0178-7010

CDS

USER'S GUIDE for the *CDS* INVERTER DRIVES

for

0.75kW to 2.2kW

INDUSTRIAL and HVAC

APPLICATIONS

Safety at Work

The voltages present in CDS 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 CDS 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.

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 to the motor and the driven equipment.

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 CDS drive to the motor.

The contents of this Guide are believed to be correct at the time of printing. In the interests of a commitment to a policy of continuous development and improvement, the manufacturer reserves the right to change the specification of the product or its performance or the contents of the User's Guide without notice.

'Electronic' stop should not be relied on for safety purposes, the drive must be isolated from the mains supply.

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USER'S GUIDE

for the

CDS INVERTER

DRIVES FOR INDUSTRIAL and HVAC APPLICATIONS

0.75kW to 2.2kW

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Illustrations

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1 Introduction

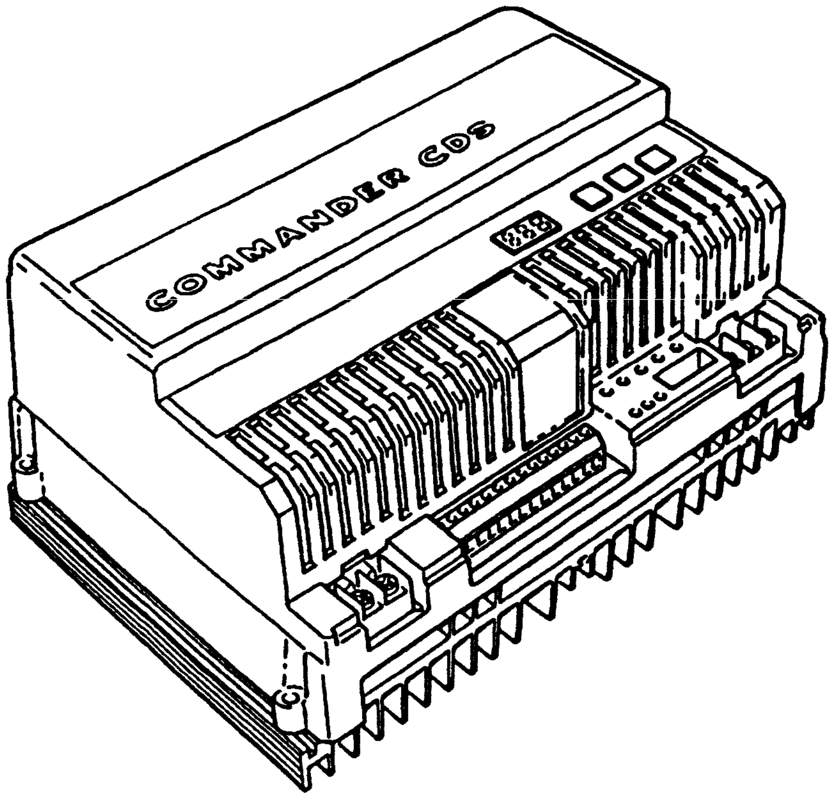


Figure 1-1
CDS

1

Introduction

1.1 Features

- Full digital control.
- Digital adjustment of most drive parameters.
- Insulated gate bi-polar transistor (IGBT) output bridge for high speed switching and low power consumption.
- Choice of up to four switching frequencies in range 2.9 to 11.7 kHz.
- High output frequency. Up to 960Hz available.
- Variable and fixed V/F characteristics.
- Internal monitoring and protection includes Ixt overload, current limit, peak limit, instantaneous overcurrent and individual IGBT protection.
- Isolation between control and power electronics.
- Ability to start drive into coasting motor, rotating in either direction with no large transient torques or current.
- 150% current.
- DC injection braking.
- 3 Preset speeds or jog facility.
- Auto restart after trip.
- Last fault indication.
- Security code protection.
- Selectable relay function.
- Selectable 'Wireproof' Mode.
- RS485 serial communications interface.
- Single phase mains supply. Wide range of input voltage.
- Voltage control for both constant and speed dependent torque applications.
- Sinusoidal waveform at all output frequencies.

1.2 Theory of Inverter Drives

1.2.1 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 speed, 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 in the stator winding. The magnitude of the field is controlled by the supply voltage applied to the stator windings. The impedence of the stator windings is low, so the volt drop across them is small, therefore the internally induced emf has to be approximately equal to the supply voltage. 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 $E = k\phi Nf$ (From Faradays Law) (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.

Torque is approximately proportional to current multiplied by flux and for economy of material, the magnetic circuits of standard motors are designed to operate very close to saturation at rated voltage and frequency. This is the optimum condition for the production of maximum torque.

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

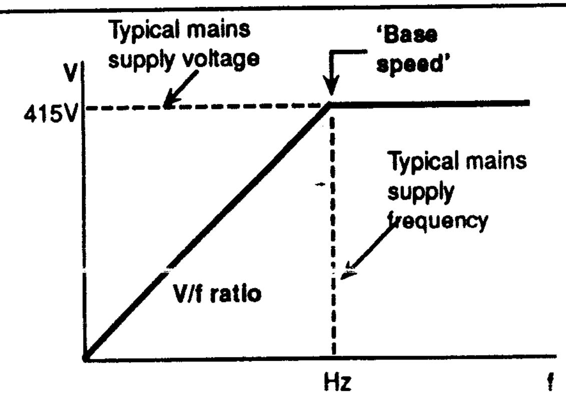
Equation (1) can be restated as —

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

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. Generally an increase in voltage above the linear v/f ratio does not cause much increase in torque because of magnetic saturation but does cause a significant increase in current and consequently to losses.

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 constant at maximum value.

The V/f characteristic is typically as shown in Fig.1-2. Since V is constant above base speed, the flux falls as the frequency increases, Fig. 1-3, in direct proportion to the V/f ratio. The ability of the motor to produce torque is correspondingly reduced; full load current produces less torque as speed increases, and in fact the power output remains approximately constant. There are many applications which are well suited by the constant-power characteristic in the region above base speed.



Variable motor speed — ideal voltage-to-frequency (V/f or V/Hz) characteristic. CT/TID/01/00

Figure 1-2
Variable Motor Speed Characteristics

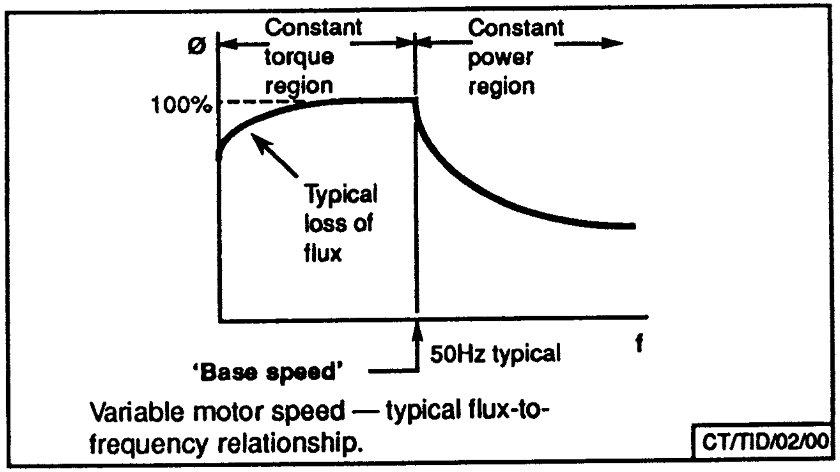


Figure 1-3
Motor Speed - Flux to Frequency Relationship

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 impedance 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 impedance effect. Compensation for stator impedance is called 'voltage boost', Fig. 1-4, and most drives offer some form of adjustment. It is also normal to taper the boost to match the linear characteristic as the frequency increases.

