CD75-750

USER'S GUIDE for the *CD75-750* VARIABLE SPEED DRIVES

for

STANDARD

AC INDUCTION MOTORS

0.75kW to 7.5kW

Safety at Work

The voltages present in standard drive modules are capable of inflicting a severe electric shock, and may be lethal. It is the responsibility of the owner or user to ensure that the installation of the drive and the way in which it is operated and maintained complies with the requirements of the Health & Safety at Work Act in the United Kingdom and applicable legislation and regulations and codes of practice in the UK or elsewhere.

Only qualified personnel should install this equipment, after first reading and understanding the information in this Guide. The installation instructions should be adhered to. Any question or doubt should be referred to the supplier of the equipment.

Operational Safety Warning

The drive software incorporates optional auto-start and restart features. Users and operators must take all necessary precautions, if operating the drive in this mode, to prevent damage to equipment and especially to prevent the risk of injury to personnel working on or near the motor and the driven equipment.

The drive stop and start inputs should not be relied upon alone to ensure the safety of personnel. If a safety hazard could arise from the unexpected starting of the drive, a further interlock mechanism should be provided to prevent the motor from running except when it is safe to do so.

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation or adjustment of the optional operating parameters of the equipment, or from mismatching of the drive to the motor.

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SOFTWARE VERSION . . .

USER'S GUIDE

for the

CD75-750

Variable Speed Drives

for

STANDARD AC INDUCTION MOTORS

0.75 to 7.5kW

CONTROL TECHNIQUES
WORLDWIDE

CONTROL TECHNIQUES DRIVES LTD
79 MOCHDRE INDUSTRIAL ESTATE
NEWTOWN, POWYS SY16 4LE

DECLARATION OF CONFORMITY

Dinverter 1	Power range 0.37kW
Commander CD2	Power range 0.75kW-7.5kW
Commander CD	Power range 11kW-75kW
Commander CDV	Power range 11kW-90kW
Commander CDE	Power range 11kW-90kW
Vector	Power range 11kW-75kW

The above listed AC variable speed drive products, have been designed and manufactured in accordance with the following European harmonised, national and international standards:

EN60249	Base materials for printed circuits
IEC326-1	Printed boards: General information for the specification writer
IEC326-5	Printed boards: Specification for single and double sided printed boards with plated through holes
IEC326-6	Printed boards: Specification for multilayer printed boards
IEC664-1	Insulation co-ordination for equipment within low-voltage systems: Principles, requirements and tests
EN60529	Degrees of protection provided by enclosures (IP code)
UL94	Flammability rating of plastic materials
UL508	Standard for Industrial Control Equipment

These products comply with the Low Voltage Directive 73/23/EEC and the CE Marking Directive 93/68/EEC.

W. Drury
Technical Director

Newtown
Date: 26th September 1996

Note
This electronic drive product is intended to be used with an appropriate motor, controller, electrical protection components and other equipment to form a complete end product or system. It must only be installed by a professional assembler who is familiar with requirements for safety and electromagnetic compatibility ("EMC"). The assembler is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used. Refer to the product manual or EMC data sheet for further information on EMC standards complied with by the product, and guidelines for installation.

Addendum 6

Part No. of addendum: 0512-0000
Issue code: C2NU2
Issue No: 2
Date of issue: February 1995
Software version: v3-3-x

E_{emc} connections

Power supply requirements

An additional transient voltage suppressor (varistor) is fitted between power terminals E_{emc} and PE as shown in Figure 1. The varistor connection permits the use of power supply configurations where the maximum line-to-ground (earth) voltage exceeds 320VAC. For example, this is possible in a 480V grounded-delta supply (Figure 2) where one phase is grounded, and the line-to-ground voltage is equal to the line voltage. The maximum line-to-ground voltage must **not** exceed 528VAC (480V +10%).

If the line-to-ground voltage is less than 320VAC for example in a grounded star (Y) configuration (Figure 3), the varistor between E_{emc} and PE may be removed and replaced by a jumper. This brings into circuit the integral RFI filter. It is recommended that the filter is used in most applications because it provides an effective reduction in RFI emissions into the AC power supply.

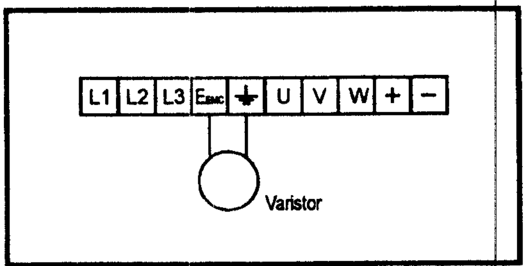


Figure 1 ***Power terminals with varistor connected between E_{EMC} and PE***

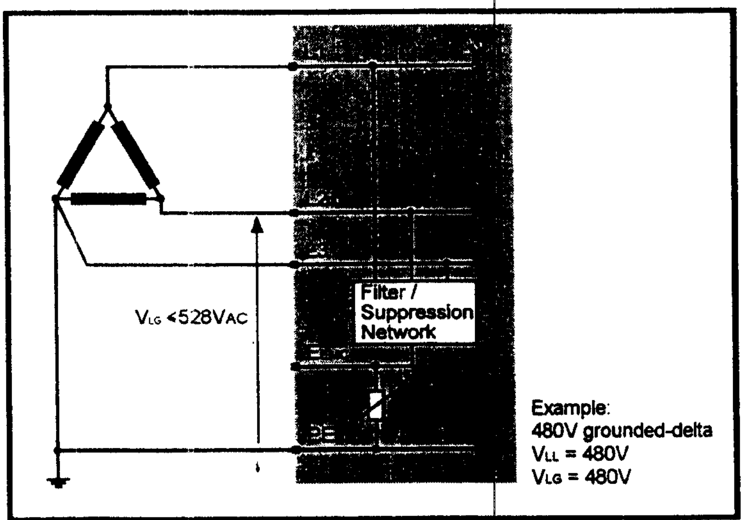


Figure 2 ***Drive connected to a grounded-delta AC supply***

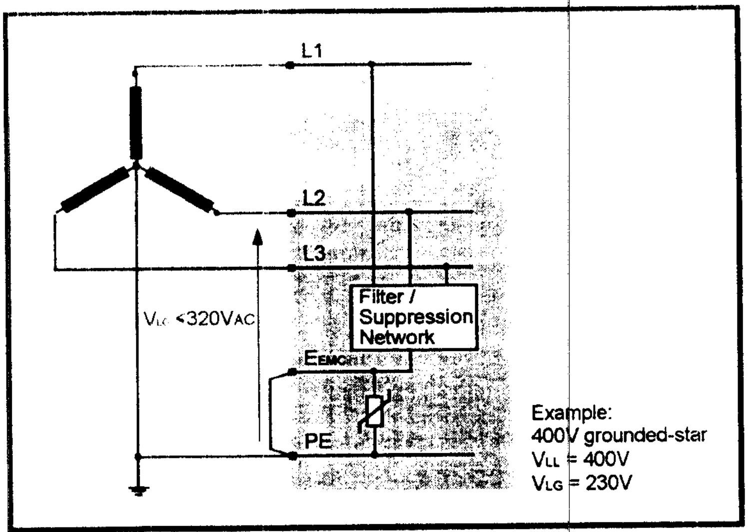


Figure 3 ***Drive connected to a grounded-star AC supply***

The following guidelines must be observed

The PE connection must always be connected to ground (power earth).

The E_{emc} connection must be connected to PE only when it is known that the line-to-ground voltage is **less** than 320VAC (in a grounded-star configuration, for example).

If there is any doubt over the type of AC supply configuration, do not remove the varistor. The drive is protected from line-to-ground voltage transients by this component.

If an application requires the integral RFI filter to be used, and the power supply configuration is not grounded-star, an isolation transformer with a grounded-star secondary is required.

The alternative to using an isolation transformer for grounded-delta AC supplies is to use an external RFI filter rated for the line and line-to-ground voltages.

Motor thermistor protection

The drive has been supplied with link PL6 in the disabled position (**not** in the enabled position as shown in Figure 16, page 4-10). Adjust this link only when a motor thermistor is connected to control terminal 9 of the drive.

Since short-circuit thermistor protection is now disabled, the drive will not trip if a short-circuit appears between 0V and control terminal 9.

Auto reset

There is **no** auto reset when an **Et** fault trip occurs.

Serial communications broadcast

When a number of drives are linked to a serial communications network, the serial communications broadcast facility allows all drives to respond to **one** command simultaneously.

This parameter operates regardless of the communication address set in parameter Pr9 of the drive.

To invoke the broadcast mode, specify address **0**.

Note

Since user address **0** is used to invoke broadcast mode, a drive having Pr 9 = 0 will not transmit data to the controlling station. The use of address **0** should be reserved for broadcast mode only.

New parameters

The following new parameters reside in the **Pr d** menu.

b21, b23 – Preset ramp selector

Using a combination of settings for bit parameters b21 and b23, the following can be achieved:

The drive can use its own preset speed acceleration and deceleration ramps.

Terminals A10, A11 and A12 can be configured as ramp select inputs.

Default settings: b21 = 0, b23 = 0

b21 = 0
b23 = 0

Preset speeds use the acceleration and deceleration ramps of Pr 2 and Pr 3.

b21 = 1
b23 = 0

Preset speeds use their own acceleration and deceleration ramps.

Pr 20 preset uses acceleration ramp Pr30 and deceleration ramp Pr40.

Pr 21 preset uses acceleration ramp Pr31 and deceleration ramp Pr41.

etc...

b21 = 0
b23 = 1

Terminals A10, A11 and A12 can be configured as digital inputs to select pre-programmed ramp times. The following table shows the terminals that correspond with the parameters.

b20 = 0
3 preset speeds and jog

A11	A10	Ramps
0	0	P2/P3
0	1	P30/P40
1	0	P31/P41
1	1	P32/P42

Note

Jog input A12 operates as normal.

b20 = 1
7 preset speeds

A12	A11	A10	Ramps
0	0	0	Pr 2/Pr 3
0	0	1	Pr 30/Pr 40
0	1	0	Pr 31/Pr 41
0	1	1	Pr 32/Pr 42
1	0	0	Pr 33/Pr 43
1	0	1	Pr 34/Pr 44
1	1	0	Pr 35/Pr 45
1	1	1	Pr 36/Pr 46

Note

When a combination of terminals are grounded, the associated ramp time become active immediately, even while a ramp is in progress. These ramps will also apply to all analogue inputs and serial communications.

b21 = 1
b23 = 1

Preset speeds use their own ramp times (same as b21 = 1, b23 = 0).

b24 – Load output

Default setting: b24 = 0

b24 = 0

Terminal 19 is a standard load output.

b24 = 1

Terminal 19 becomes a digital output in the form of a load-reached output, where the output changes state from 0V to +10V, when the drive load is equal to or greater than the value set in Pr5.

b25

Default setting: b25 = 0.

This parameter is currently not used.

b26 – Mains ride-through and phase-loss disable

Default setting: b26 = 0

b26 = 0

AcUU mains ride-through and phase-loss capability work as normal.

b26 = 1

AcUU mains ride-through and phase-loss capability are disabled. The dynamic braking voltage is now set to a fixed value of 735VDC.

b27 – Normal-running ramp selector

b27 selects the braking mode ramp during normal running when the input speed reference is reduced.

Default setting: b27 = 0

b27 = 0

Uses the standard ramp braking mode when the input speed reference is reduced when either coast-to-halt or DC injection braking are selected.

b27 = 1

Uses the high-level ramp braking mode when the input speed reference is reduced for all stopping modes.

Related parameters: b2, b7, Pr 8

b2	b7	b27	Ramp mode
0	0	0	standard
0	1	0	standard
1	0	0	standard
1	1	0	high level
0	0	1	high level
0	1	1	high level
1	0	1	high level
1	1	1	high level

b28 – PI control selector

b28 is used to select PI control when the feedback from a transducer, etc, is used to control the speed of the motor.

Default setting: b28 = 0

b28 = 0

PI mode disabled.

b28 = 1

PI mode enabled.

Serial mnemonic: PI

Related parameters: Pr 20, Pr 21, b11

When PI mode is enabled, Pr 20 and Pr 21 are used as the P and I gain parameters instead of preset speeds.

Pr20 – Proportional gain factor

Pr20 = P gain (Kp)

Default setting: 0

Range: 0 to 24.0

The Proportional gain factor Kp is a multiplication factor applied to the speed error signal in order to produce the correction term.

Kp factor = {[(Pr 20/Pr 1) x 75] x error (Hz)} in Hz

Increasing the value of Kp increases the system damping and the transient speed response. If the value is made too high for a given load, the system will become unstable. The optimum setting is the highest value possible before instability starts to occur. Optimum performance is achieved by setting the best combination of P and I gains.

Pr21 – Integral gain factor

Pr 21 = I gain (Ki)

Default setting: 0

Range: 0 to 25.5

The Integral gain factor Kp is a multiplication factor applied to the speed error signal in order to produce the correction term.

Ki factor = {[(Pr21/Pr1) x 2.25] x error (Hz)} in Hz/second.

The Ki term ensures zero speed error during steady-state load conditions. Increasing the value increases the rate of recovery after a disturbance. If the value of Ki is made too high, speed tends to oscillate instead of settling quickly. The optimum setting is the highest value before oscillation starts to occur. Optimum performance is achieved by setting the best combination of P and I gains.

Transducer feedback

The feedback from the transducer is applied to the remote-speed current input, terminal 8. The form of the input can be configured by b11.

PI control using serial communications

To enable PI control using serial communications for drive 15 for example, send the following message:

CONTROL	ADDRESS	CONTROL	MNEM	DATA	CONTROL	BCC
EOT (Ctrl-D)	1155	STX (Ctrl-B)	PI	>80	ETX (Ctrl-C)	·
			BCC calculated			

To disable PI control using serial communications for drive 15 for example, send the following message:

CONTROL	ADDRESS	CONTROL	MNEM	DATA	CONTROL	BCC
EOT (Ctrl-D)	1155	STX Ctrl-B	PI	>00	ETX Ctrl-C	$

Reading data using serial communications

To read the status of the PI control parameter using serial communications, send the following message:

CONTROL	ADDRESS	MNEM	CONTROL
EOT (Ctrl-D)	1155	PI	ENQ (Ctrl-E)

When PI control is enabled, the drive will respond as follows:

CONTROL	MNEM	DATA	CONTROL	BCC
STX Ctrl-B	PI	>80	ETX Ctrl-C	·
	BCC calculated			

When PI control is disabled, the drive will respond as follows:

CONTROL	MNEM	DATA	CONTROL	BCC
STX Ctrl-B	PI	>00	ETX Ctrl-C	$
	BCC calculated			

PI control

To select the PI control software, set b28 at 1. Also connect terminal 16 to 0V to select remote control.

The PI software can be used to regulate the speed of a motor in applications where a constant pressure or air flow, etc, needs to be maintained.

Set the drive frequency by applying a **Local speed input** signal to terminal 5.

Apply the feedback from the transducer to the remote speed input, terminal 8. The transducer output must be in one of the following current-loop formats:

4 to 20mA

20 to 4mA

0 to 20mA

Set b11 for the appropriate format.

(A voltage signal from a transducer must be converted and scaled into the appropriate current-loop signal.)

Setting up PI control

To achieve optimum performance from the PI control, the following set up procedure should be followed.

1 Connect an oscilloscope to the feedback input, terminal 8.

2 Set the drive frequency at a value which gives the nominal pressure or air flow etc, from the system.

3 Increase the value of Pr20. At the same time, monitor the trace on the oscilloscope. When the trace becomes unstable, decrease the value of Pr 20 slightly.

4 Increase the value of Pr21. At the same time, monitor the trace on the oscilloscope. When the trace becomes unstable, decrease the value of Pr 20 slightly.

5 Stop the drive. Monitor the trace on the oscilloscope and re-start the drive. When optimum performance is achieved, the trace should be as shown in Figure 4.

6 Achieve optimum performance by setting the best combination of P and I gains.

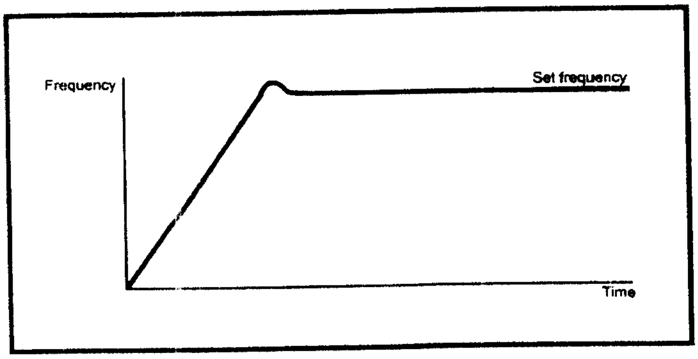


Figure 4 ***Ideal response curve under PI control***

b55 – AC power loss ramps

b55 can be used to select the acceleration and deceleration ramps which are followed by the drive during loss and restoration of AC power.

Default setting: b55 = 0

b55 = 0

When AC power is lost, the ramp times are controlled by Pr2 and Pr3 or, if selected, the required preset acceleration or deceleration rates.

b55 = 1

When AC power is lost, the deceleration ramp is controlled by Pr46. When AC power is restored, the acceleration ramp is controlled by Pr36.

b56 – Ramp selector for non-important trips

b56 is used to **Ramp to halt** when a non-important trip occurs.

Default setting: b56 = 0

b56 = 0

Non-important trips are treated as normal trips.

b56 = 1

Ramp to halt for non-important trips.

The non-important trips are as follows:

Et eL Oh th

These trips cause the drive to ramp to a halt with a deceleration rate that is determined by the drive set-up

When the drive is operated under terminal control, the display shows a steady (not flashing) trip code until the drive reaches 0Hz. The IGBT output stage is disabled and the display flashes the trip code. If b50 = 1, the status relay immediately de-energises when the drive receives the trip and starts to ramp to a halt. The trip can be reset at any time. If it occurs during the ramp stage, the drive will ramp back to the set frequency.

When the drive is operated under keypad control, the display indicates the trip condition during the ramp stage by alternating between the set speed value and the trip code. If the trip is reset, the drive will not ramp up to the set speed. It will continue to ramp down to 0Hz. The display will show **rdY** alternating with the set speed value.

Serial control of new parameters

Serial control of new bit parameters **b23 to b27**, b55 and b56 is possible. The bits are resident in the C1 configuration word. The order of the **bits is as follows**:

3rd character	Default
b22	0
b23	0
b24	0
b25	0

4th character	Default
b26	0
b27	0
b55	0
b56	0

Control Keypad

The removable control keypad can now be unclipped from the front of the drive, allowing access to the jumpers. Drives from serial number **370000** have this addition.

Enhanced frequency resolution using high resolution ASIC

The CD drive allows the motor speed **to be** controlled using either an analog reference, the keypad or the serial conununications link (**SP** command). This gives the following drive frequency resolutions:

Output frequency Hz	Resolution Hz	ULF Hz
0 to 120	0.1	120
0 to 240	0.2	240
0 to 480	0.4	480
0 to 960	0.8	960

Drives fitted with the new high resolution ASIC (from serial number 355000). allow the output frequency to be set to a higher resolution using **the serial** communications link. The new command to allow the control is **HR** and permits 0.001Hz frequency resolution, The resolution depends on the set value of ULF.

Output frequency Hz	Resolution Hz	ULF Hz
0 to 120	0.001	120
0 to 240	0.001	240
0 to 480	0.002	480
0 to 960	0.004	960

The **HR** command appears between **RC** and **TO** in the mnemonic sequence. The serial protocol for **HR** increases the numberof data characters to eight. All other commands used in the drive remain at six characters.

The following are the protocol formats for the new command:

Sending data

Send the following string:

CONTROL	ADDRESS	CONTROL	MNEM	DATA	CONTROL	BCC
EOT Ctrl-D	1144	STX Ctrl-B	HR	-047.001	ETX Ctrl-C	8
			BCC calculated			

Reading data

Send the following string:

CONTROL	ADDRESS	MNEM	CONTROL
EOT Ctrl-D	1144	HR	ENG Ctrl-E

Response string

CONTROL	MNEM	DATA	CONTROL	BCC
STX Ctrl-B	HR	-047.001	ETX Ctrl-C	8
	BCC calculated			

Long-cable driving capability

For cable sizes refer to *Fuse and Cable Data* on page 4–6 of the User Guide.

Drive	Motor cable			
	Standard 4 core Maximum length (metres)		Armoured Maximum length (metres)	
CD/CDV	Without choke	With choke	Without choke	With choke
75	45	110	35	70
110	80	170	60	110
150	125	220	110	180
220	190	310	160	250
400	310	400	180	220

Drive	Motor cable			
	Standard 4 core Maximum length (metres) without choke		Armoured Maximum length (metres) without choke	
CD/CDV	Cable size 2.5 mm 12AWG	Cable size 4.0 mm 10AWG	Cable size 2.5 mm 12AWG	Cable size 4.0 mm 10AWG
550	250	310	175	260
750	155	220	155	220

Drive	Motor cable			
	Standard 4 core Maximum length (feet)		Armoured Maximum length (feet)	
CD/CDV	Without choke	With choke	Without choke	With choke
75	145	360	115	230
110	260	555	195	360
150	410	720	360	590
220	620	1015	525	820
400	1015	1310	590	720

Drive	Motor cable			
	Standard 4 core Maximum length (feet) without choke		Armoured Maximum length (feet) without choke	
CD/CDV	Cable size 2.5 mm	Cable size 4.0 mm	Cable size 2.5 mm	Cable size 4.0 mm
550	820	1015	575	850
750	505	720	505	720

Important Notes

Cable lengths are based on a drive overload (torque) capability of 125% for CD and 120% for CDV.

Cable lengths given in the tables are typical. Operating beyond these lengths may cause the drive to trip on overcurrent (OI), or fold-back in frequency,

Motor line-chokes will allow longer cables to be driven by CD75-400. Use 2mH per phase, connected at the drive end. Select the lowest PWM switching frequency to minimise heat dissipation in the choke and reduce radio frequency emissions.

The effect of cable voltage-drop becomes increasingly significant for drives above CD400. The use of chokes is not normally necessary

Use a drive of higher rating if longer cables or a greater overload capability is needed. Driving very long cables (as a guide: greater than 200 metres armoured, greater than 350 metres standard 4 core) and using motor line chokes may cause the DC bus voltage to increase slightly at low output frequencies. This may be overcome by connecting a small capacitor between DC-VE and drive power earth. Consult the supplier of the drive for guidance.

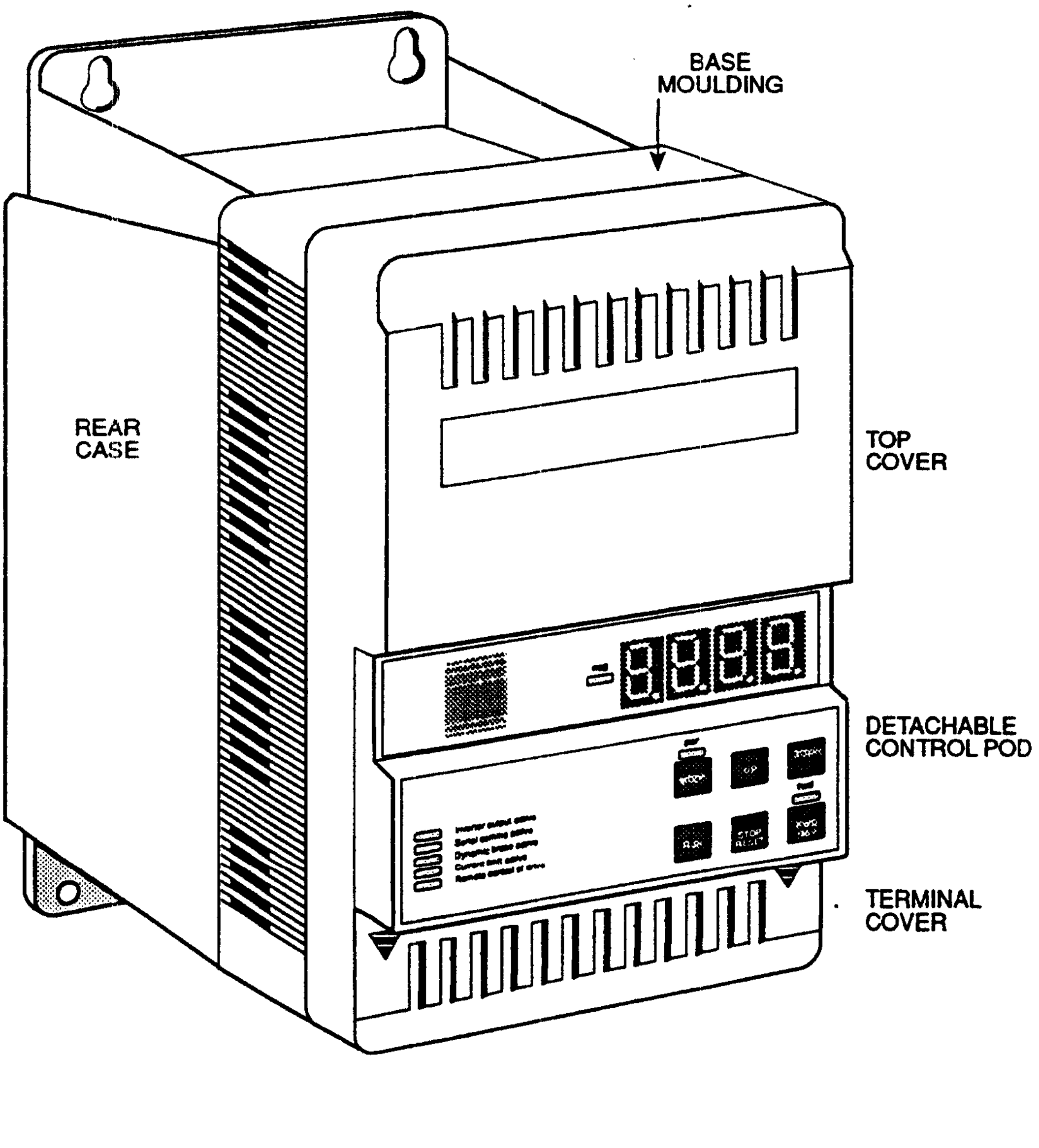
CONTENTS

ILLUSTRATIONS

Logic Diagrams

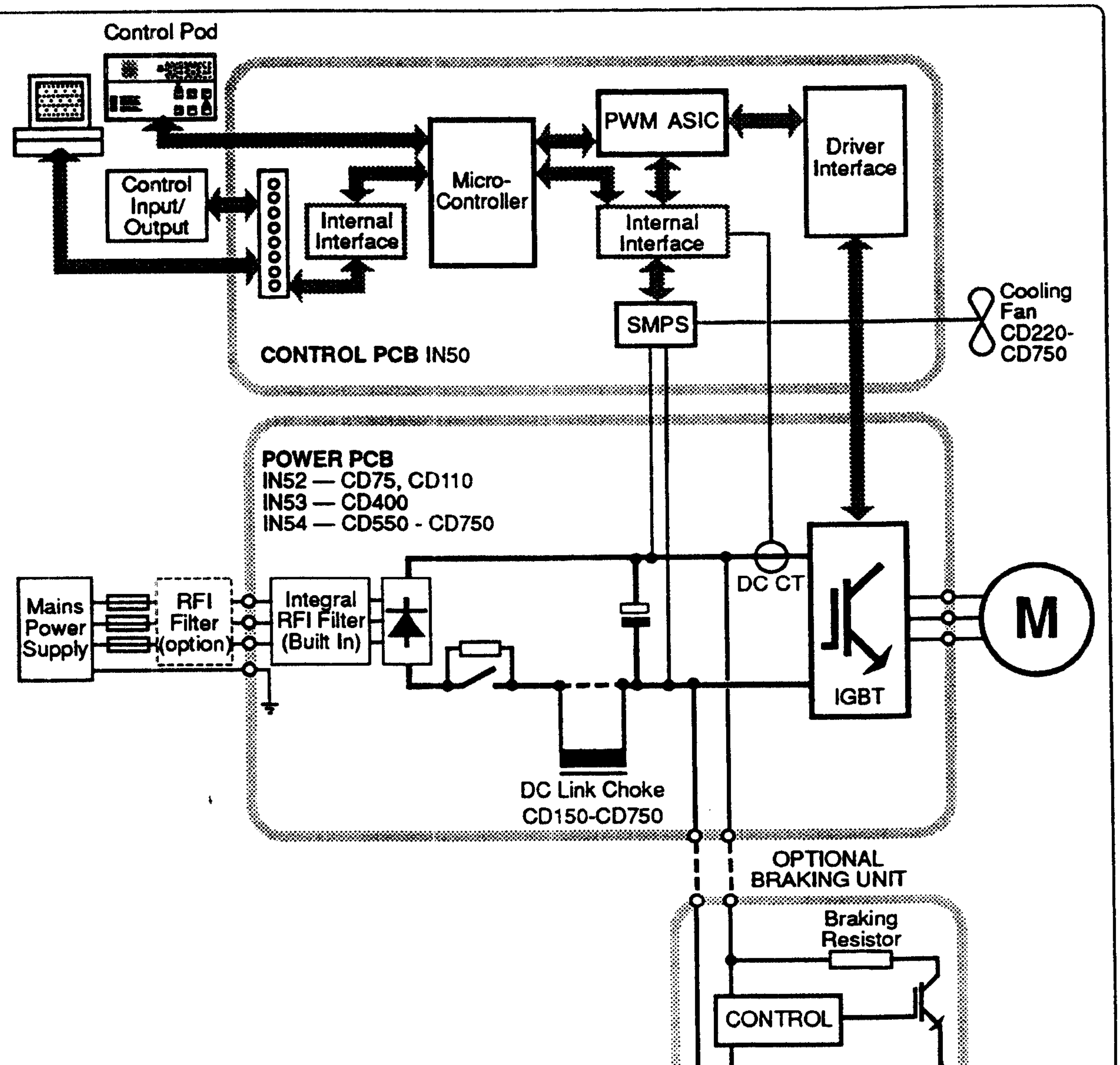
Features of *CD75-750*

FEATURES
of the
CD75-750 Drives



1 Locations of principal components.

- Full digital control.
- Complete digital adjustment of drive parameters.
- Insulated gate bipolar transistor (IGBT) output bridge for high speed switching and low power consumption.
- Motor speed digitally-controlled from 0Hz to 960Hz.
- Choice of up to four switching frequencies in the range 2.9kHz to 11.7kHz.
- Fixed and alternatively variable V/f characteristic.
- Internal monitoring and protection includes Ixt overload, current limit, peak current limit, instantaneous overcurrent and individual IGBT protection.
- Complete isolation between control and power electronic circuits. Impedance isolation for ac supply and dc link voltage feedback.
- Ability to start the drive when the motor is spinning, in either direction, without large transient torques.
- 150% (industrial) and 120% (HVAC) trarting torque.
- DC injection braking.
- Removable control pod for additional security.
- Fully-isolated RS485 serial communications interface.
- Integral RFI filter as standard.
- Supply-phase loss protection and mains discontinuity ride-through.
- Programmable presetting of speeds and jog.
- Programmable skip frequencies.
- Selectable auto-restart after trip.
- Mountings for front-of-panel or through-hole.
- Auto-logging of fault events data.
- Efficient thermal management, derating not required.
- Slip compensation.



2 Schematic block diagram of the power system.

GLOSSARY of TERMS

Base speed — The shaft speed of an induction motor when supplied at rated voltage and frequency.

DC link — ('DC bus') The dc voltage source connecting the input rectifier to the output inverter.

Default — A single pre-determined value to which a parameter is set during manufacture.

Derate — Reduce the nominal rating of apparatus because of departure from specified operating conditions.

Displacement factor — The cosine of the phase angle between fundamental voltage and fundamental current.

FLC — Full load current.

FLT — Full load torque.

HVAC — Heating, ventilating and air-conditioning.

MVF — Maximum Voltage Frequency (of a CD drive): the frequency selected to be delivered to the motor when the output voltage is equal to the rated input voltage (= **Prc**).

PLC — Programmable logic controller. Equipment designed to receive, manipulate and transmit data for controlling other equipment.

Power factor — The actual average power supplied divided by the apparent power supplied (apparent power is rms voltage x rms current).

PWM — Pulse width modulation. A technique for synthesizing a waveform by making individual pulses in a pulse train different widths.

ULF — Upper limit frequency. The highest motor output frequency of the drive. (Actual maximum frequency can be lower than this as set by **Pr 1**).

1 Theory of Inverter Drives

Theory of Inverter Drives

Induction Motor Characteristics

Standard industrial squirrel cage induction motors are wound to match the supply voltage and frequency which prevails in the country where they will be used or are manufactured. When it is desired to operate an induction motor at variable speeds, it is necessary to consider the effect of voltage and frequency on flux and torque.

An induction motor depends for its operation on the rotating field created by the balanced three-phase currents in the stator (field) winding. The magnitude of the field is controlled not by the strength of the current, but by the voltage impressed on the field windings by the supply. This is because the resistance of the field windings results in only a small voltage drop, even at full load current, and therefore the supply voltage must be balanced by the emf induced by the rotating field. This emf depends on the product of three factors:

the total flux per pole,

the total number of turns per phase of the field winding,

and the rate of field rotation.

The emf can be expressed as $E = k\phi Nf$ (1)

where E is the induced emf,

ϕ is the total flux per pole,

N is the number of turns per pole,

f is the frequency,

and k is a constant.

If the applied voltage is increased, the emf must increase to balance, and if the frequency is held constant the flux per pole must increase also, since the number of turns per pole is fixed.

For economy of material, the magnetic circuits of standard motors are designed to operate every close to saturation at rated voltage and frequency. This is the optimum condition for the production of maximum torque. At rated frequency, any further increase of voltage cannot increase torque but will cause current, and consequently losses, to rise.

For optimum acceleration, or rapid response to an increase in load torque, ϕ should be maximum to maximise the torque, as the designer intended.

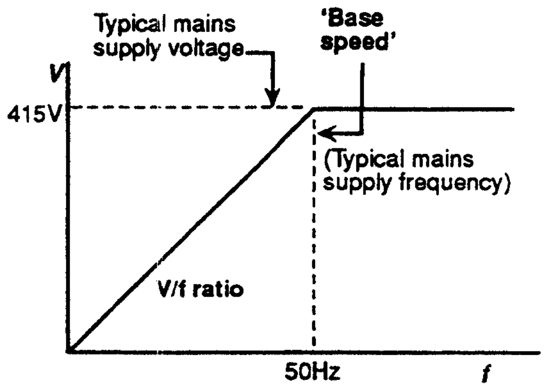
Equation (1) can be restated as —

$$\phi = \frac{1}{kN} \times \frac{E}{f} \qquad (2)$$

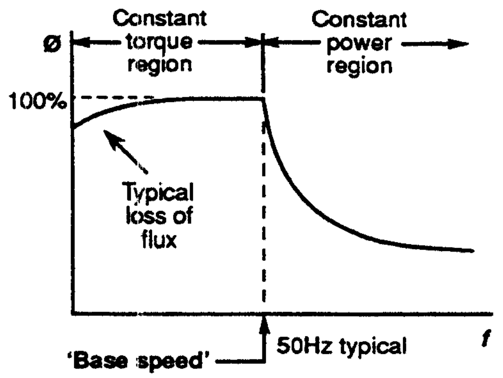
This shows that, since N is fixed and k is constant, a linear relationship must be maintained between emf (and consequently the applied voltage) and frequency, if flux is to remain constant at different speeds. This linear relationship is known as 'constant V/f' (or V/Hz). Drives possessing this essential feature are usually called 'variable voltage variable frequency' (vvvf) drives. The speed of a motor at full rated voltage and normal V/f ratio is called its 'base speed', expressed in Hz or rpm as convenient.

Although constant V/f control is an important underlying principle, departures from it enable the speed range to be extended both above and below the base speed. Operation of the motor at speeds above its base speed is achieved by increasing the output frequency of the inverter above the rated frequency while the applied voltage remains at maximum value.

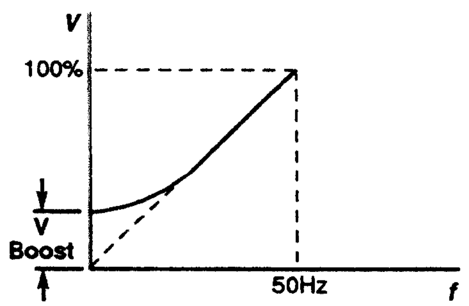
The V/f characteristic is typically as shown in Fig.3, which also shows the change above base speed. Since V is constant above base speed, the flux falls as the frequency increases, Fig. 4, in direct



3 Variable motor speed — ideal voltage-to-frequency (V/f or V/Hz) characteristic.



4 Variable motor speed — typical flux-to-frequency relationship.



5 Voltage boost to increase torque at low frequencies. (Not to scale)

proportion to the V/f ratio. The ability of the motor to produce torque is correspondingly reduced, and in fact the power output remains constant.

The second operating condition where departure from a constant V/f ratio is beneficial is at low speeds, where the voltage drop arising from stator resistance becomes significantly large. This voltage drop is at the expense of the flux. As the applied frequency approaches zero, the optimum voltage becomes equal to the stator IR drop. To maintain a constant flux in the motor at low speeds the voltage must be increased to compensate for the stator-resistance effect. Compensation for stator resistance is called 'voltage boost', Fig. 5, and most drives offer some form of adjustment so that the degree of boost can be matched to the winding resistance. It is also normal to taper the boost to zero as the frequency increases. A refinement is to increase the degree of voltage boost for loads that impose a high starting torque, since the IR drop will be greater because of the increased current. Automatic load-dependent control of the voltage boost in this manner has practical advantages for many applications.

Drive Configuration

To operate an induction motor successfully in all varieties of industrial applications a drive must at least be capable of varying both voltage and frequency, for which it is necessary to separate the input from the output. This is most conveniently done by rectifying the supply and inverting the dc output. Variable output voltage can be obtained by varying the dc link voltage and maintaining the gain of the inverter constant . The gain is the ratio of ac output to dc input. Alternatively, the dc link voltage can be uncontrolled and the gain varied. This latter method is usually achieved by pulse-width modulation (PWM) control of the inverter.

The use of a mathematically-advanced PWM switching strategy to control the latest high power high speed semiconductor switching devices — insulated gate bipolar transistors (IGBT) — in the power output bridge enables the output waveform to be closely approximated to a pure sine wave. The dc input voltage can then be derived from a simple diode bridge rectifier which, besides being highly reliable, also has the advantage of reducing the amplitude of harmonics seen on the input of the inverter.

Equipped with suitable control functions, a PWM-IGBT inverter is capable of providing any voltage from zero to input line voltage, over a frequency range from zero to some practical maximum considerably above the rated frequency of standard squirrel cage motors. The control function is also capable of enabling the voltage to be raised at low frequencies to increase torque at low speeds, and it is relatively simple to arrange that the phase sequence of the output can be changed to enable the motor to reverse. These functions are the basic minimum and they can, with a suitable control system, be considerably extended.

Digital control logic is essential to gain the full advantage of a PWM switching strategy applied to the IGBT output bridge. The speed and adaptability of digital logic makes it feasible to extend the scope of the control functions in two important directions. One is to equip the drive to monitor and protect itself and the motor; the other is to enable the performance of the drive and motor to be refined to take account of the widest possible variety of applications.

A further advantage of digital control is the precision with which operating parameters can be adjusted, and maintained without drifting from set values. A standard interface makes it possible to accept external analogue signals into the control scheme, and also to provide analogue signal outputs. Finally, digital control makes communication with other digital devices simple to implement and operate through industrial standard serial communication links.

2 Specifications & Data

2
Specifications and Data

2.1 Current and Voltage Ratings

The CD75-750 (0.75-7.5kW) range is rated for current output, thus for a fixed maximum current output the power output is dependent on the value of the supply voltage in the range 380V - 480V.

Power Supply

Input supply Voltage range, and Frequency —

380V to 480V ac ±10% 60Hz ±2Hz

380V to 440V ac ±10% 50Hz ±2Hz

Minimum supply source impedance —

Zero Ohms

Maximum supply imbalance —

2% negative phase sequence (equivalent to 3% phase voltage imbalance)

CD75-750 (0.75 -7.5kW) Industrial Inverter, 380V Supply

DRIVE MODULE	OUTPUT		MOTOR RATINGS		INPUT			
	100% RMS CURRENT (1)	150% RMS CURRENT (2)			100% RMS CURRENT		100% FUNDAMENTAL CURRENT	
	A	A	kW	HP	A	kVA	A	kW
CD75	2.1	3.2	0.75	1.0	5.4	3.6	1.8	1.2
CD110	2.8	4.2	1.1	1.5	5.9	3.8	2.4	1.6
CD150	3.8	5.7	1.5	2.0	5.3	3.5	3.3	2.2
CD220	5.6	8.4	2.2	3.0	7.1	4.7	4.9	3.2
CD400	9.5	14.3	4.0	5.3	9.5	6.3	8.3	5.5
CD550	12.0	18.0	5.5	7.3	13.7	9.0	10.4	6.9
CD750	16.0	24.0	7.5	10.0	16.3	10.7	13.9	9.2

NOTES (1) RMS current required by a 3-phase, 6-pole motor to produce rated output shaft power. 100% RMS current is available at all switching frequencies without derating, up to a maximum ambient temperature of 50°C.

(2) Maximum inverter RMS current.

CD75-750 (0.75 -7.5kW) HVAC Inverter, 380V Supply

DRIVE MODULE	OUTPUT		MOTOR RATINGS		INPUT			
	100% RMS CURRENT	120% RMS CURRENT (Overload)			100% RMS CURRENT		100% FUNDAMENTAL CURRENT	
	A	A	kW	HP	A	kVA	A	kW
CDV75	2.1	2.5	0.75	1.0	5.4	3.6	1.8	1.2
CDV110	2.8	3.4	1.1	1.5	5.9	3.8	2.4	1.6
CDV150	3.8	4.6	1.5	2.0	5.3	3.5	3.3	2.2
CDV220	5.6	6.7	2.2	3.0	7.1	4.7	4.9	3.2
CDV400	9.5	11.4	4.0	5.3	9.5	6.3	8.3	5.5
CDV550	12.0	14.4	5.5	7.3	13.7	9.0	10.4	6.9
CDV750	16.0	19.2	7.5	10.0	16.3	10.7	13.9	9.2

Losses

DRIVE MODULE	FREQUENCY Hz	POWER W	CONTROL W	TOTAL W
CD75 CD110	2.9kHz 5.9kHz 8.8kHz 11.7kHz	42 52 62 72	30 30 30 30	72 82 92 102
CD150 * CD220	2.9kHz 5.9kHz 8.8kHz 11.7kHz	82 97 112 127	35 35 35 35	117 132 147 162
* CD400	2.9kHz 5.9kHz 8.8kHz 11.7kHz	135 160 185 215	35 35 35 35	170 195 220 250
CD550 * CD750	2.9kHz 5.9kHz 8.8kHz 11.7kHz	251 311 366 421	35 35 35 35	286 346 401 456

* CD220 to CD750 are fan cooled

2.2 Specifications

Accuracy

Frequency —

Accuracy ± 0.01%, full scale.

