Def. val.	0	Res.	

When **b53** is set at 0, stop-and-hold is selected.

When **b53** is set at 1, stop-orientate-and-hold is selected.

See **Pr27**.

b55	External Trip Alarm				RO
		Def. val.		Res.	

b55 = 0 indicates no external trip has occurred.

b55 = 1 indicates the external trip is active.

b56	External trip enable				R–W
0 or 1		Def. val.	0	Res.	

When **b56** is set at 0, external trip is disabled.

When **b56** is set at 1, external trip is enabled.

b81	Digital output short-circuit trip				RO
		Def. val.		Res.	

b81 = 0 indicates the digital outputs are normal.

b81 = 1 indicates a digital output is short-circuit to 0V.

b82	DC over-voltage trip				RO
		Def. val.		Res.	

b82 = 0 indicates the DC bus voltage is below the permitted maximum (808V).

b82 = 1 indicates the DC bus voltage is above the permitted maximum.

b83	DC under-voltage trip				RO
		Def. val.		Res.	

b83 = 0 indicates the DC bus voltage is above the permitted minimum (400V).

b83 = 1 indicates the DC bus voltage is below the permitted minimum.

b84	Over-current trip				RO
		Def. val.		Res.	

b84 = 0 indicates the output current is below the set limit.

b84 = 1 indicates the output current has exceeded 110% of I_{pk}.

b85	Over-temperature trip				RO
		Def. val.		Res.	

b85 = 0 indicates the heat-sink temperature is below the permitted maximum (95°C).

b85 = 1 indicates the heat-sink temperature is above the permitted maximum.

b86	Resolver break trip				RO
		Def. val.		Res.	

b86 = 0 indicates no fault has occurred.

b86 = 1 indicates a resolver signal connection has been lost.

b87	Overspeed trip				RO
		Def. val.		Res.	

b87 = 0 indicates the motor speed is within limits.

b87 = 1 indicates the motor speed has exceeded the value set in **Pr58**.

b89	I^2t integrating alarm				RO
		Def. val.		Res.	

b89 = 0 indicates the Drive is not within I^2t zone.

b89 = 1 indicates the Drive is in 1^2t limit.

b91	**Over-temperature pre-alarm**					RO
		Def. val.		Res.		

b91 = 0 indicates the heat-sink temperature is approaching the permitted maximum.

b91 = 1 indicates the heat-sink temperature has exceeded the permitted maximum.

b96	**At-speed relative/absolute**					R–W
Relative		Def. val.	1	Res.		

Selects the type of signal produced by the At-speed status parameter **b42**.

b96	**Selects...**
0	Absolute
1	Relative

When **b96** is set at 0 (Absolute) the At-speed status held in **b42** responds to the absolute values set in **Pr56** and **Pr57**. In this case, **b42** = 1 (At speed) when the following condition is satisfied:

Pr56 < [Motor speed] < **Pr57**

When **b96** is set at 1 (Relative) the At-speed status held in **b42** is related to the Speed Reference input. In this case, **b42** = 1 (At speed) when the following condition is satisfied:

[Reference + **Pr56**] < [Motor speed] < [Reference + **Pr57**]

Refer also to **Pr56**, **Pr57** and **b42**.

b99	**Save RAM to EEPROM**					R–W
Not save		Def. val.	0	Res.		

Saves new parameter values in the EEPROM. The display will show **SAVE** while parameters are being saved. Related to **b1** and **b5**.

When **b99** is set at 0, no save occurs.

When **b99** is set at 1, parameters are saved.

10.3 Summary of default values

Variable parameters (R–W)