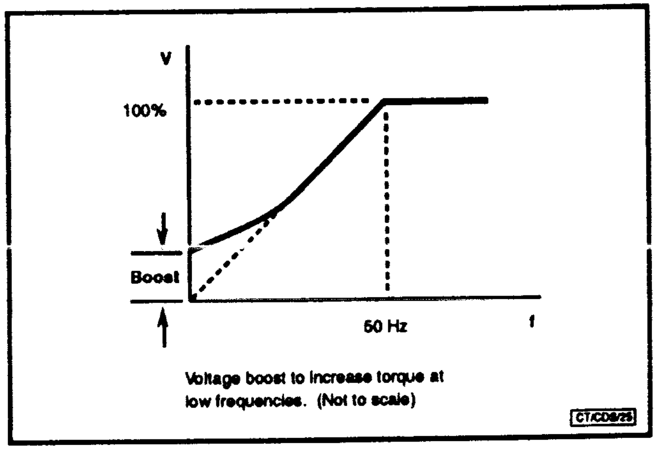


Figure 1-4
Voltage Boost

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2 Drive Specification

2

Drive Specification

2.1 Ratings

The CDS (0.75-2.2kW) range is rated for current output, therefore the actual power output depends on the output voltage, which in turn depends on the supply voltage.

2.1.1 Power Supply

Input supply voltage range and frequency:-

200 - 240V AC ± 10%, 48 - 62Hz single phase

Minimum supply source impedance:

0.09 Ohms (@ drive terminals)

2.1.2 Output Ratings

The drive system is for general purpose industrial drives which require a short term overload capability of 150% for 60 seconds refer to Table 2-1.

TABLE 2-1 CDS (0.75 -2.2kW) Industrial Drive

Drive Model	OUTPUT		MOTOR RATING kW (1)	INPUT	
	FLC A rms	OVERLOAD 150% A rms		FLC A rms (2)	OVERLOAD (150%) A rms (2)
CDS 75	4.0	6.0	0.75 -	10.5	14.5
CDS 150	7.0	10.5	1.5	18.7	25.9
CDS 220	10.0	15.0	2.2	25.6	35.6

INPUT					
DRIVE MODEL	DISPLACEMENT FACTOR (appx) (3)	POWER FACTOR (4)	MAXIMUM SWITCH ON SURGE A PEAK (5)	MAXIMUM i^2T OF SWITCH ON SURGE A^2S (5)
CDS 75	0.95	0.52	195	28
CDS 150	0.95	0.52	200	51
CDS 220	0.95	0.53	419	171

NOTE
(1) Typical motor power for stated output current, based on a typical 6 pole machine at 220V.
(2) With 220V supply and minimum source impedance.
(3) Displacement factor is the cosine of the phase angle between fundamental voltage and fundamental current and approximates to unity with a low impedance supply.
(4) Power factor is (average power supplied) ÷ (Vrms x Irms). The value shown is at 220V and minimum source impedance.
(5) With 240V + 10% supply and minimum source impedance.

2.2 Specifications - General

2.2.1 Losses

DRIVE MODEL	HEAT LOSS W	EFFICIENCY %
CDS 75	85W	93%
CDS 150	115W	94%
CDS 220	135W	95%

2.2.2 Altitude

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

RELEVANT SPECIFICATION

IEC 146-2, Section 3.1.a.
VDE 0160, Section 5.2.1.1, Part c
UL508, Section 52.2
CSA 22.2, Section 6.2.3

2.2.3 Ambient Temperature and Humidity

Rated ambient temperature:- -10^{o}C to +40^{o}C

Maximum operating ambient temperature 0^{o}C to +50^{o}C
Maximum storage ambient temperature: -25^{o}C to +50^{o}C
Humidity: Non condensing.

2.2.4 Environmental Protection

Ingress protection IP10 (Finger protection).

2.2.5 Materials

All plastics have flammability rating UL94 VO.

2

2.2.6 Weights

Module weight, including chassis, is 2.9kg.

2.2.7 Response Time

Time to energise output stage is 20 ms (maximum) using electronic 'start' terminal, or 100 ms (maximum) from application of power to the input terminal block TB1 (Auto-start mode).

2.2.8 Current loop Response Time

Fastest selectable acceleration and deceleration times 0.2 seconds to upper limit frequency.

Current loop response is fast enough to prevent tripping on fastest acceleration setting or instantaneous application of a load of 150%.

2.2.9 Electromagnetic Compatibility

EMC

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

IMMUNITY

Meets IEC801 without significant disturbance to operation at the following levels:

Part 4 (Transient Burst) Level 4 at all terminals.

Refer also to Chapter 10 (EMC).

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2.3 Specifications - Control

2.3.1 Analogue Inputs

(1)	Local speed reference (TB2/11):	unipolar 0 to +5V, 100K input impedance
(2)	Local speed reference (TB2/9)	0 to +10V, 200K input impedance
(3)	Remote speed reference: (current) (TB2/15)	4 to 20mA, 100 Ohms input impedance
	or	20 to 4mA, 100 Ohms input impedance
	or	0 to 20mA, 100 Ohms input impedance
(4)	Motor thermistor (PL6/2):	external resistor connected to 0V Voltage out < 2.5V, capable of protecting 6 standard 250R machine thermistors connected in series. Trip resistance 3k ± 15%, reset 1k8 ±15%. Trip when resistance < 100R ± 15%.

NOTE

An internal 1k5ohm resistor is connected via LK4 across this input. If the user wishes to use this input LK4 must be removed.

2.3.2 Analogue output

Frequency (Speed) (TB2/13):	0 to 5Vdc, or 1mA capability; 0V = 0Hz, 5V = <Pr1>. Accuracy ± 3%.
Load (Torque) (TB2/13):	0V = no load, 5V = +150% Accuracy ± 15% (Hardware DIL sw

2.3.3 Digital Inputs

Each digital input has an internal 10Kohm pull up resistor to 5V.

(1)	Start (TB2/4):	momentary low = start (N/O contact to 0V common)
(2)	Stop (TB2/5):	low = not stop, momentary high = stop (N/C contact to 0V common)
(3)	Forward/Reverse (TB2/6):	low = select reverse direction (contact to 0V common) high = select forward direction

(4) Jog/Preset Speed (PL6/4): low = jog/preset 1 speed (contact to 0V common)

NOTE
This input can be software selectable by bit parameter b4 to give either jog input or a preset 1 speed select input.

(5) External Trip (PL6/8): low = not stop/trip (N/C contact to 0V common)
momentary high = stop/trip

(6) Reset (TB2/10): momentary low = reset (N/O contact to 0V common), edge triggered input

(7) Local/Remote (PL6/9): Low = remote, i.e. all inputs useable
High = local, i.e. speed reference from TB2/9 or 11 only.

(8) Preset Speed 2 input (PL6/6): Low = active

2.3.4 Digital outputs

Drive Relay (TB2/1, 2 and 3): Volt free contact. Rated 110V ac, 7A. resistive. Switch configured (SW1 A, B) for STATUS/AT SPEED/ZERO SPEED, or RUN RELAY function. Changeover type relay.

2.3.5 Serial Communications Interface

RS485, RS422. Protocol is ANSI x3.28 - 2.5 - A4
Hardware interfacing is 5 wire, RS485 which is upwardly compatible with RS422. RS232 can be accomodated with some systems see Chapter 7 for details. The hardware supports multidrop operation with a maximum of 32 receiver channels connected to any one transmit channel. The hardware is not isolated.

NOTE
For interface cable details, refer to Chapter 4 "Installation — Electrical".

SERIAL COMMUNICATIONS I/O

Differential Input: 0 to 5Vdc, input impedance 3.5k.
V(A-A\) > +0.2V = Logic high at the receiver.
V(A-A\) < -0.2V = Logic low at the receiver.

Differential Output Transmitting: Output is 0.7 to 4Vdc with no load, current capability ± 60mA.
Logic high at the microprocessor A = 4V, A\ = 0.7V.
Logic low at the microprocessor A = 0.7V, A\ = 4V.

i.e. the differential voltage is ± 3.3V on no load.
Maximum input voltage 12V wrt 0V
Minimum input voltage -7V wrt 0V

2.3.6 Accuracy

Frequency:-
- accuracy ± 0.01% full scale
- resolution 0.1% full scale

NOTE
These figures imply:-
Crystal controlled internal reference
Display resolution 0.1Hz

2.3.7 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 and deceleration rates: resolution becomes coarser towards 600 seconds.

Pr0, Pr1, Pr7: ± 0.2Hz for ULF = 240Hz.
± 0.4Hz for ULF = 480Hz.
± 0.8Hz for ULF = 960Hz.

Pr6: ± 0.4%

Display resolution ± 0.1Hz.

2.3.8 Auxiliary Supplies and References

(1) +5V ±2%, 0.5mA
(2) 0V common (Qty 3)

3 Installation —Mechanical

3

Installation — Mechanical

3.1 Drive Mounting

Principal dimensions are as shown in Fig. 3-1. The drive must be mounted in the orientation as shown, ie with the terminals at the bottom. Any other mounting position may interfere with the drive cooling.