NOTE This figure implies —
Crystal-controlled internal reference

Altitude

Rated up to 1000m above sea level. In excess of 1000m above sea level derate FLC by 1%/100m to a maximum altitude of 4000m above sea level.

RELEVANT SPECIFICATION — IEC 146-2, Section 3.1.a.

Ambient Temperature and Humidity

Rated ambient temperature -10°C to +50°C

Maximum storage ambient temperature: -40°C to +50°C for one year maximum.

Humidity — Non condensing at any temperature.

Environmental Protection

Ingress protection IP10.

Materials

All plastics have flammability rating UL94 VO.

Starts Per Hour

Drive limited to 10 starts per hour if started by switching the supply. If the motor is started only by electronic control of the drive, the number of starts per hour is unlimited by the drive.

PWM Switching Frequencies

Constant switching frequencies selectable from four values —
2.9kHz, 5.9kHz, 8.8kHz or 11.7kHz.

Vibration

Tested to a level of 1g (rms) in the frequency range 5Hz to 150Hz in accordance with IEC 68-2-34.

Inverter Output

The three phase balanced output can be adjusted to either 120Hz, 240Hz, 480Hz or 960Hz maximum frequency.

NOTE

(1) With a switching frequency = 2.9kHz, ULF = 120/240Hz only are possible.

(2) 960Hz ULF is only available with a switching frequency of 11.7kHz.

Maximum output voltage is normally equal to the input voltage. Current maximum = 150% of drive FLCindustrial CD drives) and 120% for drive FLC ((HVAC CDV drives).

Resolution

When parameters are set from the keypad or serial communications link, resolution is 0.1 unit except for the following:-

Value > 100 units:	± 1.0 unit, keypad mode
Acceleration & deceleration rates:	resolution becomes coarser towards 600 seconds.
Pr0, Pr1, Pr7:	0.2Hz for ULF = 240Hz.
	0.4Hz for ULF = 480Hz.
Pr10, Pr20, Pr20 -Pr27:	0.8Hz for ULF = 960Hz.
Pr6:	0.4%
Display resolution	0.1Hz.

Serial Communications Interface

RS485, RS422 and RS232 Protocol ANSI x3.28-2.5-A4 operation —

RS485	Multidrop, equipment can be connected along the length of the cable (32 transmitters and receivers).
RS422	One transmitter can drive ten receivers at the end of the cable.
RS232	One transmitter can drive one receiver.

2.3 Encoder Specification

PULSE RATE:	15 pulses per revolution per motor pole — ie 30 pulses per rev for a 2-pole machine; 60 pulses per rev. for a 4-pole machine.
ENCODER OUTPUT:	Rectangular square wave. Quadrature or complement signals are not required. Amplitude nominally equal to the supply. Mark : space ratio from 40 : 60 to 60 : 40. Rise-and-fall times not to exceed 50µs.
SUPPLY REQUIREMENTS:	CD drives will accept either — 24V signal (current sink) or +5V signal (source and sink) The drive will supply +24V at 100mA.

2.4 Electromagnetic Compatibility

Refer also to Chapter 10

EMC

The drive is designed to facilitate compliance with EMC requirements such as EC Directive 89/336/EEC.

Immunity

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

Part 2 (ESD)	Level 3
Part 3 (Radiated RF field)	Level 3
Part 4 (Transient Burst)	Level 3 (Level 4 at control and serial link terminals)
Part 5 (Surge) (Draft 1990)	Level 4

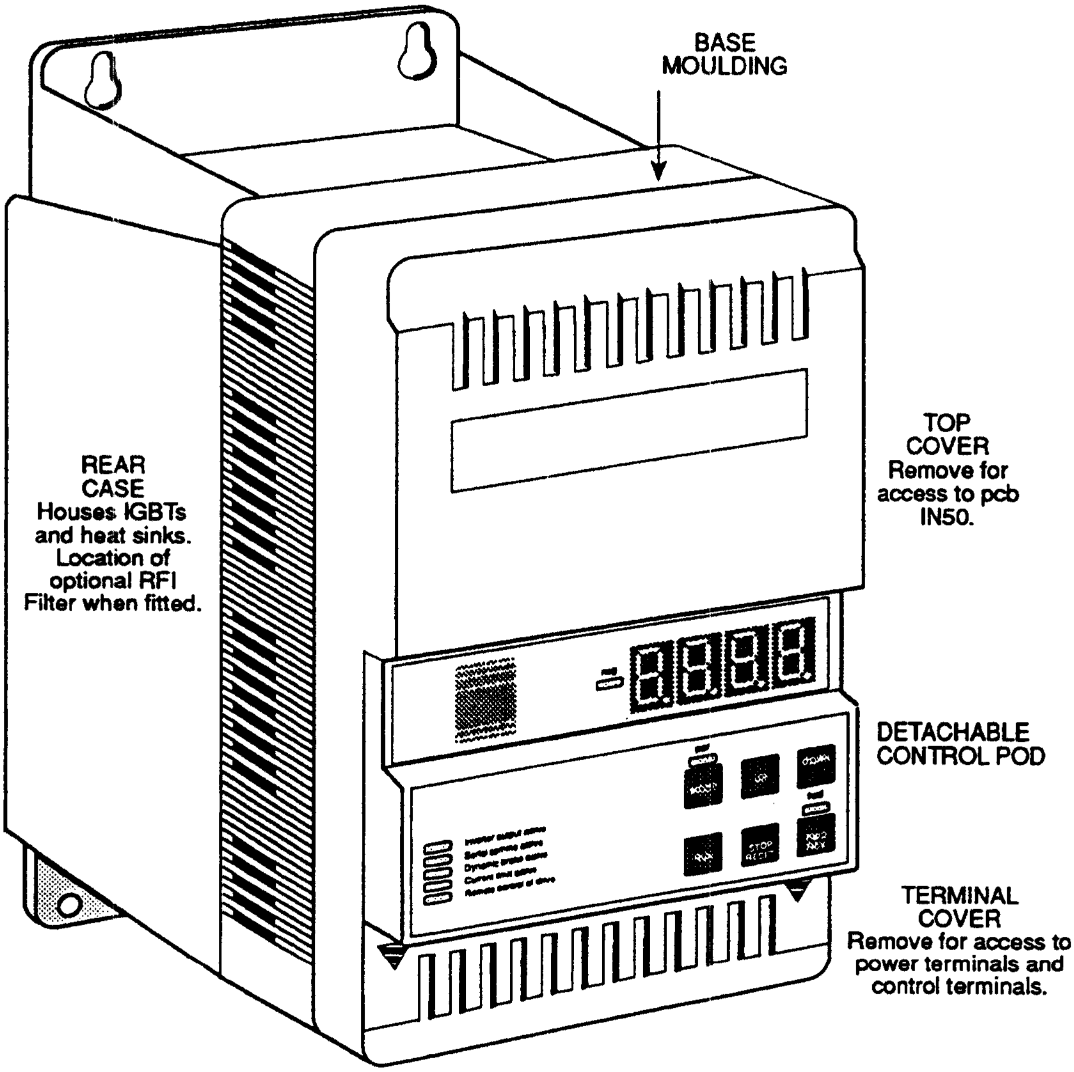
Surge immunity in accordance with IEEE587-1980

2.5 Drive Module Weights

DRIVE MODULE	*WEIGHT* kg
* CD75, CD110	4.4
* CD150, CD220, CD400	5.65
* CD550, CD750	6.4
Control Pod	0.25
Blank Pod	0.1
Optional RFI Filter	1.0
Rear Case	2.75

*Weight includes Rear Case and Control Pod. If drive is supplied with a blank pod, reduce these values by 0.15kg.

3 Installation — Mechanical



6 Locations of principal components.

3

Installation — Mechanical

3.1 Drive Mounting — General Requirements

Location

The installation should be located in a place free from dust, corrosive vapours, gases and all liquids. Care must also be taken to avoid condensation of vaporised liquids, including atmospheric moisture.

If the drive is to be located where condensation is likely to occur when the drive is not in use, a suitable anti-condensation heater must be installed. The heater must be switched OFF when the drive is energised. An automatic changeover switching arrangement is recommended.

IP Rating

The drive enclosure conforms to international enclosure specification IP10 it is therefore necessary to consider the location of the module in the light of local safety regulations applicable to the type of installation.

Hazardous Areas

The application of variable speed drives and soft starters of all types may invalidate the hazardous area certification (Apparatus Group and/or Temperature Class) of Ex-protected squirrel cage induction motors. Approval and certification should be obtained for the complete installation of motor and drive.

CD drives are not to be installed in classified hazardous areas unless correctly mounted in an approved enclosure and certified (Refer to "Hazardous Areas" Chapter 4 "Installation - Electrical".

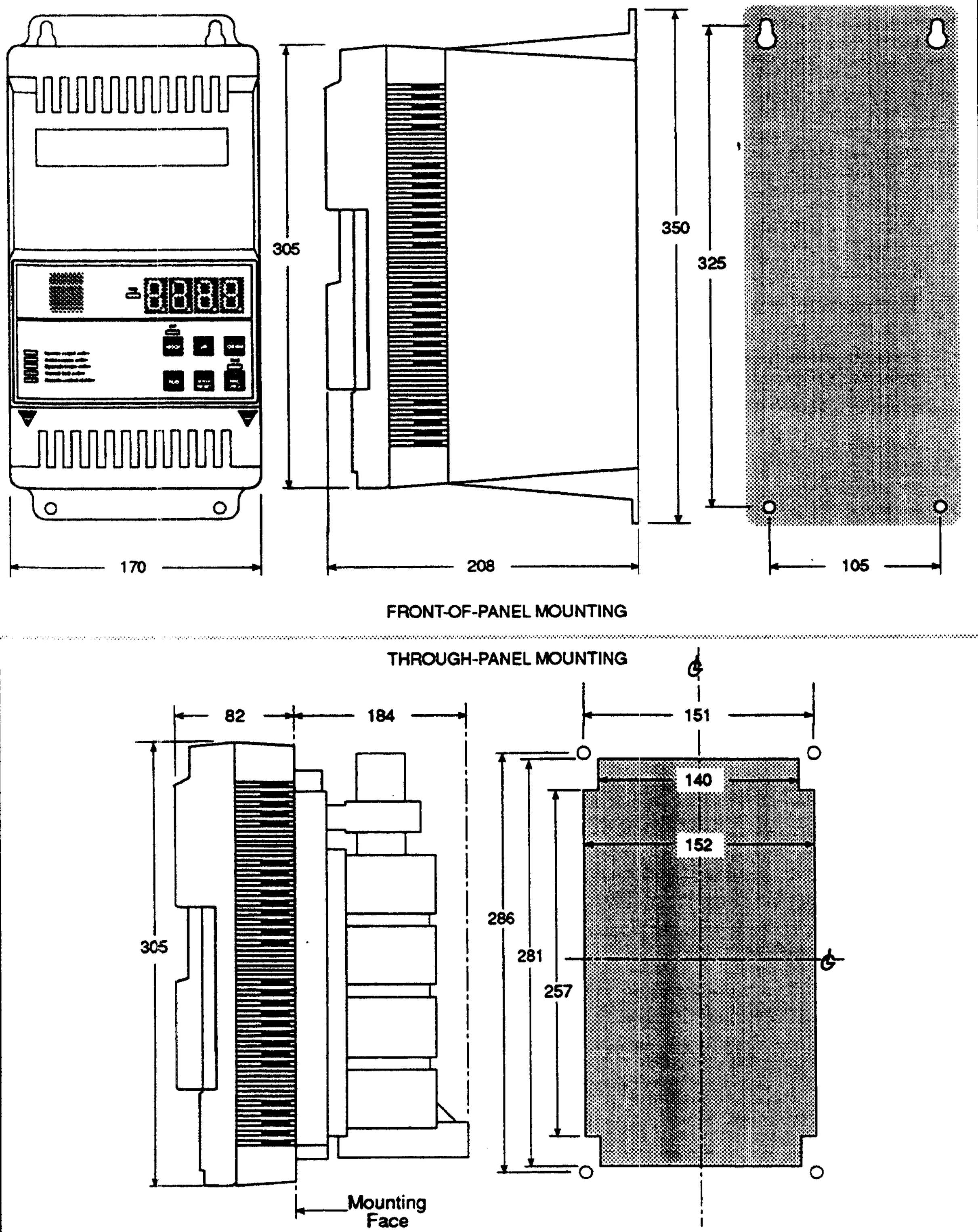
3.2 Front- and Through-panel Mounting

Front-of Panel Mounting

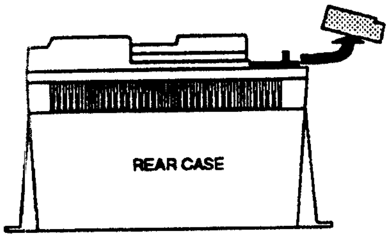
Overall dimensions and drilling dimensions are shown in Fig. 7. When mounting a drive in a cubicle, it is important to provide adequate air-circulation space for cooling. Refer to Section 3.4.

Through-Panel Mounting

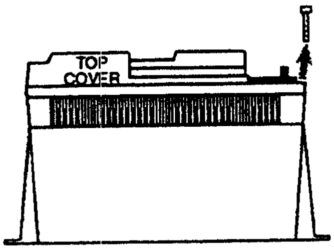
The essential dimensions are shown in Fig. 7. To mount the drive with the heatsinks projecting through the mounting panel it is necessary to remove the Rear Case of the drive. Instructions for this are shown in Fig. 8. Note that if it is intended also to mount the Control Pod remotely, the Pod can conveniently be removed from the drive during this same procedure.



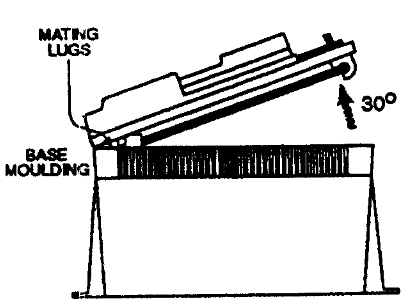
7 Overall and mounting dimensions.



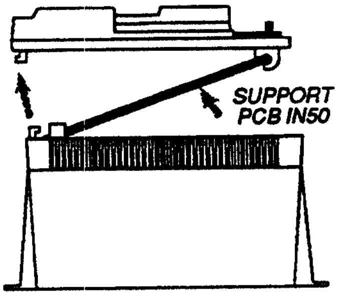
1 Remove the control terminals cover — pull down and lift away.



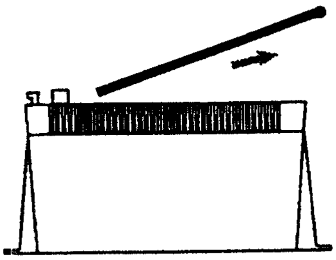
2 Remove the 2 screws, M4 x 10, either side of the power terminals, which secure the Top Cover.



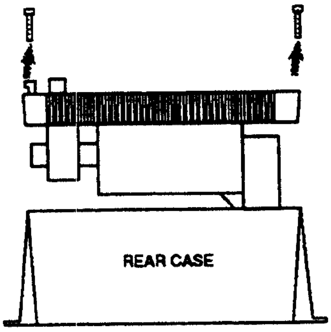
3 Lift the lower edge of the Top Cover until the Mating Lugs at the upper edge are free from the Base Moulding.



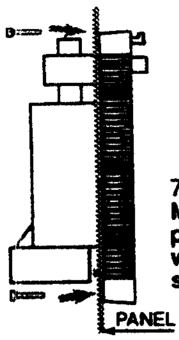
4 Disengage the Top Cover from the lug in the Base Moulding.



5 Remove the IN50 pcb complete.



6 Remove the four screws, M4 x 10, one at each corner, which secure the Base Moulding to the Rear Case. Lift the Base Moulding out of the Rear Case.

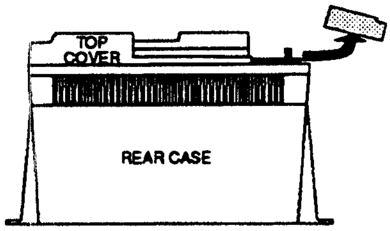


7 Install the Base Moulding into the panel and secure with four M4 x 16 screws*.

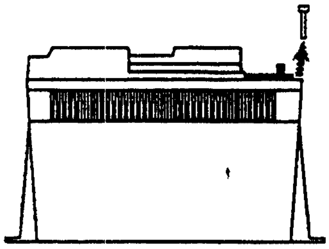
* 16mm screws for 2mm panel thichness.

TO COMPLETE, reverse the procedures of Steps 5 through to 1.

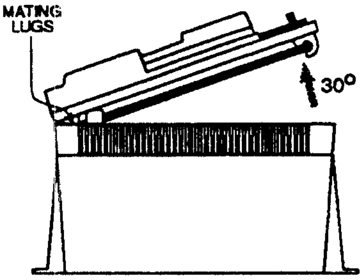
8 Procedure for removing the Rear Case.



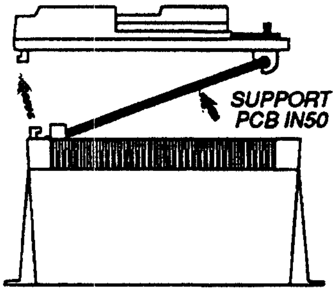
1 Remove the control terminals cover — pull down and lift away.



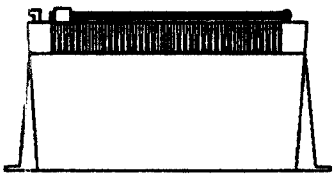
2 Remove the 2 screws, M4 x 10, either side of the power terminals, which secure the Top Cover.



3 Lift the lower edge of the Top Cover until the Mating Lugs at the upper edge are free from the Base Moulding.

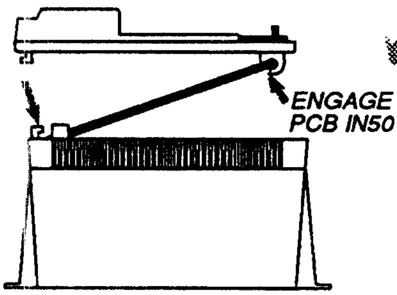


4 Disengage the Top Cover from the lug in the Base Moulding.



5 Set the Top Cover aside, and leave the IN50 pcb in the base.

6 Turn the Top Cover on its face and remove the four screws securing the Control Pod.



7 Engage the pcb IN50 into the Top Cover, and re-engage the Mating Lugs.

FINALLY, reverse the procedures of Steps 3, 2 and 1.

9 Procedure for removing the Control Pod from the module for remote location.

3.3 Control Pod Mounting

The Control Pod can be removed from its location on the front panel of the drive and mounted anywhere convenient, at a distance permitted by a maximum cable length of 100m from the drive to the Pod.

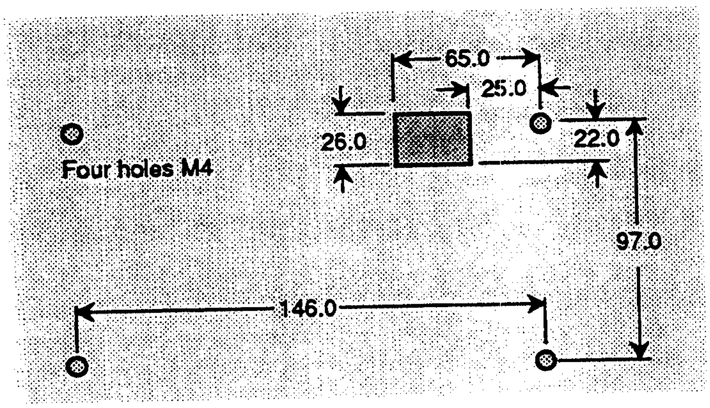
To Remove the Control Pod from the Drive

1. Disconnect and SAFELY ISOLATE the power supply from the drive. DO NOT REMOVE ANY COVER MOULDING FOR AT LEAST FIVE MINUTES, to allow ample time for internal capacitances to discharge to a safe voltage.
2. Follow the instructions shown in Fig. 9

Remote Mounting of the Control Pod

To provide access for the the control cabling to the rear of the pod, a remote mounting requires a small cut-out in the mounting panel. Drill the fixing holes and the cut-out as shown in Fig. 10.

Extension cable must be *screened data cable*. A standard 9-pin D-type plug is required at the drive end, and socket at the pod end. Full details of control cables and screening are to be found in Chapter 4, INSTALLATION — ELECTRICAL.

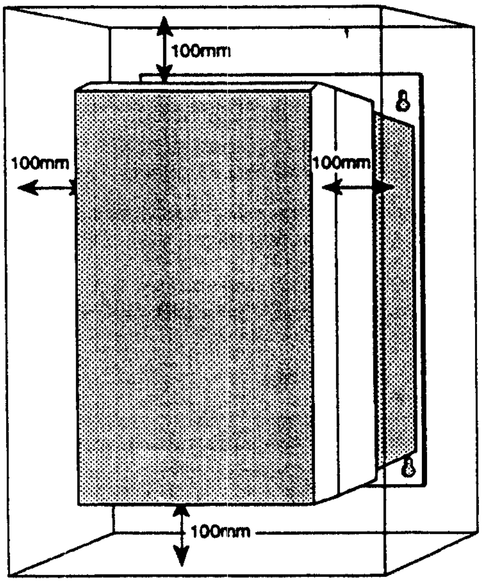


10 Remote-mounting for the Control Pod.
Drilling and cut-out dimensions.

3.4 Cooling and Ventilation

Enclosure minimum dimensions

Care must be taken that the enclosure in which the drive is sited is of adequate size to dissipate the heat generated by the drive. A minimum clearance of 100mm all around the drive is essential, Fig. 11. All equipment in the enclosure must be taken into account in calculating the internal temperature so as not to raise the internal temperature of the cubicle above the maximum allowable for the drive.



11 A minimum distance of 100mm from the enclosure boundaries or from adjacent contactors, relays and other types of heat-producing equipment is essential to allow free circulation of cooling air.

Effective heat-conducting area

The required surface area A_e for an enclosure containing equipment which generates heat is calculated from the following equation -

$$Ae = \frac{P_L}{k(T_i - T_{amb})}$$

where A_e = Effective heat-conducting area, in m^2, equal to the sum of the areas of the surfaces which are not in contact with any other surface.

P_L = Power loss of all heat-producing equipment in Watts.

T_i = Maximum permissible operating temperature of the drive module in ^oC.

T_{amb} = Maximum external ambient temperature in ^oC.

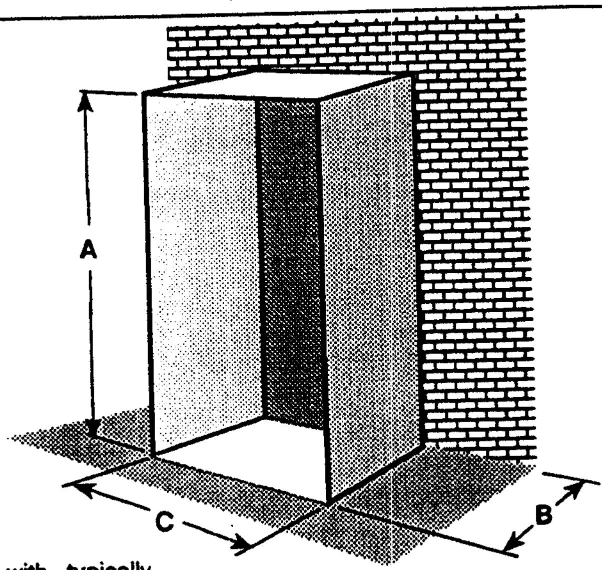
k = Heat transmission coefficient of the material from which the enclosure is made.

EXAMPLE

To calculate the size of an IP54 cubicle for a CD750 (7.5kW) drive.

The 'worst case' is taken as the basis for the example, so the following conditions are assumed:

- The drive is to be operated at 2.9kHz PWM switching frequency (**b14** = 2.9).
- The installation is to conform to IP54, which means that the drive module and its heat sink are to be mounted wholly within the cubicle, and that the cubicle is virtually sealed and without any ventilation of the air inside. Heat can escape only by conduction through the skin of the cubicle, which is cooled by radiation to the external air.



12 Enclosure with typically two surfaces unable to disperse heat.

- The cubicle is to stand on the floor and against a wall, Fig.12, so that its base and back surfaces cannot be considered to play any part in the cooling process. The effective heat- conducting area, A_e, is provided by the top, front, and two sides only.
- The cubicle is to be made of 2mm sheet steel, painted.
- The maximum ambient temperature is 25°C.

To Find the Effective Heat-conducting Area

The values of the variables appropriate to the above specification are —

P_L = 286W (from the table of Losses, CD 750 module operating at 2.9KHz PWM switching frequency, Section 2.1, page 2-3)

T_i = 50°C (for all CD75-750 and CDV75-750 drives)

T_{amb} = 25°C

k = 5.5 (typical value for 2mm sheet steel, painted)

$$A_e = \frac{286}{5.5\,(50-25)}$$

$$= 2.08\text{m}^2$$

NOTE
It is essential to include any other heat-generating equipment in the value for P_L.

To Find the Dimensions of the Enclosure —

If a cubicle is to be fabricated to suit the installation, there is a free choice of dimensions. Alternatively, it may be decided to choose a cubicle from a range of standard products.

Either way, it is important to take into account the dimensions of the drive module, Fig. 7, and the minimum clearance of 100mm round the module, Fig. 11.

The procedure is to estimate two of the dimensions — the height and depth, for example — then calculate the third, and finally check that it allows adequate internal clearance.

The effective heat-conducting area of a cubicle located on the floor and against one wall as shown in Fig. 12 is —

$$A_e = 2AB + AC + BC$$

Suppose the cubicle height A is 1.0m to allow adequate clearance above and below, and the depth B is 0.5m, as a first estimate. The actual figures chosen in practice will be guided by available space, perhaps, or standard enclosure sizes. Since A_e, A, and B are known, the dimension to be calculated is C. The equation needs to be rearranged to enable C to be found, thus —

$$A_e - 2AB = C\,(A + B)$$

or

$$C = \frac{A_e - 2AB}{A + B}$$

$$C = \frac{2.08 - (2 \times 1.0 \times 0.5)}{1.8 + 0.5}$$

$$C = \frac{2.08 - 1.0}{2.3}$$

$$C = 0.78\text{, or 780mm approx.}$$

Clearance on either side of the inverter module must be checked. The width of the module is 170mm, Fig.7. 100mm clearance is required all round, so the minimum internal width of the enclosure must be 370mm or 0.37m. This figure is within the calculated width at the selected height, and therefore acceptable. However, although the figure allows additional space, any additional equipment must be considered as a factor in the total power losses P_L and may demand that the calculation is reworked. If so, recalculate A_e, modify the value of C if necessary to allow for other equipment, and re-calculate either of the other two dimensions A and B.

If a catalogue stock enclosure is to be used the corresponding surface area should be not less than the figure calculated for A_e.

It is important that heat-producing equipment should not be located below the drive.

As a general rule, it is better to locate heat-generating equipment low in an enclosure to encourage internal convection and distribute the heat. If it is unavoidable to place such equipment near the top, consideration should be given to increasing the width and depth dimensions at the expense of the height.

Enclosure Ventilation

If a high IP rating is not a critical factor, or if a ventilating fan can be used to exchange air between the inside and the outside of the enclosure, the enclosure can be smaller.

To calculate the volume of ventilating air, V, the following formula is used —

$$V = \frac{3.1\,P_L}{T_i - T_{amb}}$$

where V = Required air flow in $m^3\,h^{-1}$

To Find the Ventilation Required for a CD750 Drive —

If, P_L = 286W

T_i = 50°C (for all CD75-750 & CDV75-750 drives)

T_{amb} = 25°C (for example)

Then

$$V = \frac{3.1 \times 286}{50 - 25}$$

$$V = 35.46\ m^3\,h^{-1}$$

or, say $36m^3\,h^{-1}$ as a practical minimum.

4 Installation — Electrical

4

Installation — Electrical

4.1 Installation Safety

Safety

The voltages present in the supply cables, the output cables and terminals, the control power supply wiring and in certain internal parts of the drive are capable of causing severe electric shock and may be lethal.

ELECTRIC SHOCK RISK!
Whenever the drive has been energised, it MUST be ISOLATED before work may continue. A period of seven minutes MUST elapse after isolation to allow the internal capacitors to discharge fully. Until the discharge period has passed, dangerous voltages may be present within the module.

Persons supervising and performing electrical installation or maintenance must be suitably-qualified and competent in these duties, and should be given the opportunity to study, and to discuss if necessary, this User's Guide before work is started.

Hazardous Areas

The application of variable speed drives and soft starters of all types may invalidate the hazardous area certification (Apparatus Group and/or Temperature Class) of Ex-protected motors. Approval and certification should be obtained for the complete installation of motor and drive. (Refer to Chapter 3 "INSTALLATION MECHANICAL".)

Earthing

The drive must be connected to the system earth at the power earth (PE) terminal provided on the power terminal block. This terminal, marked with the standard 'earth' symbol, Fig. 14, is to be distinguished from the terminal marked E_{EMC}. Earth impedance must conform to the requirements of local industrial safety regulations and should be inspected and tested at appropriate and regular intervals.

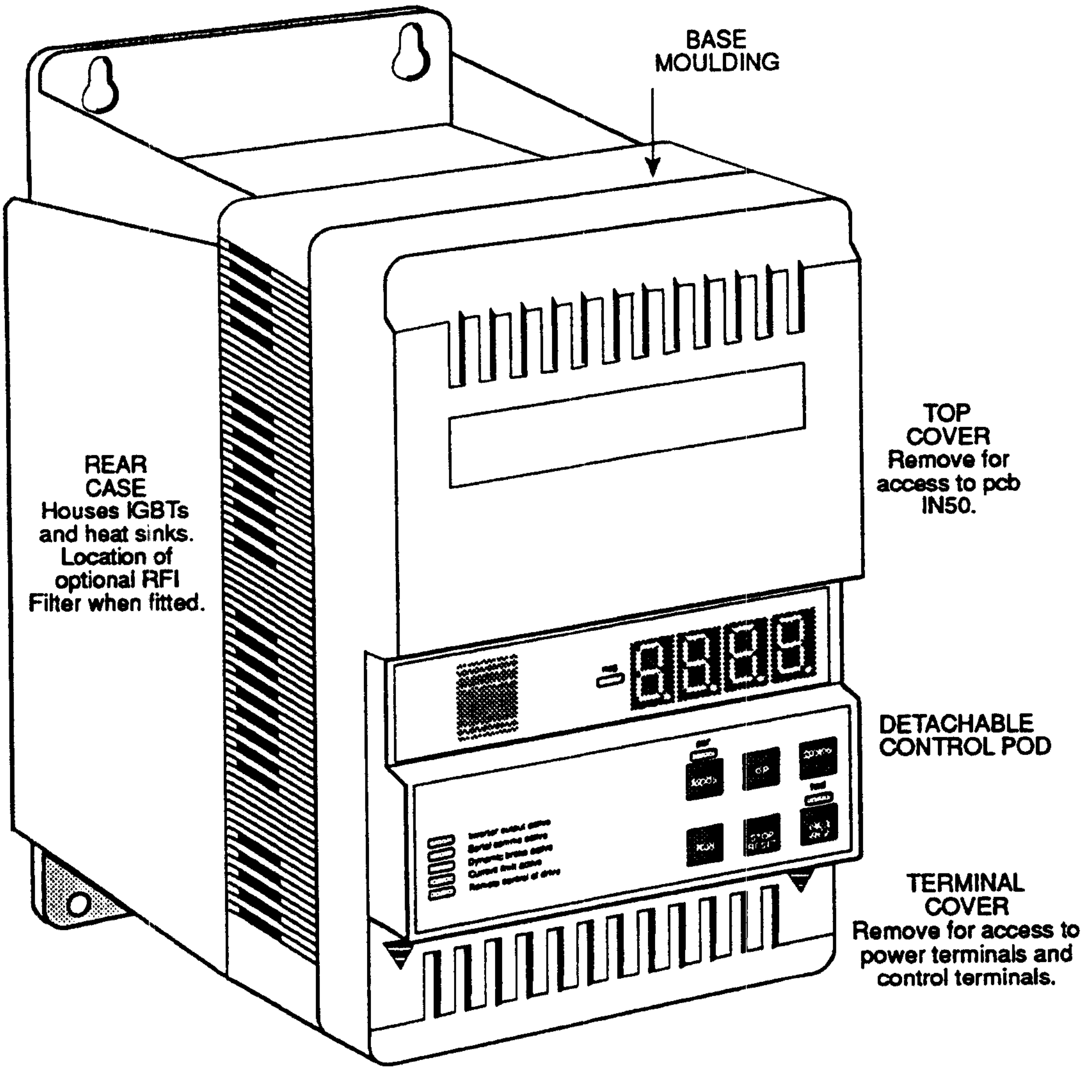
The E_{EMC} terminal must be linked to the earth (PE) terminal to bring the Integral RFI Filter into use. It is recommended that this filter is used as in most situations it provides an effective reduction of RFI emissions into the mains supply. It does, however, introduce a small leakage current. If this leakage current is not acceptable, the E_{EMC} terminal should be left unconnected. Refer to Chapter 10, Section 10.9 for information on leakage current levels.

In order to ensure the electrical safety of equipment incorporating the drive, **it is important that a fixed earth connection is provided, ie the safety earth is not connected solely through a flexible cable or connector which might become accidentally disconnected or open-circuited.**

If additional filtering is required, an optional RFI filter is available. Refer to Chapter 10.

Grounded Delta Supplies

The drive is designed for use with conventional three-phase supplies which are symmetrical with respect to earth. Surge suppression devices are included to protect the drive from lightning-induced overvoltages between lines and earth. For this reason the drive must not be used directly with supplies where one phase is grounded, ie the voltage between the other phases and ground is equal to the line voltage (the arrangement sometimes referred to as "Grounded Delta" in the USA). In such cases an isolation transformer must be used to provide a supply balanced with respect to earth.



13 Locations of principal components.

Motor Speed

Standard squirrel-cage ac induction motors are designed as single speed machines. If it is intended to use the capability of the drive to run the motor at speeds above its designed maximum, it is strongly recommended that the motor manufacturer is consulted first.

The principal risks due to overspeeding are the destruction of the rotor by centrifugal force, or of the bearings by vibration or heat.

Low speed is liable to result in overheating of the motor because the effectiveness of the internal cooling fan reduces in proportion to the square of the reduction of speed. Motors should be equipped with thermistor protection, and if full benefit of the use of low speeds is to be gained from a variable speed drive it may be necessary to arrange additional cooling for the motor.

4.2 Power Connections

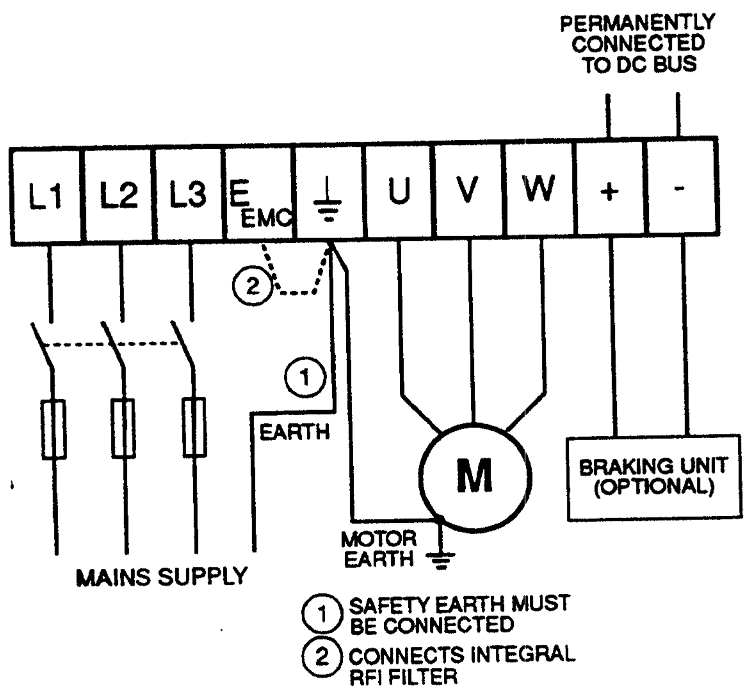
Refer to Fig 14.

Terminals

Access to the power connections is gained by removing the Terminal Cover, Fig. 13. If internal RFI filtering is required, link the power earth and the E_{EMC} terminals by a 2.5mm^2 wire link, Fig. 14.

L1	Line 1(R)	"U"	Motor Phase - U	"+"	DC Link Positive
L2	Line 2(S)	"V"	Motor Phase - V	"-"	DC Link Negative
L3	Line 3(T)	"W"	Motor Phase - W		
		E_{EMC}	Intergral RFI filter	⏚	Power earth

The layout of the power terminals and connections is shown in Fig. 14.



14 Power terminals and standard connections for the drive.

Fuses and Cables

Drive Model	**Recommended fuse ratings at 380V* A	*† Typical cable size* mm^2
CD75	6	1.0
CD110	6	1.0
CD150	10	1.5
CD220	10	1.5
CD400	16	2.5
CD550	16	2.5
CD750	20	2.5

* The use of slow fuses is recommended because a current surge may appear at power on. As an alternative to fuses, mcbs or mccbs may be used if equipped with adjustable thermal and magnetic trip devices of a suitable rating.

† The cable sizes are for 3-core and 4-core pvc-insulated armoured cable rated at 600V ac (1000V dc) and laid in accordance with the maker's defined conditions.

Power Cabling

The cabling to the drive must be rated for 600V ac or 1000V dc. Cable sizes specified are for PVC/SWA cables laid under defined conditions, and are general recommendations only. Cabling should conform to local codes of practice and regulations.

Connect the 3 phase mains supply to the large terminals, L1-L2-L3. The mains supply should be fed via an isolator, contactor, mcb or mccb, with fuses or thermal current protection.

Discard the label "WARNING — FIT FUSES". This is a reminder to ensure that the mains supply is adequately protected. Connect the motor terminals to the U, V, W terminals of the drive. The drive MUST BE EARTHED.

The power connections from the drive output to the motor may be switched, for isolation purposes, but not for control purposes, as the drive may trip. Installations prone to mains voltage disturbances may need special consideration; if so, consult the supplier of the drive.

Installations with long cable runs, to the motor, may need the addition of motor line chokes, to prevent nuisance tripping of the drive (**PrA = OI**) caused by capacitative leakage effects. Refer to the table on the following page.

Electrical Interference

Some attention is needed to the arrangement of the power and earth connections to the drive to avoid interference with nearby sensitive equipment. The cable to the motor carries rapidly-switched voltages and should be routed well away from sensitive equipment.

The earth core of the motor cable should be connected directly to the drive earth terminal, as shown in Fig. 14. It should not be connected to the drive indirectly, for example through a cubicle-earth busbar; this will cause high-frequency current to circulate in the earth system of the cubicle. At the motor end, the earth core should be connected to the motor earth terminal in the normal manner.

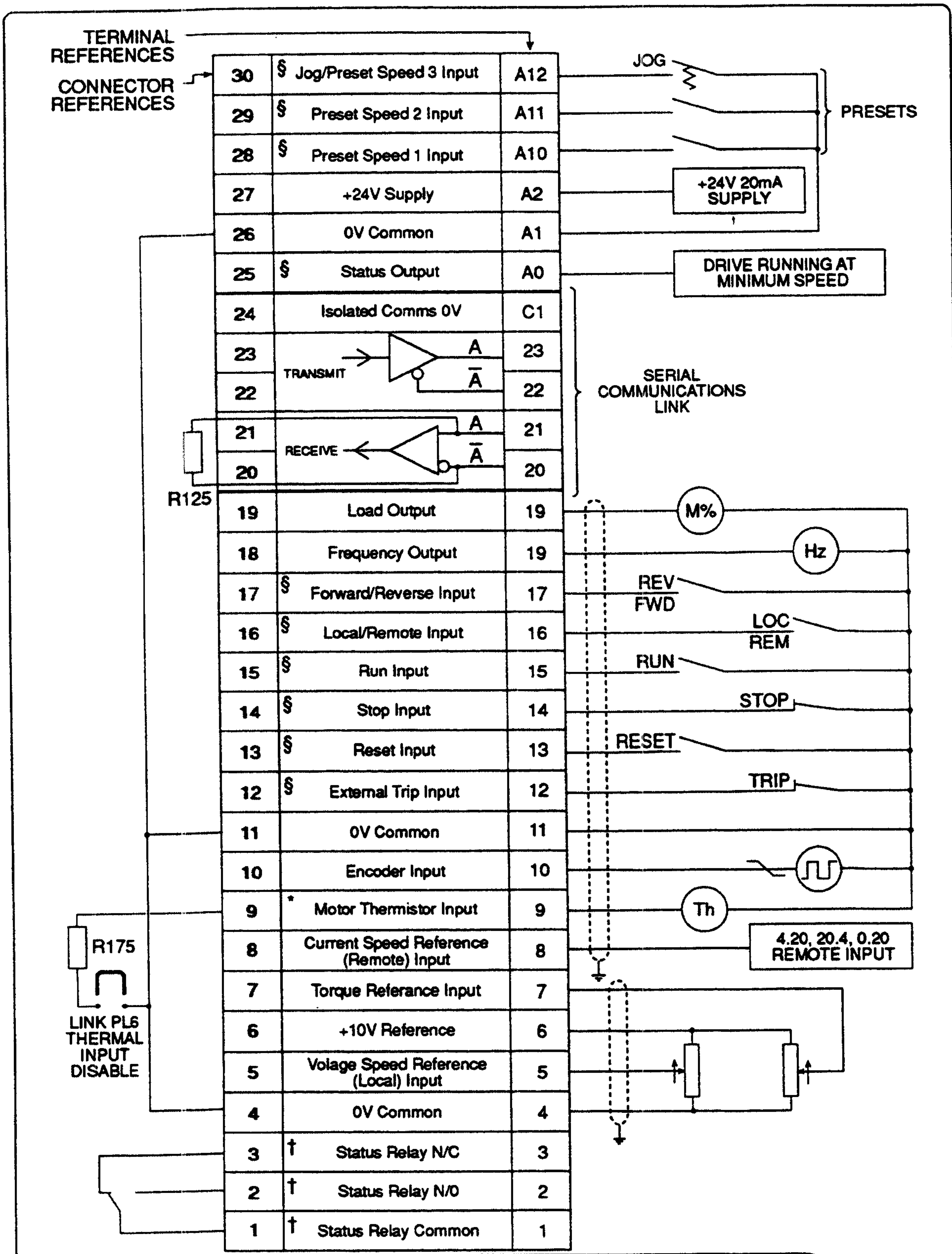
Screened or armoured cable may be used to prevent emissions from the motor cable. The screen or armour should be connected in the same way as for standard cable, that is, to both the motor earth terminal and the drive earth terminal.