Parameter	Default	Unit	Name	Notes
Pr0	0	RPM	Digital speed reference	
Pr1	0	RPM	Digital speed reference	
Pr2	0	RPM	Digital speed reference	
Pr3	0	RPM	Digital speed reference	
Pr6	0	RPM	Analog reference input offset	
Pr7	2	Hz	Speed loop bandwidth limit	
Pr8	0	% I_{pk}	Digital current reference	
Pr9	200	ms	Forward acceleration ramp	
Pr10	200	ms	Reverse acceleration ramp	
Pr11	200	ms	Forward deceleration ramp	
Pr12	200	ms	Reverse deceleration ramp	
Pr13	100		Proportional gain	
Pr14	0		Derivative gain	
Pr15	5		Integral gain	
Pr19	10.0	s	Digital reference scan time	
Pr20	0		Digital reference selector	
Pr21	0		Digital reference selector enable	
Pr22	1		Drive address	
Pr23	9600		Baud rate	
Pr25	0		Security code	
Pr27	0		Shaft orientation function	
Pr28	26	% I_{pk}	Magnetising current	
Pr29	100	RPM	Slip	
Pr30	0		Digital output selector 1	
Pr31	1		Digital output selector 0	
Pr32	1500	RPM	Motor base speed	
Pr37	12		Orientation loop gain	
Pr42	100	% I_{pk}	Maximum current limit	
Pr45	50	% I_{pk}	Nominal current	
Pr53	10		Shaft orientation window	
Pr54	150	RPM	Speed reference during orientation	
Pr56	–5	RPM	Motor at-speed window – lower limit	
Pr57	5	RPM	Motor at-speed window – upper limit	
Pr58	3200	RPM	Maximum speed limit	
Pr68	1		Simulated encoder output resolution	
Pr95	4		Number of motor poles	
Pr99	3000	RPM	Speed – full-scale	

Bit parameters (R–W)

Parameter	Default	Effect	Name	Notes
b0	0	Disable	Enable change of security code	
b1	0	Not	Recall parameter settings from EEPROM	
b2	1	Enable	Drive enable	
b3	0	Not	Alarm reset	
b5	0	Not	Recall default values from EEPROM	
b6	0	Speed	Reference selector	
b7	0	Disable	Enable ramps	
b8	0	Analog	Current reference mode selector	
b11	0	Delimit	Current limit selector	
b12	0	(b13)	Current signal selector	
b13	0	TPRC	Current signal source selector	
b14	1	Analog ref.	Reference selector	
b15	0	Polarity	Sign signal polarity selector	
b16	0	Speed selector	Digital input selector	
b17	0	Analog	Speed reference input selector	
b18	0	Digital	Digital stop selector	
b21	1	Enable	BCC enable	
b22	1	Enable	Normal-stop ramp function	
b23	1	With	Limit-switch ramp function	
b49	0	Inactive	Resolver phasing	
b50	0	Return	Display return function	
b51	0	8-bit	Serial link (interface) data format (parity)	
b52	0	ANSI	Serial link (interface) mode	
b53	0	Stop and hold	Digital stop mode selector	
b56	0	Disable	External trip (Et) enable	
b96	1	Relative	At-speed relative or absolute	
b99	0	Not	Save Working Table to EEPROM	

11 Trip Codes and Fault Finding

11.1 Trip codes

The last trip code is stored in **Pr98**. The value read from **Pr98** using serial communications is the trip code number.

OU

Trip Code number: 1
Over-voltage

The DC bus voltage has exceeded the permitted maximum of 808V.

UU

Trip Code number: 2
Under-voltage

The DC bus voltage has dropped below the permitted minimum of 404V.

OC

Trip Code number: 3
Over-current

Excessive current (>110% of I_{pk}) has been detected in the output bridge.

th

Trip Code number: 4
Over-temperature

The temperature of the heatsink has exceeded the permitted maximum of 95°C.

rb

Trip Code number: 5
Resolver circuit break

One of the connections to the resolver has been lost or broken.

It

Trip Code number: 6
I^2t Current limitation

The output current has been in excess of that set in **Pr45** for an excessive time. The Drive is limiting the current to the value set in **Pr45**.

Note

This is not a trip condition.

PA

Trip Code number: 7
Over-temperture Pre-Alarm

The heatsink temperature is close to the permitted maimum.

OS

Trip Code number: 8
Motor over-speed

The motor speed has exceeded the safe limit set in **Pr58**.

SC

Trip Code number: 9
Digital output short-circuit

A digital output (terminals B7, B8, B15) is short-circuit to 0V.

Et

Trip Code number: 10
External trip

The external trip input has been activated. If a motor thermistor (PTC) is connected, the motor is overheating.

Err or dOI

Trip Code number: 11
Hardware fault or Drive operating incorrectly

There is an internal hardware fault. Removing, then re-connecting AC power may clear the fault, otherwise consult the supplier of the Drive.