3.2 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.

CDS 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").

3.2.1 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.

3.2.2 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.

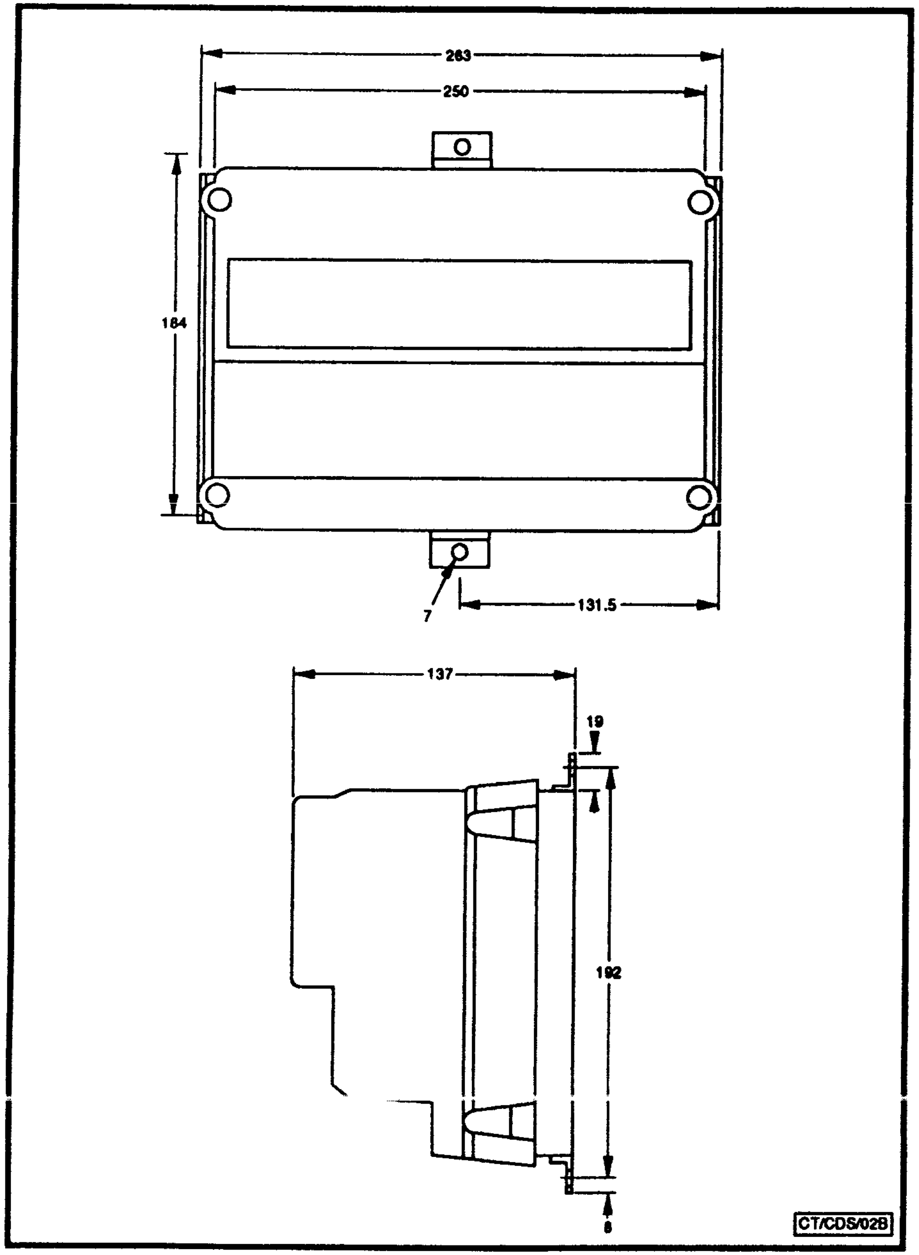


Figure 3-1
CDS - Drive Mounting Dimensic

3.3 Cooling and Ventilation

3.3.1 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 and any other equipment. A minimum clearance of 100mm all around the drive is essential (refer to Fig. 3-3). 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.

3.3.2 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.

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

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

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

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

DRIVE MODEL	HEAT LOSS W	EFFICIENCY %
CDS 75	85W	93%
CDS 150	128W	94%
CDS 220	-	-

EXAMPLE

Calculation of the size of an IP54 cubicle for a CDS 150 drive

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

- 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 wall of the cubicle, which is cooled by radiation to the external air.
- If the drive module is fitted into a cubicle its base and back surfaces cannot be considered to play any part in the cooling process (Fig. 3-2). 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 30°C.

To find the required heat-conducting area :—

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

P_L = 128 (losses)

T_i = 40°C (for all CDS drives)

T_{amb} = 30°C

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

$$A_e = \frac{128}{5.5\,(50-30)}$$

$$= 1.16\text{m}^2$$

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, and the minimum clearance of 100mm round the module as shown in Fig 3-3.

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 as shown in Fig. 3-2 is -

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

Where H is the cubicle height, D is the depth and W the width. Suppose the cubicle height H is 1.4m and the depth D is 0.3m, as a first estimate. The actual figures chosen in practice will be guided by available space, or standard enclosure sizes.

Since A_e H and D are known, the dimensions to be calculated is W. The equation needs to be re-arranged to enable W to be found, thus:-

$$A_e - 2HD = W(H + D)$$

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

Substituting known values
$$W = \frac{1.16 - 2 \times 1.4 \times 0.3}{1.4 + 0.3}$$

$$W = 0.81\text{ m}$$

Clearance on either side of the inverter module must be checked. The width of the module is 238mm, clearance of 100mm is required on either side. So the minimum internal width of the enclosure must be 438mm. This is within the calculated width, and therefore acceptable.

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

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 height of the cubicle or installing "stirrer" fans to ensure air circulation.

3

Enclosure Ventilation

If a high IP rating is not a critical factor, the enclosure can be smaller if a ventilating fan is used to exchange air between the inside and the outside of the enclusure.
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 CDS 150 Drive :—

If, P_l = 128W

T_i = 40^oC (for all CDS drives)

T_{amb} = 30^oC (for example)