The drive input power safety earth conductor should follow the same route as the input power conductors. It should be a dedicated earth wire, not 'daisy-chained' from any other equipment in the cubicle.

Length of cable above which motor line chokes may be required

Module		*CD75*	*CD110*	*CD150*	*CD220*	*CD400*	*CD550/ 750*	*Required Choke Value*
Cable Length (m)		30-90	40-125	50-145	60-165	80-200	140-300	1mH
		90--180	125-250	145-290	165-330	200-400	300-600	2mH
Current rating		5A	5A	5A	9A	9A	20A	

When using line chokes in the motor cable it is recommended that the 2.9kHz PWM switching frequency is used to minimise losses in the chokes.



NOTES

* 1 Before connecting motor thermistor, refer to text page 4-9, terminal 9.

† 2 A 'Status' relay can be programmed as an 'At-Speed' relay.

§ 3 Link PL5 inverts the polarity of the *external* logic. Factory setting is compatible with *negative* external logic.

4 A relay can be connected directly between A_0 and A_2 for 'drive running at minimum speed'.

15 Control terminals and typical external control circuits.

4.3 Control Connections

Refer to Fig. 15.

For control connections use cable of 0.5mm^2 screened. Connect screen to earth AT THE DRIVE ONLY. Always segregate control and power cabling. Connections to terminals are shown in Fig. 15 and should be made to earth at the sending end if long cables are used (i.e. greater than 5m).

Auxiliary Supplies and References

+24V ± 10% 100mA } *Short-circuit-proof* to 0V
+10V ± 2% 5mA }
0V Analogue
0V Digital
0V Serial Communications (isolated)

Logic Inversion

By altering the position of link PL5 (Fig. 16) the logic of the digital inputs and outputs is inverted, so that the 'on' state corresponds to +24V (positive logic) instead of the standard 0V (negative logic, as delivered). This allows the use of certain types of programmable controller in which positive logic is standard.

Specifications of Control Inputs and Outputs

ANALOGUE INPUTS

Local speed reference:		unipolar 0 to +10V, 110K input impedance
	or	bipolar -10 to +10V, 110K input impedance
Remote speed reference:		4 to 20mA, 100 ohms input impedance
	or	20 to 4mA, 100 ohms input impedance
	or	0 to 20mA, 100 ohms input impedance
Torque reference:		0 to +10V, 27K input impedance
Motor thermistor:		Motor thermistor terminal voltage < 2.5V, capable of protecting from 1 to 6 standard 250R machine thermistors connected in series. Trip resistance 3k ± 15%, reset 1k8 ±15%. Short circuit protection will not trip above 100R.

DIGITAL INPUTS

Digital inputs (1-9), can be configured for either positive or negative logic via hardware links, which should only be adjusted at commissioning.
Negative logic (factory fitted option), active low, 5k input impedance.
Positive logic, active high, 5k input impedance

NOTE High = +24V dc, low = zero volts — applies to negative and positive logic.

Input Functions for Negative Logic

External Trip:	low = no trip, momentary high = trip (N/C contact)
Run:	momentary low = start (N/O contact)
Stop:	low = not stop, momentary high = stop (N/C contact)
Reset:	momentary low = reset fault (N/O contact)
Local/Remote:	low = select remote reference high = select local reference
Forward/Reverse:	low = select reverse direction high = select forward direction
Preset Speed 1:	(Two binary preset inputs select 3 preset speeds,
Preset Speed 2:	when both high normal speed control is selected).
Jog/Inch:	low = jog/inch

NOTE Momentary = hold state for ≥16 ms.

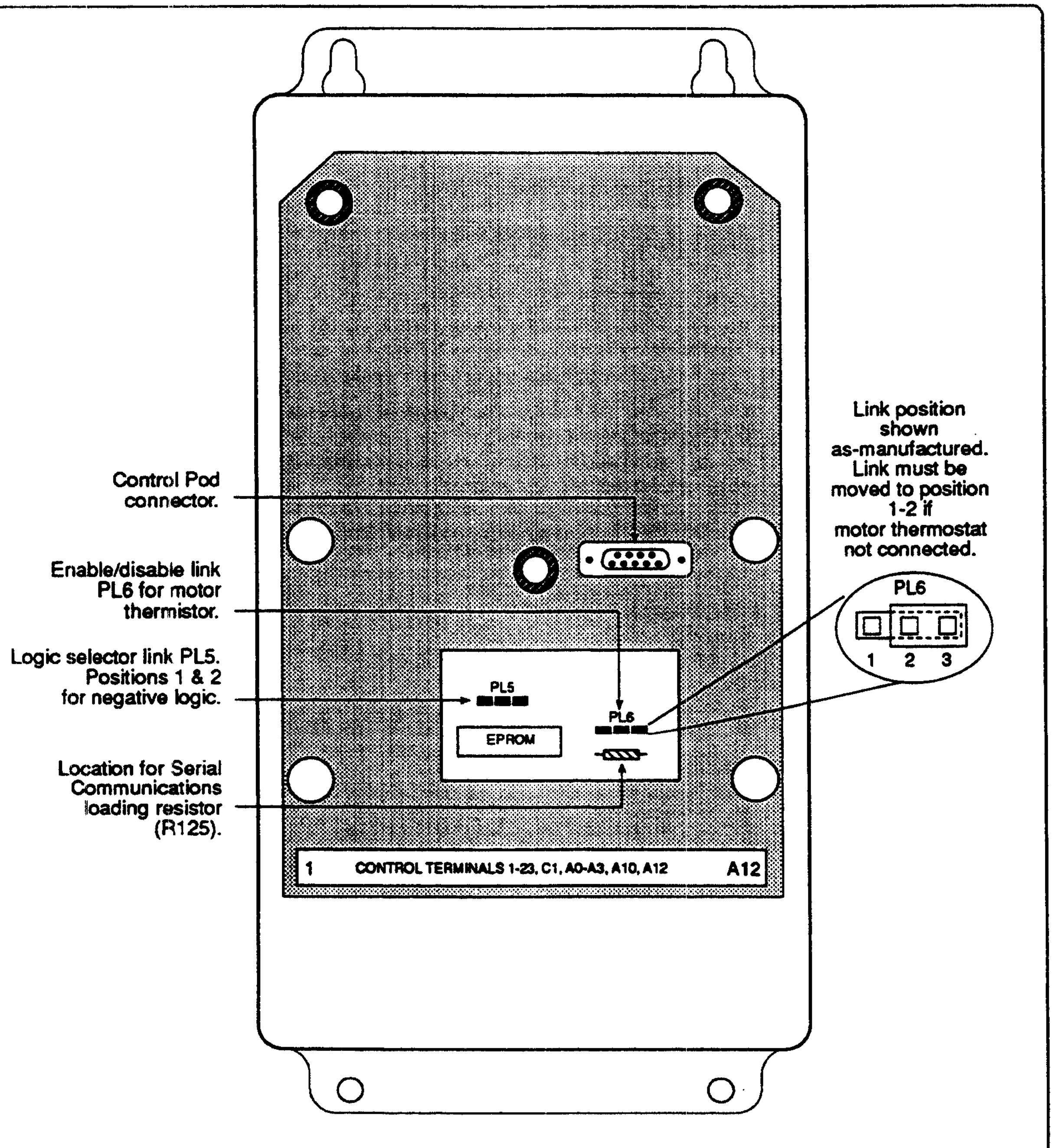
NOTE The Jog/Inch input can be software selectable to give a third preset speed input and thus a total of sevenpreset speeds.

DIGITAL OUTPUTS

Drive Status or At-Speed Relay	De-energised at power off, drive tripped at speed operational. Volt free contact, 7A resistive. Changeover type relay. Software programmable assignation.
Drive Running or Minimum Speed	Open collector or PLC type 24Vdc output, 0.25A sink capability and 0.05A source capability. Software programmable assignation.

ANALOGUE OUTPUTS

Frequency (Speed):	0 to 10Vdc, 5mA capability; 0V = <Pr0>, 10V = <Pr1>. Accuracy ± 2%.
Load (Torque):	-10V to +10Vdc, 5mA capability; 0V = no load, -10V = 150% regenerating, +10V = 150% motoring. Accuracy ± 10% above 15Hz with matched motor.



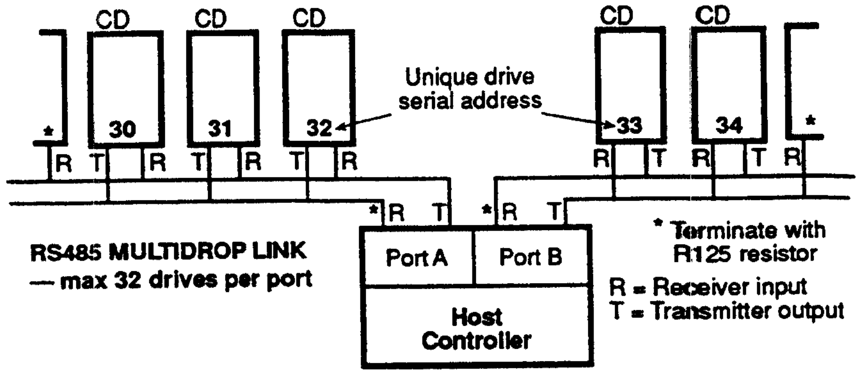
16 Top Cover removed to show location of components on pcb IN50.

Functions of Control Terminals

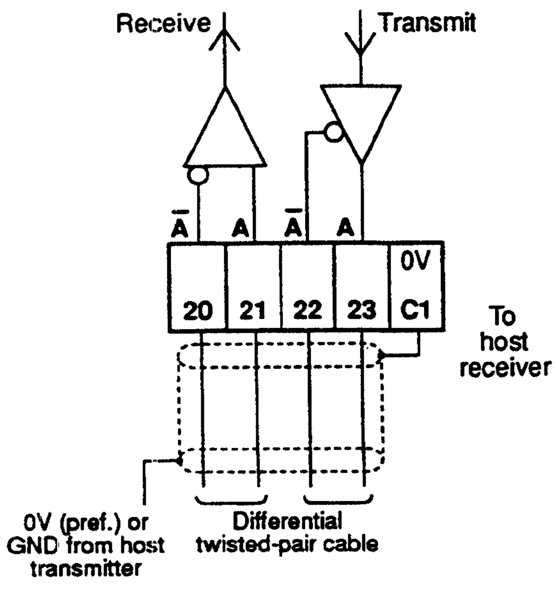
Terminal Number	D/A	Description	
NOTE D = Digital, A = Analogue			
1	D	Status or At-Speed relay common	Volt-free change-over contact, 240V AC 7A resistive load. Relay energised when drive healthy/at speed; de-energised when drive off, tripped, or not at speed. Configured by parameter **b50**.
2	D	Status or At-Speed relay normally open	
3	D	Status or At-Speed relay normally closed	
4	A	Zero volts common	Internally connected to terminals 11, A1.
5	A	Local set speed	10k potentiometer or voltage signal 0V to +10V or -10V to +10V potentiometer input (BIPOLAR) 110k input impedance. Configured by parameter **b4**.
6	A	+10V ± 2% reference voltage	5mA maximum loading (short-circuit-proof to zero volts)
7	A	Torque reference input	10k potentiometer, or voltage signal, 0V to +10V, 27k impedance (always active, independent of parameter **b0**).
8	A	Remote set speed current input	4/20mA or 20/4mA or 0/20mA, 100R input impedance. Configured by parameter **b11**.
9	A	Motor thermal protection (thermistor) input	V out <2.5V. Trip resistance 3k ± 15%, reset 1.8k ± 15%. Short circuit protection will not trip above 100R.

NOTE If no motor thermistor is to be used, a link on the IN50 pcb must be repositioned to disable the input. Refer to Fig. 16 for location of the link.
Refer also to the paragraph *Logic Inversion* on page 4-9.

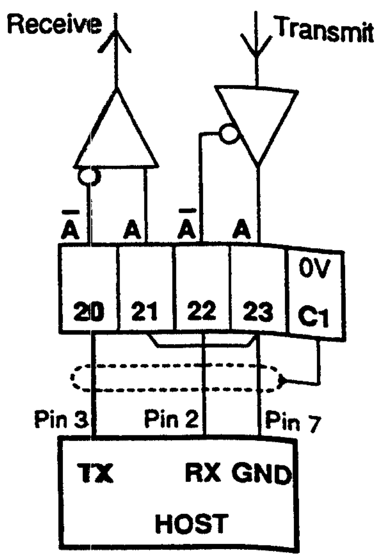
Terminal Number	D/A	Description	
10	D	Encoder input	0V to +5V at 16mA open collector. Square wave, mark:space 60:40 or 40:60, up to 24V, 15 pulses per motor pole per revolution (enabled by parameter **b5**).
11	A	0V common	Internally connected to terminals 4, A1.
12	D	External trip	low = no trip momentary high = trip (N/C contact to zero volts)
13	D	Reset	momentary low = reset fault (N/O contact to zero volts)
14	D	Stop	low = not stop, momentary high = stop (N/C contact to zero volts)
15	D	Run (start)	momentary low = start (run) (N/O contact to zero volts)
16	D	Local/Remote	low = select remote reference high = select local reference
17	D	fwd/rev input	low = select reverse direction high = select forward direction



17 Basic RS485 Serial Communications arrangement and serial address. Unique identity code for up to 32 drives per communications port at the host.



18 RS485 or RS422 serial communicatrions link connections. Cable must be screened.



19 RS232 serial communicatrions link connections. Cable must be screened.

Terminal Number	D/A	Description	
18	A	Frequency output signal	0V to +10V, 5mA. Accuracy ±2% 0V at Pr0, 10V at Pr1
19	A	Load output signal	0V to +10V, 5mA 0V = no load +10V = 150%FLT monitoring (120% -10V = 150%FLT regenerating HVAC) Accuracy ± 10% above 15Hz with matched motor
20	D	Serial link receive A or B	Two lines for differential receive
21	D	Serial link receive $\overline{A}$	Differential Input: 0 to 5Vdc, input impedance 3.5k. V(A-$\overline{A}$) > +0.2V = Logic high at the microprocessor. V(A-$\overline{A}$) < -0.2V = Logic low at the microprocessor.
22	D	Serial link transmit A or B	Two lines for differential transmit
23	D	Serial link transmit $\overline{A}$	Differential Output: Output is 0 to 5Vdc, current capability ± 60mA. Logic high at the microprocessor A = 5V, $\overline{A}$ = 0V. Logic low at the microprocessor A = 0V, $\overline{A}$ = 5V. Not transmitting (internal buffer is tri-stated): A, 10k pull up to 5V; $\overline{A}$, 10k pull down to 0V.
		Refer also to Section 4.5 below, and Figs. 16.	
C1	A	Serial link 0V common	Isolated from zero volt terminals 4, 11. Serial link is always active, parameter **b6** allows control.

NOTE Refer to Chapter 8 "SERIAL COMMUNICATIONS" for further details.

Terminal Number	D/A	Description	
A0	D	Drive running	Programmable open collector output source, 30mA from or minimum speed +24V sink, 250mA to 0V. +24V external relay de-energised if drive not running or not at minimum speed. Configured by parameter **b53**
A1	A	Zero volts common	Internally connected to terminals 4, 11.
A2	A	+24V supply, 100mA	General purpose (±10%). Short-circuit protected from 0V.
A10	D	Preset speed 1	Two binary preset speed inputs select 3 preset speeds. When both are high, normal speed control is selected. (N/O contact to zero volts)
A11	D	Preset speed 2	
A12	D	Jog/inch	Low = Jog/inch (N/O contact to zero volts) This input can be software selectable to give a third preset speed input and thus a total of 7 preset speeds. Configured by parameter **b20**)

4.4 Other Configuration Details

The outline of the control PCB is shown in Fig. 16. The only remaining customer useable selections are —

PL5 : To select positive or negative (standard) control logic.
R125 : Serial communications terminating resistor. Refer to Fig. 17.
PL6 : Link to enable/diable motor thermistor input.

4.5 Connecting Serial Communications

SERIAL COMMUNICATIONS I/O

The standard connection is RS485/RS422, refer to Fig. 18. Always use screened, twisted-pair cables for RS485 serial. Alternatively the single ended communications system, RS232 can be used, Fig. xx.

Serial communications cabling —

RS485 cable type, braid screened, 120 Ohm characteristics impedance dual twisted pair.
Termination: Cable terminated at each end by 120 Ohm resistor.
Maximum cable length: 120 m.

RS422 cable type: braid screened, 100 Ohm characteristics impedance dual twisted pair.
Termination: Cable terminated at receiver end by 100 Ohm resistor.
Maximum cable length: 120 m.

RS232 cable type: braid screened, 3 core.
Termination: None.
Maximum cable length 15 m.

5 Operating Procedures

5

Operating Procedures

5.1 Safety

Safety procedures must be properly observed
It is advisable particularly to take care to check the direction of rotation of the motor

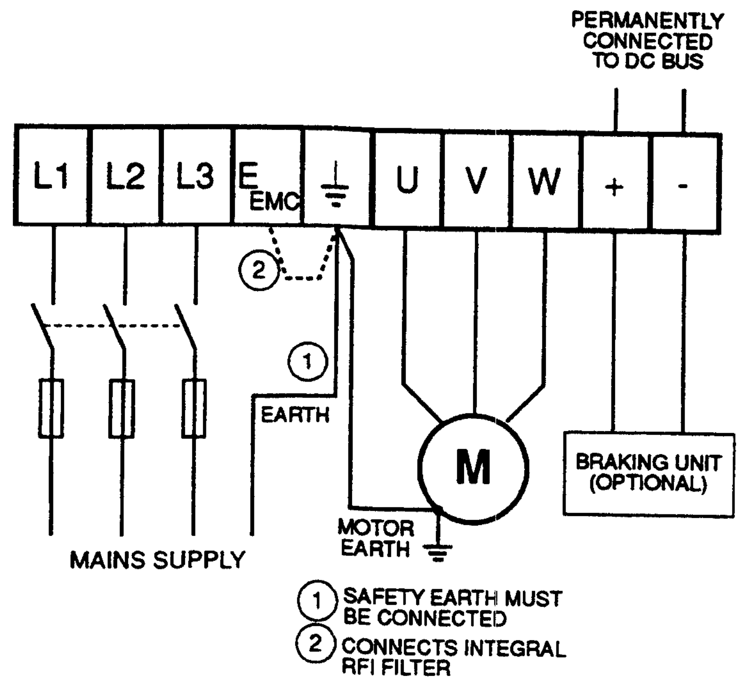
Ensure that...

- the person in charge of the trial run is fully competent to perform or supervise the mechanical and the electrical installation.
- the motor rating is compatible with the inverter rating.
- the motor is securely bolted down.
- the inverter is firmly attached in an upright position and is properly ventilated.

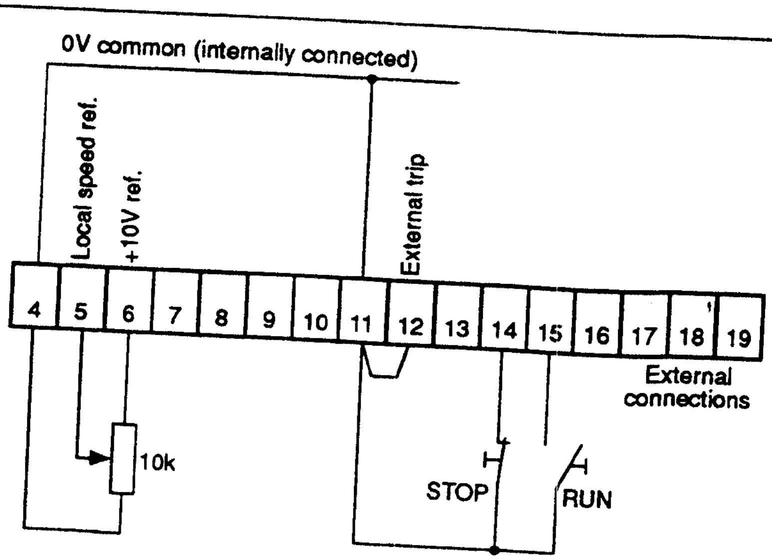
Preliminary

For access to the power and control terminals, remove the Terminal Cover — the lower portion of the lid, Figs. 6 and 13. Make power connections as shown in Fig. 20.

- Electrical supply connections must be earthed in accordance with local industrial safety regulations.
- Protective hrc fuses or a circuit breaker of the correct rating must be installed in the supply, refer to Chapter 4, Section 4.2, page 4-5.



20 Power terminals and standard connections for the drive.



21 External control components and connections to enable the drive to operate under Procedure A.

5.2 Setting Up to Run

The objective of this chapter is to enable users unfamiliar with inverter control of squirrel cage motors to gain confidence by working through simple procedures. The following procedures result in the motor running under speed control, and enable the operator to become familiar with the keypad, entering and changing parameter values, and to investigate some of the functions of the drive.

Ideally, the motor should not be connected to a load for the trial run. If it is not yet installed in its working location, it could be temporarily bolted down in a workshop. If the motor is already installed and coupled, and its starting torque will be high, it should preferably be uncoupled. If it is to drive a load such as a centrifugal fan, where low-speed torque is not significant, uncoupling can be avoided so long as trial operations will not interfere with other equipment or processes.

Procedure 'A' below requires some simple control wiring to a start and a stop switch, with a potentiometer as shown in Fig. 21, and without alteration of parameters at the keypad. Starting and running the motor in this mode is as simple as with a conventional starter, and the motor is immediately under manual speed control.

Alternatively, without external controls but with some minor control terminal links, the motor can be started and operated under speed control from the keypad, Procedure B. Procedure A can be followed immediately by procedure B, for experience in using parameters.

Procedure A

External control, not using keypad.

A1 Install the control wiring connections to terminal board, shown in Fig. 21, as follows —

Terminals 4, 5, 6.	Connect10k potentiometer. Ensure that the potentiometer is set at the zero volts point.
Terminals 9, 11.	If a motor thermistor is available, connect between terminals 9 and 11, refer to Chapter 4 Section 4.3, page 4-9. *If no motor thermistor is to be used, a link on the IN50 pcb must be repositioned to disable the input. Refer to Fig. 16 for location of the link.*
Terminals 11, 12.	Link together to bypass the external trip.

Terminals 11, 14, 15. Install two control switches —
RUN switch, normally-open contacts, terminals 11 and 15, and a STOP switch, normally-closed contacts, terminals 11 and 14.

A2 Set speed pot to minimum speed. Turn on the 3 phase input. Close the RUN control contact. Observe that the 'Inverter Active' LED and the 'FWD' LED illuminate. The keypad display indicates **0**. The motor remains at rest, but is energised at zero Hz.

A3 Turn the potentiometer a small amount to start the motor at low speed. Observe that the keypad display indicates the motor speed. The value shown is the frequency supplied to the motor.

NOTE It is not advisable to run the motor at low speed for any length of time, especially if it is loaded, unless the motor has a thermistor for over-temperature protection and this is connected to the drive as shown in Fig. 15, page 4-8, or arrangements have been made for additional cooling.

A4 Use the potentiometer to increase and reduce speed. The motor is at full speed when the display shows 50.0 and the potentiometer is at the +10V end.

A5 Operate the STOP switch.

Observe that — the motor ramps to rest,
the keypad display value reduces to zero,
the keypad display changes to **rdY**.

The display indicates that the motor is now stopped. The output bridge is not energised, as indicated by the 'Inverter Output Active' LED being extinguished when **rdY** appears.

At this stage adjustments can be made to some parameters for practice and to observe the effects. The drive can be powered-off at any stage of the procedure.

Press the RUN switch at any time to restart the drive.

Observe that — the motor ramps to the potentiometer set speed, and the keypad display changes from **rdY** to a numerical display of the set speed expressed as a frequency.

Procedure B

Keypad control, without using external control circuits.

FIRST DISCONNECT THE POWER SUPPLY

B1 If the motor has a thermistor, and this is to be used for protection, connect it between terminals 9 and 11. If the thermistor input is not being used it is necessary to **disable the internal circuit. Link PL6 must be removed.** Refer to Fig. 16, page 4-10, for the location of link PL6.

B2 Turn on 3 phase input and observe that the keypad display becomes active and shows **rdY**.

B3 Make control parameter adjustments to put the motor under Keypad Control, as follows

SELECT KEYPAD CONTROL **b9 = 0**

NOTE When using the keypad, if there is a pause of 8 seconds between successive keystrokes, the display will revert to a non-active state. Press MODE to resume wherever keying paused.

Press the MODE key to enable a parameter to be selected. Observe that the PAR LED illuminates. The display will show **Pr0**, alternating with **0**.

Press either the UP or the DOWN key. One key-stroke always changes the display to the next parameter. Choose parameter **b9**. The display alternates between **b9** and its present value, which will be **1**. This is the as-delivered value, and means that the motor is in TERMINAL control mode. (If 8 seconds elapses between keystrokes the display reverts to **rdY** and the PAR LED will go off. To resume adjustment, press the MODE key again.)

continued...

Press the MODE key to hold the display value **1**, then press the UP or the DOWN key once to change the value to **0**.

Press the MODE key to exit the parameter adjustment.

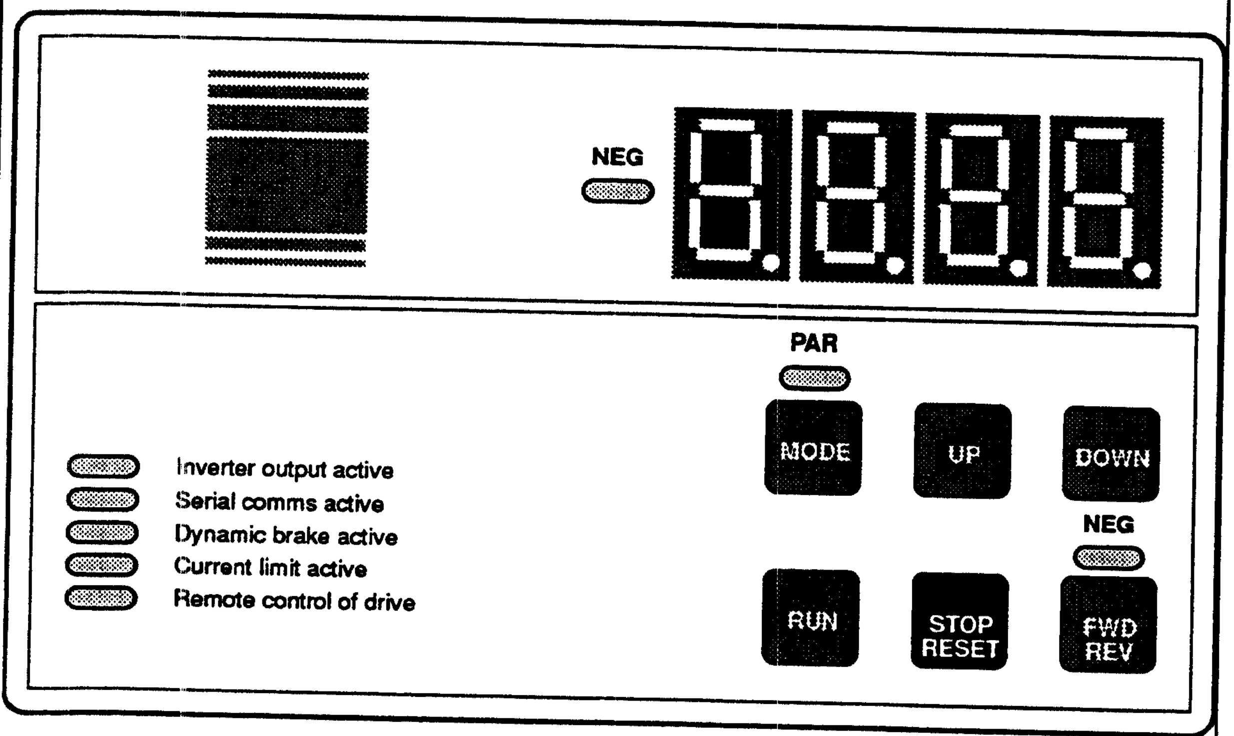
Control is now in KEYPAD mode and the display will alternate between **b9** and its new value, **0**. After 8s the display will change to **rdY** and alternate with the set speed value (initially zero).

RUN AND STOP THE MOTOR

Press the RUN key. The motor will start and run up to the set speed displayed. Press and hold the UP key to increase the set speed.

Press the STOP key. The motor will ramp to a stop, and will display **rdY**, alternating with the set speed, when the speed reaches zero.

When the display is not showing a parameter, or is not being used to change a parameter, the set speed can be adjusted by using the UP and DOWN keys.



22 The Control Pod. Top right, the four-panel digital display with 'NEG' LED to indicate negative values. Lower left, five LEDs indicate the operational status of the drive. At the keypad, the 'PAR' LED illuminates when the display is showing a parameter number. The 'FWD' LED is illuminated when the drive is controlled to run forward.

5.3 Keypad and Display

Control Pod, Fig. 22. **Display Features**, Fig. 23.

The Control Pod combines keypad and display functions. All operational functions of the drive and motor can be controlled and all parameter values can be changed from the keypad. Parameters and their values are adjusted by the three upper keys. The three lower keys control motor RUN (start), STOP/ RESET and FORWARD/REVERSE when in keypad mode (**b9** = 0).

The upper row of three keys controls the parameters in two modes — **selecting** a parameter **number** and **changing** a parameter **value.**

Parameter numbers or values, as appropriate, are shown in the four-window display, with an LED to indicate when values are negative. When parameters are being read or changed, the display defaults to the Present Indication (see Display Description, below) after 8 seconds without a keystroke.

Operational status is shown by the group of five LEDs on the left of the keypad and also by the Forward/Reverse LED above the FWD/REV key.

A feature of the control pod is that it can be demounted from the module. This enables the drive module to be located in a secure enclosure and the control pod to be located in an accessible position. The procedure for removing the Pod is described in Chapter 3, Section 3.3, page 3-7.

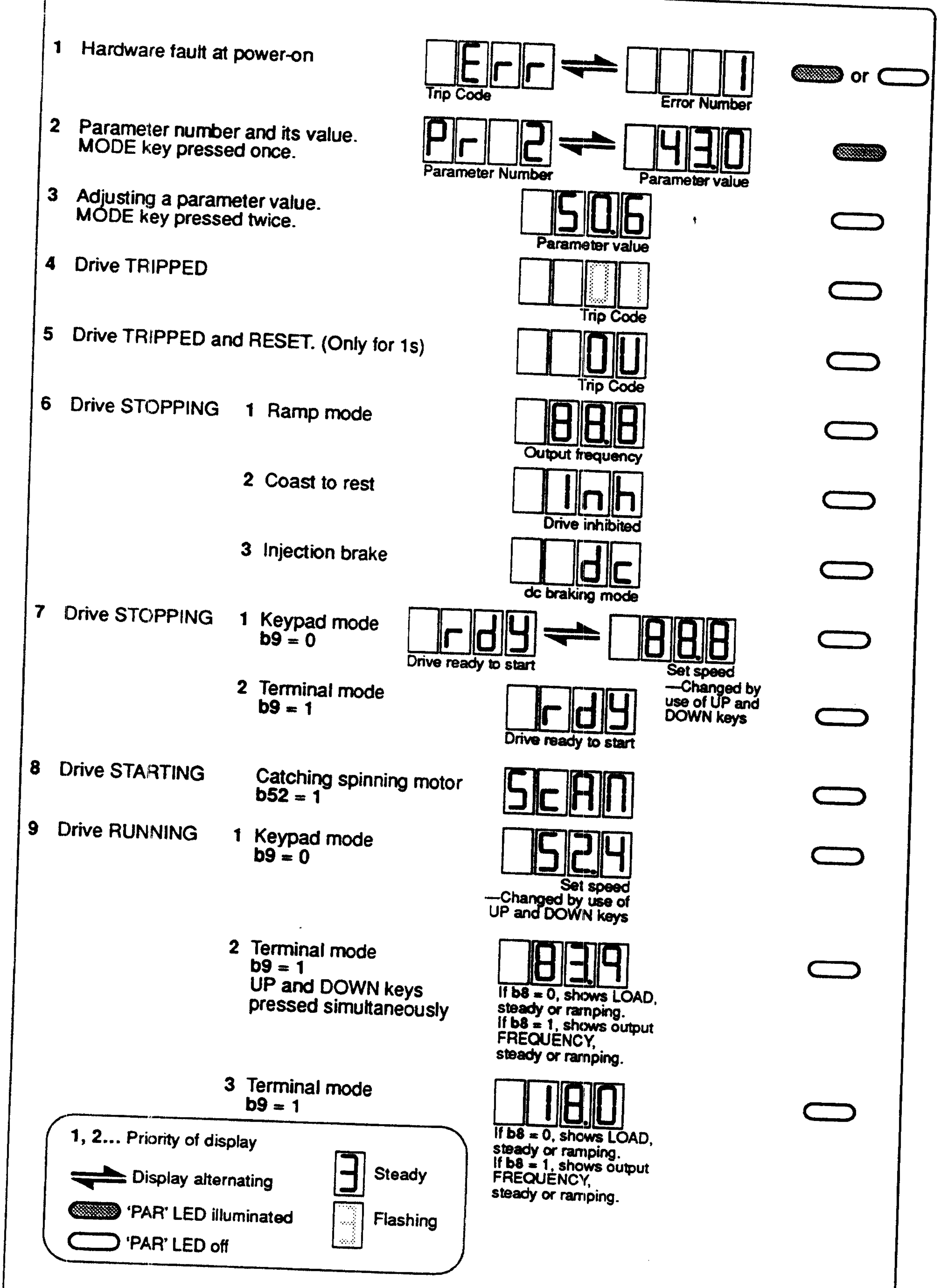
When demounted, the pod is connected to the module by standard 9-way control cable (preferably screened) connected one-for-one to standard 9-pin D-type terminations, one male, one female. Maximum length of cable is 100m. Leads can be obtained from the supplier of the drive.

The facility to demount the control pod can also be used to provide security, as the pod can be removed completely. Removal of the pod in terminal mode — even while the drive is active — has no effect on the operation of the drive. Removal of the pod in keypad mode, if the drive is running, will cause it to stop.

Display Description

When parameters are not being read or adjusted, the display shows either drive status or running performance, thus —

DRIVE CONDITION	*DISPLAY*
Healthy and stopped	either — **rdY** (Terminal Mode, **b9** =1) or — **rdY** alternating with SET SPEED (Keypad Mode, **b9** = 0)
Healthy and running	**b9** =1 either — output f//requency (**b8** = 0) or — load in % of output FLC (**b8** = 1) Note that whichever value is displayed, the other can be viewed by pressing both UP and DOWN keys simultaneously. **b9** = 0 set frequency
Tripped	Trip Code Refer to page 5-xx When the drive trips, Trip Code flashes. When the drive is in the process of being reset, Trip Code is steady (not flashing). When the drive completes the reset, either — the display shows **rdY** (Manual Start mode) and the drive waits for a start signal or — the drive automatically starts (Auto Start mode)



23 Display features.

Display Flashing

The display flashes when one of the following conditions is present —

- The drive has tripped and display is showing a Trip Code
- A parameter value has been adjusted to one of its limits
- All unused decimal points flash to indicate when the drive output has entered the I x t region

Display Value

Selected by parameter **b8**. During normal operation, and when the drive is **not** in Keypad mode (**b9** = 1), the keypad display can show either the motor speed or the load. Load is displayed as a percentage of full load current.

Speed in Hz **b8** = 0 — Actual frequency delivered to the motor, **not** the set speed frequency
Load%FLC **b8** = 1

A quick way of changing the displayed value from speed to load or from load to speed is to press both the UP and DOWN keys simultaneously. If **b9** = 0, the Set Speed is displayed regardless of **b5**.

Operational Status

Five red LEDs to the left of the keypad, and the LED above the FWD/REV key indicate the status of the drive.

INVERTER OUTPUT ACTIVE indicates that the output power bridge is active (even if output frequency is zero Hz).

SERIAL COMMS ACTIVE indicates the serial link is actively sending or receiving information.

DYNAMIC BRAKE ACTIVE indicates the dynamic braking threshold has been exceeded, due to regeneration — that is, the dc link voltage has exceeded a given level above the ac supply voltage.

CURRENT LIMIT ACTIVE indicates the drive is in current (torque) limit which means one of the following —

- the load exceeds either the full load of the motor as set by **Pr4**, or —
- the torque limit as set at terminal 7.
- the output current transiently exceeds the 150% (HVAC 120%) drive output.

REMOTE CONTROL OF DRIVE is an indication that the control mode is Remote, as determined by terminal 16. This means that the drive speed reference is either 4-20mA current controlled or serial comms controlled.

The LED above the FWD/REV key indicates the direction of rotation demanded. The actual direction of motor rotation at any instant may or may not correspond. LED illuminated means FWD demand. LED not illuminated means REV demand.

Manipulating the Parameters via the Keypad

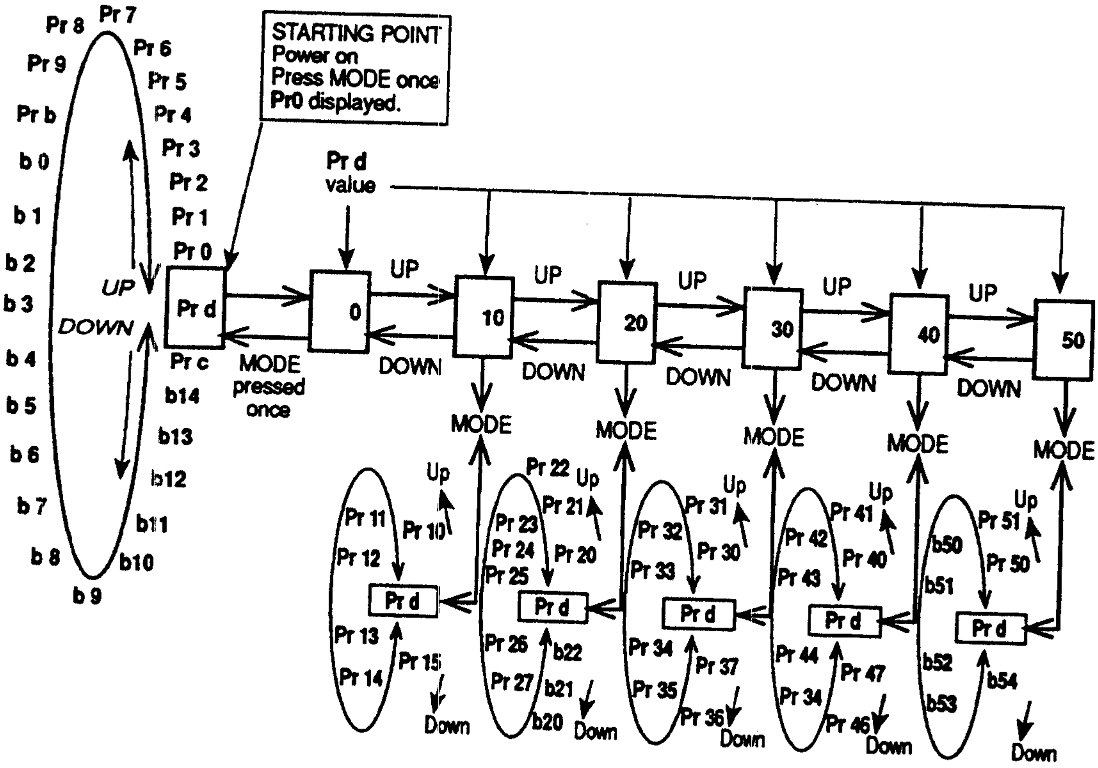
To Select a Parameter

The MODE key enables a parameter number to be selected. When the MODE key is pressed the green LED (PAR) above the MODE key is illuminated, a parameter number is displayed, and alternates with the parameters value. Ordinarily, the PAR LED is extinguished.

With the PAR LED illuminated, press the UP or the DOWN key once to select the NEXT parameter. To scroll through parameter numbers press UP or DOWN repeatedly. If there is a delay of more than 8s in pressing another key, the display will default to the Present Indication (see above) of the output of the drive. Pressing MODE again returns to the parameter selected.

To Read a Parameter

Select a parameter (when the PAR LED is extinguished) by pressing the MODE key once. The LED will illuminate, and the display will show the **Pr** or **b** number, alternating with the value, of whichever



24 Structure of **Prd** menus and access procedure.

parameter was last read or adjusted. The display will alternate between the parameter number and its value for a period of 8s, after which it will default to the Present Indication. If a different parameter is required, select as explained above. The new parameter will alternate with its value in the display for 8s.

To Change a Parameter

STOP FOR BIT PARAMETERS!
Bit-parameter values can be changed only when

the drive is stopped and the display is showing **rdY**, or

the drive has tripped, then the Trip Code will flash in the display.

In both cases, the Inverter Output Active LED is not illuminated.
To stop the drive, press the STOP/RESET key if the drive is in Keypad control mode (**b9**=0), or open the STOP terminal14 in Terminal control mode (**b9**=1). Wait until the display shows **rdY**.

SECURITY CODE!
If a Security Code (see below) has been assigned it is not possible to **change** any parameter value until the correct code has been entered. Any parameter can be **read** without need for the Security Code, with the exception of **Pr d** menu 10 to 50.

Select the required parameter. When the PAR LED is illuminated, press MODE once. The display will hold the parameter value steady. If a further keystroke is not made within 8s, the displayed value will default to the Present Indication.

The values of all **Pr** parameters can be adjusted whether the motor is running or not.

Change the parameter value by pressing the UP or the DOWN key. A single keystroke changes the value by zero or ±0.1, depending on display resolution. Press and hold either key) to increase or decrease the parameter value to the maximum or minimum available. The parameter change acts immediately on the internal setting. If the drive is operating the motor, the motor responds to the change as it is being made. The last parameter value set is stored if the power supply is disconnected, and is restored when the drive is next energised.

DECIMAL VALUES!
The display operates an automatic floating decimal point. According to the range of values of the parameter, the display inserts a decimal point appropriately.

For example, the range of **Pr2** is 0.2 to 600s. The display will therefore show all values between 0.2 and 600. The range of **Pr6** is 0 to 25.5%. The values displayed will therefore be 0 to 25.5.

NEGATIVE VALUES!
A negative value is indicated by the negative LED beside the display becoming illuminated. Parameters **Pr20** to **pr26** are the only ones which can have negative values. The priority is set by the FWD/REV key.

Access to Parameters

Fig. 24 shows the configuration and manipulation of drive parameter menus.

Security Code

Selected by parameter **Prb**. Prevents unauthorised alteration of any parameters.

To assign a security code, the drive must be energised.

Using the Control Pod, the code can be set to any three-digit number from 100 to 255, or 0. Press MODE to enter.