11.2 Fault finding

Condition	Causes	Actions
When AC power is applied, the Drive is enabled but the motor is disabled.		
	b2 set at 0	Set **b2** at 1
Analog speed reference ≠ 0 but motor does not turn and is in torque.		
	Hold-zero-speed function active	Check that the input applied to pin **B6** is 0V and that **b18** is set at 0.
	Digital ref. selected	Check that **b17** is set at 0.
Analog speed reference varies but motor rotates at constant speed.		
	Digital ref. selected	Check that **b17** is set at 0.
Motor speed changes with analog reference change, but speed and reference do not correspond.		
	Torque control selected	Check that **b6** is set at 0.
When the Drive is enabled, the motor is in torque at maximum current, and the Drive enters the I^2t region.		
	Faulty connections	Check the wiring, especially for inverted phases
When the Drive is enabled and a speed reference is applied, the motor is at a standstill but free to rotate.		
	No current in motor	Check that current limit (either analog or digital) ≠ 0. Refer to **b11** or **Pr42**, **Pr43** and **Pr45**
Communication with host computer not possible.		
	Serial communications programming error	Check Baud rates and data formats correspond. Check polarity of wiring connections.
When AC power is applied, the Drive displays **dEf**.		
	The User Table of parameters has become corrupted or parameters do not match the version of the software	Set **b99** at 1. Re-program the parameters and again set **b99** at 1. **Model sizes 1 and 2** If **dEf** re-appears when AC power is next applied, change the Control Keypad **Model sizes 3 and 4** If **dEf** re-appears when AC power is next applied, change the NOVRAM control box.

12 Serial Communications

12.1 Introduction

Serial communications can be used by a host computer or plc to read and edit parameters, and control any function on the drive. The serial communications port is an RS422/RS485 specification, and allows the host to communicate with up to 32 drives on a single line. The protocol is industry standard ANSI x 3.28–2.5–A4.

12.2 Connecting to a Drive

RS485 and RS422

RS485 uses 4-wire differential lines which ensure a high level of immunity to noise. It also has high common-mode rejection.

RS485 full-duplex four-wire connection allows multi-drop links to be made to a maximum of 32 Drives. See Figure 12–1. The maximum permissible cable length for each link is 1200m.

On the final Drive in each serial communications link, connect the following pins in order to terminate the receive line with the internal line termination resistor:

Pin 8 to pin 7
Pin 4 to pin 3

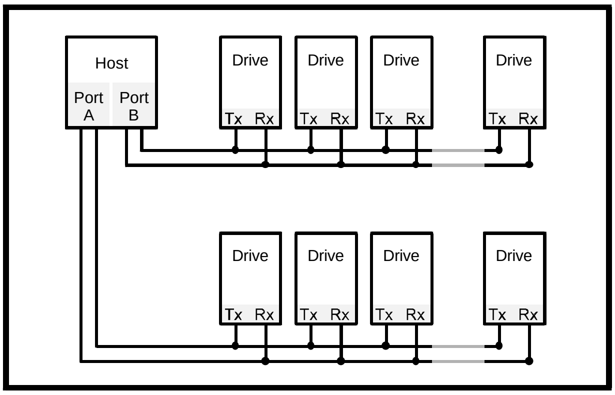


Figure 12–1 Up to 32 Drives can be connected to each communications port of the host computer