Then $$V = \frac{3.1 \times 128}{40 - 30}$$

V = $40\ m^3\,h^{-1}$

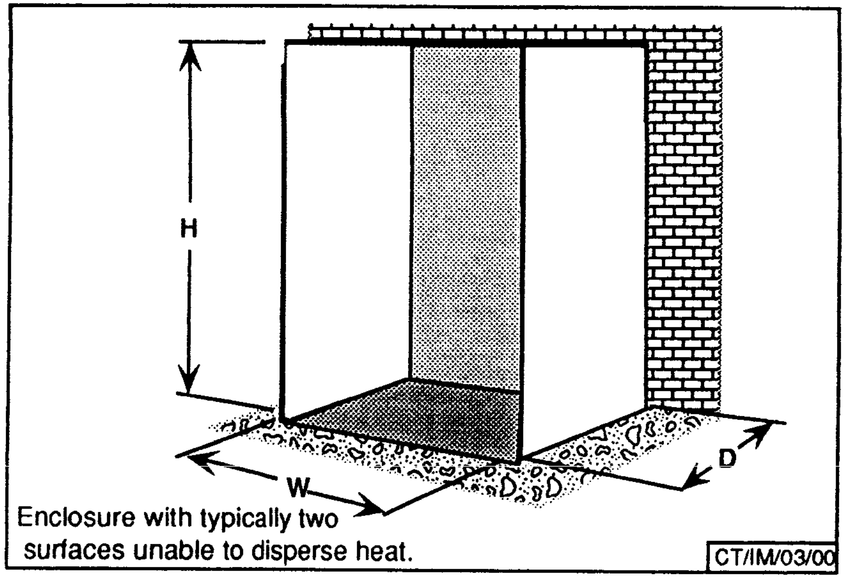


Figure 3-2
Cubicle

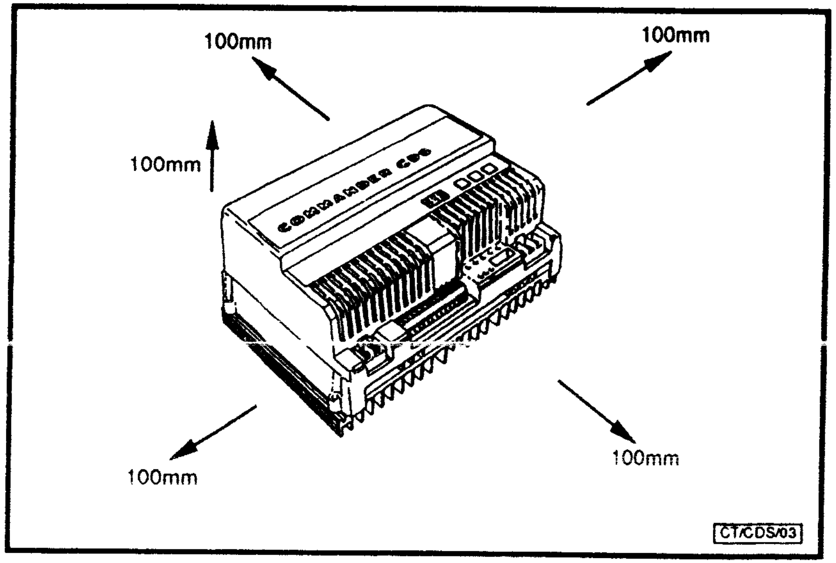


Figure 3-3
Minimum Ventilation Distances

4 Installation —Electrical

4

Installation — Electrical

4.1 Installation Safety

4.1.1 Safety

The voltages present in the supply cables, the output cables and terminals, 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 ten minutes (CDS 220), seven minutes (CDS 150), or four minutes (CDS 75) 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.

4.1.2 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.

4.1.3 Earthing

The drive must be connected to the system Earth by the heatsink Earth connection.

Earth impedance must conform to the requirements of local industrial safety regulations and should be inspected and tested at regular intervals.

4.1.4 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 manufacture , 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.

IMPORTANT NOTE

In order for access be obtained to the switches and links it is necessary for the module cover to be removed. Removal of the module cover requires that all power and control connections are disconnected.

It is therefore advised that the required drive configuration is selected by the necessary link and switch selections before the module cover is fitted.

It is also advised to connect any option boards e.g. IBD-2 at this stage.

When re-fitting the module cover it is necessary to ensure that the keypad ribbon cable is correctly fitted.

4.2 Power Connections

Access to the power and control connections are gained by removing the snap-fit cover at the bottom of the drive.

L1 Line 1(R) } TB1
L2 Line 2(S) }
Earth/Ground - on heatsink

"U" Motor Phase - U }
"V" Motor Phase - V } TB3
"W" Motor Phase - W }

Earth/ground connections are made to the metal heatsink. There are three earth/ground terminals, one for the mains input, motor output and control terminals.

4.2.1 Fuses and Cabling

Drive Model	**Fuse/Circuit Breaker* A	*Minimum cable size* mm^2
CDS75	16	1.5
CDS150	32	4.0
CDS220	40	6.0

DISPLACEMENT FACTOR (appx)	POWER FACTOR	MAXIMUM SWITCH ON SURGE A PEAK	MAXIMUM i^2T OF SWITCH ON SURGE A^2S
0.95	0.52	195	28
0.95	0.52	200	51
0.95	0.53	419	171

* 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 supplier of the mcbs or mccbs should be asked to advise.

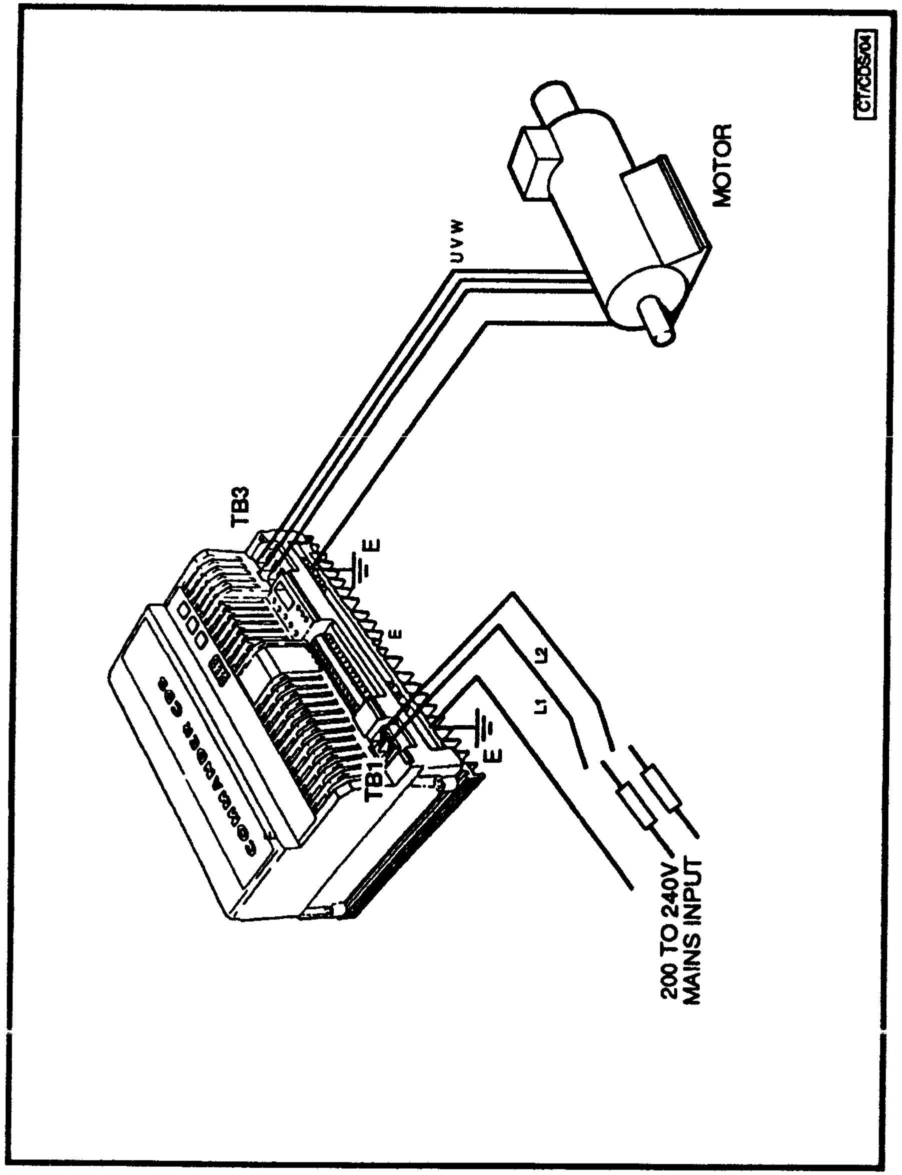


Figure 4-1
Power Connections

4.2.2 Power Cable Rating

600/1000V ac/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.

!!! IMPORTANT !!! THE MAINS SUPPLY TO THE DRIVE MUST BE PROTECTED BY EITHER FUSES, OR AN M.C.B.

The power connections to the motor, from the drive output, 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 considerations; if so, consult with your supplier.

Long cable runs, in excess of 20 metres, between the drive and the motor may give rise to spurious tripping due to transmission line effects. If in doubt 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.

4.3 Control Connections

For control connections use cable of $0.5mm^2$ screened. Connect screen to 'earth' AT DRIVE ONLY using a very short connection (50mm Max.). Always segregate control and power cabling. Connections to terminals are shown in Fig. 4-2 to 4-5 and should be made to 'earth' at sending end if long cables are used (i.e. greater than 5m).