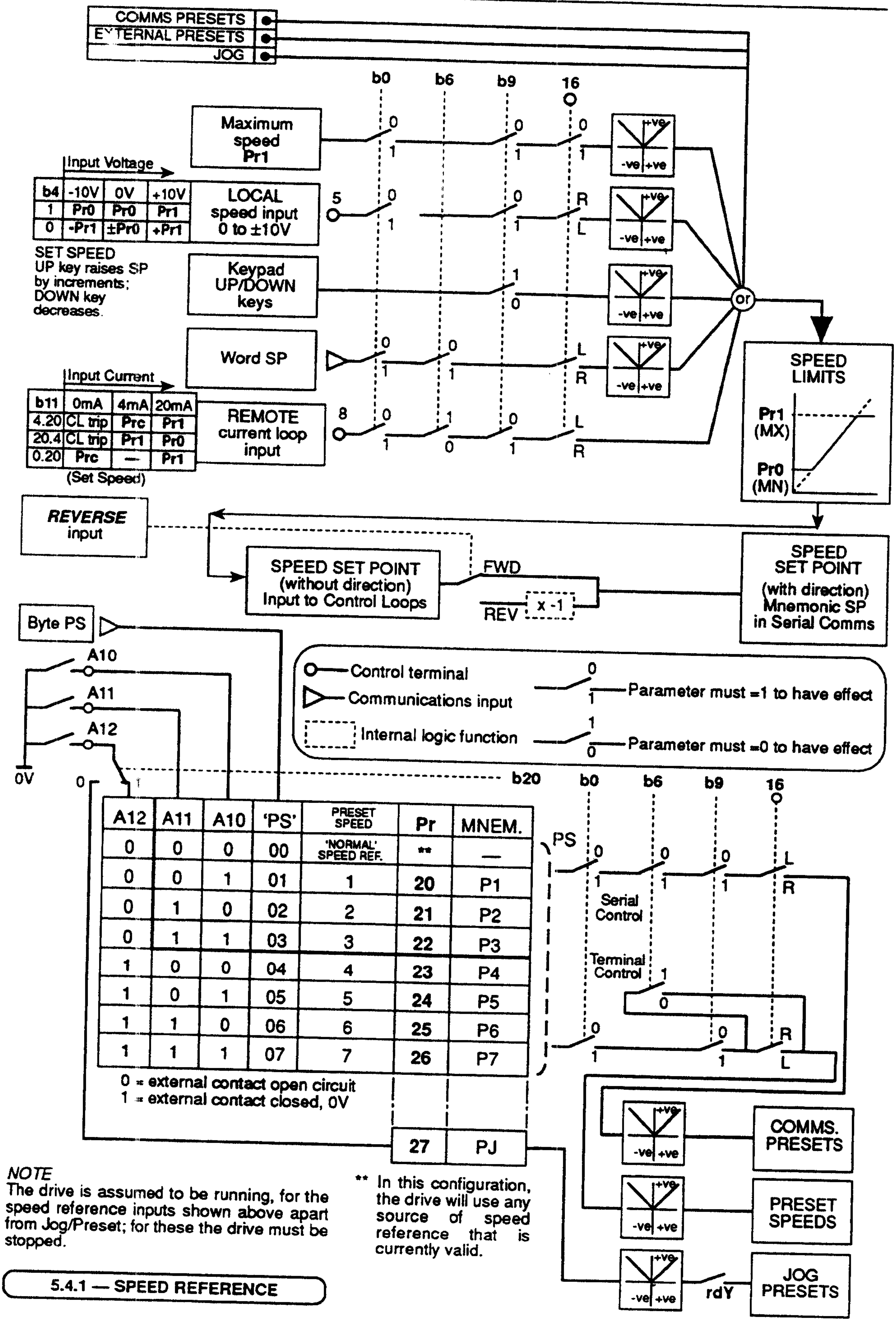
Using Serial Communications, the code can be set to any number from 0 to 255.

When a security code has been assigned, each time the drive is energised the code must be used to allow adjustment of parameters. To gain access, select **Prb**, set the code number and press MODE. Parameters remain alterable without further use of the security code until the power supply is disconnected from the drive.

If the wrong code is entered, parameters will not be available for adjustment. Return to **Prb**, and enter the correct code.

As delivered, **Prb** = 0, that is, the Security Code is not operational. If desired, the code can be left at this so that access is available without a code. It is convenient to do this during commissioning, and to assign a security code after the operating parameter settings are satisfactory.

5.4 Modes of Operation — Logic Diagrams



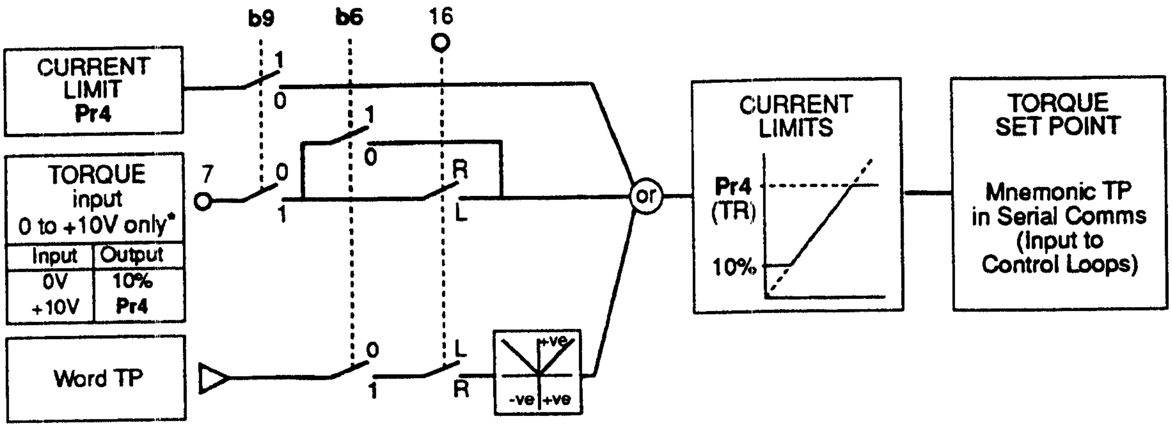
A12	A11	A10	'PS'	PRESET SPEED	Pr	MNEM.
0	0	0	00	'NORMAL' SPEED REF.	**	—
0	0	1	01	1	20	P1
0	1	0	02	2	21	P2
0	1	1	03	3	22	P3
1	0	0	04	4	23	P4
1	0	1	05	5	24	P5
1	1	0	06	6	25	P6
1	1	1	07	7	26	P7

0 = external contact open circuit
1 = external contact closed, 0V

NOTE
The drive is assumed to be running, for the speed reference inputs shown above apart from Jog/Preset; for these the drive must be stopped.

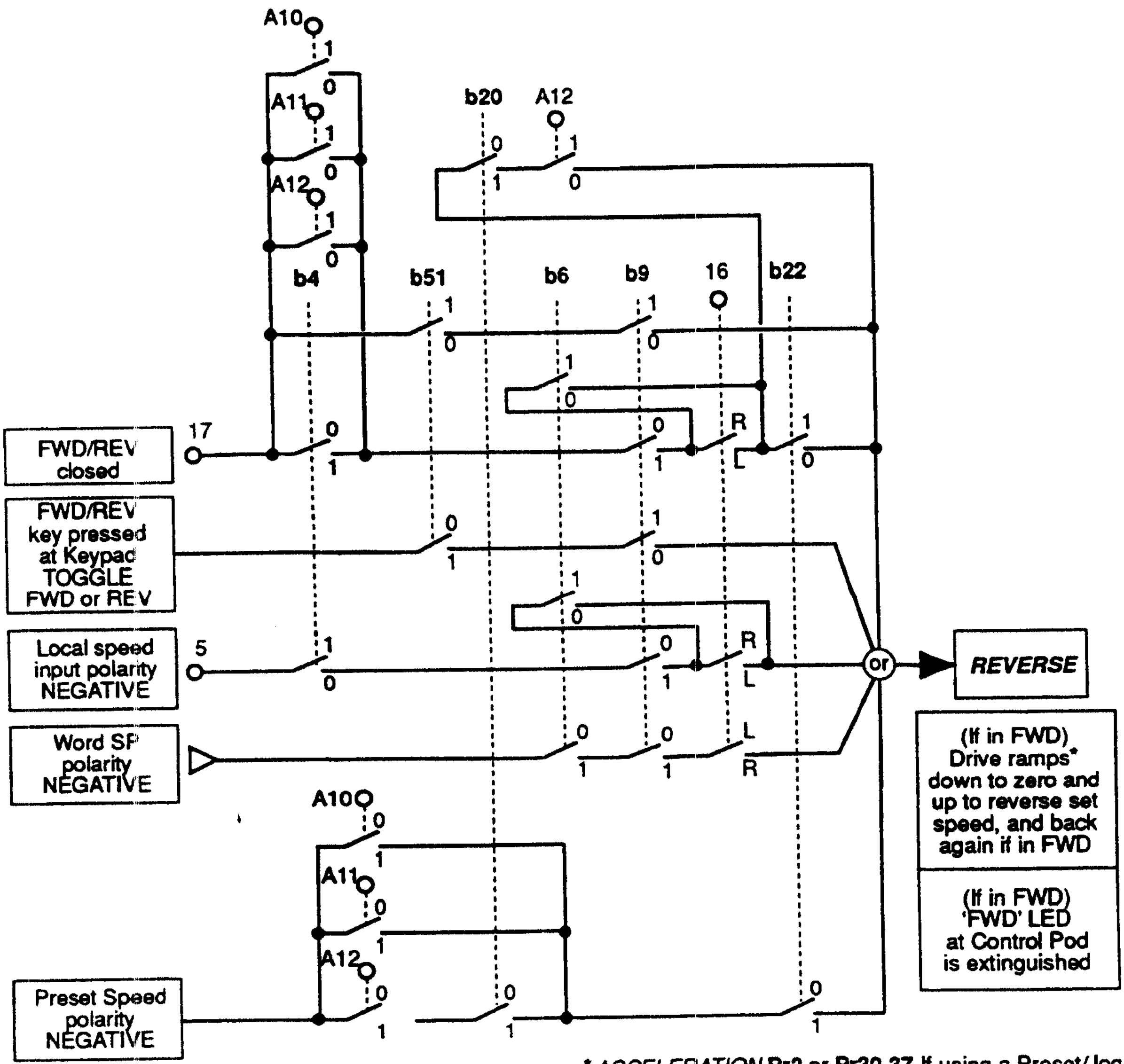
** In this configuration, the drive will use any source of speed reference that is currently valid.

5.4.1 — SPEED REFERENCE



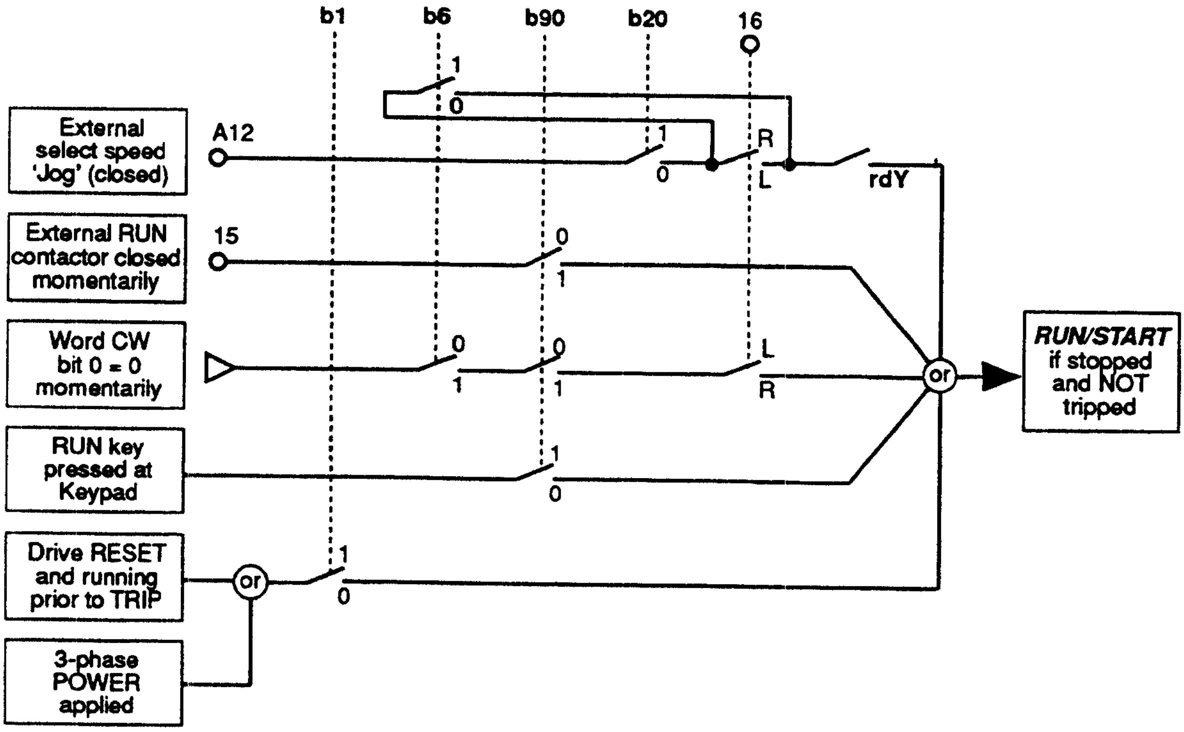
NOTE
* +10V if input is open-circuit.

5.4.2 — TORQUE REFERENCE

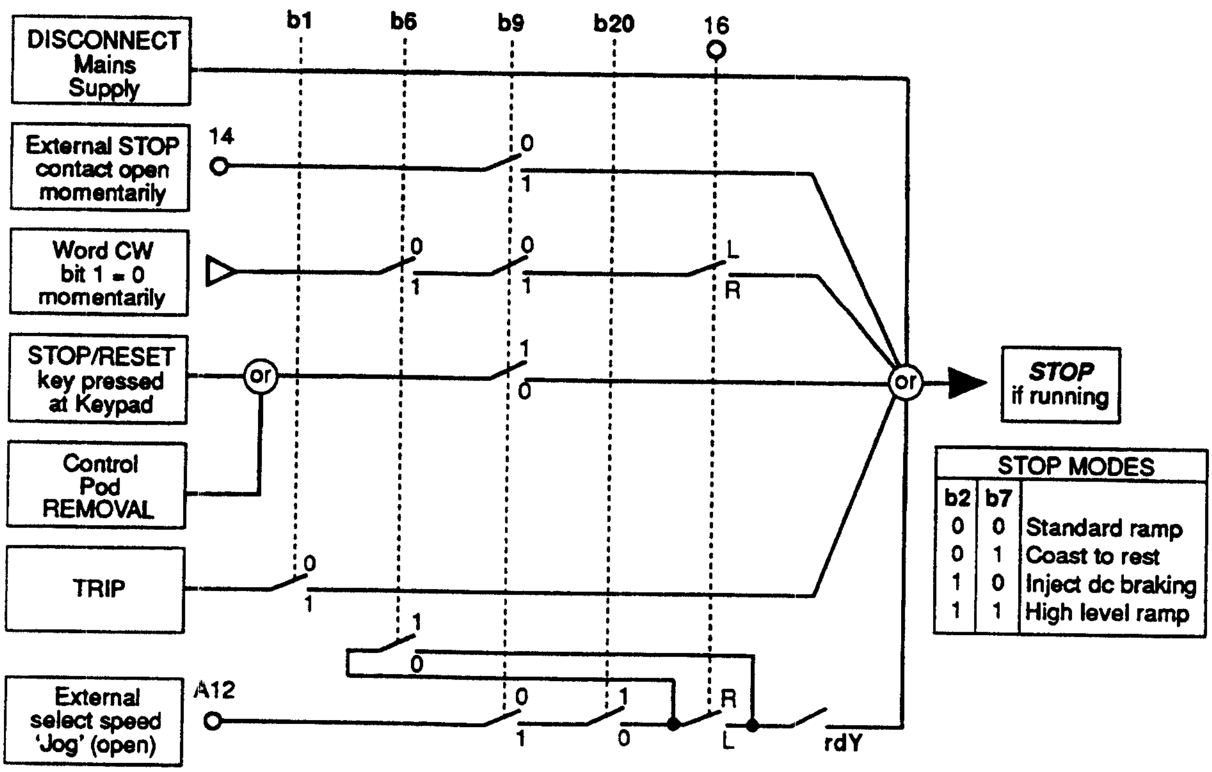


* *ACCELERATION* Pr2 or Pr30-37 If using a Preset/Jog
* *DECELERATION* Pr3 or Pr40-47 If using a Preset/Jog

5.4.3 — REVERSING

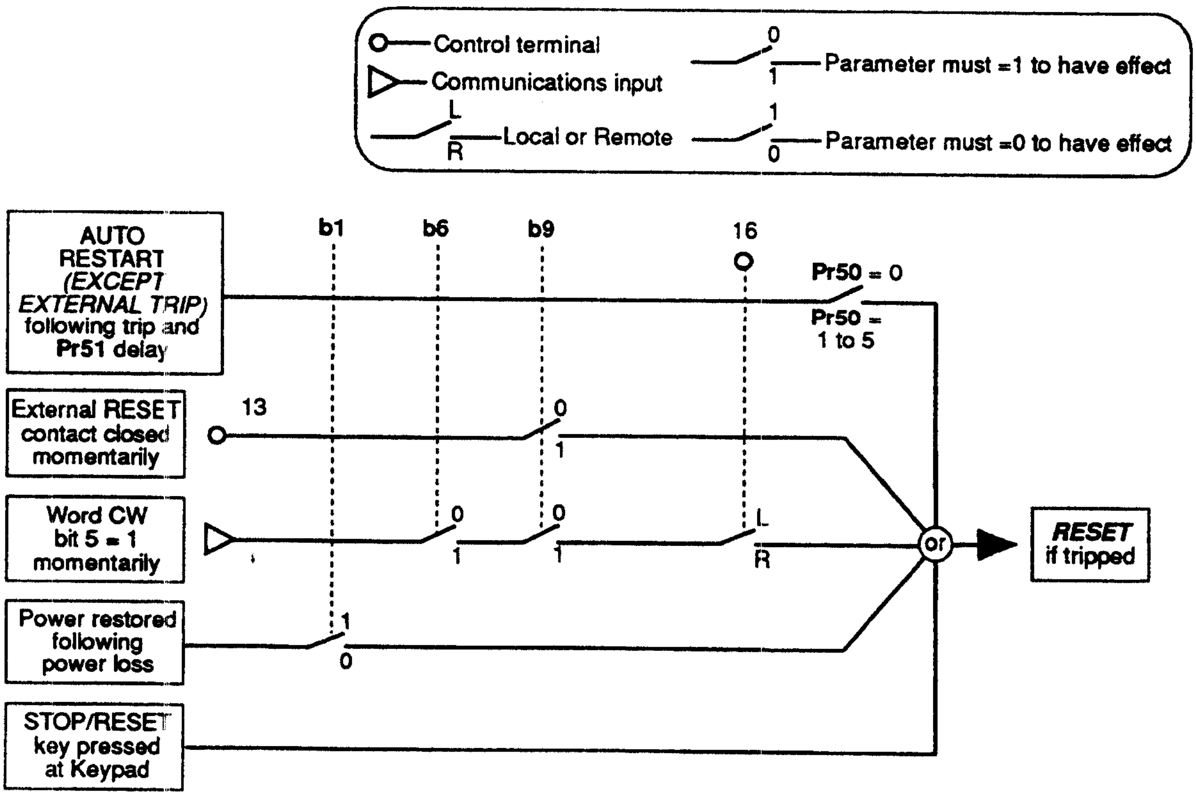


5.4.4 — STARTING



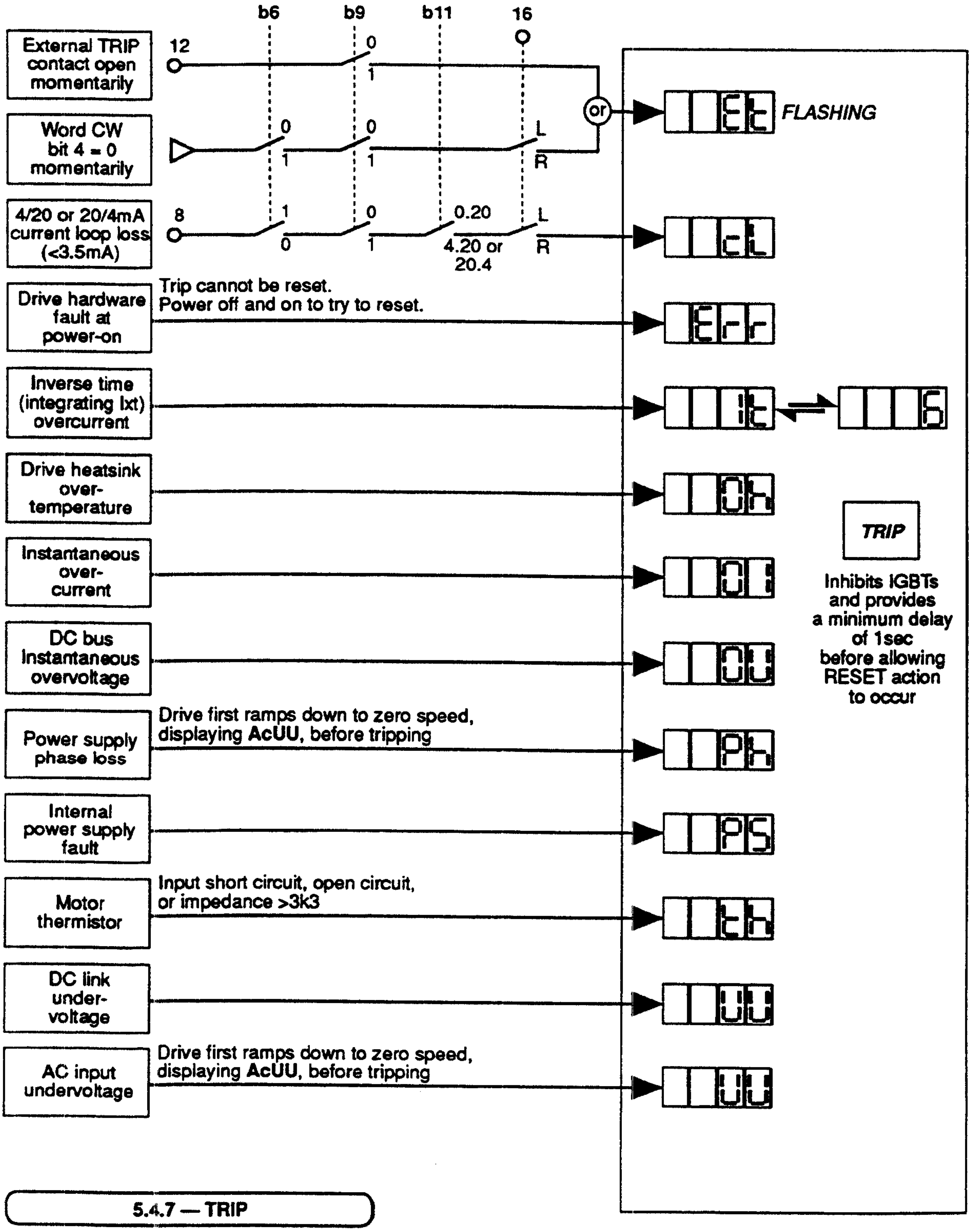
STOP MODES		
b2	b7	
0	0	Standard ramp
0	1	Coast to rest
1	0	Inject dc braking
1	1	High level ramp

5.4.5 — STOPPING



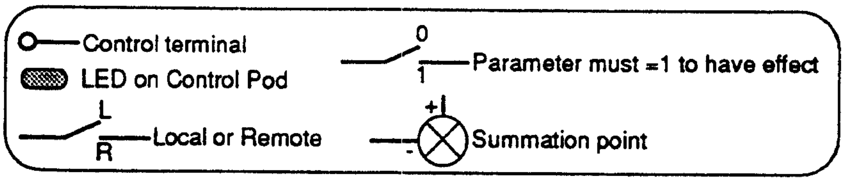
Control terminal
Communications input
L
R
Local or Remote
0
1
Parameter must =1 to have effect
1
0
Parameter must =0 to have effect
AUTO RESTART (EXCEPT EXTERNAL TRIP) following trip and Pr51 delay
b1
b6
b9
16
Pr50 = 0
Pr50 = 1 to 5
External RESET contact closed momentarily
13
Word CW bit 5 = 1 momentarily
Power restored following power loss
STOP/RESET key pressed at Keypad
or
RESET if tripped

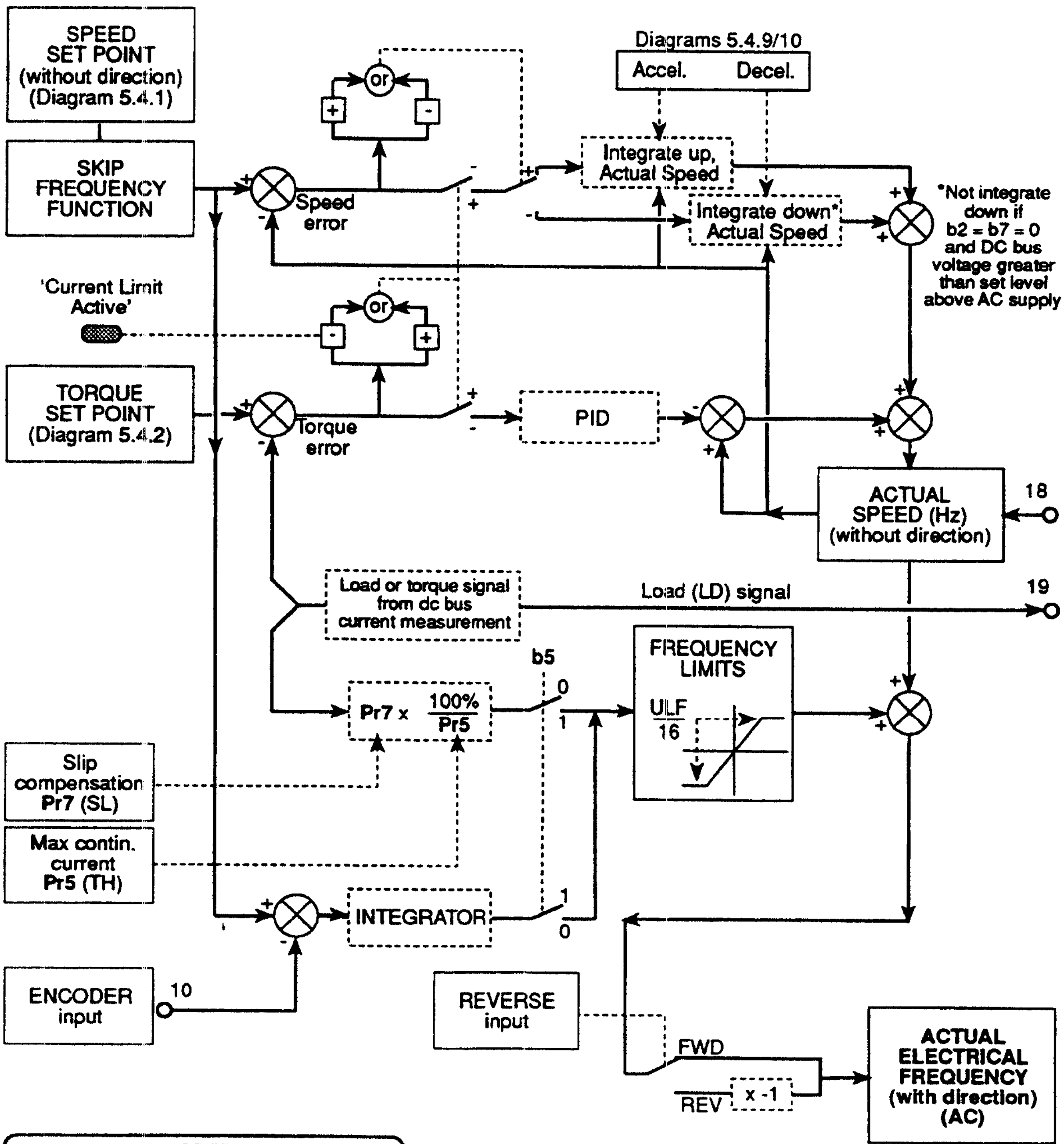
5.4.6 — RESET



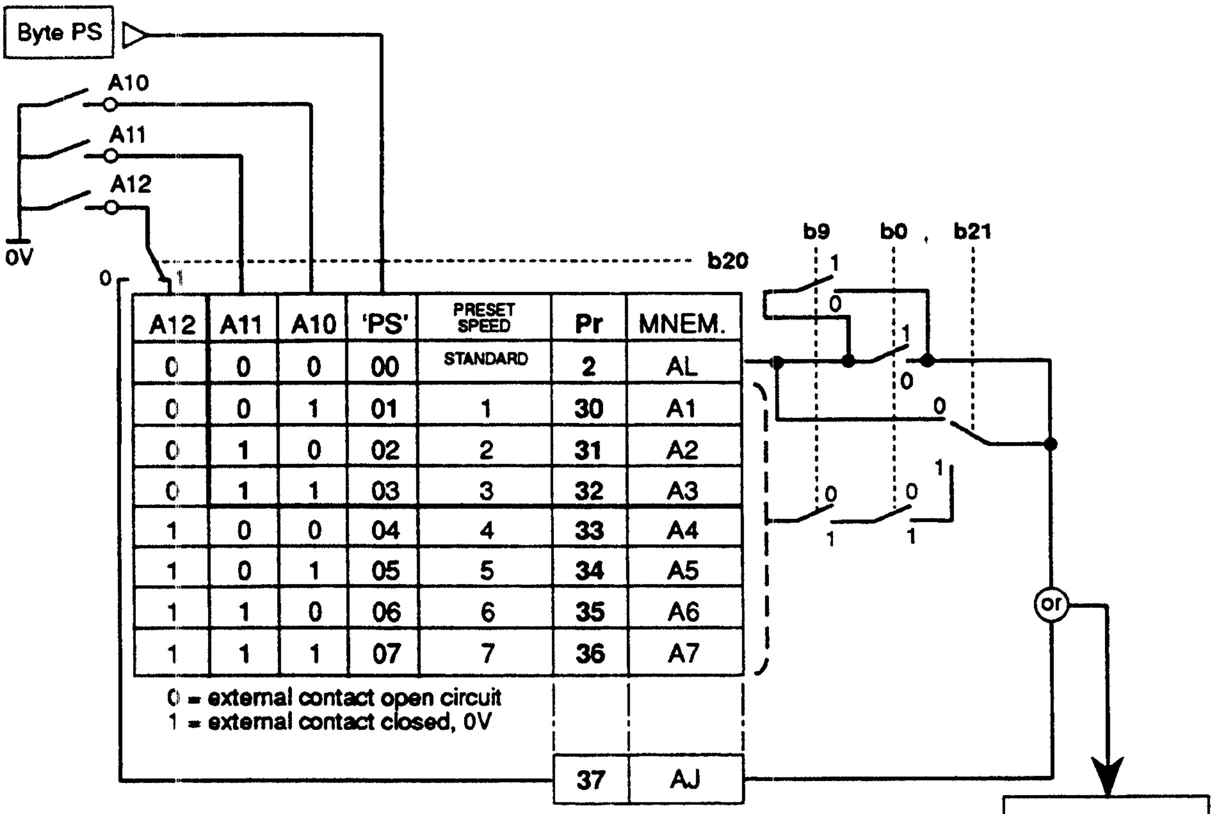
b6
b9
b11
16
External TRIP contact open momentarily
12
0
1
or
FLASHING
Word CW bit 4 = 0 momentarily
0
1
L
R
4/20 or 20/4mA current loop loss (<3.5mA)
8
0.20
4.20 or 20.4
Drive hardware fault at power-on
Trip cannot be reset. Power off and on to try to reset.
Inverse time (integrating Ixt) overcurrent
Drive heatsink over-temperature
TRIP
Inhibits IGBTs and provides a minimum delay of 1sec before allowing RESET action to occur
Instantaneous over-current
DC bus Instantaneous overvoltage
Power supply phase loss
Drive first ramps down to zero speed, displaying AcUU, before tripping
Internal power supply fault
Motor thermistor
Input short circuit, open circuit, or impedance >3k3
DC link under-voltage
AC input undervoltage
Drive first ramps down to zero speed, displaying AcUU, before tripping

5.4.7 — TRIP





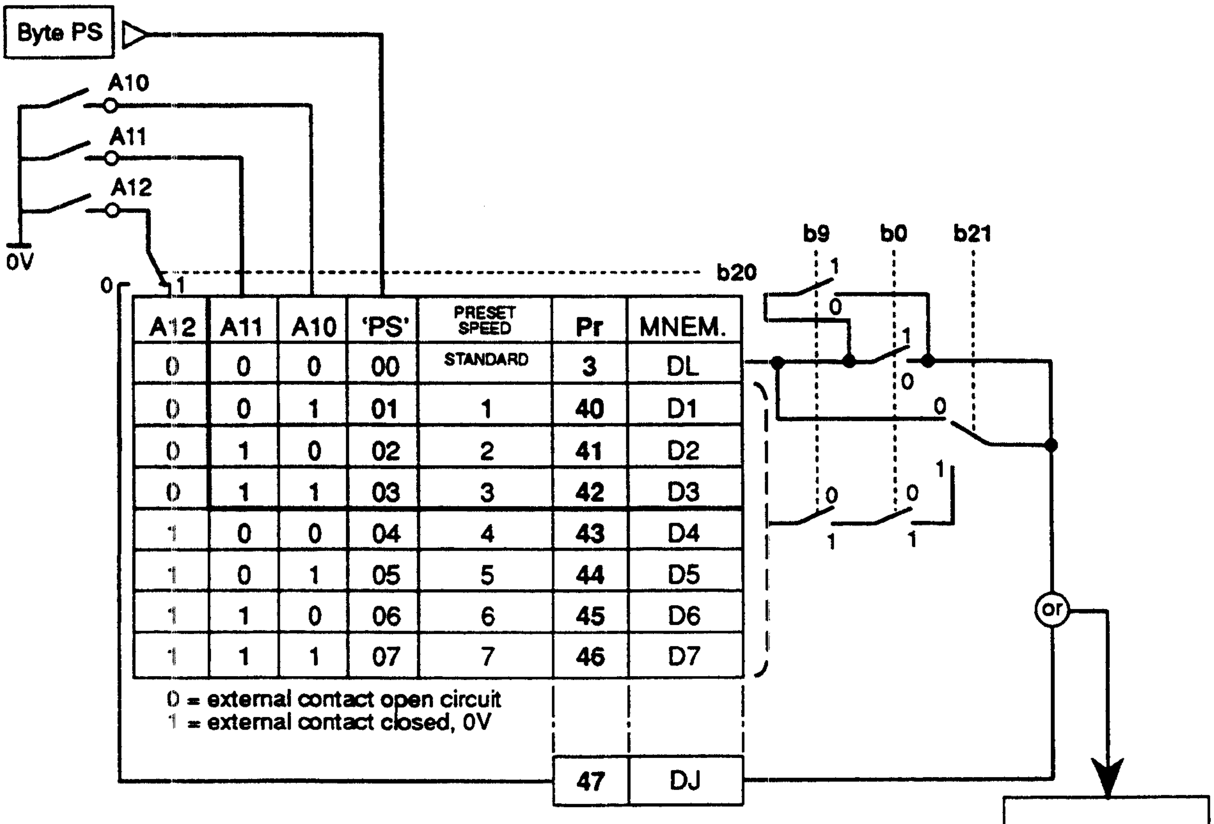
5.4.8 — SPEED LOOP



A12	A11	A10	'PS'	PRESET SPEED	Pr	MNEM.
0	0	0	00	STANDARD	2	AL
0	0	1	01	1	30	A1
0	1	0	02	2	31	A2
0	1	1	03	3	32	A3
1	0	0	04	4	33	A4
1	0	1	05	5	34	A5
1	1	0	06	6	35	A6
1	1	1	07	7	36	A7
					37	AJ

0 = external contact open circuit
1 = external contact closed, 0V

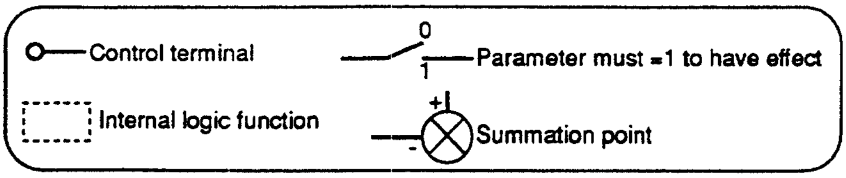
5.4.9 — ACCELERATION



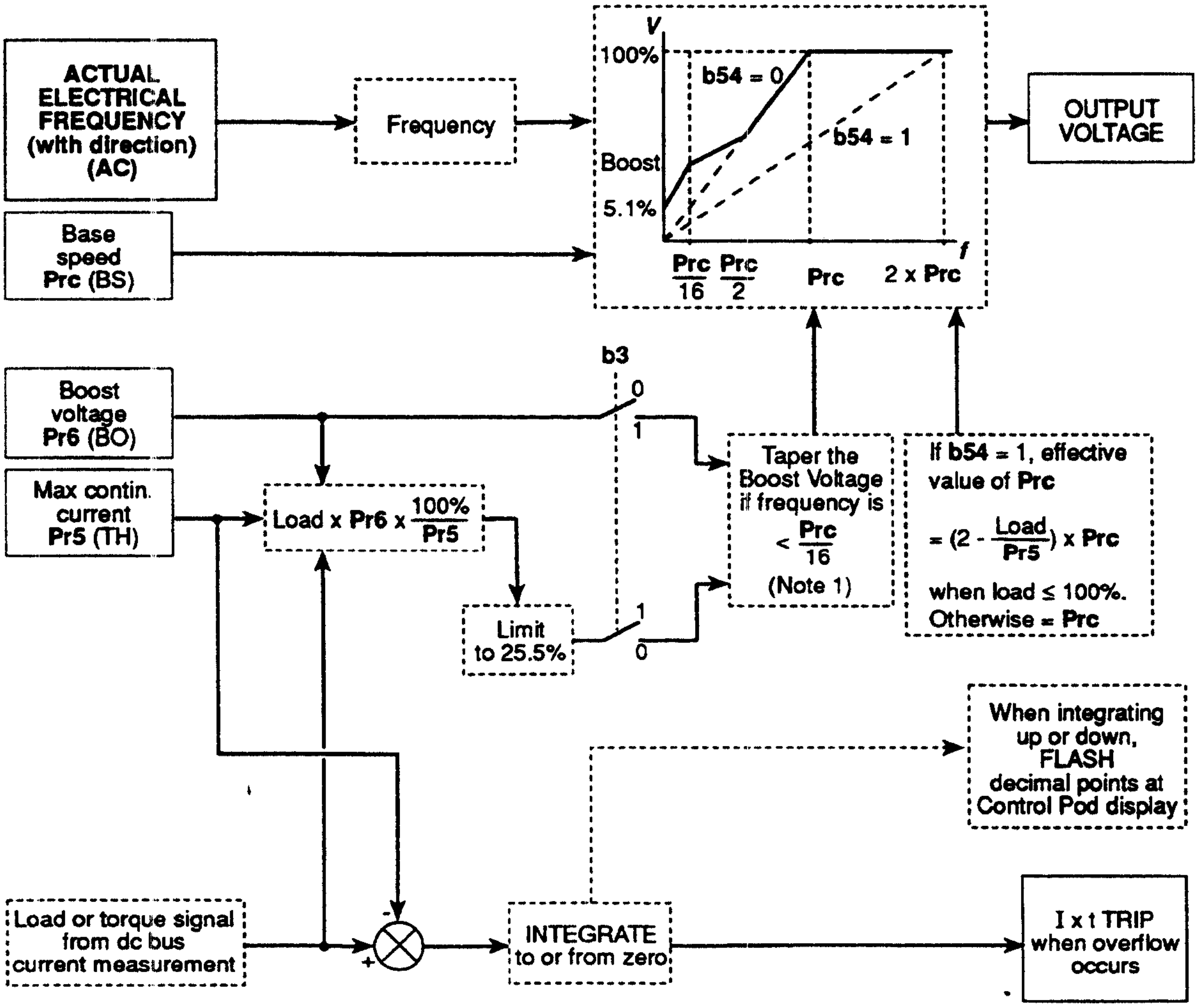
A12	A11	A10	'PS'	PRESET SPEED	Pr	MNEM.
0	0	0	00	STANDARD	3	DL
0	0	1	01	1	40	D1
0	1	0	02	2	41	D2
0	1	1	03	3	42	D3
1	0	0	04	4	43	D4
1	0	1	05	5	44	D5
1	1	0	06	6	45	D6
1	1	1	07	7	46	D7
					47	DJ

0 = external contact open circuit
1 = external contact closed, 0V

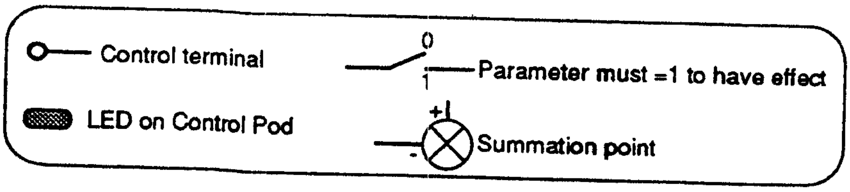
5.4.10 — DECELERATION

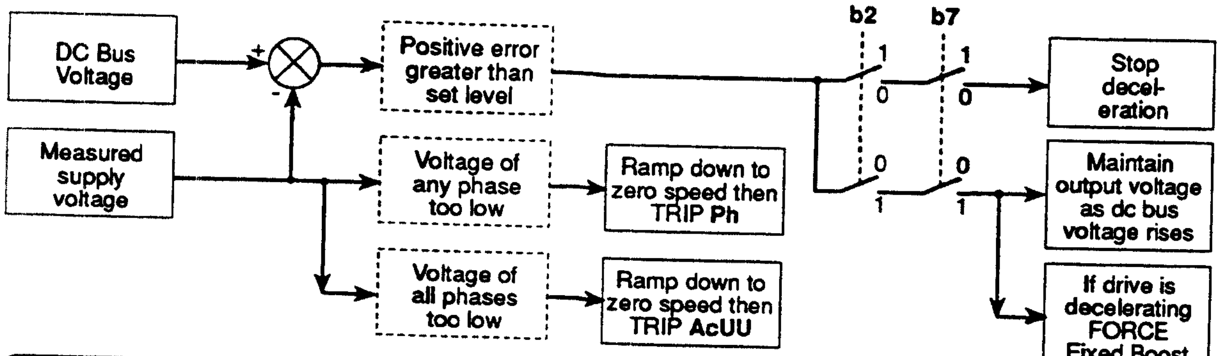


NOTES
1 Boost taper prevents boost voltage exceeding 5.1% at zero frequency.