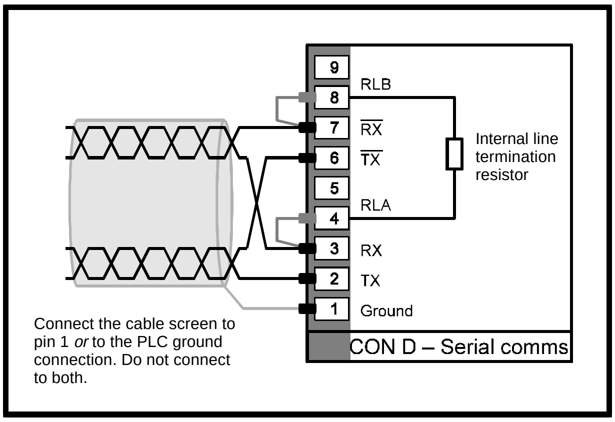


Figure 12–2 Connections for 4-wire RS485 or RS422 serial communications

Serial communications connector

Pin No.	Function	Type	Description
D1	GND		Ground
D2	TX	Out	Transmit signal (non-inverted)
D3	RX	In	Receive signal (non-inverted)
D4	RLA		Network terminating resistor
D5	FREQOUT	Out	Frequency output
D6	$\overline{TX}$	Out	Transmit signal (inverted)
D7	$\overline{RX}$	In	Receive signal (inverted)
D8	RLB		Network terminating resistor
D9	DIROUT	Out	Direction output

12.3 Serial communications configuration

The configuration for the serial port must be determined before attempting to communicate with the Drive. These parameters should be set up using the control keypad.

Baud rate

The Baud rate is selected using parameter **Pr23**. The selected rate must be the same as that of the host computer.

Data format

The data field format is selected using bit 51

7-bit plus parity (bit 51 set at 0)

One start-bit
Seven data bits
One even parity bit
One stop bit

8-bit, no parity (bit 51 set at 1)

One start bit
Eight data bits
One stop bit

12.4 Message structure

Serial messages consist of the following:

Control characters
Serial address code
Parameter identifier
Data field
Block checksum (BCC)

Control characters

If a message is initiated from a keyboard, control characters may be entered by holding down the CTRL key and pressing the key shown in the table below:

Character	Purpose	ASCII code (HEX)	CTRL + key
EOT	Reset Message begins	04	D
ENQ	Enquiry Interrogate the Drive	05	E
STX	Start of text	02	B
ETX	End of text	03	C
ACK	Acknowledge (Go to next parameter)	06	F
BS	Backspace (Go to previous parameter)	08	H
NAK	Negative acknowledge (Repeat same parameter)	15	U
CR	Carriage return	0D	M

Serial address code

Each Drive on a serial link must have a unique address. This allows the host computer to communicate with each Drive individually. The Drive address code is entered in **Pr22**, and can be any value between 1 and 32. (Drive address 00 has a special use — see *Addressing all Drives* below). Each digit of the address is transmitted twice: to address Drive number 08, the following must be transmitted:

0	0	8	8

Addressing all Drives

It is possible to send an instruction to all Drives on a serial link using Drive address 00. All Drives will receive the instruction, but none will transmit an acknowledgment. This can be useful for ensuring that all Drives on a flow-line receive a start signal at the same instant.

Parameter identifier

To address an individual parameter, the host must send a code that relates to the parameter. There are two types of parameter in the SpindAx, as follows:

Numerical parameters	Pr00 to Pr99 (Parameter identity 000 to 099)
Bit parameters	b00 to b99 (Parameter identity 100 to 199)

Data field

Data is sent as a numerical value with sign and decimal point. The data field can consist of up to six characters, two of which must be the sign and decimal point. The data field can be shortened when transmitting data to a Drive, since the **ETX** control character (see above) indicates the data is complete. When interrogated, the response of the Drive always has six data characters.

Block checksum

The block checksum character **BCC** is used to check the received message has not been corrupted during transmission. The BCC is a value that is calculated from the ASCII codes of the characters in the parameter identifier and data fields.

The BCC is calculated by using an XOR function. The calculation starts with the first character following the STX (ctrl B) control character. The following example shows how to calculate the BCC.

Example

To change the value of **Pr06** to −35.8

Character	ASCII code	XOR
0	011 0000	
0	011 0000	000 0000
6	011 0110	011 0110
–	010 1101	001 1011
0	011 0000	010 1011
3	011 0011	001 1000
5	011 0101	010 1101
.	010 1110	000 0011
8	011 1000	011 1011
ETX	000 0011	011 1000
8	011 1000	

Note

If the calculated value for the BCC is less than 32 decimal, (20 in hexadecimal) 32 must be added. The resulting character is used as the BCC value.

The BCC can be disabled by setting **b21** at 0, but a CR (ctrl M) character *must* be transmitted in place of the BCC character.

12.5 Messages from host to Drive

Interrogating a Drive

To find the value of a parameter, the host must send a message in the format shown below. No data field is needed.