4.3.1 Terminal Block TB1

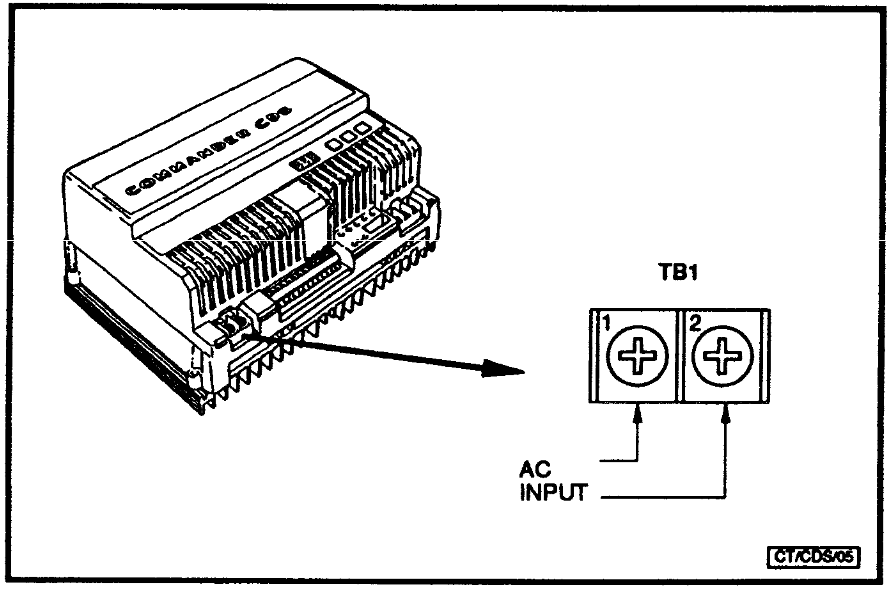


Figure 4-2
Terminal Block TB1

Terminal
No.

1 L1 } 200 - 240V ac ± 10%
2 L2

48 Hz - 62 Hz single phase

Minimum supply source impedance:-
0.09 ohms (@ drive terminals)

Earth connection is via heatsink.

In common with all inverter drives, the unit will produce a certain level of Radio Frequency Interference. It is the users' responsibility, to ensure compliance with local requirements for RFI control. Filters specifically designed for use with the inverter are available from your supplier. In some cases general purpose mains supply RFI filters may be sufficient. Note that lowest levels of RFI emissions occur at the lowest switching frequencies. For further information see Chapter 10 (EMC).

4

4.3.2 Terminal Block TB2

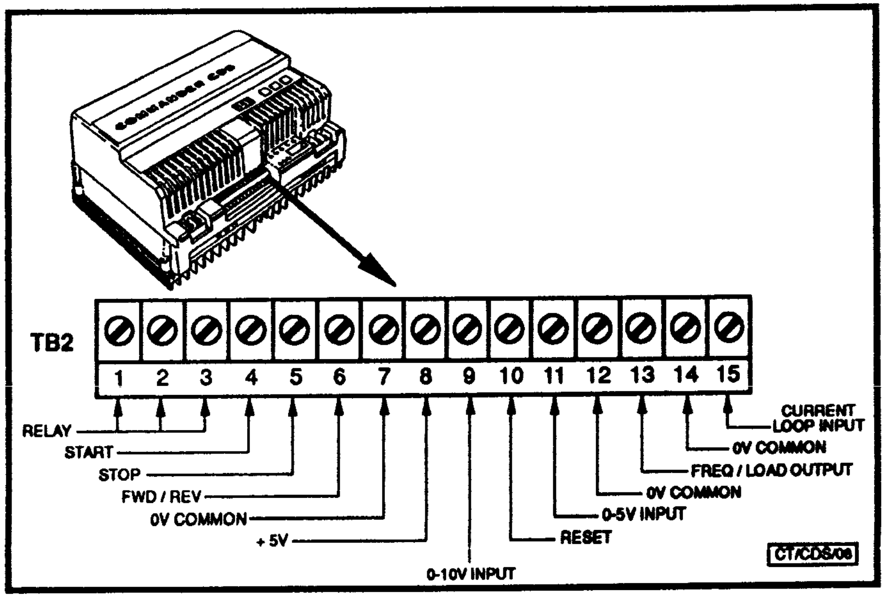


Figure 4-3
Terminal Block TB2

Terminal No.	I/O	Name	Specification
1	O	Relay N/C	110V ac, 7A non-inductive (terminals 1–3)
2	O	Relay N/O	
3	O	Relay common	
4	I	Start Input	Momentary low to start (low = 0V)
5	I	Stop Input	Momentary high to stop
6	I	Forward/Rev	Low to select reverse direction
7	O	0V common	
8	O	+ 5V reference potentiometer O/P	5V ± 2% tolerance, 0.5 mA
9	I	0 to 10V input	
10	I	Reset input	Momentary low to reset
11	I	0 to 5V input	e.g. via 10K potentiometer
12	O	0V common	
13	O	Frequency/Load Output	0 - 5V (>100K source impedance) or, 0 - 1 mA (<500Ω source impedance) to 100% speed (Pr1) or 150% load.
14	O	0V common	
15	I	Current loop input	0-20 mA, 4-20 mA, 20-4 mA selectable by bit 11 (b11)

All contactor coils, solenoids and brake coils must be suppressed with an RC network or equivalent.

The control electronics will be interfaceable with other industrial control products referenced to potentials within ± 50V (peak) relative to earth of the drives mains supply input.

Load signal: For a positive load, i.e. motoring, the display shows a steady value. For a negative load, i.e. regenerating, the display flashes. The analogue output, TB2/13 only gives an indication for positive load.

4.3.3 Connector PL6

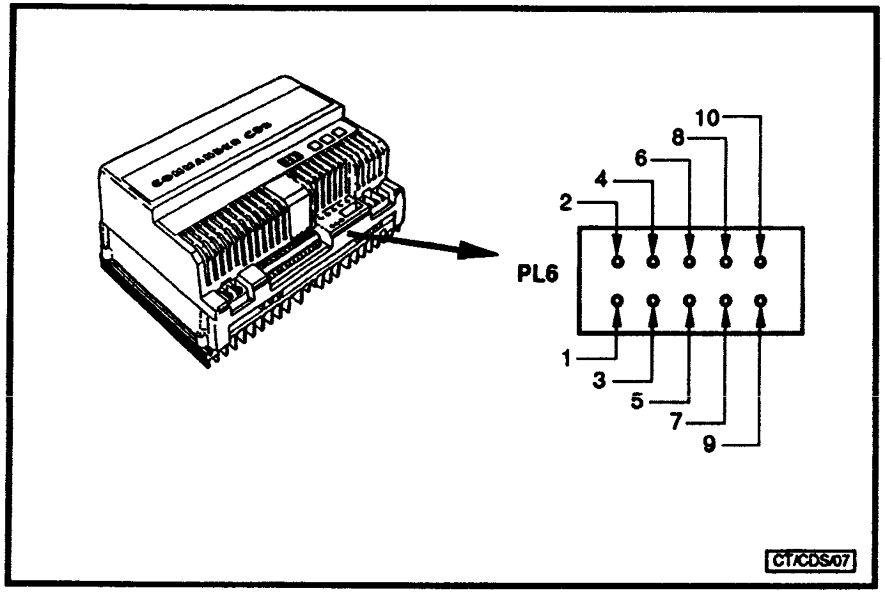


Figure 4-4
Connector PL6

Connector Pin	I/O	D/A	
1	I	D	Serial Link receive A1
2	I	A	Motor thermal protection thermistor input (ref.Note(1))
3	I	D	Serial Link receive A
4	I	D	Jog/Preset 1 input
5	O	D	Serial Link transmit A\
6	I	D	Preset speed 2
7	O	D	Serial Link transmit A\
8	I	D	External trip (ref.Note(2))
9	I	D	Local/Remote (low = remote) (Ref Note 4)
10	O	D/A	OV common

NOTES

(1) If motor thermistor is fitted then remove link 4 (by PL6).

(2) To prevent the drive tripping the 'Et' trip is disabled via a jumper link fitted between PL6 pins 8 and 10. If features associated with PL6 are required then this link can be removed and the connection made elsewhere.

(3) Serial communications I/O

Differential Input: 0 to 5Vdc, input impedance 3.5k.
V(A-A\) > +0.2V = Logic high at the receiver.
V(A-A\) < -0.2V = Logic low at the receiver.

Differential Output Transmitting: Output is 0.7 to 4Vdc with no load, current capability ± 60mA.
Logic high at the microprocessor A = 4V, A\ = 0.7V.
Logic low at the microprocessor A = 0.7V, A\ = 4V.

i.e. the differential voltage is ± 3.3V on no load.

(4) If the local/remote facility (Pin 9) is to be used then link 5 must be removed.