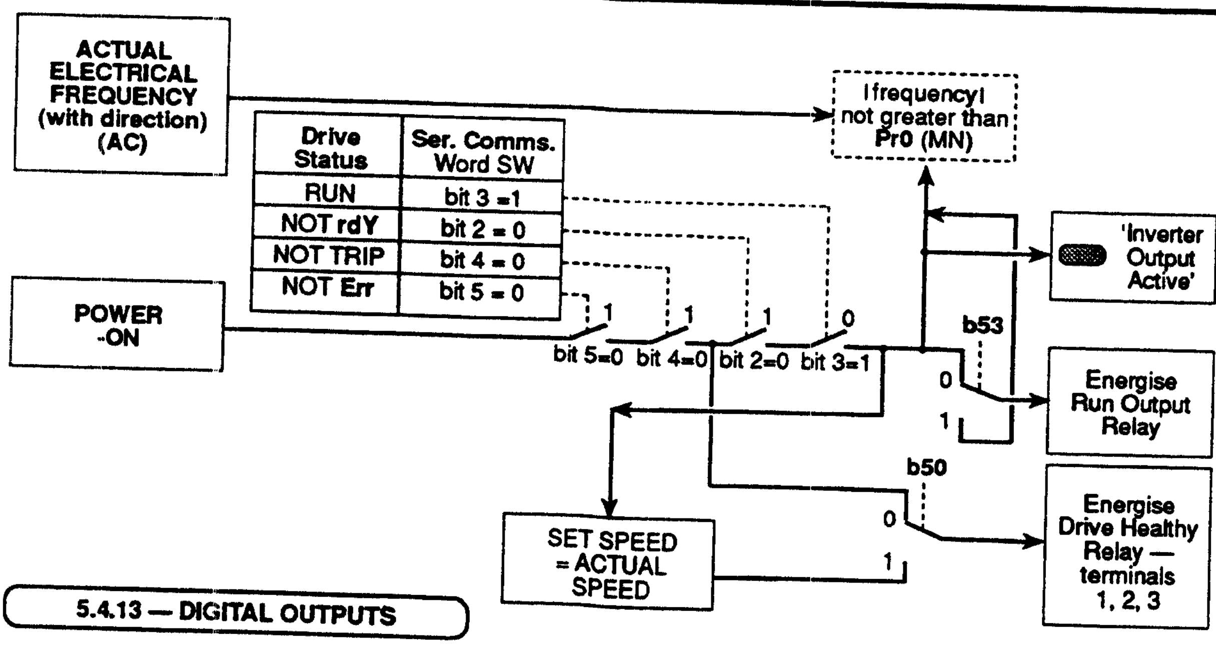


5.4.11 — VOLTAGE LOOP

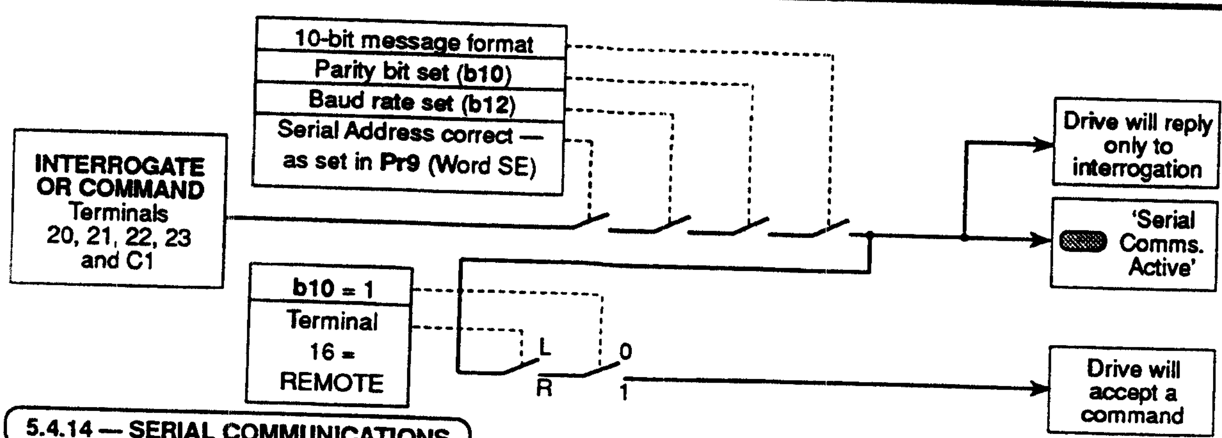




5.4.12 — DC BUS VOLTAGE CONTROL



5.4.13 — DIGITAL OUTPUTS



5.4.14 — SERIAL COMMUNICATIONS

6 Drive Configuration Parameters

6

Drive Configuration Parameters

6.1 Parameters and their Functions

Parameters are the means by which the operating characteristics of a system are controlled and monitored. The two principal kinds of parameter of a digital drive are the operating parameters and the bit parameters.

Operating parameters have a real-value range, for example from 0 to 150%, and take the place of variable potentiometer settings.

Bit parameters take the place of the links as used in analogue drives for selecting different control configurations and are 'either-or' functions.

The response of the drive and the motor depends fundamentally on the set up of the drive parameters (designated by the initials **Pr**). These values are accessible through the keypad, and additionally by signals through the serial communications link from a host computer, a terminal, a programmable logic controller, or other communicating device.

The operator can read the value or state of any parameter, so all parameters are 'read' parameters. Those which the operator can change are called 'write' parameters. Some parameters are therefore known as 'read-write'. The rest are 'read only'. Read-write parameters can be adjusted in any sequence and changed as desired.

Operating parameters can be adjusted while the motor is running. Bit parameter adjustment requires the motor to be **stopped** and the display to show **rdY**, or to be tripped, when the display will flash the Trip Code indicating the condition.

No parameter can be adjusted to a value outside the operating range of the drive, and all are limited to safe levels of inverter operation.

All parameters can be allowed to remain at their default values, or as set at the factory during final test, or can be adjusted in any sequence to suit specific applications. Default values are settings to which all parameters can be caused to return at will.

6.2 Operating Parameters

Parameters are listed in the sequence which they appear in the keypad display when the UP key is used following one press of the MODE key.

Parameter: Pr0

Minimum frequency: The lower limit of inverter output frequency, determining the minimum speed of the motor.

Range:	0Hz ≤ Pr0 ≤ Pr1
Default value:	0Hz
Serial mnemonic:	MN
Related parameters:	**Pr1, pr20 - 26, Pr10 - 12, b14**

NOTE Adjusting **Pr0** may alter the Preset Speeds and the Skip Frequencies —

Preset Speeds — **Pr0 ≤ Pr20 - 26 ≤ Pr1**

Skip Frequencies — **Pr0 ≤ Pr10 - 12 ≤ Pr1**

The 0 to +10V range of the external voltage reference V_{in} (terminal 5) operates on the difference between **Pr0** and **Pr1**. For example, if **Pr0** = 10, the inverter output is 10Hz when the minimum speed reference is 0V. If **Pr1** = 50, say, then when the speed reference is 5V the output frequency is —

$$[(Pr1 - Pr0) \times \frac{V_{in}}{10V}] + Pr0$$

$$(50 - 10) \times (\frac{5}{10} + 10) = 30Hz$$

Parameters **Pr0** and **Pr1** apply to both forward and reverse operation.

Parameter: Pr1

Maximum frequency: The value of speed in Hz above which the motor is not to operate.

Range:	Pr0 ≤ Pr1 ≤ ULF (Refer to **b14** for information about ULF)
Default value:	50Hz
Serial mnemonic:	MX
Related parameters:	**Pr1, pr20 - 26, Pr10 - 12, b14**

NOTE Adjusting **Pr1** may alter the Preset Speeds and the Skip Frequencies —

Preset Speeds — **Pr0 ≤ Pr20 - 26 ≤ Pr1**

Skip Frequencies — **Pr0 ≤ Pr10 - 12 ≤ Pr1**

CHANGE-OF SPEED RAMPS

Provision for controlling acceleration and deceleration has three objectives — to serve the many applications where abrupt changes of speed are not acceptable, to limit current demand during any upward speed change, and to limit DC link voltage during a downward speed change.

Deceleration time is set by parameter **Pr3** which has a range from 0.2s to 600.0s, Fig. 26. The effect of deceleration time is, however, not exactly analogous to acceleration time, even though the two characteristics shown in Figs. 25 and 26 apparently have much in common.

When the frequency of the supply to an induction motor is reduced while it is rotating, slip takes a negative value. In effect, the motor becomes a generator and returns power to the inverter. To some extent, this power can be absorbed by the DC link capacitor and by losses within the system, but the DC voltage cannot be allowed to rise without risk of damage to drive components. The DC link protection logic is not adjustable.

If it is found that a chosen deceleration time causes the inverter to trip and indicate a DC link overvoltage, either the deceleration time must be increased or, if this is not possible due to the needs of the driven system, the optional dynamic braking unit will have to be utilised to absorb the excess energy. This alternative is discussed further in Chapter 9 "OPTIONAL BRAKING UNIT".

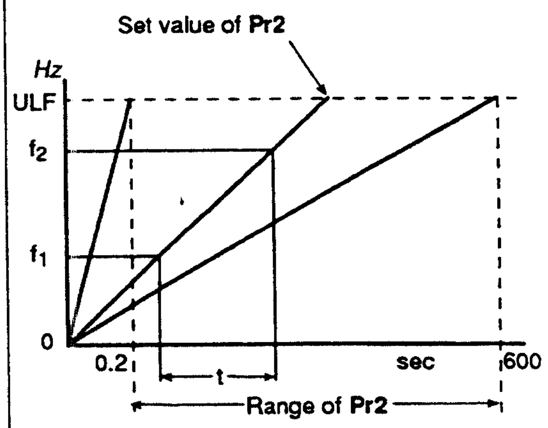
Parameter: Pr2

Acceleration time:	The time to accelerate from 0Hz to the selected value of ULF; determines the slope of the acceleration ramp. (Refer to **b14** for information about ULF)
Range:	0.2s to 600s
Default value:	5.0s
Serial mnemonic:	AL
Related parameters:	**Pr3, b14**

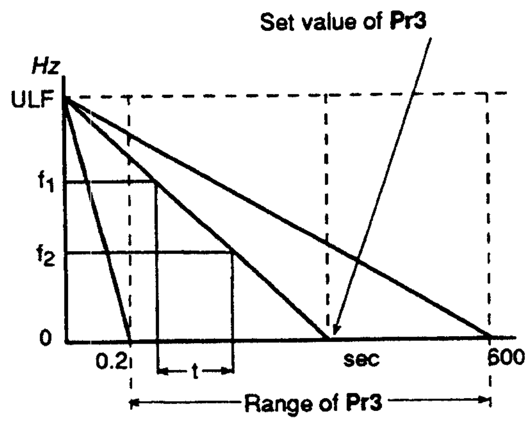
Acceleration time is set by parameter **Pr2** which has a range from 0.2s to 600.0s. The actual time to accelerate from any speed to any other is then a linear proportion of **Pr2**, Fig. 25. Acceleration limits are imposed by the maximum and minimum available values of **Pr2** and by the chosen value of ULF (**b14**).

Parameter: Pr3

Deceleration time:	The time to decelerate from the selected value of ULF to 0Hz; determines the slope of the deceleration ramp.
Range:	0.2s to 600s
Default value:	10.0s
Serial mnemonic:	DL
Related parameters:	**Pr2, b14**



25 Acceleration Time **Pr2.** The time *t* to accelerate from *f1* to *f2* depends on the value selected for the ULF as well as for **Pr2.**



26 Deceleration Time **Pr3.** The time *t* to decelerate from *f1* to *f2* depends on the value selected for the ULF as well as for **Pr3.**

CURRENT & PROTECTION

An inverter is usually selected with a maximum continuous current rating to match, that of the motor. To prevent overheating at full load the motor full load current (FLC) rating must not be exceeded. The continuous current limit is parameter **Pr5** and its value is the ratio of the motor rated FLC to the inverter FLC, expressed as a percentage —

Pr5 = (motor FLC / inverter FLC) x 100

Pr5 is the lower threshold of the inverse time-current protection of the motor and its cabling. Any current value in excess of **Pr5** when integrating in the I x t region is signalled at the keypad display by flashing of the unused decimal points in the display and will, if sustained, result in tripping of the inverter. Curves are shown in Fig. 28.

Trip time = k x **Pr5** / (actual % current - **Pr5**) in seconds,
where k = 25.7 for Industrial or HVAC drives

A short acceleration time combined with a high inertia load may demand a current higher than the maximum continuous current **Pr5** and the current is likely to enter the I x t inverse time protection zone. Only if the drive were grossly under-rated relative to load inertia or if the current limit (**Pr4**) were set low would there be a likelihood of an overload trip during acceleration.

The drive logic recognises three levels of high transient current above the current limit **Pr4**, such as might be caused by severe shock loading, or by short circuit or earth fault in the motor or cabling. The logic responds to transients protecting the motor, the cabling and the drive by shutting down the inverter IGBT bridge.

The speed of electronic fault detection is greatly superior to the performance of hrc fuses.
Note that the internal current limit is scaled by the torque reference input (terminal 7) such that —

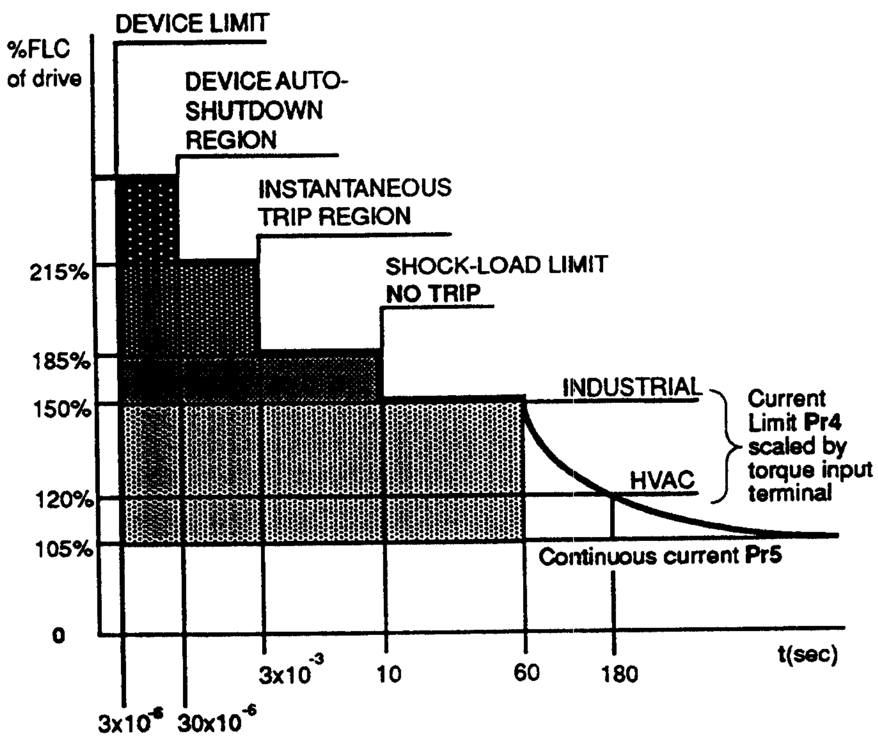
$$\text{Internal current limit} = \left(\text{Pr4} \times \frac{V_{in}}{10V}\right) + 10\%$$

Parameter: Pr4

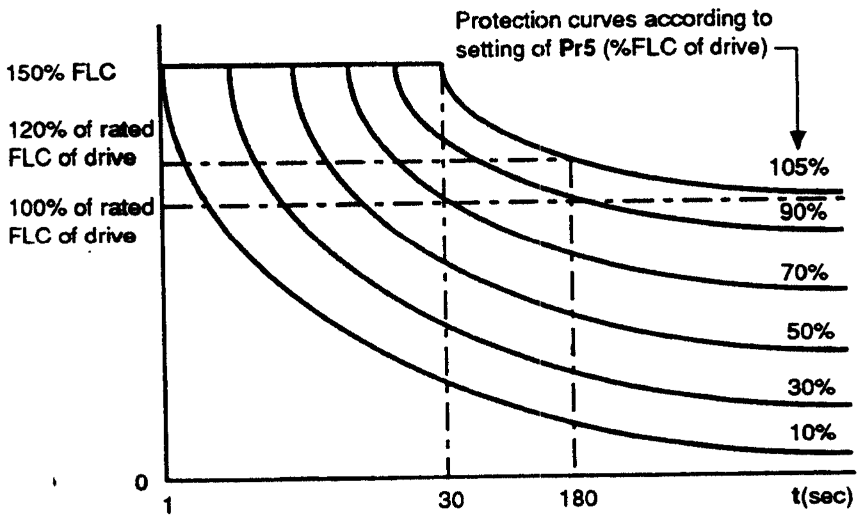
Timed current limit:	Maximum level of inverse time-current overload.
Range:	Pr5 ≤ Pr4 ≤ 150%FLC for Industrial rating drives Pr5 ≤ Pr4 ≤ 120%FLC for HVAC rating drives
Default values:	150% FLC for Industrial rating drives 120% FLC for HVAC rating drives
Serial mnemonic:	TR
Related parameters:	Pr5, Terminal 7

Parameter: Pr5

Max. continuous current:	Percentage of FLC at which current can be supplied continuously; threshold level of timed current limit.
Range:	10% to 105%FLC, and not greater than Pr4
Default value:	100%FLC
Serial mnemonic:	TH
Related parameters:	Pr4



27 Overcurrent protection by internal electronic monitoring.



28 I x t characteristics (not to scale), selected by Pr5

TORQUE (VOLTAGE) BOOST

Parameter: Pr6

Voltage (torque) boost:	Maximum level of voltage boost at zero frequency.
Range:	0 to 25.5% of main supply voltage
Default value:	5.1%
Serial mnemonic:	BO
Related parameters:	**b3**

When the boost value (**Pr6**) is set high, the profile below a frequency of one-sixteenth of **Prc** assumes the gradient of constant V/f provided that the line will intersect the 0Hz axis at a value of 5.1% of mains supply voltage or less. Otherwise, the intercept is made at 5.1%. If the chosen value of boost is low, the gradient of boost values is constant (refer to Fig. 29b).

It is best to choose the lowest effective degree of boost as too high a value may, when starting the motor, result in stalling. For this reason it is recommended that Pr6 should be increased in small steps from a low value until the motor starts smoothly and with minimal hesitation.

When AUTO boost (**b3** = 0) is selected, the inverter logic applies a boost increase proportional to the load demand as a percentage of the chosen value of maximum continuous current **Pr5**. The applied voltage boost is therefore given by —

$$\mathbf{Pr6} \times \frac{\text{Load}}{\mathbf{Pr5}}$$

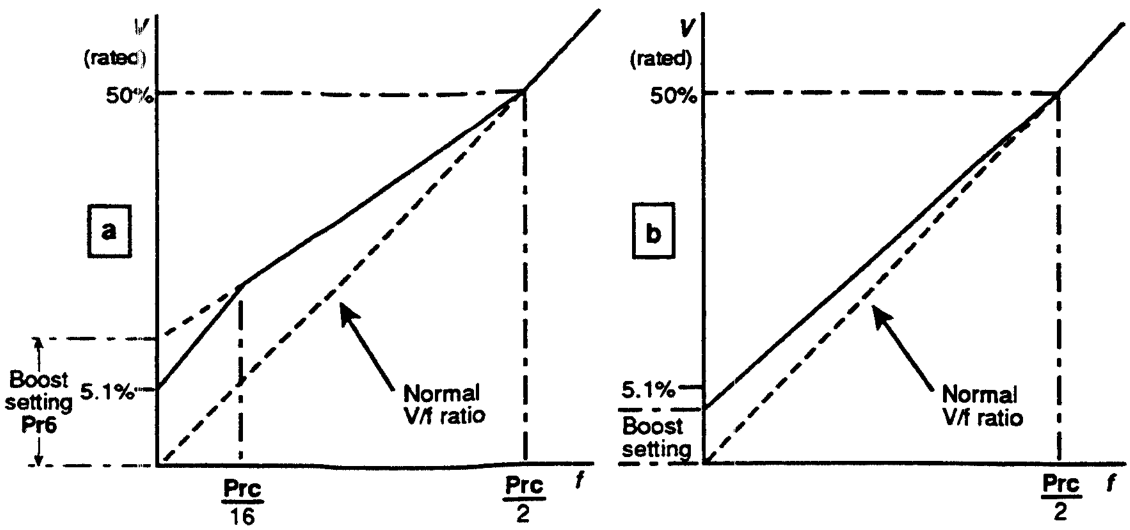
If, for example —

the selected value of **Pr6** is 10%
the selected value of **Pr5** is 100% FLC
and the actual load demand is 47% FLC

then the applied voltage boost is —

$$10 \times \frac{47}{100} = 4.7\%$$

This is tapered from 4.7% boost at zero frequency to 50% of MVF (ie at 0.5 x **Prc**).



29 Voltage (torque) boost.
(a) High level of boost, tapering to 5.1% at 0Hz. Note that boost is maintained at high level above a frequency of one sixteenth of **Prc**.
(b) Low level of boost — tapers evenly from boost setting when boost is <5.1% of rated voltage.

SLIP COMPENSATION

Slip compensation compensates for speed varied by increasing load due to the slip characteristic of squirrel cage induction motors. It is applied by parameter **Pr7**, Fig. 30. In open loop mode (**b5** = 1) **Pr7** increases the output frequency of the inverter to a value above the frequency demanded by the speed reference. In closed loop mode, (**b5** = 0), **Pr7** has no effect. The available values of slip compensation are —

ULF Hz	Available Range of **Pr7**	Maximum Compensation
120	0 to 5Hz	7.6Hz
240	0 to 10Hz	15.2Hz
480	0 to 20Hz	30.3Hz
960	0 to 25Hz	60.6Hz

The amount of compensation applied is dependent on the following factors —

- The value of ULF selected
- The value of **Pr7** selected from the available range for the ULF
- The actual load as a proportion of the selected value of maximum continuous current **Pr5**.

For example, if the ULF is 120Hz and **Pr7** is set to 5Hz, then when the motor is drawing current equal to the selected value of **Pr5** the compensation will be 5.0Hz. If a lower setting of **Pr7** had been selected, the compensation would be proportionally less at the same load current. In any case, at loads below the value set in **Pr5** the compensation is proportionally less.

For good compensation, **Pr5** should be set to the value of the motor full load current, and **Pr7** adjusted to the slip frequency of the motor.

Slip compensation applies in both forward and reverse operation and gives near-constant speed holding with fluctuating speed and load.

$$\text{Compensation in Hz} = \text{Pr7} \times \frac{\text{Load}}{\text{Pr5}}$$

Parameter: Pr7

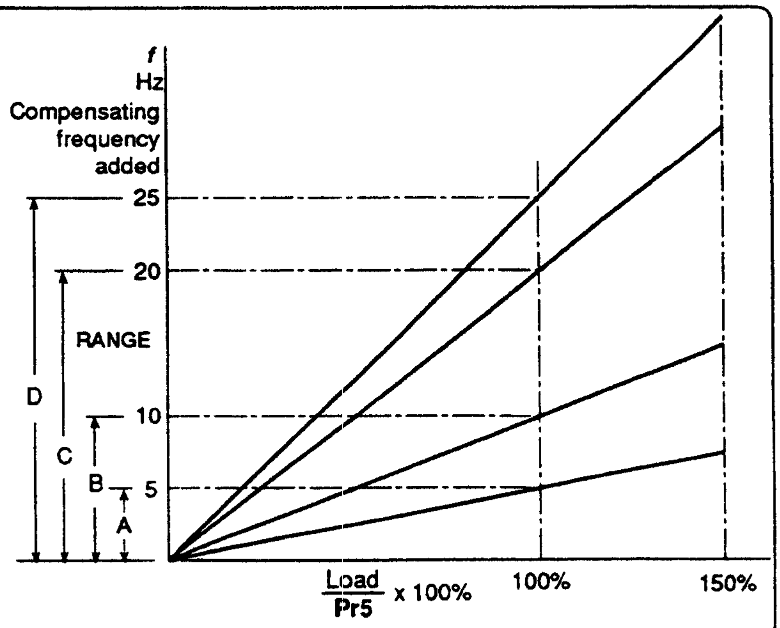
Slip compensation: Increases inverter output frequency as load increases; scaled by the ratio of actual current to the selected value of **Pr5**, up to the frequency increase selected.

Range: 0 to 5Hz — ULF 120Hz
0 to 10Hz — ULF 240 Hz
0 to 20Hz — ULF 480Hz
0 to 25Hz — ULF 960Hz

Default value: 0Hz

Serial mnemonic: SL

Related parameters: **b5, b14**



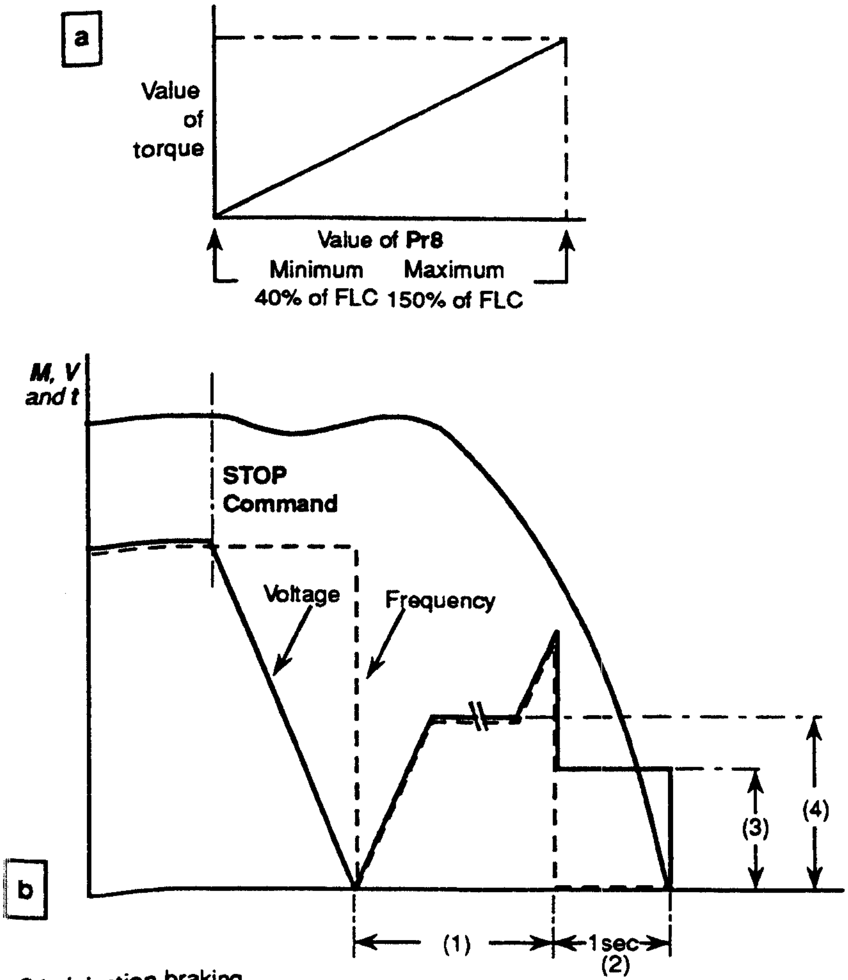
30 Slip Compensation Pr7 increases the output frequency according to load.
Compensation may be selected within the available ranges —
A — ULF = 120Hz;
B — ULF = 240Hz;
C — ULF = 480Hz;
D — ULF = 960Hz.

INJECTION BRAKING

Parameter: Pr8

Injection braking:	Maximum level of injection braking current; value as a percentage of rated FLC.
Range:	40% to 150%FLC (Industrial) or 120% FLC (HVAC)
Default value:	150%FLC for Industrial Drives 120% FLC for HVAC Rated Drives
Serial mnemonic:	BR
Related Parameters:	**b2, b7**

NOTE — Injection braking is operational only when the drive is stopping and when **b2** = 1 and **b7** = 0



31 Injection braking.
(a) The linear relationship of the assigned value of **Pr8** to the braking torque applied.
(b) The effect of a STOP command, which causes the voltage to be reduced linearly to zero at full frequency followed by:-
(1) injection of braking current at low frequency for a period which is dependent on the inertia of the load;
(2) the holding torque time, 1s.
The value of the dc holding torque (3) is a proportion of **Pr8.**
The braking current level (4) is determined by the value of **Pr8.**

SERIAL ADDRESS

Parameter: Pr9

Serial address:	Identifies the inverter to enable serial device to address a selected drive in a multiple drive system.
Range:	0 to 99
Default value:	11
Serial mnemonic:	SE
Related Parameters:	b6, b10, b12

FAILURE MODE (MEMORY)

Parameter: PrA

		SERIAL MNEMONICS
Failure Mode Parameter:	Contains the last 10 trip codes seen by the drive Does not hold **UU** if the drive was in a tripped state during power down. Holds the last 10 trip codes even when power disconnected.	PrA-0 = T0 PrA-1 = T1 PrA-2 = T2 PrA-3 = T3 PrA-4 = T4 PrA-5 = T5 PrA-6 = T6 PrA-7 = T7 PrA-8 = T8
Range:	PrA-0 last trip to PrA-9 previous tenth trip	PrA-9 = T9
Default:	PrA-0 to PrA-9 Blank	

Data Logging

The drive can be interrogated for the history of fault trips for logging and for system analysis. The software saves the most-recent ten trips. Data is read-only, and is not lost when power is disconnected from the drive. The procedure at the keypad is as follows —

Find **PrA** in the main menu. Press the MODE key to go into parameter adjustment mode. The display will then show the code of the most recent trip in the windows to the right-hand side of the display. The left-hand window will show 0, the log sequence number. To view the codes of earlier trips, press DOWN to view in sequence, 0 to 9, or UP to view in reverse sequence, 9 to 0. After power-up, the starting point will always be 0. (NOTE The minus LED also illuminates for log sequence numbers 1 through to 9.) If no keystroke is made, the display reverts to the main menu after 8 seconds.

SECURITY CODE

Parameter: Pr b

Security code selector:	Permits choice of the security code for each individual inverter. Prb = 0 corresponds to no security code. In keypad adjustment mode, values of 100 to 255 and zero can be set. In serial comms control mode, values of 0 to 255 can be set.
Range:	0 to 255
Default value:	0
Serial mnemonic:	SC

Once the Security Code has been correctly entered, all paramters can be adjusted. The code needs to be entered only once to allow access to all parameters after power-on, until the drive is powered off.

VOLTAGE/FREQUENCY PROFILE

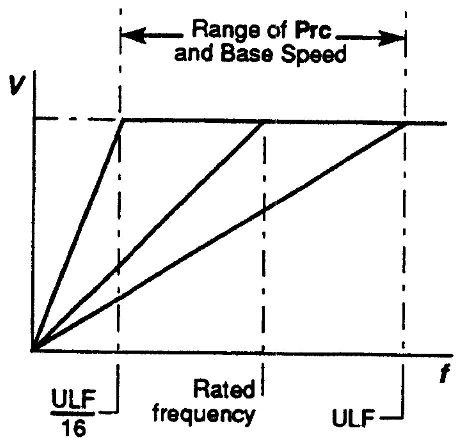
The voltage-to-frequency ratio (V/f) delivered by an inverter is normally held constant up to the maximum (rated) voltage and frequency of the motor — the base speed. Up to this point the motor torque is, in principle, constant. Above base speed, where the voltage can no longer increase, further increase of frequency output produces a constant-power characteristic.

The value of the frequency to be assigned at the rated voltage of the motor is called the **maximum voltage frequency** (MVF) and is adjusted by parameter **Prc**. The MVF is defined by relating **Prc** to the selected value of the upper limit of frequency (ULF), parameter **b14**. The maximum value of the MVF is equal to the ULF (**Prc = b14**). The minimum value is one-sixteenth of the ULF, and when ULF = 960Hz the maimum value of MVF is 60Hz.

Parameter: Prc

Max. voltage frequency:	Defines the lowest frequency at which the inverter delivers the rated output voltage. Fig. 32.
Range:	ULF/16 < Prc < ULF
Default value:	50Hz
Serial mnemonic:	BS
Related Parameters:	**b14, b54**

32 Profiling the motor output characteristic by relating the values assigned to **Prc** and **ULF**. **Prc** can be made equal to any value of ULF (minimum one sixteenth).
Note that ULF is itself selectable from one of three frequencies. Refer to **b14**.



MENU SELECTOR Prd

Parameter: Pr d

Menu selector:	**Prd** allows access to a separate menu, which permits extra drive features to be selected.
Range	0, 10, 20, 30, 40, 50
Default value:	0 (Allows access to **Pr0** to **Prc** and **b0** to **b14**)

Summary of Prd Parameters

Prd = 10	Skip frequencies
Prd = 20	Preset speeds
Prd = 30	Preset accelerations and Jog
Prd = 40	Preset decelerations and Jog
Prd = 50	Auto reset

SKIP FREQUENCIES

Prd = 10— SKIP FREQUENCIES

Pr	*Function*	*Serial Mnemonic*	*Range*	*Default*
10	Skip frequency 1	S1	Pr0 to Pr1	
11	Skip frequency 2	S2		0Hz
12	Skip frequency 3	S3		
13	Skip band 1	B1	±0.5 to ±5.0Hz	
14	Skip band 2	B2	giving a skip frequency	±0.5Hz
15	Skip band 3	B3	band from 1.0Hz to 10Hz	

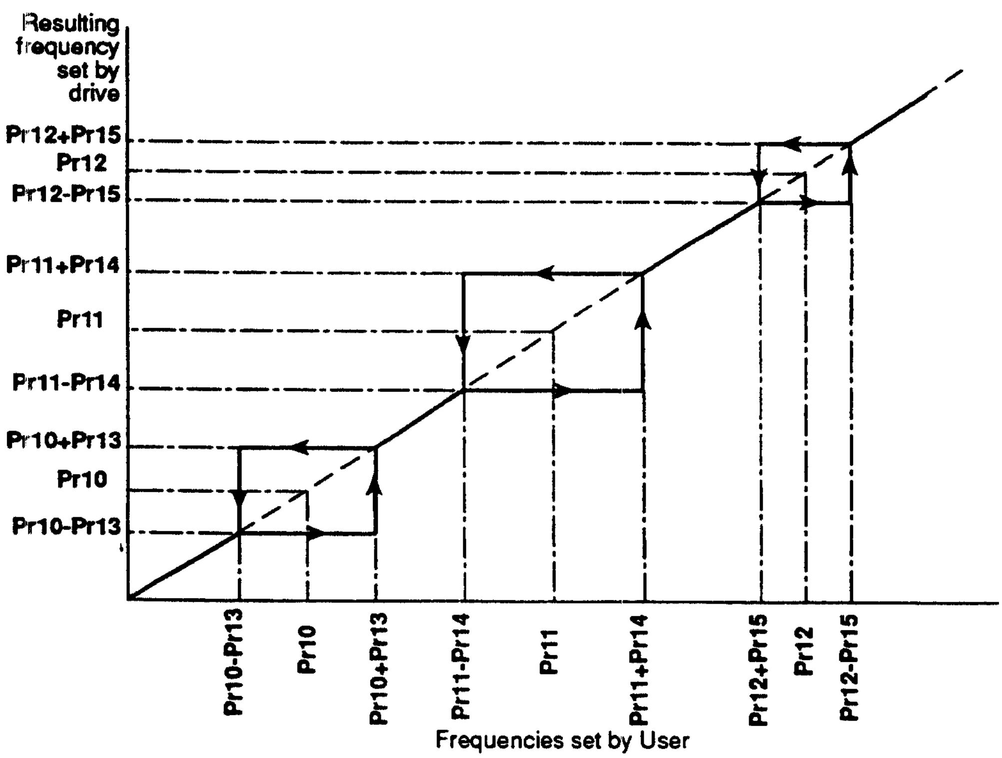
Allows the introduction of a band of frequencies through which the drive will ramp through when achieving a set speed set speed.

NOTE Skip frequencies 1 to 3 are modified by changes to **Pr0** and **Pr1**.
If any of **Pr10**, **Pr11** or **Pr12** = **Pr0** or **Pr1**, that skip frequency is disabled.
Skip frequencies are not operational during jogging.

For an application in which the mechanical system resonates at one (or at more than one) particular frequency of drive output it is desirable to prevent the drive operating continuously at this frequency. With a skip frequency in operation, the drive will always accelerate and decelerate through the skip frequency band, and will only maintain a frequency at or outside the skip frequency band limits. The acceleration and deceleration rates are defined by to values of **Pr2**, **Pr3**, **Pr30-36**, and **Pr40-46** currently in operation.

Up to three skip frequencies can be selected, and each may have a different band. The skip frequencies operate in both forward and reverse machine directions. The skip frequency bands can overlap, and can also touch. For example, if (**Pr10** + **Pr13**) ≤ (**Pr11** - **Pr14**), these settings effectively make one skip frequency band from (**Pr10** - **Pr13**) to (**Pr11** + **Pr14**).

If a skip frequency band 'touches' **Pr0** or **Pr1**, for example, if (**Pr11** + **Pr14**) ≥ **Pr1**, the effective band is (**Pr11** - **Pr14**) to **Pr1**. Alternatively, if (**Pr12** - **Pr15**) ≤ **Pr0**, the effective band is **Pr0** to (**Pr12** + **Pr15**).



33 The effect of skip-frequency control.
Parameters **Pr10**, **Pr11** and **Pr12** select the frequencies to be skipped.
Parameters **Pr13**, **Pr14** and **Pr15** set the range of frequencies skipped.

PRESET SPEEDS

Prd = 20 PRESET SPEEDS

Pr	Function	Serial Mnemonic	Range	Default
20	Preset speed 1	P1		
21	Preset speed 2	P2		
22	Preset speed 3	P3		
23	Preset speed 4	P4	Pr0 to ± Pr1	0Hz
24	Preset speed 5	P5		
25	Preset speed 6	P6		
26	Preset speed 7	P7		
27	Jog	PJ	0-15Hz	1.5Hz

Related parameters: **Pr30 — 37, Pr40 — 47, b20, b21, b22,**

Preset Speeds allows the selection of up to seven preset speeds when **b20** = 1 (or the serial mnemonic PS), or 3 preset speeds and jog when **b20** = 0, via terminals A10, A11 and A12, to ensure the value is within the allowable range.

NOTE —Changing the value of **Pr0** or **Pr1** may alter **Pr20 — 26** to ensure that the value is within the permissible range.

Up to seven speeds can be selected, any of which can then be instantly applied by connecting control terminals A10, A11, A12 to A1 (0V) as shown in the table below.

Acceleration and deceleration between Preset Speeds may either be controlled by Preset acceleration or deceleration rates set by **Pr37** and **Pr47**, independent of **b21**., or by parameters **Pr2** and **Pr3**, if **b21** = 0. If all terminals are open-circuit, the drive will use any source of speed reference that is currently valid. When any of the three terminals is at 0V, the Preset Speeds take precedence over all other speed references. Note that terminals A10, A11 and A12 are not functional if the drive is in REMOTE mode and **b6** = 1.

Presets only operate when the drive is in the RUN status, whereas Jog only operates when the drive is in the **rdY** state and not tripped.

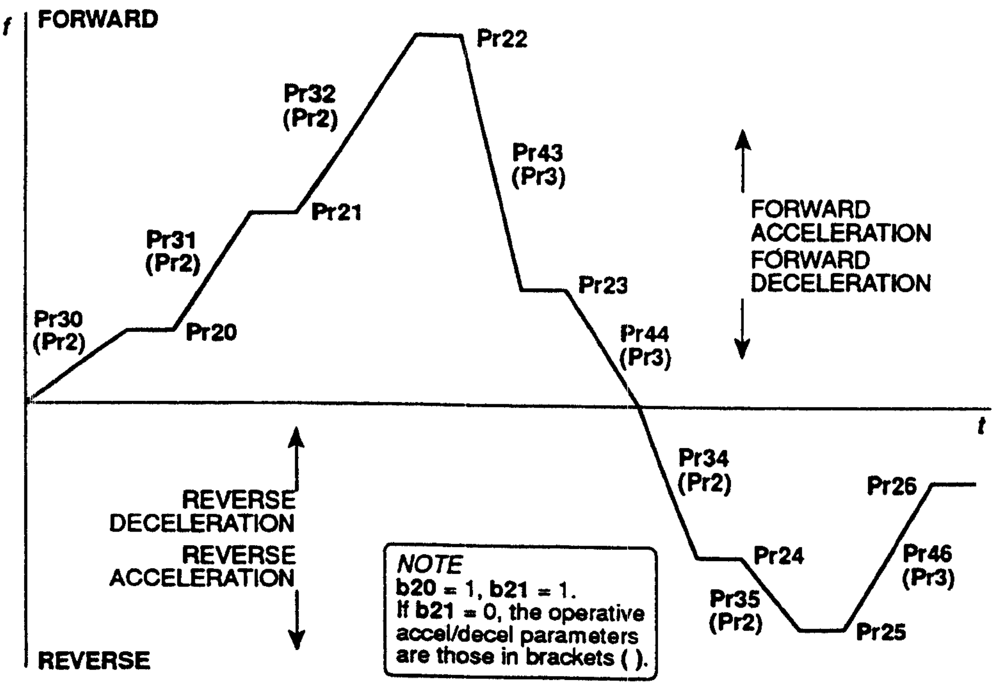
PRESET SPEED CONTROL CONFIGURATIONS

A12	A11	A10		PRESET SPEED	Pr	
0	0	0		'Normal' set speed reference	-	
0	0	1		1	20	
0	1	0		2	21	
0	1	1		3	22	
1	0	0	If b20 = 0, Jog (Pr27)	4	23	only if b20 = 1
1	0	1		5	24	
1	1	0		6	25	
1	1	1		7	26	

In the table, 0 = open circuit; 1 = 0V, ie 'closed' **provided that** the logic has not been inverted. Refer to Chapter 4 "INSTALLATION – ELECTRICAL".

Reverse Rotation

All seven preset speeds, but not jog, can be set negative for reverse rotation by pressing the FWD/REV key on the keypad to toggle the preset speed direction whilst adjusting the preset speed parameter (MODE LED not illuminated). These reverse rotations are available only if **b22** = 1. If **b22** = 0, the present speed directions are controlled by the normal forward/reverse input at terminal 17, as is always the case for the jog preset.



34 Application of Preset Speeds (Pr20...), Acceleration Times (Pr30...) and Deceleration Times (Pr40...).
Note that acceleration and deceleration parameter *numbers* requires the correct unit-digit independent of the tens-digit. Thus the change-of-speed parameter between the Preset Speeds **Pr21** and **Pr22** must be **Pr32** if accelerating, or **Pr42** if decelerating. If the motor is is driven directly into reverse without any Preset Speed at zero speed (as illustrated) the successive forward-deceleration and reverse-acceleration parameters have the same unit-digit but different tens-digits. Rate of change of speed can change at zero speed, as illustrated, or can be the same, as required.

PRESET ACCELERATION

Accelerations between Preset Speeds can be set if **b21** = 0. If **b21** = 0, acceleration is controlled by **Pr2**, except for Jog.