	Drive address				Pr			
EOT	0	0	1	1	0	0	6	ENQ
Ctrl-D								Ctrl-E

The response from the Drive will be in the format shown below. The data field always consists of six characters.

	Drive address					Pr			Data field							BCC
EOT	0	0	1	1	STX	0	0	6	–	0	3	5	.	8	ETX	8
Ctrl-B					Ctrl-B										Ctrl-C	

If the interrogated parameter does not exist, the Drive replies with the following message:

	Pr			
STX	0	2	8	EOT
Ctrl-C				Ctrl-D

Quick commands

When the Drive has been interrogated, it is possible to extract data from the Drive using the quick commands, without addressing the Drive each time.

NAK Repeat last response

The Drive repeats the data for the same parameter. This is a quick way of monitoring a continuously changing parameter.

ACK Read next parameter

The Drive responds with the data for the parameter with the next number.

BS Read previous parameter

The Drive responds with the data for the parameter with the previous number.

12.6 Writing data to a Drive

To write data to a Drive, the message must be in the format shown below. The data field does not need to be six characters long, since the ETX (ctrl C) character indicates the end of the data. The BCC can be disabled, but a CR (ctrl M) character *must* be transmitted in its place.

	Drive address						Pr			Data field							BCC
EOT	0	0	1	1	STX	0	0	6	–	0	3	5	.	8	ETX	8
Ctrl-B					Ctrl-B										Ctrl-C	

The Drive responds with either of the following:

ACK Message received, understood and carried out.

NAK Message received, but not carried out. The data is out of range, or the message was corrupted during transmission.

The EOT character and Drive address can be omitted from subsequent write instructions to the Drive.

12.7 Terminal mode

Terminal mode uses a simplified protocol. To communicate with a Drive having address 02, the terminal must be opened using the selection string. This is done by transmitting the following message:

	Drive address				
EOT	0	0	2	2	Cr
Ctrl-D					Ctrl-M

The Drive responds by transmitting the following:

0	2	>

The terminal remains in open communication with the Drive until a different selection string is sent.

Interrogating the Drive

To interrogate the Drive, for example, to find the value of parameter **Pr6**, the message sent would be as follows:

Pr			
P	6	=	CR
			Ctrl M

For bit parameter **b24**, the message would be as follows:

	Pr				
P	1	2	4	=	CR
					Ctrl M

Sending commands to the Drive

To send a command to the Drive, the string is composed of the same characters but with the new value inserted after the **=** sign, as follows:

Pr			Data field						
P	6	=	–	0	3	5	.	8	CR
									Ctrl-M

Quick commands

ESC Resets the current command line, clearing it of entered information.

= Requests a repeat of the data for the parameter last addressed.

> Requests the data for the parameter with the next number.

< Requests the data for the parameter with the previous number.

Errors

Plain-language error messages are sent to the terminal, as follows:

Parameter not recognised

Message string does not comply with format.

Parameter not recognised

A number has been given in the Address field which does not apply to any parameter.

Value out of range

Value sent is above or below the maximum or minimum value permissible for the parameter addressed.

Too many characters

Up to 20 characters are permitted in Terminal Mode.

Read Only Parameter

An attempt has been made to write to a read-only (RO) parameter.

12.8 Parameters related to serial communications

Number	Type	Name and description	Range	Resolution	Default
Pr22	R–W	Drive Address	1 to 32	1	1
Pr23	R–W	Baud Rate This parameter can be set only at the control keypad, not by the host computer. Adjust the value to the Baud rate of the host computer	300, 600, 1200, 2400, 4800, 9600,19200.		9600

Number	Type	Name and description	Default	Default Status
b21	R–W	BCC enable When **b21** is set at 0, BCC is disabled When **b21** is set at 1, BCC is enabled	1	Enabled
b51	R–W	Data format When **b51** is set at 0, 8 data bits, no parity is selected When **b51** is set at 1, 7 data bits, even parity is selected This parameter can be set only at the control keypad, not by the host computer.	0	8 bits no parity
b52	R–W	Serial communications mode When **b52** is set at 0, ANSI standard is selected When **b52** is set at 1, Terminal mode is selected	0	ANSI mode