4.3.4 Terminal Block TB3

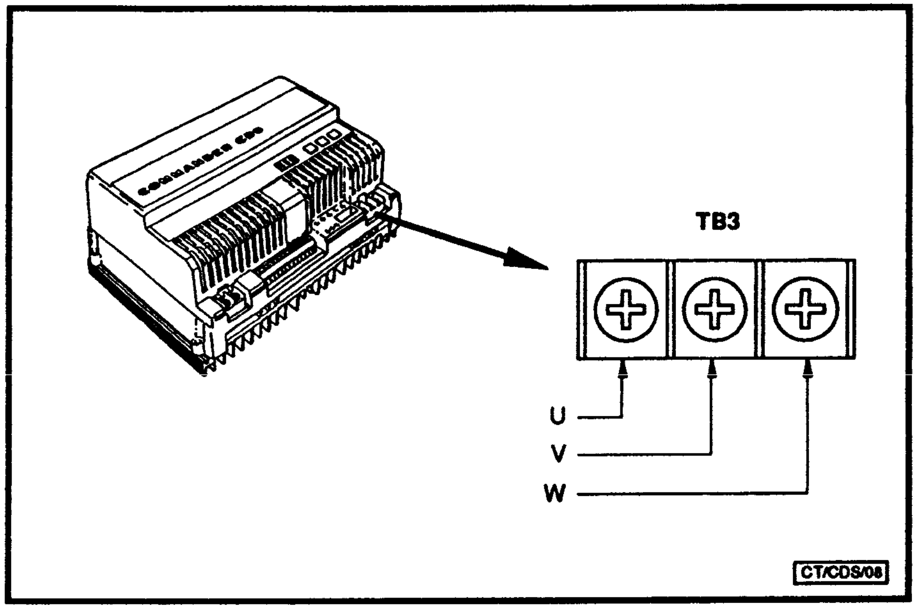


Figure 4-5
Terminal Block TB3

Terminal No.	I/O	Name	Specification
U	O	Motor phase O/P U	Max. Output nominally equal to supply input voltage. Variable frequency.
V	O	Motor phase O/P V	
W	O	Motor phase O/P W	

Motor Speed:

WARNING:
Standard induction motors are not designed to operate at 240, 480 or 960 Hz. Any attempt to run such a motor at above twice synchronous speed may result in catastrophic motor failure. Consult your motor supplier for advice and details of special high frequency motors.

4

5 Drive Configuration

5

Drive Configuration

5.1 Operating Procedures

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%.

Bit parameters are used 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. 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.

5

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.

NOTE

In the keypad mode, adjusting the parameters while the drive is tripped will reset the drive.

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, and are listed in the **Parameters Quick Reference** (Chapter 6). The values set at the factory (as delivered values) may, for special customer requirements, differ from default values.

5.1.1 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, a parameter number is displayed, and alternates with the parameters value.

With the parameter number alternating with its value, 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 8 seconds in pressing another key, the display will default to the Present Indication (see below) of the output of the drive. Pressing MODE again returns to the parameter selected.

TO READ A PARAMETER

Select a parameter by pressing the MODE key once. The display will show the Pr number, alternating with the value, of whichever parameter was last read or adjusted. The display will alternate between the parameter number and its value for a period of 8 seconds, 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 8 seconds.

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.

To stop the drive, press the DOWN key until the display shows 0 if the drive is in Keypad control mode (**b9**=0), or open the STOP terminal TB2/5 in Terminal control mode (**b9**=1). Wait until the display shows **rdY**.

Select the required parameter and press the MODE key once more. The display will hold the parameter value steady. If a further keystroke is not made within 8 seconds, 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 plus or minus one digit. Press either key repeatedly to increase or decrease through the parameter values 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 next the drive is energised.

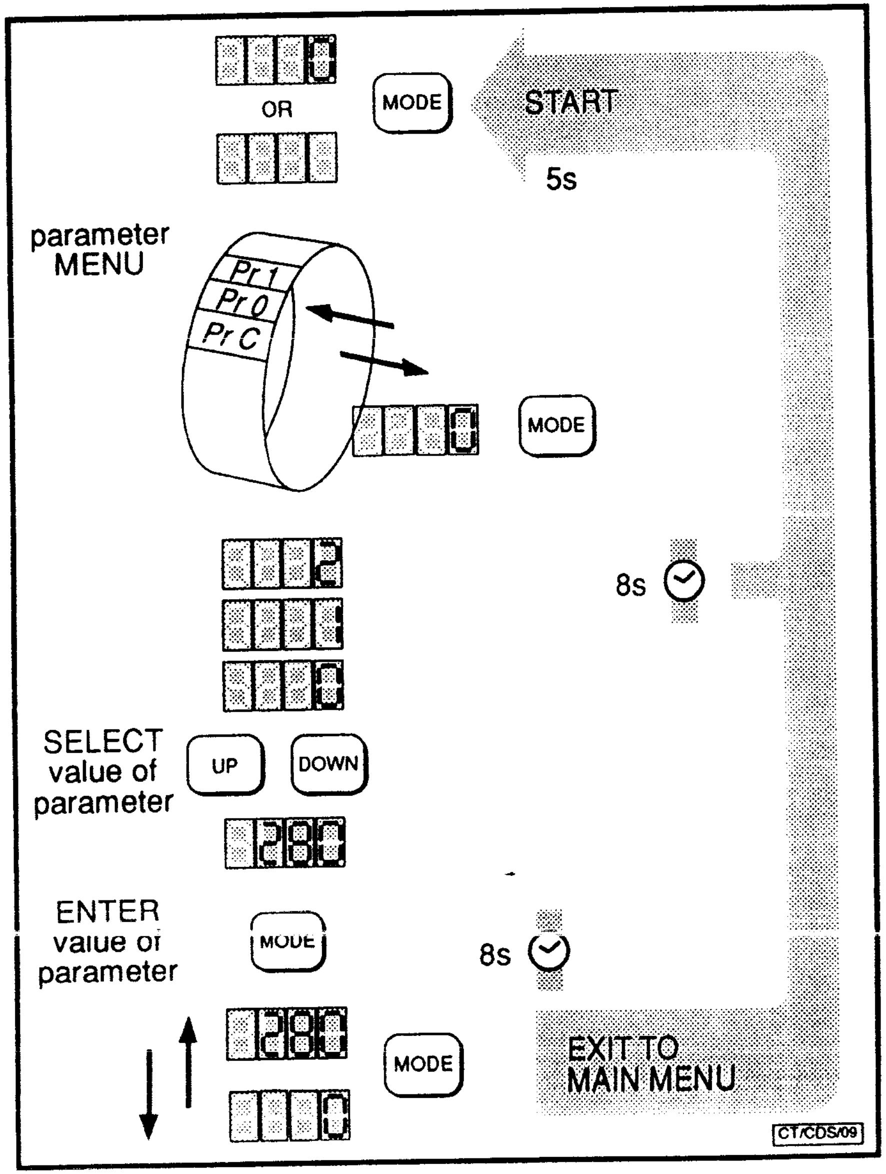


Figure 5-1
Configuration of Drive Parameter Menus

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.

ACCESS TO PARAMETERS

Figure 5-1 shows an example setting Parameter 0 (Pr0) to 28.0 Hz. To adjust other parameters the user can use the UP (▲) and DOWN (▼) keys to scroll through the parameter menu loop.

5.2 Configuration Examples

5.2.1 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, refer to Chapter 4 "Installation – Electrical".

- 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 "Installation – Electrical".