Prd = 30 PRESET ACCELERATION

Pr	*Function*	*Serial Mnemonic*	*Range*	*Default*	
30	Preset 1 Accel	A1			
31	Preset 2 Accel	A2			
32	Preset 3 Accel	A3			
33	Presbt 4 Accel	A4	0.2s to 600s	5.0s	only if **b20** = 1
34	Preset 5 Accel	A5			
35	Preset 6 Accel	A6			
36	Preset 7 Accel	A7			
37	Accel Jog	AJ		0.2s	

Related parameters: **Pr20 — 27**, **Pr40 — 47**, **b21**, **b22**,

Individual acceleration rates can be set for each preset speed and jog function.

PRESET DECELERATION

Decelerations between Preset Speeds can be set if **b21** = 1. If **b21** = 0, deceleration is controlled by **Pr3**, except for Jog.

Prd = 40 PRESET DECELERATION

Pr	*Function*	*Serial Mnemonic*	*Range*	*Default*	
40	Preset 1 Decel	D1			
41	Preset 2 Decel	D2			
42	Preset 3 Decel	D3			
43	Preset 4 Decel	D4	0.2s to 600s	10.0s	only if **b20** = 1
44	Preset 5 Decel	D5			
45	Preset 6 Decel	D6			
46	Preset 7 Decel	D7			
47	Decel Jog	DJ		0.2s	

Related parameters: **Pr20 — 27, Pr30 — 37, b20, b21, b22,**

Individual deceleration rates can be set for each preset speed and jog function. (See **Prd - b21**).

Calculating Acceleration or Deceleration Time

To determine the required value of a Preset Acceleration or Deceleration parameter to give acceleration or deceleration time (t) between two preset speeds—

Example

$$\mathbf{Pr43} = t \times \frac{\text{ULF (Hz)}}{\text{(previous speed) - }\mathbf{Pr23}\text{ (Hz)}} \quad \text{(seconds)}$$

NOTE

t = required time to decelerate from previous set speed to **Pr23** preset speed.

AUTO RESET

Allows auto reset after drive trip with programmable number of attempts and reset delay.

Prd = 50 RESET

Pr	Function	Mnemonic	Range	Default
50	Number of reset attempts	RN	1, 2, 3, 4, 5	0 (disable)
51	Reset delay	RD	1.0 s to 5.0 s	1.0 s

Related parameters: **b1**

Parameters **Pr50** and **Pr51** are Real, Read-write.

AUTO RESET

This function enables the drive to be configured to reset after a trip, automatically. It does not apply to an external trip **Et** condition. The facility provides for selection of the time delay before reset following the trip condition **Pr51**, and for selecting the number of attempts before the auto reset facility is disabled and the drive remains tripped.

With the drive in AUTO-start mode (**b1** = 0), any user-resettable trip will be automatically reset and the drive will restart. If **b1** = 1, the drive will simply reset and revert to **rdY**, ready to start.

If the trip condition persists after the selected number of start attempts, the drive will latch the trip and load the trip condition into the fault log (**PrA**). If the trip condition clears within the selected number of start attempts, the reset count is reset to the value of **Pr50**. The reset count is also reset on power-up, or whenever **Pr50** (RN) is given a new value. When the drive trips and **Pr50** ≠ 0, the keypad display shows the trip code and the remaining reset count.

6.3 Bit Parameters

Speed Reference

Parameter: b0

Speed reference or torque reference selector:	0 = torque reference 1 = speed reference
Default value:	**b0 = 1**
Serial mnemonic:	DS location 14 in the 2-byte hex word)

Related parameters: **Pr4**

SPEED CONTROL AND TORQUE CONTROL

Depending on the nature of the process in which the inverter and its motor are installed, the controlling reference may be required to cause the motor to follow a speed or a torque demand.

In speed control, **b0** =1, both the speed reference and the torque reference are active. The torque reference is always subject to current limit **Pr4**.

In torque control, **b0** = 0, only the torque reference is active. The speed is set to **Pr1**, and direction is determined by the internal forawrd/reverse control.

Auto or Manual Start

Parameter: b1

Auto start or manual start selector:	0 = auto start 1 = manual start
Default value:	**b1 = 1**
Serial mnemonic:	DS (location 13 in the 2-byte hex word)

Related parameters: **Pr50** , **Pr51**

AUTO START AND MANUAL START

In the AUTO-start mode, the inverter starts the motor (delay 120ms) when the power supply circuit to the inverter is energised, provided that a STOP command has not been given. If there is a temporary loss of supply, auto-start mode restarts the motor under proper control when the supply is restored, regardless of the operating status of the motor at the time of supply failure.

Manual-starting will normally be used where it is essential that there should be a start command before the drive runs. To start the motor in MANUAL start mode, the drive must receive a RUN signal from the external control system after the drive has been energised from the main supply, or after supply has been restored after a temporary loss of power.

RUN / RESET In AUTO start mode: after a trip has occurred, performing a RESET will cause the drive to restart immediately.

In MANUAL start mode: after a trip has occurred, performing a RESET will set the drive to **rdY**. The drive then requires a RUN (keypad)or an external START signal to start the motor.

SUMMARY OF STARTING CHARACTERISTICS

AUTO start	When drive is initially energised	120ms delay then auto start
	After stopping due to power supply disturbance	120ms delay then auto start
	After a TRIP signal	(Trip Code signalled) 1.0s delay to RESET Immediate start after RESET
	After a STOP signal	(**rdY** signalled) Waits for RUN or START signal

MANUAL start	When drive initially energised	(**rdY** or Trip Code signalled) Waits for RUN or START signal (after RESET if tripped)
	When stopped by any signal other than a trip	Signals **rdY**, requires RUN or START signal
	When stopped by a trip signal	Signals a Trip Code, waits for RESET, then waits for RUN or START signal

POWER LOSS AND RIDE-THROUGH TRANSIENT DISTURBANCE OF THE SUPPLY

Whilst the drive is ramping down as a result of the loss of either one phase or all three, the display will show **AcUU**. If the supply is restored to normal during the ramping period, the drive will accelerate back to set speed.

If the fault persists, that is, if the supply is not restored to normal during the ramping period, the drive will trip, the display will show **UU** or **Ph**, (after a delay) as appropriate. **UU** — if all three phases are below specification. **Ph** — if one phase is below specification.

Stopping Mode Selector

Parameter: b2 & b7

b2	b7	
0	0	Standard ramp
0	1	Coast
1	0	Inject DC
1	1	High level ramp

Default values: **b2 = 0**
b7 = 0

Serial mnemonic: DS (**b2** — location 12 in 2-byte hex word; **b7** — location 7)

Related parameters: **Pr8**

STOPPING & BRAKING MODES

A STOP command is required to bring the motor to rest regardless of which of the stopping and braking options is chosen.

The CD75-750 & CDV75-750 range of drives is available with or without a separate optional braking unit for resistively absorbing regenerated energy during deceleration.

Resistive braking with the optional unit is preferable for applications where the inertia of the load is high and short stopping times are required. For further information, refer to Chapter 9, BRAKING UNIT (OPTIONAL). The options for bringing the motor to a halt are —

OPTION	*KEYPAD DISPLAY during stopping period*
coast	**Inh**
ramp* (Standard or High Level)	normal— speed or load according as **b8** = 0 or 1
injection	**dc**

*With or without external resistor

COAST MODE

Following a stop, the IGBTs are disabled immediately and the motor coasts to rest. One second after stopping, **rdY** appears in the display and the drive can then be restarted

RAMP MODE

Ramp brings the motor to rest in a time proportional to the decelerating time parameter **Pr3** (or **Pr30 — 36** if presets are used and **b21** =1). The rate of deceleration is linear.

If **b2** = **b7** = 0 (standard ramp) the ramp is momentarily halted if the DC link voltage reaches the voltage limit and continues when the voltage falls below the limit. In this mode, as the DC voltage rises the voltage applied to the motor rises proportionally.

If **b2** = **b7** = 1 (high level ramp) the ramp is continuous. In this mode, fixed boost is automatically selected during deceleration, and a constant voltage is applied to the motor as the DC bus voltage rises.

INJECTION MODE

Injection braking requires parameter **Pr8** to be adjusted between the limits of 40% and 150% of motor rated FLC (120% for HVAC). The applied braking torque depends on the value of **Pr8**. Higher values produce shorter stopping times, refer to Fig. 31 and details of **Pr8**.

At the STOP command, the output voltage is rapidly reduced at constant frequency so that the motor is defluxed. A braking current is then applied at low frequency. The value of **Pr8** determines the level of current injected. As the motor comes to rest, direct current is applied for one second. During the stopping sequence described, any RUN command is inhibited until after the one-second DC injection period.

> *NOTE*
>
> During normal acceleration and deceleration (not stopping) the ramp control mode is as for Standard Ramp, *unless* **b2** = **b7** = 1, when the ramp control mode is High Level.

Torque Boost Selector

Parameter: b3

Low speed torque boost selector:	0 = auto boost 1 = fixed boost
Default value:	**b3** = 0
Serial mnemonic:	DS (location 11 in the 2-byte hex word)

Related parameters: **Pr56**

VOLTAGE (TORQUE) BOOST

FIXED boost (**b3** = 1) uses a set value, dependent on **Pr6**.
AUTO boost (**b3** = 0) uses a load-dependent boost value, *also* dependent on **Pr6**.
Fixed boost is better suited to very high constant starting torque.
Auto boost is better suited to lower and variable starting torque.

Bipolar/Unipolar Reference Selector

Parameter: b4

Bipolar/unipolar reference selector:	0 = bipolar 1 = unipolar
Default value:	**b4** = 1
Serial mnemonic:	DS (location 10 in the 2-byte hex word)

BIPOLAR/UNIPOLAR REFERENCE SELECT

Permits the drive to accept a bipolar reference to control forward and reverse operation as the alternative to a unipolar reference with a forward/reverse signal.

Set speed	**-Pr1**	**±Pr0**	**+Pr1**
Input voltage Terminal 5	-10V (rev)	0V*	+10V (fwd)

*Direction immaterial

In bipolar reference mode, terminal 17 **is not functional**.
In unipolar mode, input voltages <0V and up to -10V are treated as 0V.

Encoder Feedback Selector

Parameter: b5

Feedback selector:

0 = encoder feedback (closed loop)
1 = open loop

Default value: **b5 = 1**
Serial mnemonic: DS (location 9 in the 2-byte hex word)

Related parameters: **Pr7**

OPEN LOOP AND CLOSED LOOP

These are two fundamentally-different control modes for a drive and motor. Open loop uses an internal measurement of output frequency as the speed demand signal. Slip compensation can be applied in open loop mode by **Pr7**. In closed loop mode, **Pr7** is not functional).

Closed loop control requires an external measurement of motor speed to be fed back to the inverter from a digital encoder. With encoder feedback, a digital trim system locks the motor frequency to the required set frequency, providing (integral) absolute tracking. Slip compensation is ineffective. If the encoder signal fails, the motor frequency is automatically increased by a fixed amount above the set frequency, the amount depending on the selected value of the ULF —

ULF (Hz)	120	240	480	960
Increase above set speed (Hz)	7.6	15.2	33	60.6

NOTE For optimum performance when the encoder is used for closed loop control, ensure that the minimum operating frequency of the drive is above approximately 5Hz output.

Master/Slave Selector

Parameter: b6

Master/slave selector :
(when in Remote, Terminal 16, mode *only*)

0 = Master (current loop)
1 = Slave (serial comms link control)

Default value: **b6 = 0**
Serial mnemonic: DS (location 8 in the 2-byte hex word)

When the drive is in the remote mode (terminal 16) *and* **b6** = 1, the drive can be controlled by the serial link, that is, parameters can be read and written. In all other modes (local mode or **b6** = 0), parameters can always be read via the serial link, but cannot be written.

Stopping Mode

Parameter: b7

See **b2**

Display Mode Selector

Parameter: b8

Display frequency or load current value:	0 = frequency (Hz) 1 = load (%FLC)
Default value:	**b8 = 0**
Serial mnemonic:	DS (location 7 in the 2-byte hex word)

Keypad or Terminal Mode Selector

Parameter: b9

Keypad or terminal mode selector:	0 = keypad 1 = terminal
Default value:	**b9 = 1**
Serial mnemonic:	DS (location 5 in the 2-byte hex word)

Related parameters: **b51**

Parity Selector

Parameter: b10

Parity selector:	
	0 = even parity 1 = odd parity
Default value:	**b10 = 0**
Serial mnemonic:	DS (location 4 in the 2-byte hex word)

Remote Reference Input Selector

Parameter: b11

Remote reference selector:

Input:	4 to 20mA = 4.20 20 to 4mA = 20.4 0 to 20mA = 0.20
Default value:	**b11 = 4.20**
Serial mnemonic:	DS (locations 2 and 3 in the 2-byte hex word)

Parameter **b11** controls the terminal 6 input mode. Terminal 17 controls the direction.

b11	=	4.20
4mA	⇒	**Pr0** speed
20mA	⇒	**Pr1** speed
b11	=	20.4
20mA	⇒	**Pr0** speed
4mA	⇒	**Pr1** speed
b11	=	0.20
0mA	⇒	**Pr0** speed
20mA	⇒	**Pr1** speed

Baud Rate Selector

Parameter: b12

Baud rate selector:	
	4.8 = 4800 baud 9.6 = 9600 baud
Default value:	4.8
Serial mnemonic:	DS (location 0 in the 2-byte hex word)
Related parameters:	**Pr9, b6, b10**

Reset Defaults

Parameter: b13
Reset parameters to default values:

0 = inactive
1 = set default values

Default value: 0

Setting **b13** = 1 affects *ALL* parameters.

Define Values of PWM and ULF

Parameters: b14
Define PWM switching frequency and ULF

First entry — PWM switching frequency -
2.9 = 2.9kHz
5.9 = 5.9kHz
8.8 = 8.8kHz
11.7 = 11.7kHz

Second entry (press MODE once) — Upper limit of frequency (ULF)
120 = 120Hz,
240 = 240Hz,
480 = 480Hz
960 = 960Hz

Press MODE a second time to exit.

Default values: - PWM 2.9kHz
- ULF 120Hz

Serial mnemonic: FQ

NOTES

(i) When a switching frequency of 2.9kHz is selected only 120Hz and 240Hz ULF are available. ULF of 960Hz is available only with 11.7kHz.

(ii) Altering **b14** can affect **Pr0, Pr1, Pr7, Prc, Pr10 — 12, Pr20 — 26,**

FREQUENCY RELATIONSHIP

The ULF, the maximum frequency **Pr1**, and the minimum frequency **Pr0** are related as follows —

0Hz ≤ **Pr0** ≤ **Pr1** ≤ ULF

FREQUENCY RESOLUTION

0 to 120Hz	0.1Hz	ULF = 120Hz
0 to 240Hz	0.2Hz	ULF = 240Hz
0 to 480Hz	0.4Hz	ULF = 480Hz
0 to 960Hz	0.8Hz	ULF = 960Hz

PWM SWITCHING FREQUENCY

Selected by parameter **b14** (first entry) — alternative values are displayed by repeated operation of the UP or the DOWN key.

In making a choice of PWM switching frequency, the factors to be considered are the effect on the motor performance, and the relationship to the upper limit of inverter output frequency (ULF, see below). Lower PWM switching frequencies improve motor torque at low speed, keep heat losses to a minimum, and would be preferred for applications involving high-inertia loads, repeated acceleration, or frequent start-stop duty. The higher switching frequencies reduce torque ripple and acoustic noise, but increase losses due to inverter heating.

Parameter **b14** also enables the ULF to be adjusted as a second entry, see below. To leave PWM switching frequency, without altering the ULF value after adjusting the PWM value, press MODE twice instead of once.

continued...

UPPER LIMIT OF FREQUENCY (ULF)

Selected by parameter **b14** (second entry) — integer values of 120Hz, 240Hz, 480Hz or 960Hz are displayed successively by repeated operation of the UP or the DOWN key.

The ULF is the highest frequency of the inverter AC output sinewave. As the behaviour of other control functions is dependent on the ULF value chosen, it is convenient to select a value at an early stage. The main reason for choosing one ULF value rather than another will be, primarily, the required value of **Pr1** and **Prc**.

ULF is adjusted by bit parameter **b14** as a second entry after setting the PWM switching frequency. It is necessary to press the MODE key once again, after it has been pressed to set the PWM switching frequency, and then to enter the ULF value, finally pressing MODE once more to exit **b14** adjustment. To set the ULF without entering a value for PWM first, press MODE twice after adjusting the parameter code to **b14**.

Special Function Parameters

Prd = 20

b	*Function*	*Serial Mnemonic*	*Default*
20	Select jog and 3 preset speeds or 7 preset speeds	C1 (location 8)	0 = jog and 3 presets
21	Standard or selected preset, accel/decel rates	C1 (location 9)	0 = standard
22	Preset speed, reverse source, keypad/terminal	C1 (location 7)	0 = terminal

BIT-PARAMETERS **b20, b21** and **b22**

Related parameters Pr20 — 27, Pr30 — 37, Pr40 — 47

Preset Speeds are further controlled by two bit parameters, **b20** and **b21**, in the menu **Prd** = 20, as follows —

1 Bit parameter **b20** = 0 (default) enables only terminals A10 and A11 for Preset Speeds. In this mode, Preset Speeds **1**, **2** and **3** are available, with Jog (otherwise called 'inch', meaning that the motor is under momentary on-off control). The Jog facility is controlled by applying 0V at terminal A12 so that terminal A12 becomes a Jog control.

   Only from **rdY** will the drive run at the set Jog frequency (**Pr27**) for as long as terminal A12 is connected to 0V. The acceleration and deceleration rates of the Jog operation are always controlled by **Pr37** and **Pr47**.

2 Bit parameter **b20** = 1 enables terminals A10, A11, A12 to control seven possible Preset Speeds. There is no Jog facility in this mode.

3 Bit parameter **b21** = 0 (default) puts **Pr2** and **Pr3** in control of acceleration and deceleration, for presets **Pr20 — 26**.

4 Bit parameter **b21** = 1 enables the individual profiling accelerations and decelerations available in menu **Prd** = 30... and = 40...

   Pr20 uses acceleration **Pr30** and deceleration **Pr40**
   Pr21 uses acceleration **Pr31** and deceleration **Pr41**
   ...etc.

5 Bit parameter **b22** = 0 (default) enables reversing of preset speeds to be controlled from terminal 17 while the motor is running. The polarity of **Pr20 — 26** is ignored.

6 Bit parameter **b22** = 1. The direction of rotation of preset speeds is preset by parameters **Pr20** to **Pr26**.

Prd = 50

b	Function	Serial Mnemonic	Default
50	Drive healthy/at speed relay relay	C1 (location 10)	0 = Drive healthy
51	Disable or enable fwd/rev key on control pod	C1 (location 11)	0 = Disable
52	Disable or enable catch-spinning motor software	C1 (location 12)	0 = Disable
53	Run/minimum speed status output	C1 (location 13)	0 = Drive running
54	Fixed or dynamic v/f ratio	C1 (location 14)	0 = fixed v/f ratio

NOTE

On all CDV drives the following defaults will alter.
Drive Healthy = not tripped and not in Err condition after power on.
At-Speed = indicated speed equal to set speed.

b52 spinning motor = 1 enabled
b54 dynamic v/f = 1 dynamic v/f enabled

BIT PARAMETERS **b50** to **b54**

b50 = 0 Status relay indicates (default) Drive Healthy when energised (terminals 1, 2, 3)

b50 = 1 Status relay indicates At-Speed when energised (terminals 1, 2, 3)

b51 = 0 DISABLE keypad FWD/REV key (default) } Relevant only in keypad mode, **b9** = 0

b51 = 1 ENABLE keypad FWD/REV key

NOTE When **b51** = 1, terminal 17 controls motor direction when **b9** = 0

b52 = 0 Not catch spinning motor (default)

b52 = 1 Catch spinning motor

Enables the drive to be energised onto a motor whose shaft is rotating, without causing a trip. On receiving a RUN signal, the drive scans the motor frequency and synchronises at the values. The drive scans from **Pr1** to zero in the last direction of rotation, then from **Pr1** to zero in the opposite direction. Once the drive synchronises at the motor speed, it then ramps to the set speed.

During the scanning period the keypad displays **SCAN**. On systems where there is no mechanical load on the motor when it is over-running, a change of speed may be observed during the scanning operation. Dependent on the system and the dynamic conditions, there may be a delay of up to 5 seconds before the drive resumes normal operation.

b53 = 0 Open-collector output = (default) Drive Running } Terminal A0

b53 = 1 Open-collector output = minimum speed } External relay energised

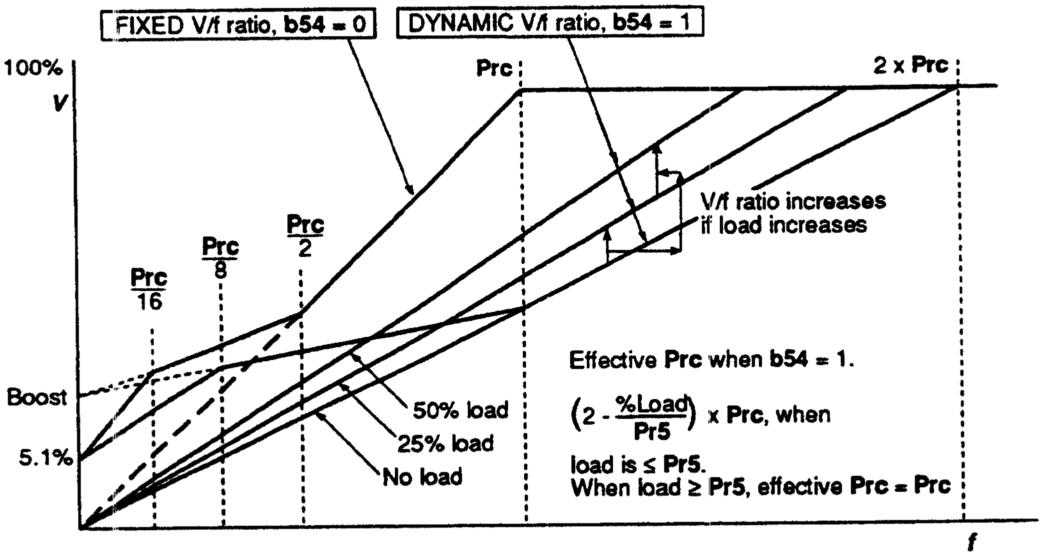
NOTE — Drive Running = IGBTs being switched in the inverter bridge.
Minimum speed = Ouput frequency greater than **Pr0** and IGBTs being switched

Fixed or Dynamic V/f Ratio

b54 = 0 FIXED V/f ratio (default)

b54 = 1 DYNAMIC V/f ratio

Provides the option of load sensitive voltage response, with energy saving and reduced noise at light loadings. At no load, the applied voltage is 50% of the normal full voltage. As the load increases the applied voltage increases in proportion, to a maximum of the normal voltage at full load. Auto boost and fixed boost (**b3**) and **Pr6** function as for a higher value of **Prc**.



35 In dynamic V/f mode the V/f ratio is proportional to load. (Not to scale)

6.4 Parameter Quick Reference and Setting Record

	Parameter	Factory Default Settings	First Change Date		Set by	Second Change Date		Set by
Pr0	Min frequency	0Hz						
Pr1	Max frequency	50Hz						
Pr2	Acceleration time	5 seconds						
Pr3	Deceleration time	10 seconds						
Pr4	Current limit	150/120% FLC						
Pr5	Max contin I x t	100% FLC						
Pr6	Voltage boost	5.1%						
Pr7	Slip compensation	0Hz						
Pr8	DC braking level	150/120% FLC						
Pr9	Serial address	11						
PrA	Failure mode	Blank						
PrA-0	Failure mode	Blank						
PrA-1	Failure mode	Blank						
PrA-2	Failure mode	Blank						
PrA-3	Failure mode	Blank						
PrA-4	Failure mode	Blank						
PrA-5	Failure mode	Blank						
PrA-6	Failure mode	Blank						
PrA-7	Failure mode	Blank						
PrA-8	Failure mode	Blank						
PrA-9	Failure mode	Blank						
Prb	Security code	0						
b0	Torque or speed	1 = speed						
b1	Auto/Manual start	1 = manual						
b2	Stop mode with b7	0 = standard ramp						
b3	Auto/fixed boost	0 = auto						
b4	Uni/bipolar ref	1 = unipolar						
b5	Open/Closed loop	1 = open loop						
b6	Master/Slave	0 = master						
b7	Stop mode with b2	0 = standard ramp						

	Parameter	Factory Default Settings	First Change Date	Set by	Second Change Date	Set by
b8	Freq/Load Display	0 = frequency				
b9	Keypad/Terminal	1 = terminal				
b10	Even/Odd parity	0 = even				
b11	Remote speed ref	4.20 mA				
b12	Baud rate	4.8 kb				
b14	PWM	2.9 kHz				
b14	ULF	120Hz				
Prc	MVF	50Hz				
Prd 0-10	Menu access					
Pr10	Skip frequency 1	0Hz				
Pr11	Skip frequency 2	0Hz				
Pr12	Skip frequency 3	0Hz				
Pr13	Skip freq. band 1	± 0.5Hz				
Pr14	Skip freq. band 2	±0.5Hz				
Pr15	Skip freq. band 3	±0.5Hz				
Prd 10-20	Menu access					
Pr20	Preset speed 1	0Hz				
Pr21	Preset speed 2	0Hz				
Pr22	Preset speed 3	0Hz				
Pr23	Preset speed 4	0Hz				
Pr24	Preset speed 5	0Hz				
Pr25	Preset speed 6	0Hz				
Pr26	Preset speed 7	0Hz				
Pr27	Jog speed	1.5Hz				
b20	7 presets or 3 presets and Jog	0 = jog and 3 presets				
b21	STD/preset	0 = standard ramps				
b22	Preset speed reverse source	0 = terminal				
Prd 20-30	Menu access					
Pr30	Preset 1 accel.	5 seconds				
Pr31	Preset 2 accel.	5 seconds				

	Parameter	Factory Default Settings	First Change Date	Set by		Second Change Date	Set by	
Pr32	Preset 3 accel.	5 seconds						
Pr33	Preset 4 accel.	5 seconds						
Pr34	Preset 5 accel.	5 seconds						
Pr35	Preset 6 accel.	5 seconds						
Pr36	Preset 7 accel.	5 seconds						
Pr37	Jog accel.	0.2 seconds						
Prd 30-40	Menu access							
Pr40	Preset 1 decel.	10 seconds						
Pr41	Preset 2 decel.	10 seconds						
Pr42	Preset 3 decel.	10 seconds						
Pr43	Preset 4 decel.	10 seconds						
Pr44	Preset 5 decel.	10 seconds						
Pr45	Preset 6 decel.	10 seconds						
Pr46	Preset 7 decel.	10 seconds						
Pr47	Jog decel.	0.2 seconds						
Prd 40-50	Menu access							
Pr50	Reset attempts	0						
Pr51	Reset delay	1 second						
b50	Drive healthy/ at speed relay	0 = drive healthy relay						
b51	FWD/REV key disable	0 = disable						
b52	Spinning motor	0 = disable						
b53	Run/min speed Status output	0 = drive running						
b54	Dynamic V/F or fixed V/F	0 = fixed V/F						

NOTE — On all CDV drives the following defaults will alter:

b52 Spinning motor = 1 enabled
b54 Dynamic V/F = 1 dynamic V/F enable

7 Diagnostics and Fault Finding

7

Diagnostics and Fault Finding

7.1 Fault Finding

DISPLAY does not illuminate and drive does not run
CHECK control pod is connected to drive module
CHECK mains supply, supply fuses or circuit breaker
Replace supply fuses if blown, or reclose circuit breaker, but if supply fuses blow or breaker trips again contact the supplier of the drive.
If control pod is remote mounted, check extension cable wiring.

MOTOR does not start, display shows **rdY**
Drive is in MANUAL start mode.
Operate RUN key, or START pushbutton
CHECK the control wiring, and that external stop/run/trip contacts and circuits are in order.

MOTOR does not start, display shows **0.**
CHECK wiring of speed reference, and that the correct mode (REMOTE/LOCAL) has been selected.
CHECK that KEYPAD mode is not selected.
Check preset speeds are not selected with default setting i.e. "0" Hz. Check max frequency parameter (Pr 1) is not at the "0" Hz.

FAULT CODE at display REFER to Operational Control for possible cause.
Note that:

- Thermal trip devices should not be continually tripped and reset.
- **OI** trip can be caused by shock load, cable or motor insulation faults, length of cable to motor too great, or attempting to accelerate too large a motor.
- **OI** and **OU** trips may be caused by decelerating too fast:
  when operating below motor base speed — **OI** trip
  when operating above motor base speed — **OU** trip
  Increase the value of **Pr3** and check that **b2** and **b7** are set correctly.
- If **PS** or **Err** are displayed, try disconnecting the drive from the supply, wait 2 minutes, reconnect and run the drive. If the fault persists, contact the supplier of the drive.

MOTOR fails to turn the load, and is noisy
Fixed boost setting too high (**Pr6**). Try auto-boost also.
Also check the settings of current limits **Pr4** and **Pr5**.

DRIVE fails to respond to serial communications
CHECK local/remote, master/slave (**b6**), parity (**b10**), baud rate (**b12**), and serial address (**Pr9**) are set correctly.
CHECK the wiring and termination of the serial link.

DRIVE appears to be set to an unusable state
If the security code is known—
Enter the security code (**Prb**) to gain access to **b13**.
Set **b13** = 1 to reset all parameters to default values.

If the code is not known —
the code can be accessed from the serial communications link.

If, after performing any of the above checks, the drive still malfunctions, contact the supplier of the drive for assistance.

7.2 Control Pod Trip Codes

Any trip, internal or external, immediately stops the drive.
The IGBT bridge is no longer active, and the motor coasts to rest.

Internal protection trips are always active and cannot be disabled.

An external trip **Et** can be forced by the operator.

cL	4/20mA current loop loss. The current has fallen to<3.5mA when b11= 4. 20 or 20. 4. When b11 = 0.20 current loop loss trip is inactive.
Err **	Hardware fault within the drive. Occurs only at power-up. Is a lock-out condition — no reset (power can be removed then re-applied).
Et	External trip is operated by (terminal 12) or via the serial comms word CW, bit 4.
It	Integrating overload (Ixt) trip. The output current as defined by Pr4 and Pr5 has reached the allowable time limit.
Oh	Heat sink overtemperature. The heatsink has reached its upper safe working limit due to loss of cooling air or cooling air too hot.
OI	Instantaneous overcurrent trip. Excess current flowing in the IGBT inverter bridge, caused by short circuit, low impedance earth fault or excessive shock load.
OU	DC bus overvoltage. Caused by main supply overvoltage (even if momentary), or high impedance earth fault, or excessive regeneration due to a high rate of deceleration.
Ph	Can be caused by loss of one or two phases, or low phase voltage (<380V -15%).
PS **	Internal power supply fault.
th	Motor thermistor (if fitted) impedance high due to sensing excess temperature, or impedance less than 100R due to cable short circuit or similar.
UU	DC link voltage has fallen below the operating range. The drive trips instantaneously.
AcUU	AcUU will be displayed when the input volts to the drive falls 15% below the nominal value or below the operating voltage level (380V ± 15%). The display remains as long as the condition persists. The condition does not trip the drive if running, but causes it to ramp down to zero speed. If corrected before zero speed is reached, the drive will ramp up to whatever speed reference applies and operate normally. If zero speed is reached before the condition is corrected, there will be a 15 second delay and then the drive will trip. The indication is either UU or Ph.

* UU trip can also be caused by a failure of internal components of the drive.

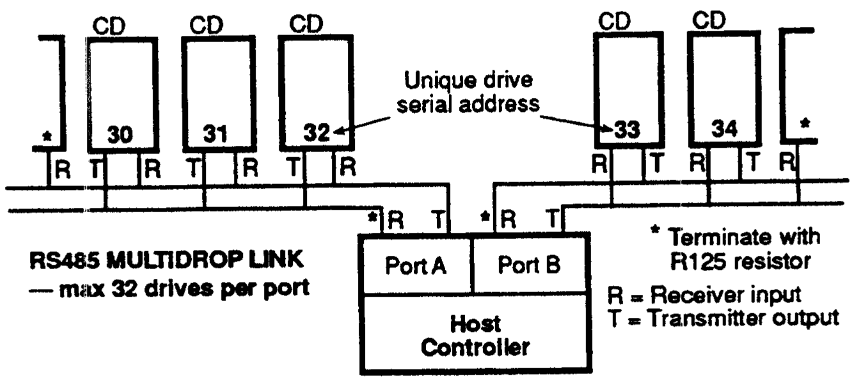
** *These conditions require expert attention. Please consult the supplier of the drive.*

Healthy Indications overleaf...

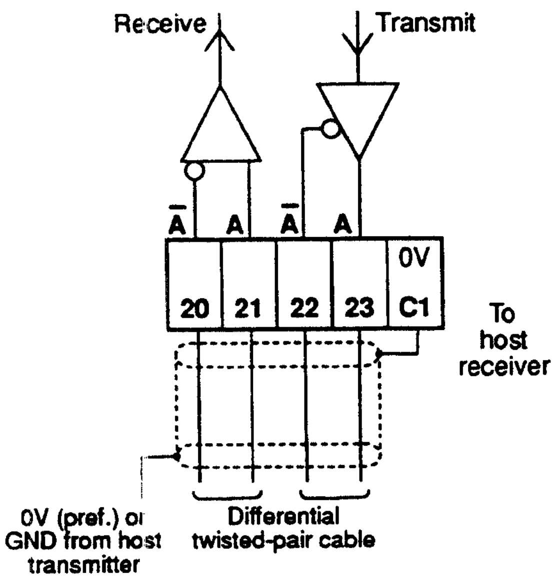
7.3 Healthy Indications

rdY	Motor stopped, drive energised.
Numerical value displayed	Motor speed (Hz) or load (%FLC) dependent on the setting of b8. (Set speed is displayed only in Keypad mode).
dc	dc braking active.
Inh	Motor coasting to rest; IGBT bridge inhibited.
SCAN	Spinning motor software is selected and the drive is scanning for the correct motor frequency before catching the motor/load and taking them to the set speed.
Flashing decimal points	This indicates that the drive is in the I x t region.

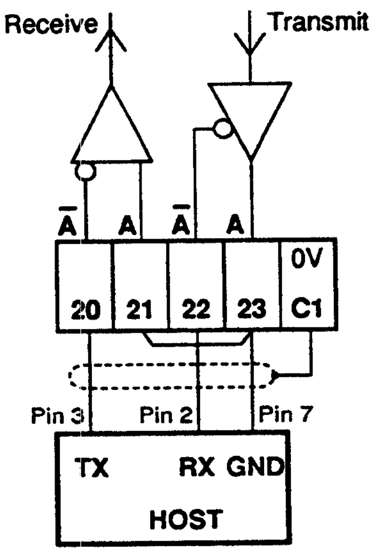
8 Serial Communications



36 Basic RS485 Serial Communications arrangement and serial address. Unique identity code for up to 32 drives per communications port at the host.



37 RS485 or RS422 serial communicatrions link connections. Cable must be screened.



38 RS232 serial communicatrions link connections. Cable must be screened.

8

Serial Communications

8.1 Introduction

A communications link is standard in all CD75-750 and CDV75-750 drives. It is a machine-machine link, enabling one or more drives to be used in systems controlled by a host such as a programmable logic controller (PLC) or computer. CD75-750 and CDV75-750 drives can be directly controlled, their operating configuration can be altered, and their status can be interrogated by such a host, and continuously monitored by data logging equipment. A host can operate up to thirty-two drives, refer to Fig. 36, and up to 99 if line buffers are used.

The communication port of the drive module is the four terminals 20 to 23, and the 0V terminal C1. The standard connection is four wire RS485 or RS422, Fig. 37. Three wire RS232 can also be used, Fig. 38.

The serial communications protocol used is ANSI x 3.28 - 2.5 A4 which is standard for many industrial interfaces.

8.2 Fundamentals

Digital communications systems such as RS485 communicate by means of binary logic. Binary logic is 'two state', and is readily implemented by an electrical circuit which is either "on" or "off". The two different states represent two distinct bits of data, either binary digit (bit) 0 or 1.

By fixing a time duration for each bit, a series of bits transmitted can be recognised by a receiver. If, a group of bits contain the same number of bits it becomes possible to construct a variety of different 'characters' that the receiver can recognise and decode. A group of four bits has sixteen possible variants — 0000, 0001, 0010, and so on to 1111. Each of the sixteen variants represents one 'hexadecimal' character-unit — the decimal numerals 0 to 9 followed by the six letters A to F — making 16 different and distinct characters.

Two hexadecimal characters each of four bits, making eight bits in all are known as a 'byte'. Each byte can be used to represent a character of data.

The character set used in CD75-750 drives is the 'low' American Standard Code for Information Interchange (ASCII), comprising 128 characters. In the low ASCII set only 7 data bits are used in the byte to represent the characters, refer to the Table of Control Characters overleaf.

The first 32 characters in the ASCII set (hex 00 to 1F and the 'space' character, decimal 32) are used to represent special codes. These are the Control Codes, each of which has a particular meaning. For example, 'start of text' is STX, and, from a keyboard, is made by holding down the Control key and striking B once (Control-B). This is hex 02, and the actual transmission ios the binary byte 0000 0010. The drive is programmed to know that this character signals that a command will follow. The codes for the CD drives are shown in the table on page 8-5.

'Low' ASCII Character Set

HEX	Most Significant	0	1	2	3	4	5	6	7
Least Significant	Binary	000	001	010	011	100	101	110	111
0	0000	NUL 0	DLE 16	Space 32	0 48	@ 64	P 80	' 96	p 112
1	0001	SOH 1	DC1 17	! 33	1 49	A 65	Q 81	a 97	q 113
2	0010	STX 2	DC2 18	" 34	2 50	B 66	R 82	b 98	r 114
3	0011	ETX 3	DC3 19	# 35	3 51	C 67	S 83	c 99	s 115
4	0100	EOT 4	DC4 20	$ 36	4 52	D 68	T 84	d 100	t 116
5	0101	ENQ 5	NAK 21	% 37	5 53	E 69	U 85	e 101	u 117
6	0110	ACK 6	SYN 22	& 38	6 54	F 70	V 86	f 102	v 118
7	0111	BEL 7	ETB 23	' 39	7 55	G 71	W 87	g 103	w 119
8	1000	BS 8	CAN 24	(40	8 56	H 72	X 88	h 104	x 120
9	1001	HT 9	EM 25	) 41	9 57	I 73	Y 89	i 105	y 121
A	1010	LF 10	SUB 26	* 42	: 58	J 74	Z 90	j 106	z 122
B	1011	VT 11	ESC 27	+ 43	; 59	K 75	[91	k 107	{ 123
C	1100	FF 12	FS 28	, 44	< 60	L 76	\ 92	l 108	124
D	1101	CR 13	GS 29	– 45	= 61	M 77	] 93	m 109	} 125
E	1110	SO 14	RS 30	. 46	> 62	N 78	94	n 110	~ 126
F	1111	SI 15	US 31	/ 47	? 63	O 79	— 95	o 111	DEL 127

Control Characters in CD75-750 and CDV75-750 Drives

Character	Meaning	ASCII code hex —	Keyed as... Control-
EOT	Reset or End of Transmission	04	D
ENQ	Enquiry, interrogating the drive	05	E
STX	Start of text	02	B
ETX	End of text	03	C
ACK	Acknowledge (message accepted)	06	F
NAK	Negative acknowledge (message not understood)	15	U

The components of all messages between the host and a CD75-750 and CDV75-750 drive are formed of ASCII characters.

Each ASCII character that is transmitted or received has a start bit prior to the 7 ASCII bits, a parity bit and a stop bit. The 3 extra bits are necessary to synchronise data transmission and provide error checking. The convention is that the start bit is a 0 and the stop bit a 1. The parity bit is present to allow the receiver of the character to check that the character is valid. The format (i.e. time sequence) of the ASCII character is shown diagrammatically.

'Low' ASCII character byte

Start bit	Seven data bits, variable							Parity bit	Stop bit
0 1st bit	lsb 2nd bit						msb 8th bit	9th bit	1 10th bit

→ Time

Each bit is transmitted for a set defined time as indicated by the baud rate (i.e. bits per second).

8.3 Components of Messages

CONTROL CHARACTERS

To conform to the standard structure of a message, the stages of a message are signalled by control characters.

Serial Address
Each drive is given a unique identity or address (Pr9) so that only the drive that is addressed will respond. For security, the format is that each digit of the two-digit drive address is repeated, thus the address of drive number 23 is sent as four characters—

2	2	3	3

The serial address follows immediately after the first control character of the message.

Data Mnemonics
To identify which operating parameter a message relates to, the parameters are represented by a data mnemonic, which is a simple two-character code. When data is being communicated, it is preceded by the appropriate mnemonic. The data mnemonic follows the serial address characters.

Data
Data to be sent or requested occupies the next six characters after the data mnemonic. Data is handled in two different forms —

as a plain numerical value, or
as a Hex Code Word.

Most of the operating parameters of the drive, are **numerical** data, such as a value of frequency, load, current, etc. For example, speed is given as frequency in the range +960.0 to - 960.0Hz. The value '95Hz in a reverse direction' is sent as —

-	0	9	5	.	0
1	*2*	*3*	*4*	*5*	*6*

To enable the **state of bit-parameters** (and **Pr9**) to be transmitted conveniently, 2-byte and 4-byte Hex Code Words are used, as described fully under Hex Code Words below. Each byte decodes to describe the status of the bit parameter in detail. Use of a code for this purpose enables blocks of complex data to be handled quickly and economically and avoids long series of messages to cover the many bit parameters.

Block Checksum BCC
To permit the drive and the host to ensure that messages from one to the other have not become corrupted in transmission, all communications other than acknowledgements are terminated by a block checksum character.

8.4 Structure of Messages

INTRODUCTION

Host to Drive
A message cannot be sent to two or more more addresses simultaneously. If the same request or instruction is to be sent to more than one drive, it must be repeated with the new address each time.

Messages from host to the drive are of two kinds —

a request for information (Reading data), or
a command (Sending data)

Drive to Host
Messages from the drive to the host are of two kinds —

a reply to a data request, (see section "Reading Data") or —
acknowledgement of a message. (see section "Sending Data")

Drive/Host Set-up
The following drive/host set-up is important to ensure correct and satisfactory communications. Each drive requires a unique identity number, or serial address set by parameter **Pr9**. The baud rate **b12**, and the parity bit **b10**, require to be set to match the host. Data, drive status and the parameter set-up can be read from the drive in any mode, provided only that the drive is energised, and the above conditions met. To enable the host to control the drive or to change parameter settings, the drive mode must have the above settings and be adjusted as follows:-

Four parameters are required to be set to enable operation of the Serial Communications Link —

- Parity bit to be adjusted to suit the host

  b10 = 0 even parity
  b10 = 1 odd parity

- Baud rate to suit the host

  b12 = 4.8 4800 baud
  b12 = 9.6 9600 baud

- Serial address

  Pr9 = 0 to 99

- Master/slave selector to be set as follows —

  b6 = 1 **and** terminal 16 in REMOTE mode (ie closed) if parameters are to be adjusted by the host.

  b6 = 0 **or** terminal 16 in LOCAL mode (ie open) allows parameters only to be read by the host.

SENDING DATA (from Host to Drive)

NOTE
If the data to be sent is one of the following:-
Drive Configuration DS
or PWM Switching Frequency FQ
or Max. Voltage Frequency BS, or configuration C1
the drive must also be in the **rdY** or tripped state, that is with the motor stopped or tripped.

The format of the command from host to drive is:-
Host command —

reset - address - start of text - mnemonic - 6 characters - end - BCC

If the intended message to the drive is, for example, "change set frequency of drive number 14 to 47.6Hz in reverse", it would be sent as —

CONTROL	ADDRESS				CONTROL	MNEM		DATA						CONTROL	
EOT Control-D	1	1	4	4	STX Control-B	S	P	-	0	4	7	.	8	ETX Control-C	& (BCC)

The drive will reply with an acknowledgement, either —

ACK if the message is understood (whether implemented or not), or
NAK if the message is invalid, the data is too long, or the BCC is incorrect.

If a value sent is outside the limits for a parameter, the drive will set the maximum value.

Parameters which cannot be written to are:-
b6, b10, b12 and b13 (contained in DS), AC, LD, SE, SW, TO, T1 to T9.

READING DATA

The format of a data request message is —

Host request —

reset - address - mnemonic - end

For example, to find the speed set point SP of drive number 12, send —

CONTROL	ADDRESS				MNEM		CONTROL
EOT Control-D	1	1	2	2	S	P	ENQ Control-E

The drive replies in the following form —

start - mnemonic - 6 characters of data - end - BCC

For example —

CONTROL	MNEM		DATA						CONTROL	
STX Control-B	S	P	+	0	1	1	.	2	ETX Control-C	, (BCC)

The reply first confirms that the data sent is the speed set point, SP; the six characters immediately following give the present setting in Hz. The first character is either + or -, to indicate direction of rotation; the remainder is the numerical value — "forward at11.2Hz" in this example.

The host may now request more information by: (or starting a new request as described above).

Repeat Enquiry (From Host)
The negative acknowledgement NAK (Control-U) sent by the host causes the drive to repeat the data sent for the same mnemonic. This process can be repeated as often as necessary by the host.

Next Parameter (Enquiry From Host)
To obtain data from the same drive for the next mnemonic in the mnemonic table (see below) send the positive acknowledgement ACK (Control-F). The drive will respond by transmitting the data relating to the next mnemonic in sequence. Mnemonic sequence with ACK response is as follows:-

SP ➤ TP ➤ AC ➤ LD, MN, MX, AL, DL, TR, TH, BC, SL, BR, SE, SC, SW, DS, FQ, BS, CW, S1, S2, S3, B1, B2, B3, P1, P2, P3, P4, P5, P6, P7, PJ, A1, A2, A3, A4, A5, A6, A7, AJ, D1, D2, D3, D4, D5, D6, D7, DJ, C1, PS, RN, RD, RC, TO, T1, T2, T3, T4, T5, T6, T7, T8, T9 ➤ SP (start)

Invalid Mnemonic (From Host)
If the host sends a mnemonic which the drive does not recognise, eg XY, the drive will respond by repeating back the unrecognised characters in a message of the form —

start of text - unrecognised mnemonic - reset

Thus—

STX Control-B	X	Y	EOT Control-D

BLOCK CHECKSUM (BCC)

To ensure that data received can be verified, a block checksum is attached to the end of each command or data response. The BCC is automatically calculated by the sending device (either host or drive) and is derived in the following manner.

First, a binary exclusive-OR is performed on all nine characters of the message after the start-of-text command mnemonic (but excluding the parity, stop and start bits).

For example, if the message to be sent to drive number 14 is —

"set frequency to 47.6Hz in reverse"

it is sent as —

RESET	EOT (Control-D)
Serial Address	1 1 4 4
Start of text	STX (Control-B)
	Not included in BCC calculation
	BCC calculation starts here
Set frequency mnemonic SP	SP
Reverse	- (a minus sign)
47.6	0 4 7 . 6
End of message	ETX (Control-C)
finally,	the calculated BCC

Each of the nine separate character digits, "S" "P" "-" "0" "4" "7" "." "6" and "Control-C", is represented by a hexadecimal character and calculated in binary as shown in the table below; the XOR is shown progressively for each character.

Character	ASCII Binary Code	XOR
S	0101 0011	—
P	0101 0000	0000 0011
- (minus)	0010 1101	0010 1110
0	0011 0000	0001 1110
4	0011 0100	0010 1010
7	0011 0111	0001 1101
. (decimal)	0010 1110	0011 0011
6	0011 0110	0000 0101
ETX (Control-C)	0000 0011	0000 0110

The final XOR, underlined, is the BCC provided that its equivalent decimal value exceeds 32. As the ASCII characters from hex 00 to 1F, plus 'space', are used only for control codes, the BCC has to exceed the value of 32 decimal. Whenever the XOR produces a (decimal equivalent) number less than 32, 32 is added. Thus, in the above example,

0000 0110 = 6 decimal, so that the BCC must be —

6 + 32 = 38 decimal,

for which the ASCII character is "&".

Thus the complete message to set the speed of drive number 14, to 47.6Hz in reverse is—

EOT Control-D	1	1	4	4	STX Control-B	S	P	-	0	4	7	.	6	ETX Control-C	& (BCC)

Serial Communication Response Timing
Transmitting and receiving messages takes a finite time, to which further time must be added for the drive to process the information. To send a new drive parameter value will take 43.5ms at 4800 baud or 25.8ms at 9600 baud. To read a drive parameter will take 47.7ms at 4800 baud, or 27.9ms at 9600 baud.

8.5 Configuring the Drive Through Serial Communications

Most drive mnemonic parameters can be expressed by six digit numbers, however the following mnemonic are expressed by two of four hexadecimal code digits:-

SE	Serial Address (Pr9)
SC	Security Code (Prb)
SW	Status Word, SW (also T0 - T9)
DS	Drive Configuration
FQ	PWM Switching Frequency (b14)
CW	Command Word
PS	Preset Speed Selection Word
RN	Reset Number Word
RC	Reset Counter Word
C1	Configuration Word

The drive configuration (DS), for example, expresses the state of each of the 13 parameters b0 to b12 inclusive. This simplifies the programming of such changes and enables blocks of relatively complex data to be delivered by one message using two-byte hexidecimal 'word' codes.

Hex Code Words are transmitted in ASCII format, but are always preceded by the symbol ">" which enables the receiving drive/host to decode them in a special way. This is best explained by an illustration of each of the above special mnemonics.

SE — SERIAL ADDRESS (2 Hexadecimal Digits)

This is a read-only parameter. To read SE for drive number 22, for example, send —

EOT Control-D	2	2	2	2	S	E	ENQ Control-E

The drive will reply —

STX Control-B	S	E				>	1	6	ETX Control-C	, (BCC)

The data following the > symbol is hex 16, which is 22 decimal, confirming the Serial Address.

SC — SECURITY CODE (2 Hexadecimal Digits)

It is possible to find or change the security code of a drive. If the drive address is 11, for example, send —

EOT Control-D	1	1	1	1	S	C	ENQ Control-E

The drive will reply, for example —

STX Control-B	S	C				>	5	7	ETX Control-C	/ (BCC)

The data following the > symbol is hex 57, which is 87 decimal.
The security code for drive number 11 is 87.

A security code does not need to be entered to read or adjust any parameter via the serial communications link.

SW — STATUS WORD or previous trip words (T0 - T9, note T0 = SW) (4 Hexidecimal Digits)

This is a 2-byte hex value word (of four characters) which enables the status or previous trip indications of the drive to be read. (It is read only). The four characters decode to indicate the status of each of the four states —

RUN — LAST TRIP — ERROR — and the **PrA** Trip Codes

Thus, to read the state of drive number 11, send —

EOT Control-D	1	1	1	1	S	W	ENQ Control-E

The drive replies, for example —

STX Control-B	S	W		>	O	E	1	C	ETX Control-C	> (BCC)

The four ASCII characters following the > symbol are treated as hex characters and are further decoded into their binary equivalents —

0 — 0000, E — 1110, 1 — 0001, C — 1100

Comparing each character with the appropriate section of the Status Word table enables the message to be translated as

first 4 trips ok — overvoltage trip — tripped status — set to run and drive ready (ie awaiting reset)

The format for T0 - T9 is identical to SW with T0 and SW being identical, T1 gives the last but one trip states, T2 gives the last but two trips states etc. and T9 gives the previous tenth trips information.

Status Word SW (with example)

Flags and Trip Code		ok	fault
NOT USED		—	—
Drive over-temperature	**Ot**	0	1
Motor over-temperature	**th**	0	1
I x t overload	**It**	0	1
Current peak trip	**OI**	1	0
Power supply failure	**PS**	1	0
Undervoltage trip	**UU**	1	0
Overvoltage trip	**OU**	1	0
Phase loss	**Ph**	0	1
Current loop loss	**cL**	0	1
Error flag	**Err**	0	1
Tripped flag (status relay)		0	1
Run flag, 1 = set to run			
Ready flag, 1 = drive ready			
Status of terminal 16, 0 = LOCAL, 1 = REMOTE			
NOT USED			

Example

Hex	Binary
O	0(msb)
(1st char)	0
	0
	0(lsb)
E	1(msb)
(2nd char)	1
	1
	0(lsb)
1	0(msb)
(3rd char)	0
	0
	1
C	1(msb)
(4th char)	1
	0
	0(lsb)

Run / Ready States

Run	Ready	Status Indicated
0	0	Drive stopping
0	1	Drive stopped and ready to run (rdY)
1	0	Drive running
1	1	Drive tripped, awaiting RESET, and Trip Code flashing on the keypad display

Note that trip states are held in **PrA** even after a reset and will be changed only by a subsequent trip. The old trip conditions will ripple through the **T0** to **T9** last trip storage registers. The trip itself, however, continues to exist only if the tripped flag (status relay) equals 'fault'.

To detect an external trip (**PrA = Et**), note that the tripped flag (status relay) indicates **1** while all other indications and flags are **ok** — not faulty.

DS — DRIVE CONFIGURATION (4 Hexadecimal Digits)

This is a 2-byte hex-value word (four characters) enabling the state of bit-parameters **b0** to **b12** inclusive to be read or changed. Parameters b6, b9, b10 and b12 are read-only and cannot be changed. The four characters following the > symbol decode into binary states, in a similar way as for the Status Word, to indicate the value of the bit parameters. For example, to read DS for drive number 11, send —

EOT Control-D	1	1	1	1	D	S	ENQ Control-E

The drive replies, for example —

STX Control-B	D	S		>	4	F	8	4	ETX Control-C	t (BCC)

The data following the > character are treated as hex characters, and decode to binary as follows —

4 — 0100, F — 1111, 8 — 1000, 4 — 0100

The message decodes, from the Drive Configuration table, as —

speed control mode — auto start mode — coast to stop — fixed boost — unipolar speed reference — open loop feedback — slave mode — frequency (speed) display — keypad control — even parity bit — 4/20mA speed reference — Baud rate 4800.

There are four possible states of **Stopping Mode**

Parameter		Mode
b2	b7	
0	0	Standard ramp
0	1	Coast
1	0	Inject DC
1	1	High level ramp

To write to drive number 11, sending the same parameter settings as in the example on page 8-11, which is a complete set-up command, the message would be —

EOT Control-D	1	1	1	1	STX Control-B	D	S		>	4	F	8	4	ETX Control-C	t (BCC)

The drive replies ACK if the transmitted data is understood, or NAK if not (in which case look for an error in writing the characters or in the format of the message).

Note that parameters **b6, b10** and **b12** cannot be written to the drive through the Serial Communications link, although they must be included to form a complete message. The drive ignores these when received, but does not ignore them when interrogated about the drive configuration.

DRIVE CONFIGURATION DS **Example**

Bit parameter		0	1	Hex	Binary
NOT USED		—	—	4	0(msb)
Control mode	b0	torque	speed	(1st char)	1
Start mode	b1	auto	manual		0
Stopping mode	b2	see Stopping Mode table			0(lsb)
Boost mode	b3	auto	fixed	F	1(msb)
Uni- or bipolar speed reference	b4	bipolar	unipolar	(2nd char)	1
Feedback	b5	encoder	open loop		1
Master or slave	b6	master	slave		1(lsb)
Stopping mode	b7	see Stopping Mode table		8	1(msb)
Display	b8	frequency	load	(3rd char)	0
Control mode	b9	keypad	terminal		0
Parity bit	b10	even	odd		0(lsb)
Current loop — a	b11	see current loop table		4	0(msb)
Current loop — b	b11	see current loop table		(4th char)	1
NOT USED		—	—	—	0
Baud rate	b12	4800	9600		0(lsb)

There are three possible states of **Current Loop**

Current Loop		Speed Reference Input
a	b	
0	0	0/20mA
0	1	4/20mA
1	0	20/4mA

FQ — PWM SWITCHING FREQUENCY & MVF (2 Hexadecimal digits)

FQ is a one-byte, ie two-character, word. The status of PWM switching frequency and ULF are given by the following FQ codes:-

FQ codes

Word FQ	PWM Switching Frequency	ULF
00	2.9kHz	120Hz
01	2.9kHz	240Hz
10	5.9kHz	120Hz
11	5.9kHz	240Hz
12	5.9kHz	480Hz
20	8.8kHz	120Hz
21	8.8kHz	240Hz
22	8.8kHz	480Hz
30	11.7kHz	120Hz
31	11.7kHz	240Hz
32	11.7kHz	480Hz
33	11.7kHz	960Hz

To read FQ for drive number 15, send —

EOT Control-D	1	1	5	5	F	Q	ENQ Control-E

The drive replies, for example —

STX Control-B	F	Q				>	1	0	ETX Control-C	+ (BCC)

The two characters following the symbol > require no further translation. They are compared with the codes in the table for FQ. The reply in this example means that drive 15 is operating at 5.9kHz PWM switching frequency, and the ULF is set at 120Hz.

The settings of these frequency parameters can be changed by an operator (computer) or by a plc programmed to send the FQ codes. To set the frequency parameters of drive number 15 to 5.9kHz and 120Hz, the complete message is —

EOT Control-D	1	1	5	5	STX Control-B	F	Q				>	1	0	ETX Control-C	+ (BCC)

CW — COMMAND WORD (2 Hexadecimal Digits)

This is a one-byte hex-value word (two characters) enabling the drive to be controlled through the serial link. It is important to note that although the external local/remote control is set to REMOTE as part of the set-up for serial link operation, the terminal inputs are **not disabled** — they remain operative.

The two characters decode into states which control the principal command functions of the drive, as follows —

RESET, TRIP (external), STOP, RUN.

CW allows the drive to state the direction of rotation as set by the control terminal in reply to interrogation, but cannot be used to reverse the rotation. REVERSE command is given by using a negative speed reference SP (see table of mnemonics).

External LOCAL/REMOTE and LOCAL FWD/REV cannot be changed through the serial communication link, but CW permits the state to be read. To read CW for drive number 11, send —

EOT Control-D	1	1	1	1	C	W	ENQ Control-E

The drive replies, for example —

STX Control-B	C	W				>	1	6	ETX Control-C	. (BCC)

The data following the character > decodes from hex to binary, to mean —

remote direction set to forward — not reset — external trip input closed — local direction set to forward — local/remote terminal switched to remote — not stop — not run

Command Word CW

Function	Terminal input status	
	0	1
NOT USED	—	—
NOT USED	—	—
Reset	open	closed (reset)
External trip	open (tripped)	closed
FWD/REV *	open	closed (rev)
Local/Remote *	open (local)	closed (rem)
Stop	open (stop)	closed
Run	open	closed (run)

Example

Hex	Binary
1	0(msb)
	0
(1st char)	0
	1(lsb)
6	0(msb)
(2nd char)	1
	1
	0

* Cannot be changed through the Serial Communications Link

Typical Values of Command Word CW

Function option selected	CW values during ...					Not start Not reset Not trip
	Power -on	Start	Stop	Reset	Trip	
forward remote	16	17	14	36	06	16
reverse remote	1E	1F	1C	3E	0E	1E
forward local	12	13	10	32	02	12
reverse local	1A	1B	18	3A	0A	1A

C1 — DRIVE CONFIGURATION WORD 1 (4 Hexadecimal Digits)

This is a 2-byte hex-value word (four characters) enabling the state of bit-parameters **b20** to **b54** to be read or changed. The four characters following the > symbol decode into binary states, in a similar way as for the DS Word, to indicate the value of the bit parameters. For example, to read C1 for drive number 11, send —

EOT Control-D	1	1	1	1	C	1	ENQ Control-E

The drive replies, for example —

STX Control-B	C	1		>	2	0	0	0	ETX Control-C	(BCC)

The data following the > character are treated as hex characters, and decode to binary as follows —

2 — 0010, 0 — 0000, 0 — 0000, 0 — 0000

The message decodes, from the C1 table, as :—

Run Status o/p — Fixed V/F ratio — spinning motor disabled — FWD/REV key disabled — RL1 is DRIVE HEALTHY — standard accel/decel rates — 3 presets + jog — terminal reverse control.

C1 — CONFIGURATION WORD (2 Hexadecimal digits)

bit	= 0 (Default)	=1	Function
1st Character			
—	0	—	—
b54	Fixed	Dynamic	V/f ratio
b53	Run	Minimum speed	Open collector output
b52	Not catch	Catch	Spinning motor sync.
2nd Character			
b51	Disabled	Enabled	FWD/REV key
b50	Drive Healthy	At Speed	Drive Healthy/ At speed relay
b21	Standard	Preset	Accel/Decel
b20	3 Preset + Jog	7 Preset, no Jog	Preset Speed inputs
3rd Character			
b22	Terminal	Preset	Preset reverse
Not used	0		
Not used	0		
Not used	0		
4th Character			
Not used	0		
Not used	0		
Not used	0		
Not used	0		

PS — PRESET SPEED SELECTION WORD (2 Hexadecimal digits)

PS is a one-byte, i.e. two character word that enable the preset speed to be controlled via the serial link. The PS characters decode into the following equivalent states of terminals A10 - A12.

PS codes	Terminal A10	Terminal A11	Terminal A12	
00	open	open	open	
01	closed	open	open	
02	open	closed	open	
03	closed	closed	open	
04	open	open	closed	Relevant only if b20 = 1
05	closed	open	closed	
06	open	closed	closed	
07	closed	closed	closed	

NOTE — PS cannot control jog input (terminal A12) if **b20** = 0 but can always read the status of A12 input.

To read PS for drive number 15, send —

EOT Control-D	1	1	5	5	P	S	ENQ Control-E

The drive replies, for example —

STX Control-B	P	S				>	0	1	ETX Control-C	(BCC)

The two characters following the symbol > require no further translation. They are compared with the codes in the table for PS. The reply in this example means that drive 15 is operating with terminal A10 closed and A11, A12 open.

RN — RESET NUMBER (2 Hexadecimal Digits)

This is a read-write parameter. To read RN for drive number 22, for example, send —

EOT Control-D	2	2	2	2	R	N	ENQ Control-E

The drive will reply —

STX Control-B	R	N				>	0	4	ETX Control-C	(BCC)

The data following the > symbol is hex 04, which is 4 decimal indicating that 4 resets, as set by **Pr50** for example, are allowed before the trip condition locks out drive operation.

RC — RESET COUNTER VALUE (2 Hexadecimal Digits)

This is a read only parameter. To read RC for drive 11, for example, send:-

EOT Control-D	1	1	1	1	R	C	ENQ Control-E

The drive will reply, for example —

STX Control-B	R	C				>	0	3	ETX Control-C	(BCC)

The data following the > symbol is hex 03, which is 3 decimal, indicating that if RN = 4, one life has been used to reset the drive prior to being reset back to 4 again if the drive resets and works for a given period of time.

9 Braking Unit (Optional)

9

Braking Unit (Optional)

9.1 Introduction

This chapter covers the various aspects of the optional braking unit, such as the following points:

Why do we need an optional braking unit?
How does the unit connect to the CD drive?
What are the mechanical requirements for installing the unit?
Can we use the in-built braking resistor or do we need to use an external resistor?
How do we size the separate braking resistor?
How does the braking unit operate?
How do you know when the unit is operating correctly?

9.2 Principles of Operation

A decelerating AC motor regenerates energy into the inverter drive as the load 'overhauls' the machine. The regenerated energy can only be dissipated within the drive, it cannot be returned to the AC supply by the CD unit. If the regenerated power is less than the losses of the CD unit, the unit will perform satisfactorily. If the regenerated power is more than the losses of the CD, the unit will trip on 'overvoltage' unless the optional braking unit is fitted. Typically a drive will dissipate about 3% of its rated power as losses, and as such will tolerate about 3% regenerative power without a braking unit and without tripping the drive.

Factors which influence the amount of regenerative power are:

The inertia of the machine and load
The maximum speed of the machine and load
The required deceleration rate of the drive
The mode of drive deceleration set by 'b2' and 'b7'
The power rating of the drive

From theory the amount of regenerative power 'P' for a constant rate of deceleration 'a', for a given inertia 'I', and at a certain speed 's' is:

$$P = asI$$

where
$P =$ watts
$a =$ radians s^{-1}
$s =$ radians s^{-2}
$I =$ $kg.m^2$

For a drive with a given deceleration rate (set in Pr3 or Pr40—46) and a certain speed in Hz the above equation becomes:

$$P = 120\omega I \left[\left(\frac{4\pi}{p}\right)^2 \times \frac{1}{t}\right]$$

where
$\omega =$ speed in Hz of drive
$p =$ number of machine poles (e.g. 2, 4, 6 etc)
$t =$ deceleration time set in Pr3 or Pr40—46 for 120Hz maximum frequency. (If b14 set for upper limit frequency other than 120Hz, modify constant of 120 to correct upper limit frequency.)

From the above equation it can be seen that the regenerative power is directly dependent on the machine/load inertia and the drive speed of operation. The lower the value of **Pr3**, the greater the regenerative power by the inverse relationship. This equation therefore explains the first three of the factors which influence the regenerative power.

The influence of the **b2** and **b7** settings only has a small influence on the regenerative power produced during deceleration. It must be noted that regeneration will occur whenever the drive speed is reduced whether or not the drive is stopping. The consequences of **b2** and **b7** described below are valid for all speed reductions. When **b2** and **b7** are both zero, the internal ramp is stopped whenever the drive's DC link voltage exceeds about 70V above the normal working value, and this also corresponds to when the optional braking unit will turn on the dumping resistor. This mode of operation extends the deceleration ramp to reduce the likelihood of the drive tripping on overvoltage. In this mode of operation as the DC link voltage rises the applied voltage to the machine will increase by the same percentage rise. This has the added consequence of increasing the magnetizing current to the machine which will increase the dissipation capability of the machine/drive for regenerative power. Unfortunately this may also cause overcurrent tripping if the DC link voltage rises too much, increasing the magnetizing current up to the trip level of the drive. Typically **b2** and **b7** set to zero provides extra drive regenerative dissipation capability and reduced sensitivity to the **Pr3** setting without the need for the optional braking unit.

When **b2** and **b7** are both set to 1 the internal ramp is maintained at the set rate whether the drive's dc link voltage exceeds the 70V margin above the normal working value. In this mode of operation, as the dc link voltage rises the applied voltage to the machine is maintained constant. This has the consequence of maintaining the magnetizing current to the machine, which maximises the amount of regenerative power back into the drive. Unfortunately this may cause overvoltage tripping if the dc link voltage rises too much. Typically **b2** and **b7** set to 1 is characterised for use with the optional braking unit.

The above explanation details how the **b2** and **b7** influence the braking capability of the drive. finally the drive rating has an influence on the regenerative capability of the drive in that regenerative power relates directly to drive current, and as such the drive will trip out on overcurrent if the current exceeds 150% of the drive rating during regeneration. Therefore the drive rating determines the maximum regenerative capability of the drive.

Operation of the Braking Unit

The braking unit is a self contained unit that contains the braking resistor and the control electronics for controlling the braking resistor. The unit powers itself from two phases of the three phase supply used for the drive, and uses the voltage of this incoming supply to determine the correct voltage for applying the braking resistor across the dc link from the CD drive.

The braking unit continuously monitors the CD's internal DC link voltage and compares it to the incoming supply voltage. When the DC link voltage exceeds a set margin (approximately 70Vdc) above the expected value the braking resistor is applied across the DC link. When the voltage reduces back to the expected value the braking resistor is removed from circuit.

The braking unit automatically adjusts itself according to the AC supply for the drive, anywhere from 380 to 480Vac ± 10%.

9.3 Braking Unit Specification

Summary

The CD external braking unit is an optional unit that is completely self-contained with the inclusion of a standard braking resistor. The minimum electrical connections to the unit will be the DC supply connections from the CD unit, two AC supply connections from the CD unit for power and voltage sensing, and a relay output for indicating healthy/fault conditions. The internal resistor has a power dissipation capability of 220W ± 10%, however if this is not sufficient the internal resistor can be easily linked out and a customer supplied resistor connected instead.

AC Input Supply

The same range as the CD unit:-
380 - 480Vac (three-phase) ± 10%
However all input frequencies from 50Hz to 60Hz ± 2 Hz will be tolerated.

In-built Braking Resistor

The resistor rating is nominally 220W. The resistor is capable of sustaining pulses of energy switched from a 850Vdc source (15.4 kW instantaneous up to 2 milli-seconds), with 11 kW dissipation for 1 sec repeated every 50 seconds. The resistance value is 47 Ohms ± 10%.

Isolation Withstand Voltage

The braking unit will tolerate 2.5 kV ac, 50Hz for 1 minute between all electrical terminals and the electrical earth connection.

Temperature Range

The operating ambient temperature range is 0°C to +50°C.

In-built Braking Transistor

The transistor is a standard part for 380 - 480Vac supplies, with a peak capability of 20A. Whilst switching 20A the transistor will operate continuously with a 10% on-time duty cycle when the braking unit, is in a 50°C ambient, i.e. it will tolerate a 1 second on-time followed by a 9 second off-time on a continuous basis. The transistor will also tolerate a 6.3 A rms continuous duty.

Protection and Indication

The unit has 4 LED indicators, one for AC control power present, one for DC control power present, one to indicate when the braking transistor is 'on', and the last one is a brake resistor fault LED. The control power supply derived from two AC input phases will be fused. The unit also has a protection relay that can be used to de-energise the main incoming supply contactor for the drive and braking unit.

The brake resistor fault LED will indicate two fault conditions:-

The braking transistor has no resistor connection (i.e. open circuit).
The braking resistor is short-circuited. The unit will need to be powered off to reset either of these faults.

The protection relay is used to indicate two fault conditions:-

The internal resistor has overheated as measured by a heat detecting device mounted close to the in-built resistor.
The measured AC supply voltage is below specification (380 Vac - 10%).

The above fault conditions de-energise a volt-free change-over relay for tripping the main drive supply via its own incoming supply contactor. The braking unit will not operate the braking transistor when the relay is not energised.

A fault condition can only be reset by removing power to the drive unit and braking module.

If an external braking resistor is used instead of the internal resistor, thermal protection of this resistor must be provided by the user. This is necessary to avoid the resistor causing a fire hazard if the braking transistor fails on. Any thermal protection must disconnect the AC supply to the drive and braking unit.

External Braking Resistor (If required)

Minimum resistance = 47 Ohms ±10%.

Maximum continuous braking power dissipation = 1.9 kW (derived from rms transistor rating and minimum braking resistance)

Instantaneous power dissipation capability = 15.4 kW (for a maximum time of 2 milliseconds derived from 47 Ohms across 850 Vdc.)

9.4 External Braking Resistor Sizing

Firstly the peak power dissipation requirement must be determined from the machine/load inertia, the maximum operating drive speed, and the minimum required deceleration rate. From the previously stated equation, but modified for maximum conditions:

$$P = 120\omega_{max} \left[\left(\frac{4\pi}{P}\right)^2 \times \frac{1}{t_{min}}\right]$$

where ω_{max} = maximum operating speed in Hz of drive
p = number of machine poles (e.g. 2, 4, 6, 8 etc)
t_{min} = minimum required deceleration time set in Pr3 for 120 Hz maximum frequency. (If **b14** is set for upper limit frequency other than 120 Hz, modify constant of 120 to correct upper limit frequency.)

P_{max} must be less than 1.5 times the drive rating to ensure the drive can handle the braking duty. P_{max} must also be less than the peak power dissipation of the braking resistor when applied to the maximum DC link voltage level of 850 Vdc:

$$Pmax \leq \frac{850^2}{R}$$

where R = Braking resistor value in Ohms

Provided the braking resistance value satisfies the above equation, and is greater than the minimum resistance of 47 Ohms, the resistor will meet the required application.

Secondly the power rating of the braking resistor must be determined. (We currently know its resistance value and peak power dissipation capability.) The power rating of the resistor is dependent on the energy removed from the machine load during deceleration conditions and the repetition rate of this occurrence. The energy removed from the machine drive for a given speed change is:

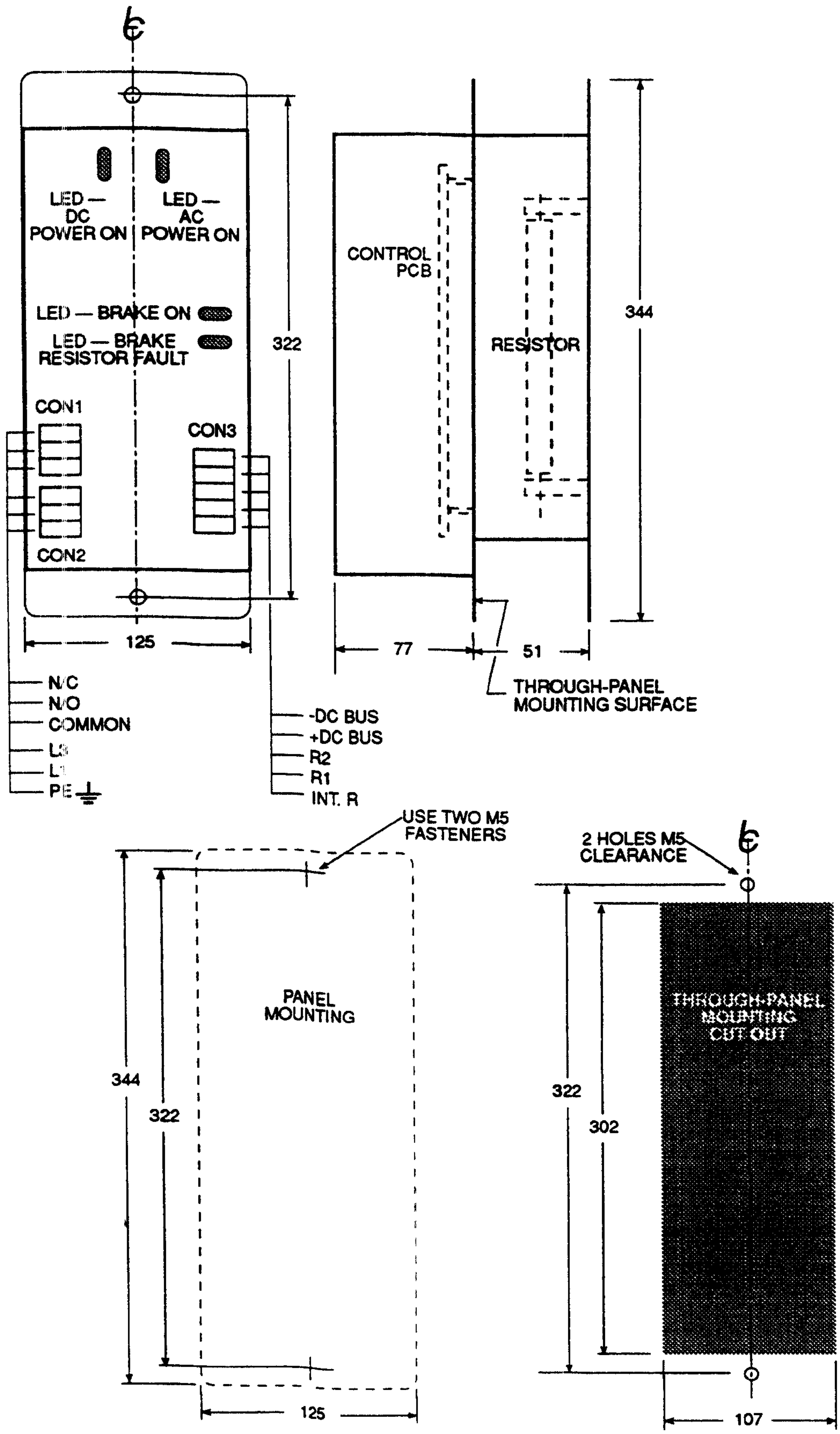
$$E_{loss} = 0.5\left[\left(\frac{4\pi}{p}\right)^2 (\omega_1{}^2 - \omega_2{}^2)\right]$$

where ω_1 = highest operating speed in Hz
ω_2 = speed decelerated to in Hz (possibly 0Hz if the machine is stopping or reversing)

If this event takes t_1 seconds to occur and repeats after t_2 seconds, the average power dissipation in the braking resistor is:

$$P_{av\,loss} = \frac{E_{loss}}{(t_1 - t_2)} \text{ Watts}$$

$P_{av\,loss}$ defines the average power loss in the braking resistor. If this value is greater than 220W then an external braking resistor is required. If the value is greater than 1.9 kW two or more braking units are required to handle the large power dissipation.



39 Optional braking unit, outline and mounting dimensions and terminals.

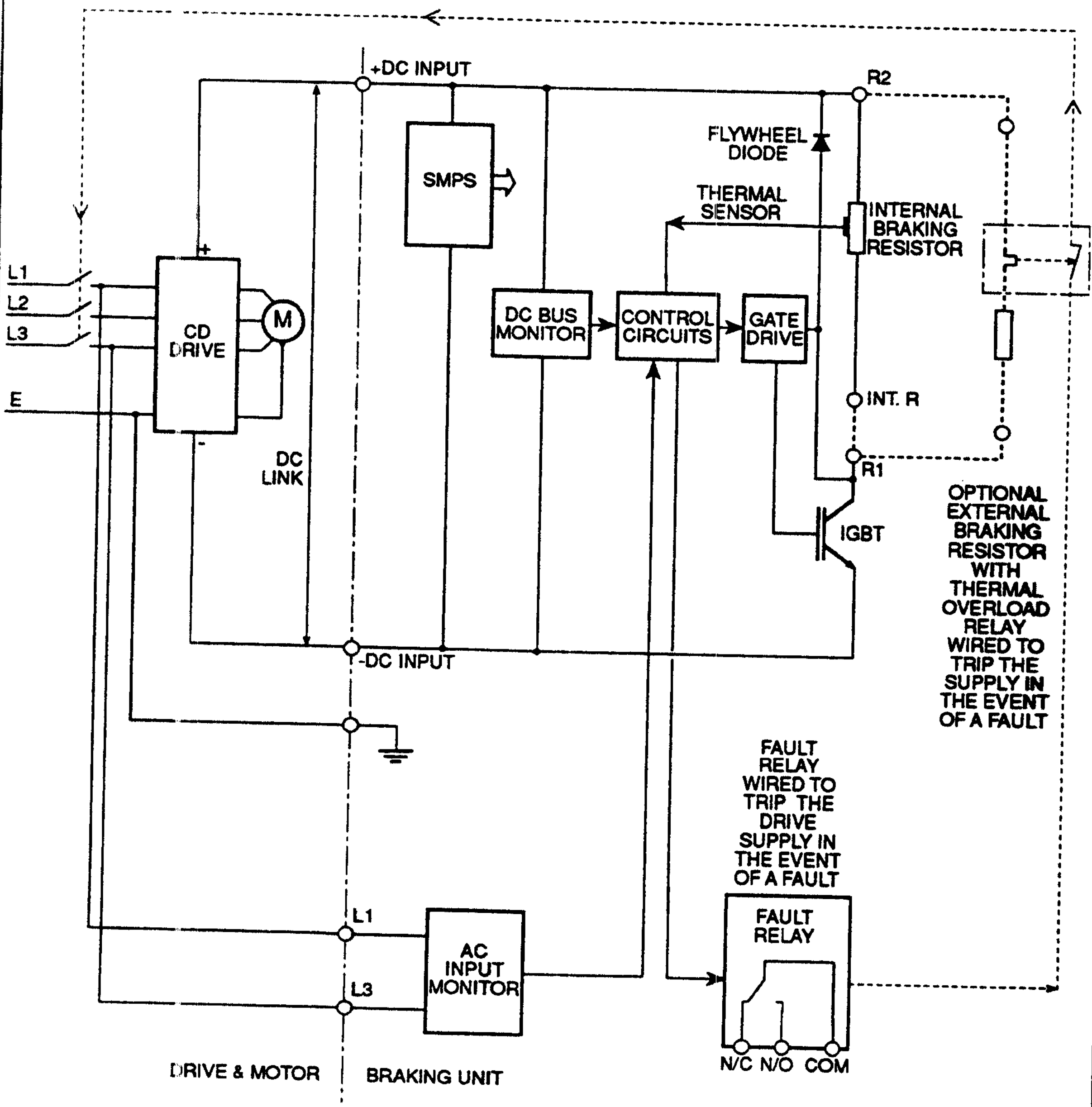
9.5 Electrical Installation

Refer to Fig. 40

The braking unit has 2 sets of electrical connections. One set consists of the power connections for connecting to the CD drive (both AC and DC power), and the option of either using the internal braking resistor or connecting an external resistor. The other set of connections is for the control relay which is used for protection purposes.

The unit can be connected in one of two ways:

for use with the internal braking resistor;
for use with an external braking resistor. For dimensions, refer to Fig. 39.



40 Schematic diagram of braking system, showing optional external braking unit.

WARNING

WHEN CONNECTING DC LINK, ISOLATE UNIT FROM SUPPLY. HIGH VOLTAGES PRESENT.

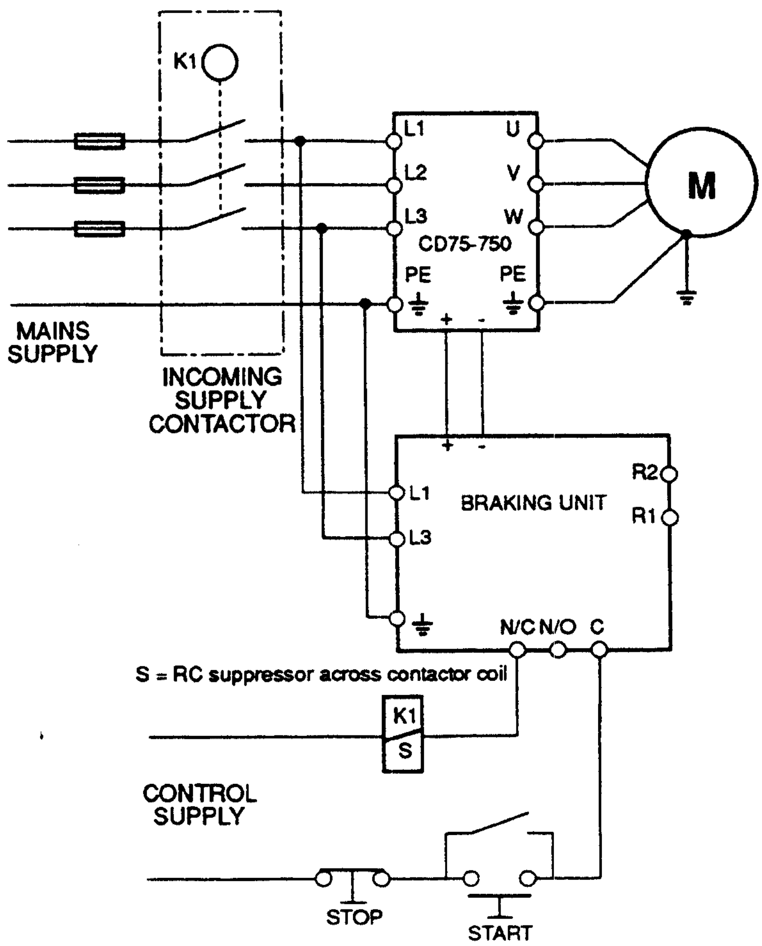
Internal Braking Resistor Employed

For the unit to operate correctly the two AC line connections (L1 and L3) must be connected directly to the two incoming lines (L1 and L3) of the CD drive that the braking unit is operating with. These connections must be made with power cable with at least a 1A rating i.e. 0.5 mm^2. Refer to Fig. 41.

The +DC INPUT connection must go directly to the + connection on the CD. The -DC INPUT connection must go directly to the - connection on the CD. The INT R connection must be directly linked to the R1 connection. (No connection is to be made to R2.) The above connections must be made with power cable with at least a 10A rating i.e. 1.5 mm^2.

The EARTH connection must go to the supply earth with a suitably rated power cable specified by local earthing practice.

The control relay connections (COMM, N/O and N/C) must be used to trip the incoming supply contactor/circuit breaker in the event of a protection trip within the braking unit. Typically the COMM and N/C connections would be connected in series with the trip circuit of the circuit breaker, or the contactor coil circuit of the contactor. These connections can be made with control cable with 0.5 mm^2 conductor.