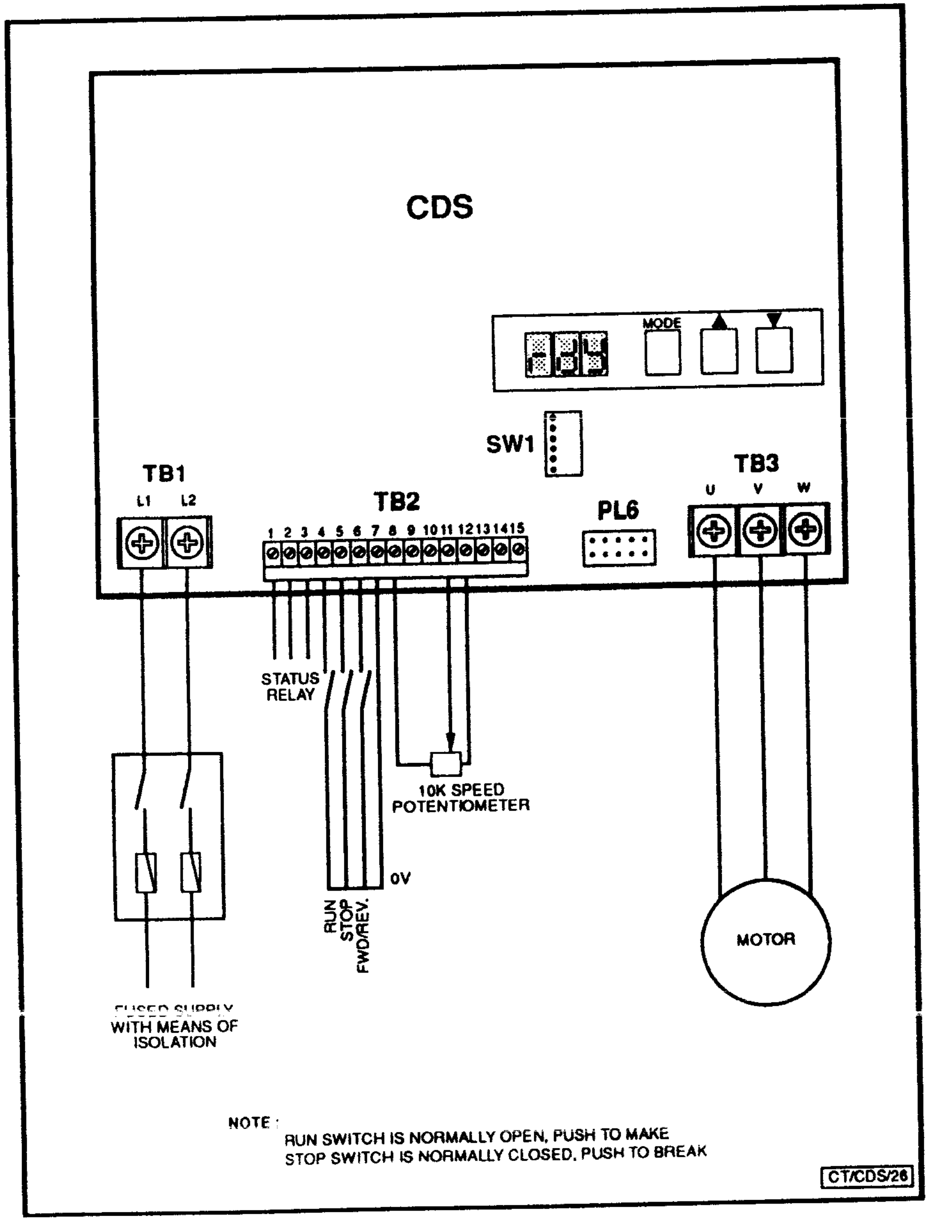


Figure 5-2
Basic Application

5.2.2 Basic Application

It is required to drive a 1.1 kW, 4.4A indication motor to 50 Hz frequency.

Basic control of speed and direction is required, with a controlled ramp to stop.

No motor thermistor is fitted.

Connections

Typical connections are shown in Fig. 5-2.

Commissioning

A CDS 150 is chosen to run the 1.1 kW, 4.4A motor. In order to provide some motor thermal protection the in-built thermal model is to be re-scaled.

Power up the drive and set parameter 5 (maximum continuous current) to 4.4/7.0 x 100 = 63%. The drive can now be run by closing the run switch. Speed can be controlled by the setting of the speed potentiometer.

Further adjustments can be made at this stage, including minimum and maximum speed adjustment (Pr0, Pr1) and also acceleration and deceleration rates (Pr2, Pr3). Frequency can be monitored on the 3 digit display.

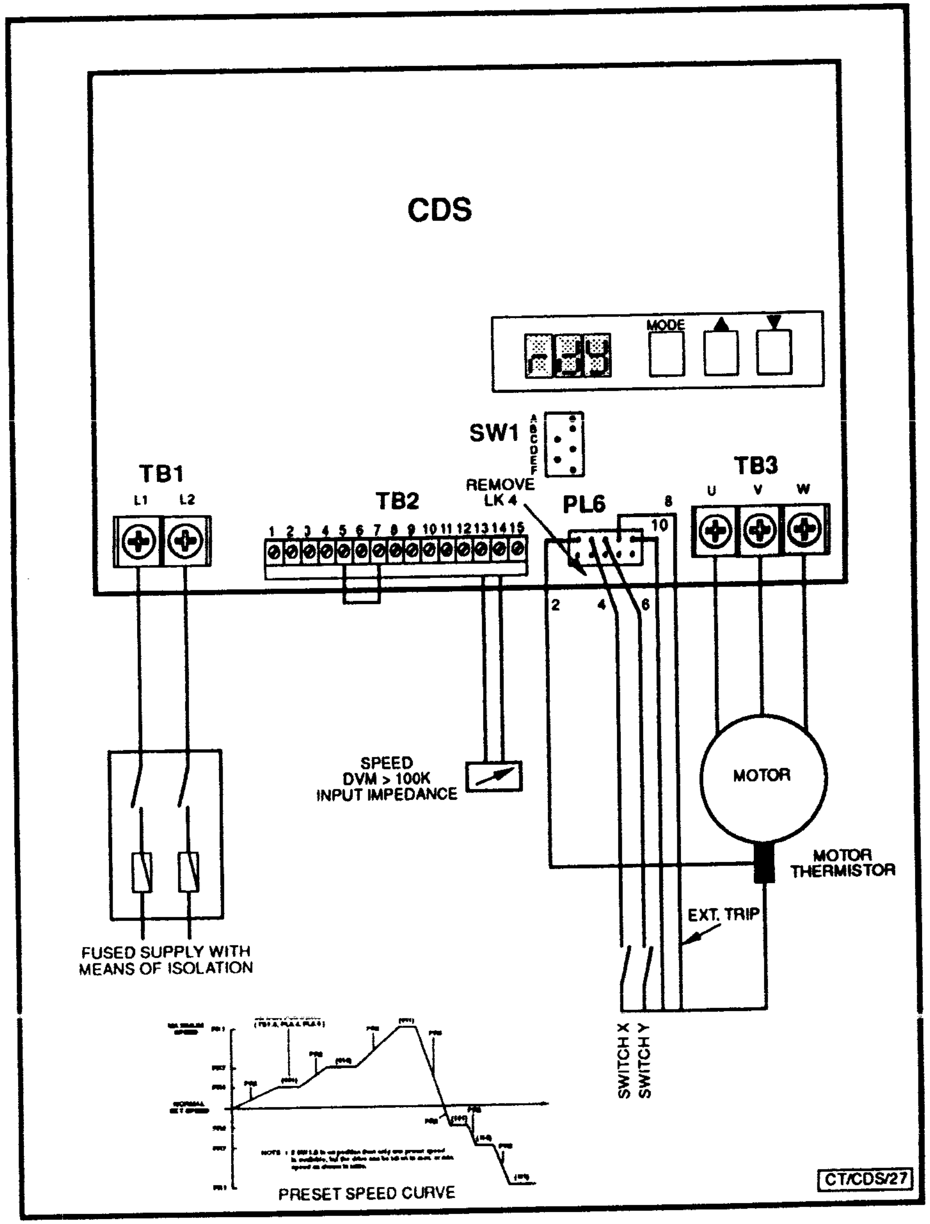


Figure 5-3
HVAC Application

5.2.3 HVAC Application

It is required to drive a 1.5 kW (6A) motor to 70 Hz frequency for a HVAC application. Noise is a prime consideration and an automatic restart facility is required to restart the drive in the event of a spurious trip.

Three fan speeds are required (30, 50 and 70 Hz) and an indication of 'at speed' is also required.

Connections

Typical connections are shown in Fig. 5-3.

NOTE

When using PL6 the jumper link (LK4) has to be removed and the external trip connection re-made externally across pins 8 and 10..

Commissioning

A CDS 150 is chosen to drive the 1.5 kW motor and the motor is suitable for operation at 70 Hz.

Parameters

Automatic start is required and is set by b1 to 0.
Automatic reset is required and is set by b0 to 0.

NOTE

Will automatically start the motor in the event of a trip. See detailed parameter description in Chapter 6.

The ability to catch a spinning motor is required and is carried out by setting b5 to 1.

NOTE

Scn will be displayed when run.
Bit parameter b14 is adjusted to the maximum allowable switching frequency.

Switches

Switches 1A and 1B are set to 'ON' to configure the relay as an 'at speed' relay. Switch 1D is set to 'ON' to set dynamic v/f characteristic to quieten the motor on light load.