41 Connections to Braking Unit when using the internal braking resistor.

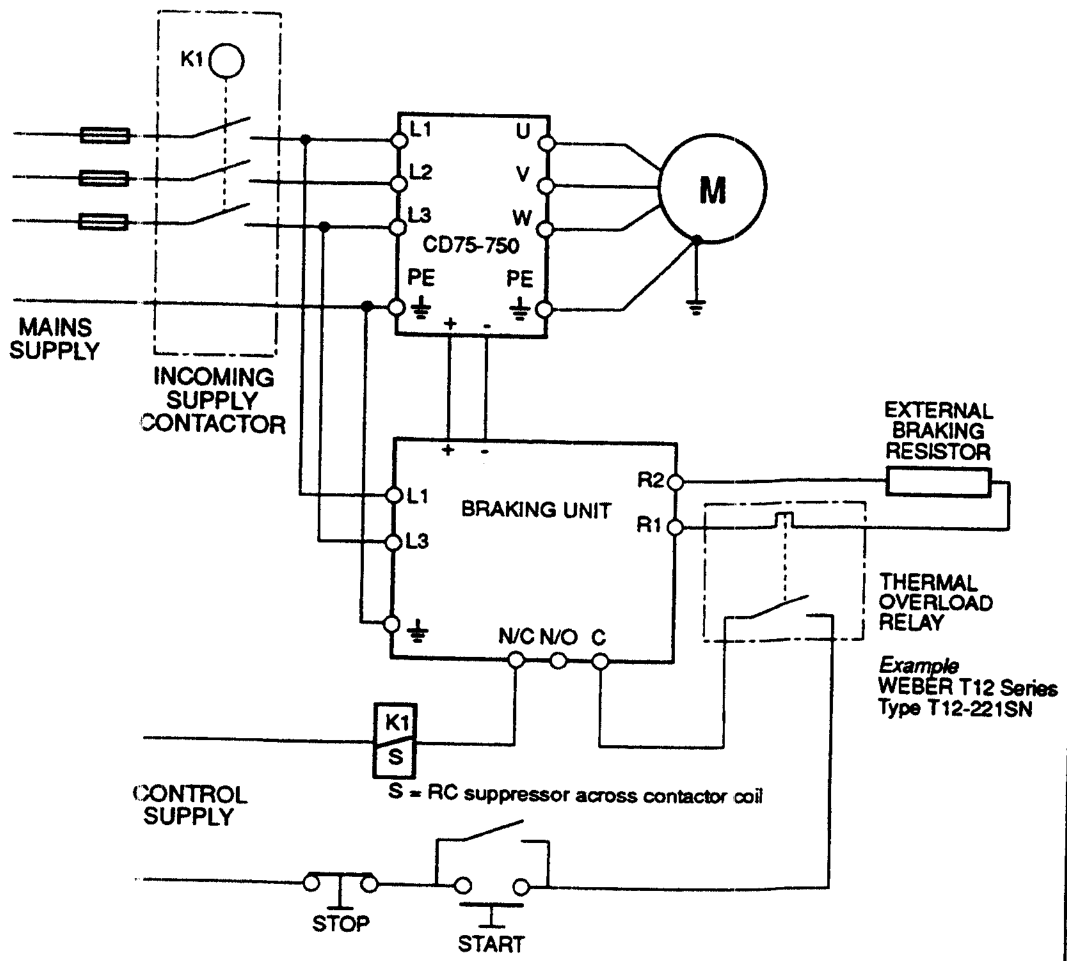
External Braking Resistor Employed

For the unit to operate correctly the two AC line connections (L1 and L3) must be connected directly to the two incoming lines (L1 and L3) of the CD drive that the braking unit is operating with. These connections must be made with power cable with at least a 1A rating i.e. 0.5 mm². Refer to Fig. 42.

The +DC INPUT connection must go directly to the + connection on the CD. The -DC INPUT connection must go directly to the - connection on the CD. (No connection is to be made to INT R.) The R1 connection is to be connected to the external resistor via a suitably rated thermal overload relay. The R2 connection is to be connected to the other end of the external resistor. The above connections must be made with power cable with at least a 10A rating i.e. 1.5 mm².

The EARTH connection must go to the supply earth with a suitably rated power cable specified by local earthing practice.

The control relay connections (COMM, N/O and N/C) can be used to trip the incoming supply contactor/circuit breaker in the event of a protection trip within the braking unit. Typically the COMM and N/C connections would be connected in series with the trip circuit of the circuit breaker, or the contactor coil circuit of the contactor. The normally closed contact of the thermal overload relay protecting the external resistor must also be connected into the above trip circuitry. These connections can be made with control cable with 0.5 mm² conductor.



42 Connections to Braking Unit when using an external braking resistor.

WARNING

The design of the user's control wiring system must ensure that in the event of a fault being flagged by the fault relay of the braking unit, OR if the external thermal overload relay operates, the incoming supply contactor will trip to disconnect the drive.

9.6 Mechanical Installation

Refer to Fig. 39, page 9-7.

The CD braking unit is designed to accept two alternative mounting arrangements. The unit can be mounted either on its back plane (surface mounting) or with the heatsink and resistor projecting through the mounting panel.

The unit must be mounted vertically, and sufficient clearance must be allowed around the unit to allow adequate flow of cooling air over the fins of the heat sink. A minimum of 100mm is required above and below the unit, and some clear space should also be allowed at the sides and front.

9.7 Operating Procedures

If power is now applied to the drive, the associated braking unit should automatically be powered up also. To verify this the 'AC power on' and 'DC power on' LEDs should light on the braking unit control PCB. If either LED does not light, power down the drive, wait at least 10 minutes to ensure all voltages have decayed to a safe level, and then check the power connections to the AC supply and the dc link.

If the 'brake resistor faulty' LED also comes on at power up, this means that either the braking resistor is not in-circuit or short or that the unit is faulty. Power down and wait 10 minutes before checking for an open circuit or short circuit.

If the unit is healthy, after power-up, the AC and DC power on LEDs should be lit, and the 'brake resistor on' and 'brake resistor faulty' LEDs should be 'off'. The control relay should also change state if all is healthy following power-up.

To operate the braking unit, the drive will need to be turning the machine at a reasonable speed and a rapid deceleration condition must be created. If the inertia is significant the dc link voltage should rise and cause the braking unit to operate. When the braking unit operates the 'brake resistor on' LED should flicker whenever the braking resistor is connected to the dc link. If the deceleration is not fast enough, or the drive speed is not high enough, or the machine inertia is not large enough the 'brake resistor' 'on' LED may not come on.

The control relay will de-energise if the internal braking resistor overheats, or there is an internal fault within the braking unit. To reset the unit the power must be removed from the product long enough for the unit to power off, i.e. when all LED's on the braking unit extinguish.

9.8 Diagnostics - Problem Solving

AC Power On LED does not light

Check that the L1 and L3 inputs are connected to the drive's AC input and AC power is present.

Check that the fuse on the control PCB is not faulty. If open circuit, replace with an equivalent rated fuse and re-power up the unit. If the fuse fails again, the unit is probably faulty.'

DC Power On LED does not light

Check that the +DC Input and -DC Input connection are connected to the drive's DC outputs with the correct polarity and DC power is present.

Drive trips on overvoltage 'OU' whilst decelerating

The braking unit should be turning on the braking resistor. Check that the 'braking resistor on' LED is coming on during deceleration. If it is not the unit is faulty.

If an external braking resistor is being used, the resistance value may be too high and needs reducing provided the resistance does not become lower than the minimum value of 47 Ohms.

The deceleration rate is too fast for the drive even with the braking unit functioning correctly, and thus the **Pr3** value will need increasing.

Brake Resistor Faulty LED lights

Check that the braking resistor is not short circuit or open circuit.

If the braking resistor is in-circuit, the unit is faulty.

Brake Resistor On LED does not light during deceleration

The deceleration rate is not fast enough to require the unit to operate.

The inertia and load of the machine configuration is such that the unit does not need to operate.

If the drive trips on overvoltage/overcurrent during deceleration, then the unit is faulty.

Drive trips on overcurrent 'OI' during deceleration

The deceleration rate is too fast. Reduce **Pr3**.

If the drive is set up with **b2** and **b7** set to both 0, set to both 1 to perform best with the braking unit.

10 Electromagnetic Compatibility

10

Electromagnetic Compatibility

10.1 Introduction

The purpose of this note is to assist system designers to incorporate drives into complete systems without encountering problems with electromagnetic interference. Because drives use fast switching of high voltages and currents to achieve high efficiency and low acoustic noise in the motor, they generate some radio-frequency (RF) energy which has the potential to disturb other circuits.

The majority of sensitive circuits are deigned to be immune, to a reasonable degree, from the various kinds of disturbance which may arise, for example, supply disturbances, fast electrical transients caused by switches, relays and contactors, and radio-frequency fields caused by radio transmitters. Many of these sources are random in occurrence. If often arises that the first sign of inadequate immunity in a circuits is when disturbance is caused by a drive or other powerful electrical circuit during the commissioning procedure. Although the drive may well be blamed in these circumstances, it is important to ensure that the immunity of the related circuits is adequate. If this is not done, random problems will occur during subsequent operation from the various existing sources of disturbance.

10.2 Immunity

The immunity of drives to externally-generated interference is good. Usually, no special precautions are required beyond normal good installation practice. It is recommended particularly that the coils of dc-energised contactors associated with drive should be suppressed with a diode or similar device, since they can generate severe electrical transients.

In areas subject to frequent lightning strikes, and where supplies are carried on lines above ground, additional surge suppression is advisable beyond that fitted to drives as standard. Suitable varistors (MOVs) connected between each line and earth should be used.

10.3 The Nature of Drive Emissions

10.3.1 Frequency Range

Switching takes place in the range 1 to 30kHz in ac variable speed and servo drives. Because the switching is fast, harmonics may be generated up to frequencies of several MHz. The most important range is the radio-frequency (RF) range, 100kHz to 5MHz, because the energy can be propagated over quite long distances and a variety of other circuits may be sensitive to disturbance in this range.

10.3.2 Propagation Routes

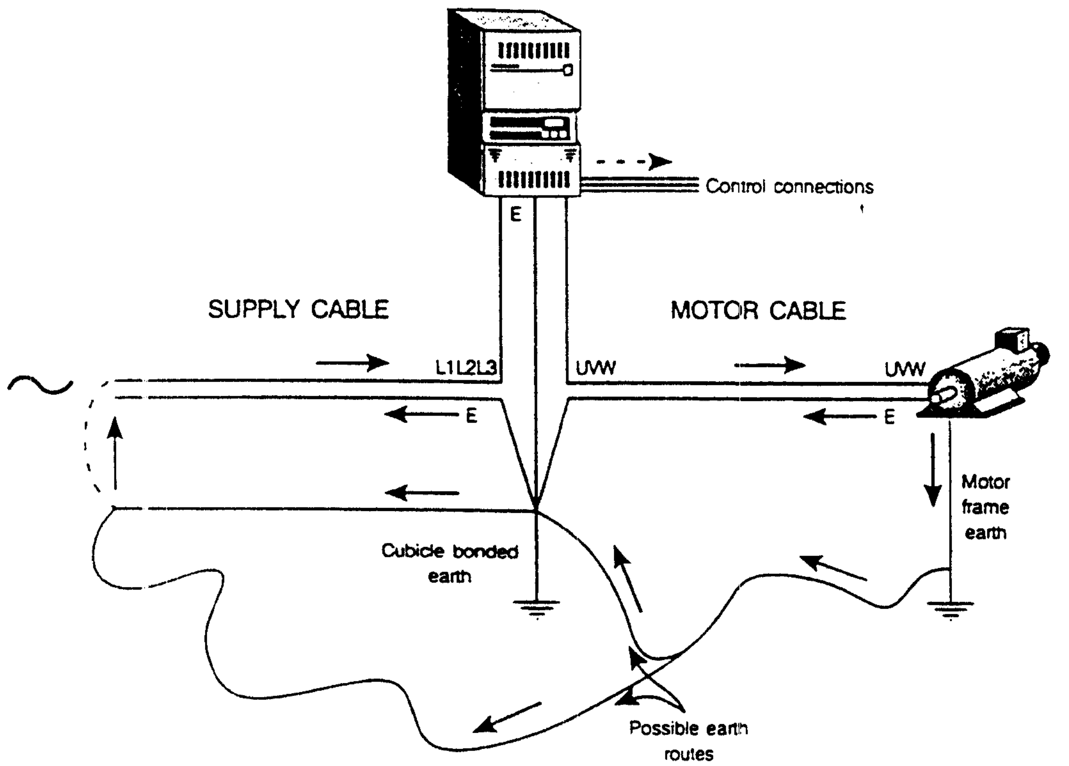
It is important to appreciate that the drive itself does not radiate much RF energy. Within about 100mm of a drive there are quite high electric and magnetic fields, but as they diminish according to a cube law, they are insignificant at 300mm.

Tha main mechanism for the propagation of RF energy produced by drives is by conduction through electrical connections. The main routes are illustrated in Fig. 43.

The connections in order of emission level are —

(a) *The Motor Cable*

This carries high RF voltage and current, and may disturb a nearby circuit. However, the electric and magnetic fields fall off rapidly with increasing distance from the cable.



43 RF current paths for drive with no special precautions.

(b) *The Supply Cable*

Although this carries a lower RF voltage than the motor cable, it is connected to a widespread network. This means that it can act as an effective transmitting aerial. Also, it conducts emissions into a wide variety of other equipment. The supply cable is the single most important route for emissions into victim equipment.

The length of the motor cable affects the emission into the supply cable. If the motor cable exceeds about 50m, the emission from the supply cable will be particularly severe.

(c) *The Earth System*

The drive earth wire carries the RF current returning from the motor. Because the inductance of the wire is significant at high frequencies, both the drive earth and the motor frame may carry RF voltage. This may be a problem if sensitive circuits share these earth connections.

(d) *The Control Connections*

Inside the drive the control circuits have stray couplings to the power circuit. The RF levels are much less than on the power connections and the source impedance is high, so problems do not often occur with these connections.

A drive may be thought of as a source of RF current which leaves its output terminals. The capacitance of the output cables and motor windings with respect to earth present quite a low impedance to the RF frequencies, so the current flows from the output to earth. It then has to find its way back to the drive earth and power input terminals. If it does not have a low-impedance path it may flow in unexpected directions and disturb nearby sensitive equipment. The principle of good layout for emission control is to provide a direct, low-impedance path for this current.

10.4 Immunity of Sensitive Circuits

In many drive installation there are either no sensitive circuits vulnerable to disturbance, or the sensitive circuits have been designed by their manufacturers to have good immunity. To avoid unnecessary costs through reducing drive emissions it is useful to be able to assess the likelihood of other circuits being disturbed and to be aware of standard methods for ensuring immunity.

The following list indicates the relative sensitivity of typical electronic circuits and systems. The list does not cover all possibilities, and some degree of judgment will be required in assessing a given situation.

10.4.1 Not Sensitive

Purely-electrical circuits comprising only relays, contactors and electromechanical instruments.

10.4.2 Not Significantly Sensitive

Many electronic systems are insensitive to drive emissions — computers, PLCs, all digital electronic circuits, and analogue circuits using high levels (over 1V), are unlikely to be disturbed unless they include components which fall into the 'Sensitive' category, below, or are installed in such a way that they are closely-coupled to drive emissions.

10.4.3 Sensitive

Analogue measuring circuits using low levels, such as thermocouples, resistive temperature sensors, strain gauges, *pH* and similar instruments: particularly if the connections are long and/or unscreened.

Analogue measuring circuits using high levels (over 1V) only if the connections are long and/or unscreened *or* they are required to give high resolution (better than 1 in 1000).

Analogue circuits which have very fast response or wide band-width, for example, audio circuits. Most industrial systems in fact have intentionally slow response to minimise disturbance by transient effects.

Video circuits, such as closed-circuit tv, and possibly computer monitors.

Digital data links, but only if they are unscreened or in an unusual configuration. Conventional RS232, RS485 and fast links such as 'Ethernet' have good immunity when correctly installed with high-screening cable.

Proximity sensors which rely on high-frequency oscillators, particularly capacitance types.

10.4.4 Very Sensitive

Only systems which are specifically designed to be sensitive to electromagnetic radiation in the 100kHz to 5MHz range are included here —

Radio receivers — long and medium wave only.

Inductive-loop pagers and communications systems.

Mains-borne communications systems

— But *not* television, VHF radio receivers, mobile telephones, radio remote-controllers or other modern radio-based equipment which uses very high frequencies.

10.5 Precautions for Drive Installations

There are precautions which cost little to implement, and are recommended for any installation. They are summarised in the following paragraphs and in Fig. 44.

10.5.1 Segregation

No signal circuit should be run parallel to an unscreened motor cable or unfiltered supply cable with a spacing less than 0.3m and over a distance exceeding 1m.

For parallel runs longer than 10m, the spacing should be increased in proportion to the run. For example, for a run of 40m paralleled, spacing should be 0.3 x 40/10 = 1.2m.

No signal circuit should pass within less than 0.3m of the drive itself. If this is unavoidable, an earthed aluminium screen should be erected between the circuit and the drive. (This constraint obviously does not apply to signal connection to the drive itself. The immunity of the drive to external interference is compatible with its emissions.)

10.5.2 Earthing

In any cubicle, a single, low-impedance earth point or busbar should be established, to which circuits are earthed independently and directly, and to which the incoming earth is connected. It is particularly important that the drive earth connection is not shared with any other equipment.

However, the earth return in the motor cable should, at the drive end, be connected directly *to the drive earth terminal, not to the cubicle busbar.*

The motor cable should be 4-core, the earth core being connected directly to the drive earth terminal and to the motor frame earth terminal. (This is, in any case, normal practice for electrical safety.)

If the drive control connections are to be linked to any electronic circuit, the common or '0V' line should, if possible, be earthed *at that circuit and at no other point.*

10.5.3 Supply Filter

Generally, no supply filter is needed in this type of installation. However, a filter is recommended if there is a likelihood of sensitive circuits being installed on the same mains low voltage supply. Also, if the motor cable is long (exceeding about 50m) its capacitance to earth will increase the supply emissions and a filter is recommended.

In general, the filter is best installed physically close to the drive, with short connections to the drive. (The CD75-750 drives have provision to accept an optional filter installed internally — refer to Section 10.8)

10.6 Additional Precautions for Sensitive Circuits

If a drive is associated with sensitive circuits, further precautions are advisable. These are summarised below and illustrated in Fig. 45.

10.6.1 Switching Frequency

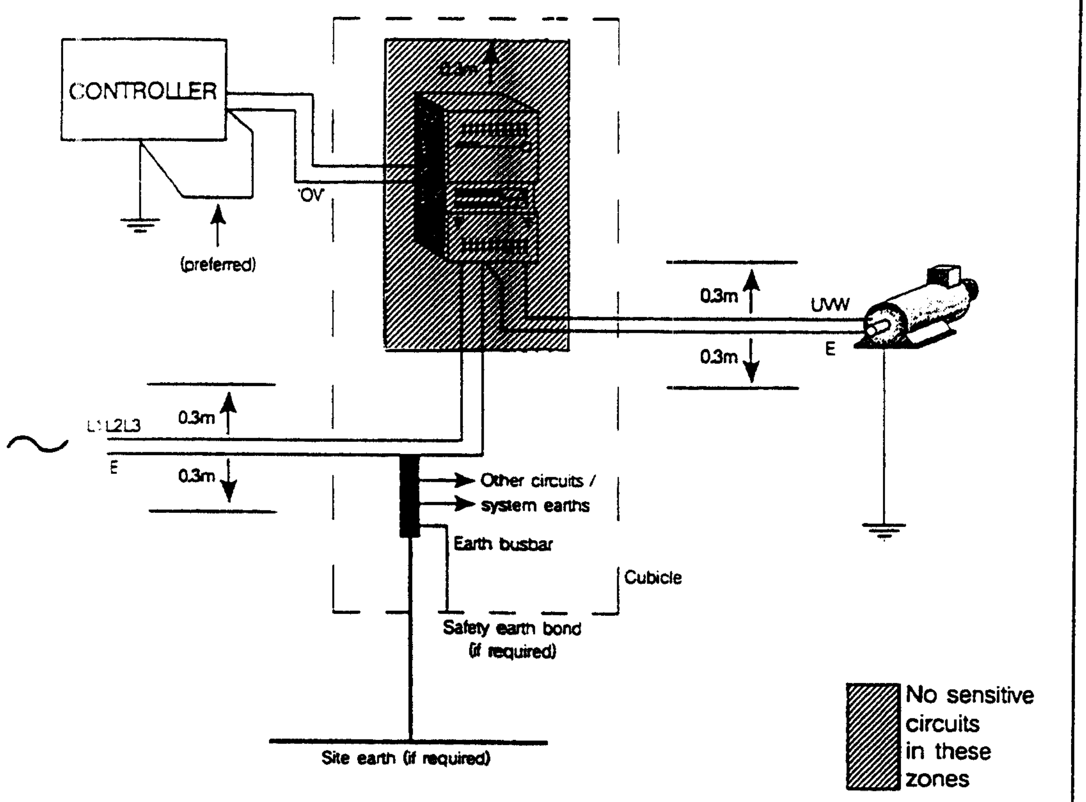
The emitted energy is proportional to the switching frequency. It is preferable therefore to use the lowest acceptable switching frequency.

10.6.2 Supply Filter

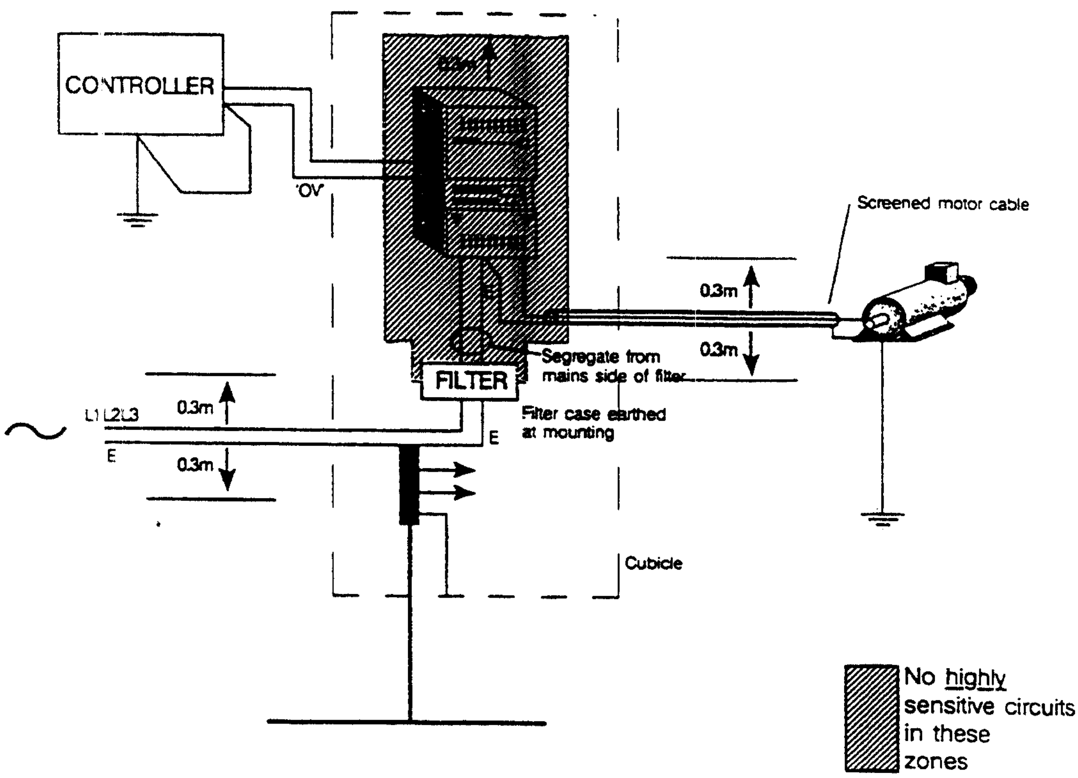
A filter must be fitted in the mains supply line and should be of a type recommended by the supplier of the drive.

10.6.3 Motor Cable

The only sure way of preventing emission from the motor cable is to screen it. Screened cable, however, is more expensive than conventional cable, and may be inconvenient. For many installations, unscreened cable is



44 Wiring and layout for non-sensitive systems.



45 Wiring and layout for sensitive systems.

adequate — provided that it can be segregated from sensitive circuits. As an approximate guide, allow a spacing of 1m for every 10m length of run. In any case, avoid long parallel runs (paragraph 10.5.1).

If in doubt, the motor cable should be screened, and the screen should be connected to *both* the drive earth and the motor frame earth. It is important that the connection should be made at both ends to minimise the external magnetic field.

Screened cable is also effective in ensuring that the RF current which flows through the motor stray capacitance to the motor frame returns along the screen to the drive and not by stray paths through the metal structure to which the motor is attached. Screened cable is recommended if any sensitive circuits are connected or fixed to the machinery driven by the motor.

Armoured cable provides effective screening. It should ideally be earthed only at the drive and the motor frame. If it has to be earthed at the cubicle penetration, screened cable should be used within the cubicle to continue as far as possible the coaxial arrangement of power cable and earth.

If it is not possible to screen the motor cable — for example, where it is an existing installation — fit an output inductor of the kind recommemded for use with long motor cables. Refer to Chapter 4 Section 4.2, pages 4-6 and 4-7.

In some hazardous environments it is not permissible to earth both ends of the cable armour because of the risk of high current circulating at mains frequency if the earth loop is cut by a strong magnetic field. This only applies in the proximity of powerful electrical machines. In such a case, the earth connection at one end may be made through a capacitance of 1.0μF, which will block the mains-frequency current but present a low impedance to RF. Because of the highly pulsed nature of the circulating current, the type used must be rated for ac mains-to-earth voltage.

10.6.4 Earthing

Care must be taken with the earthing arrangements. The essential objectives are to define firmly the paths though which the high-frequency earth current flows, to ensure that no sensitive circuit shares a path with such current, and to minimise the area enclosed by these paths.

The current paths are illustrated in Fig. 46. The bold lines show the desired paths and the broken lines show the stray paths which the layout is designed to minimise. The drive RF current paths are kept compact and the earth is shared with other circuits at one point only (except for the unavoidable motor frame terminal point).

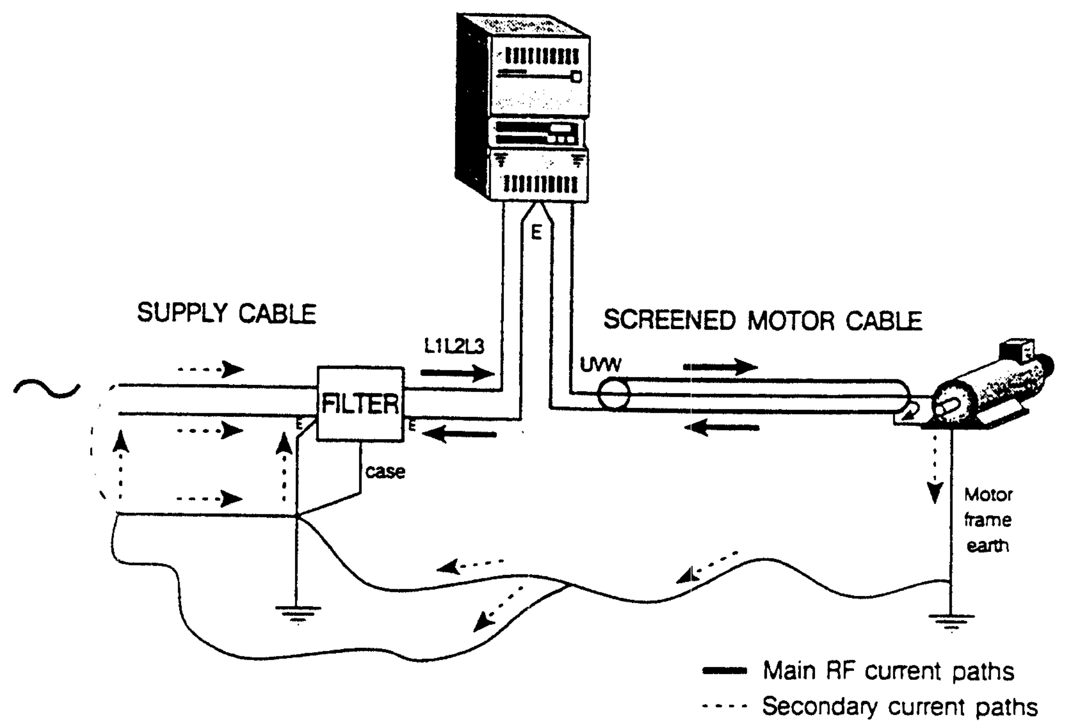
The arrangements of the output cable is particularly important, being earthed directly to the drive and filter, since this provides a direct route for high-frequency current returning from the motor frame and the screening sheath or earth core.

Note also that segregation of current-carrying earth conductors must be maintained — that is, a signal earth conductor should not be run close and parallel to a drive earth conductor.

10.6.5 Control Circuit

CD drives have electrically-isolated control circuits. The control circuit should preferably be earthed at a single point in the user's system, remote from the drive. This means the the '0V' terminal should be earthed at the equipment to which the control lines are connected.

For those situations where it is required to maintain the earth isolation of the control circuits, a sufficient effect can be achieved by earthing through of capacitor of 100nF and suitable voltage rating. If even this is not acceptable, the control lines should be screened and the screens connected to earth. If the control connections are short, and located within a cubicle which contains no sensitive circuits, these precautions are not necessary.



46 Current paths with supply filter and screened motor cable.

10.6.6 Very Sensitive Systems, Radio Receivers

Very careful attention is needed if radio reception is required in the LW and MW bands close to the drive. European and other standards on emissions are intended to permit undisturbed reception of normal broadcasts at a distance of 10m. A receiver closer than this, or tuned to a weak transmitter, may be disturbed to some extent. It can be very difficult to achieve operqtion of a long/medium wave radio actually standing on the cubicle in which a drive is mounted. On the other hand, if the guidance given here is followed, clear reception of the main transmitters is usually obtained at a distance of about 1 to 2m.

All of the precautions given in Section 10.5.2 must be observed as well as those following.

10.6.7 Wiring Layout

It is important that the wiring layout does not cause coupling of emissions from the drive and its wiring back into the filtered mains supply. Individual judgement is required here.

An obvious error to avoid it that of combining the filter input and output wires in the same loom. The 'clean' wires must go to the drive by a short, direct route, and be segregated from all circuits on the 'clean' side of the filter. The output wires must also be strictly segregated from the motor cable.

If the cubicle does not contain power circuits associated with the motor or other drives, the filter should be located close to the drive, with short — preferably screened — connections to the drive.

If this is not the case, for example if the main motor has a separate fan motor or other circuits which are wired back into the cubicle, it is best to locate the filter at the cubicle power incoming terminal block or board. The disadvantage of this arrangment is that other wiring leaving the cubicle may carry RF energy picked up from the internal power cables.

In complex multi-drive installations the recommended filters should be fitted close to each drive (refer to Section 10.7) plus a further, general purpose, filter at the cubicle incoming supply terminals to attenuate the pick-up in the 'clean' wiring.

10.6.8 Screening

The motor cable must be screened unless it is short — not more than 1m from the cubicle to the motor. Armouring is sufficient, provided that both ends are earthed. Metallic trunking may be adequate, but it is important to ensure that it maintains a good electrical circuit around and along the cable in order that circulating current may flow to cancel the magnetic field due to the cable.

The conformity of the drive and filter to EN55014 does not guarantee the conformity of the complete installation, although the standard is unlikely to be seriously infringed if these guidlines are adhered to. If strict conformity with EN55014 is required, it is necessary to carry out measurements on the complete installation.

10.7 Optional RFI Filter

The CD75-750 drives are equipped with an integral RFI filter which controls radio-frequency emission into the mains supply and earth wiring. Provided that the routine wiring precautions described above are adhered to, it is unlikely that interference problems will be encountered when the drive is used with conventional industrial electronic circuits and systems.

Where it is essential that very low emission levels should be achieved, the optional RFI filter may be used. This designed to be connected between the incoming supply and the drive power input terminals, and reduces emissions to a sufficiently low level for radio receivers and other sensitive equipment to be used near the drive.

To ensure that the filter is effective, the motor cable must be screened or armoured, and the guidelines given in the foregoing sections of this chapter must be rigorously adhered to.

10.8 Installation of the Optional RFI Filter

10.8.1 Mounting the Filter in the Drive Module

The optional filter can be installed in the space within the drive, between the heat sink and the rear moulding, only if the drive is to be surface-mounted (by its back-plate), not through-panel mounted.

To install the filter in the drive module, follow the instructions in Fig. 47A, B and C. It is important to ensure that the electrical connections are made as shown, without any alterations.

10.8.2 Mounting the Filter Externally

If the filter cannot be mounted within the drive, it must be installed in a protective enclosure. The same applies if, having installed a filter within a drive, it is necessary to fit a second filter to obtain compliance with domestic emission standards.

NOTE

Connections must be made with the short length of screened cable provided with the filter. If this cable is altered in any way the filter will operate, but compliance with any emission standard is no longer assured.

10.9 Earth Leakage Current

10.9.1 Integral RFI Filter

The integral filter connected to the E_{EMC} terminal in the drive causes a small AC current to flow to earth, which may be up to 9mA with a 415V 50Hz supply, and *pro rata* at other voltages and frequencies. For example, at 460V 60Hz the current is —

$$9 \times \frac{460}{415} \times \frac{60}{50} = 12\text{mA approx}$$

In most installations, this current will not cause any difficulty, since it is insufficient to cause a residual current protective device to operate.

10.9.2 Optional RFI Filter

The optional filter causes a relatively high earth leakage current. Also, surge suppression devices are incorporated in the filter to clamp line surges to a limiting voltage above earth potential. Consequently, a solid earth connection must be provided. Earthing must not rely on flexible conductor, neither should there be any form of plug-and socket or other isolating device in the earth circuit which would permit the drive to be inadvertently disconnected from earth. The integrity of the earth connection should be periodically confirmed by testing.

With a supply voltage of 415V 50Hz, the worst-case earth leakage current of the drive and filter is 12mA, and *pro rata* for other voltages and frequencies. Current at 460V 60Hz is —

$$12 \times \frac{460}{415} \times \frac{60}{50} = 16\text{mA approx}$$

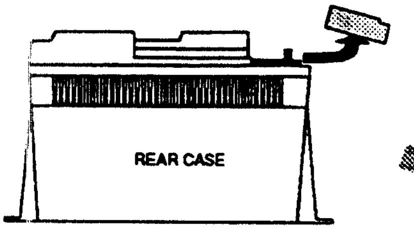
In the event that the earth should become disconnected, the maximum voltage which metal parts could attain relative to earth is 41.5V for a 415V supply, and *pro rata* for other voltages.

It must be noted that the voltage could rise to a dangerous level in the event that the supply system loses one phase.

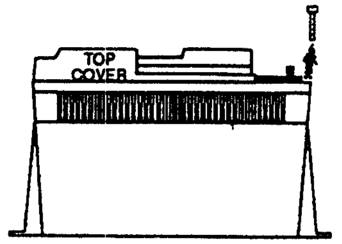
WARNING

In some countries, although not in Europe, 3-phase supplies are occasionally connected in a 3-wire mode with one phase earthed, known as 'grounded delta'.

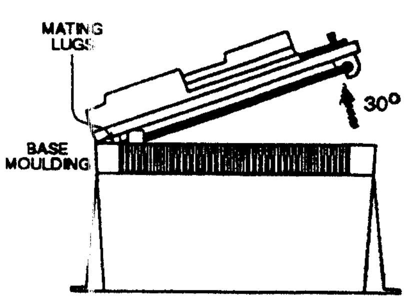
The RF filter is designed ONLY for supplies which are nominally balanced with respect to earth. The filter must NOT be used with grounded delta supplies.



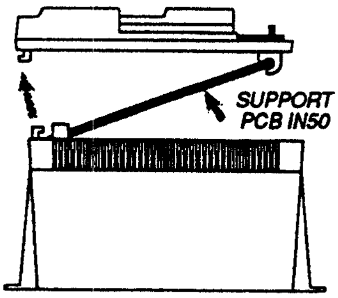
1 Remove the control terminals cover — pull down and lift away.



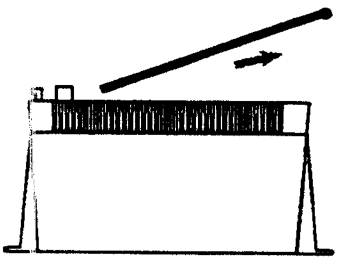
2 Remove the 2 screws, M4 x 10, either side of the power terminals, which secure the Top Cover.



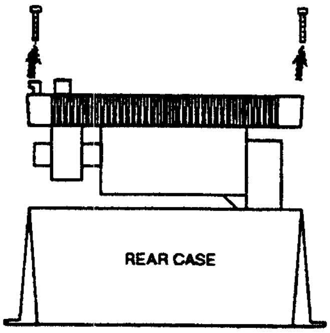
3 Lift the lower edge of the Top Cover until the Mating Lugs at the upper edge are free from the Base Moulding.



4 Disengage the Top Cover from the lug in the Base Moulding.



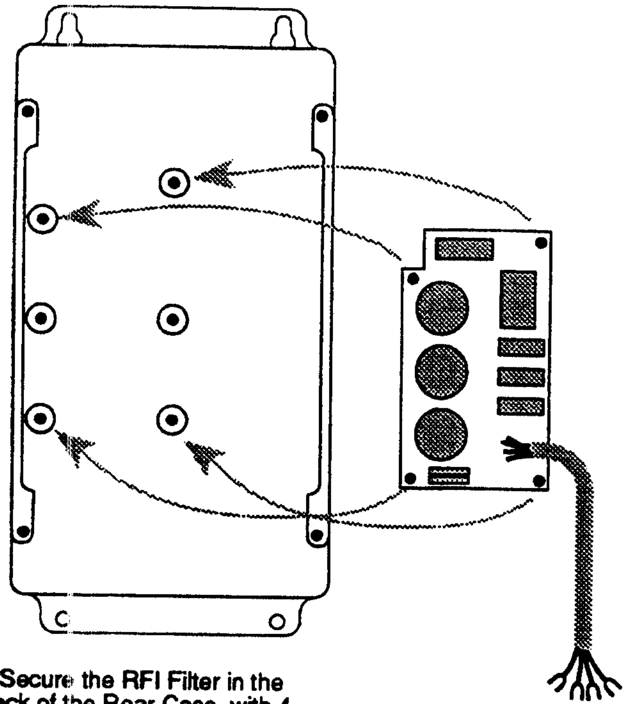
5 Remove the IN50 pcb complete.



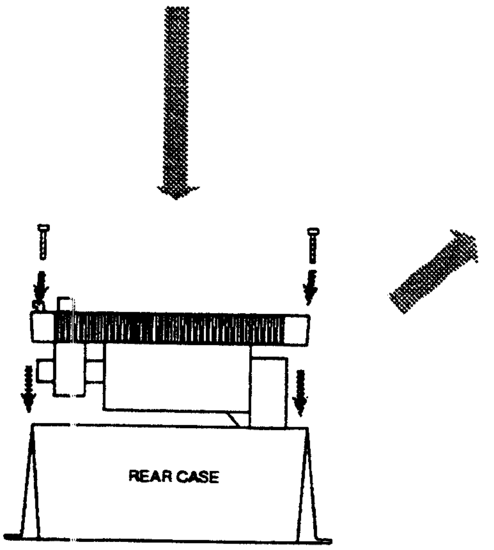
6 Remove the four screws, M4 x 10, one at each corner, which secure the Base Moulding to the Rear Case. Lift the Base Moulding out of the Rear Case.

Continued in Fig. 47B

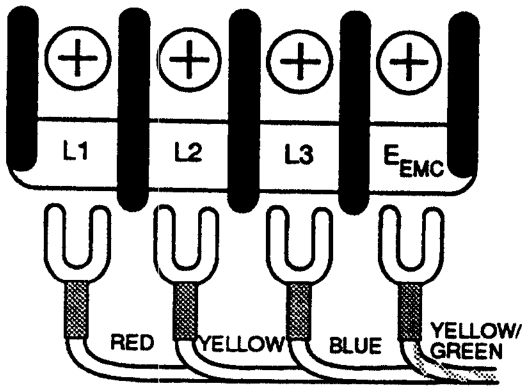
47A Procedure for installing the RFI Filter inside a module.



7 Secure the RFI Filter in the back of the Rear Case, with 4 screws M4 x 10.



8 Replace the Base Moulding into the Rear Case and secure with the 4 screws, M4 x 10.

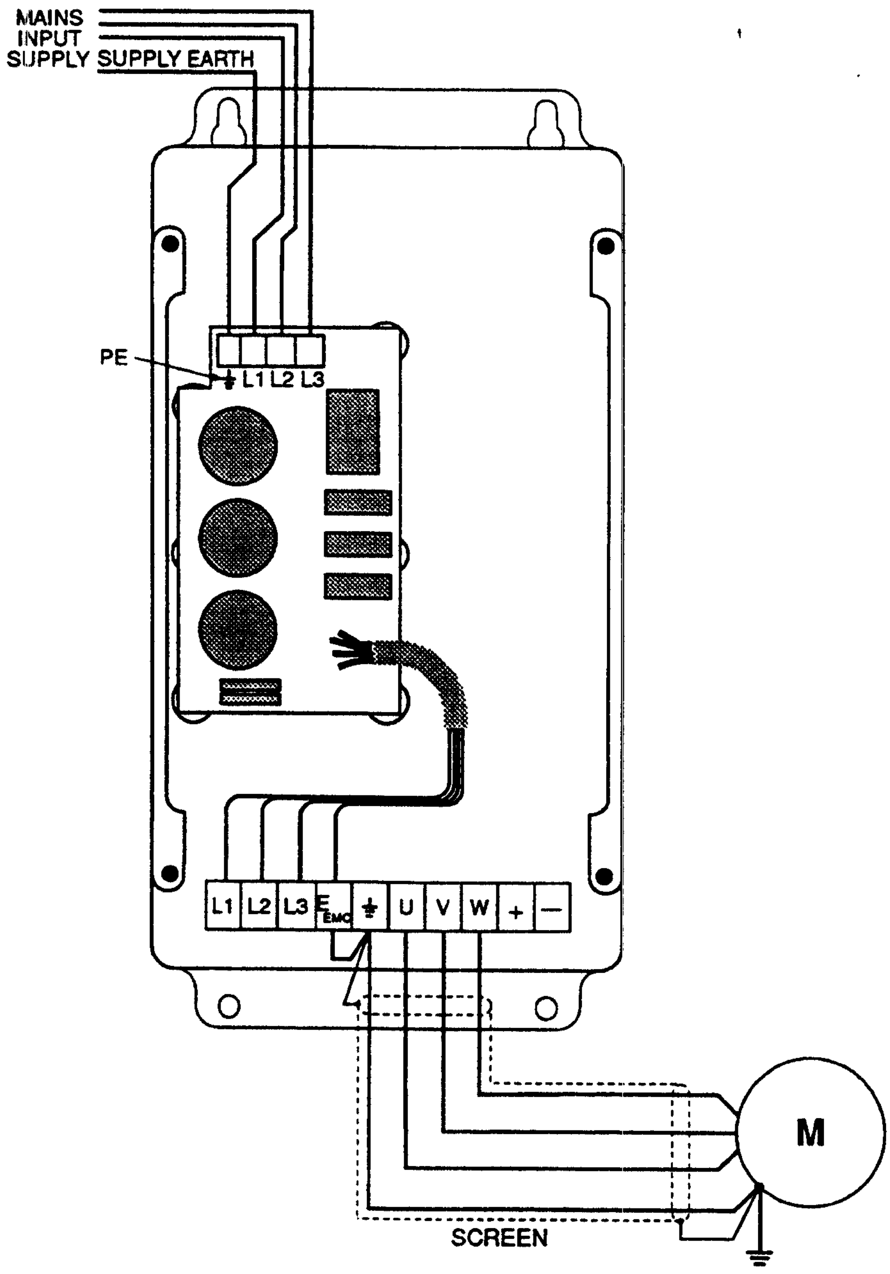


9 Connect the RFI Filter cable to the Power Terminal block as follows —
Red wire to L1
Yellow wire to L2
Blue wire to L3
Yellow/Green wire to E_{EMC}

FINALLY, reverse the procedures of Steps 5 through to 1.

CONNECTIONS — Fig. 47C

47B Procedure for installing the RFI Filter inside a module.



47C Optional internal RFI Filter — power connections.

NOTE: Screen/Shield of inverter output cable should be earthed both at the motor AND at the inverter.

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