Switch IF is set to on to select Pr0 as a preset speed.

By configuring the control switches in a binary sequence the preset speeds can be selected as set in parameters 0, 1 and 7. (see graph shown in Fig. 5-3).

x	y	Speed (Hz)
off	off	0*
off	on	30
on	off	50
on	on	70

* Assumes no connection is made to analogue inputs, e.g. terminal 11.

NOTE

Parameter 7 must be set to the range Pr0 ≤ Pr7 ≤ Pr1 as Pr0 and Pr1 will act as a clamp on Pr7.

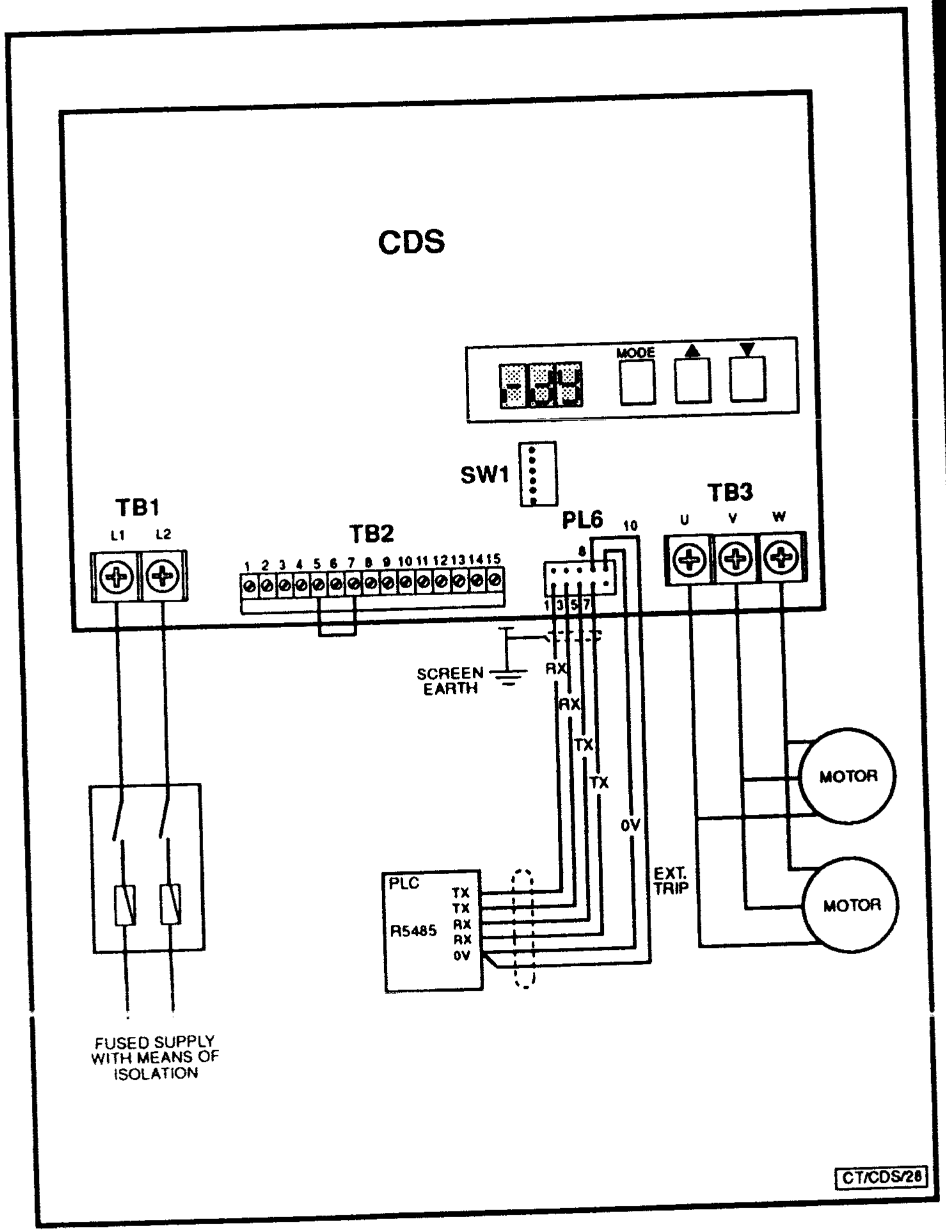


Figure 5-4
Serial Communications Example

CDS

5.2.4 Serial Communications Application

It is required to drive two 0.55 kW motors from one drive. The motors are connected in parallel and are configured identically for load and environmental conditions. Control is via a resident PLC using RS485 line.

Connections

Typical connections are shown in Fig. 5-4.

NOTE
The cable screen is to be earthed at one end only.

Commissioning

A CDS 150 drive is used to power the two 0.55 kW motors and allows 20% and headroom for acceleration. The drive is to be configured for serial communications by setting the following parameters:

Adjust parameters b12, b10 and Pr9 to match the host PLC:

b12	baud rate 4800 or 9600
b10	even or odd parity
Pr9	serial address

Select serial communication control via b6 to 1. For further details see SERIAL COMMUNICATIONS Chapter 7.

5

5.3 Diagnostics and Fault Finding

DISPLAY does not illuminate and drive does not run.
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 key pad is remote mounted, check extension cable wiring.

MOTOR does not start, display shows **rdY**.
Drive is in MANUAL start mode.
Operate UP 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. If in KEYPAD mode press UP key.
Check preset speed is not selected with a setting of "0" Hz.
Check max frequency parameter (**Pr1**) is not "0" Hz.

TRIP CODE at display .
Note that:

- Thermal trip devices should not be continually tripped and reset.
- **Ol** 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.
- **Ol** and **OU** trips may be caused by decelerating too quickly:
  when operating below motor base speed — **Ol** trip
  when operating above motor base speed — **OU** trip
  Increase the value of **Pr3** and check that **b2** and **b7** are set for ramp stop.
- If **PS** or **Err** are displayed, try disconnecting the drive from the supply, wait 2 seconds, 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**).
Also check the settings of current limits **Pr4** and **Pr5**.
Check mechanical load is free to turn.

DRIVE fails to respond to serial communications
CHECK serial communications mode (**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
Set **b13** = 1 to reset all parameters to default values.

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

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.

5.3.1 Trip Codes

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. Hardware fault: 1 - ASIC reading error. 4 - Processor error in serial interrupt. 5 - Keyboard fault. 6 - NOVRAM initialised. 7 - Current sense circuitry has too high positive offset at power up. 8 - Current sense circuitry has too high negative offset at power up.
Et	External trip is operated by terminal PL6/8 or via the serial comms word CW.
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.
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.
to	'timeout'. Trip to indicate that the auto reset function has failed to reset the drive after the third attempt to start with the same trip fault.
UU	The internal power supply voltage has fallen below the operating range. The drive trips instantaneously.
**	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.*

5.2.7 Healthy Indications

rdY	Motor stopped, drive energised.
Numerical value displayed	Motor speed (Hz) or load (%FLC) dependent on the setting of b8 or a parameter value if accessed.
dcb	dc braking active.
Inh	Motor coasting to rest; IGBT bridge inhibited.
Scn	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 point	This indicates that the drive is in the Ixt region.

6 Parameters & Switches

6

6

Parameters & Switches

6.1 Operating Parameters

Parameters are listed in the sequence which they appear in the keypad display when the UP key is used.

Parameter: Pr0
Minimum/Preset 2 frequency: The lower limit of inverter output frequency, determining the minimum speed of the motor.

Range:	0Hz $\leq$ Pr0 $\leq$ Pr1
Default value:	0Hz
Serial mnemonic:	MN

Minimum speed is set by parameter **Pr0**, which can be any value less than or equal to **Pr1**. The logic does not allow the value of **Pr0** to be greater than **Pr1**. The 0 to +5V range of the external reference 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, then when the speed reference is 5V the output frequency is 50Hz.

For values of speed reference voltage between 0 and 5V, the output frequency is given by:—

$$f = (Pr1 - Pr0)\frac{V}{5} + Pr0$$

NOTE
f = frequency
V = speed reference voltage

e.g. if V = 2.5

then $f = (50 - 10)\frac{2.5}{5} + 10$

= 30Hz

or if switch SW1.F is 'on'.

Minimum/Preset 2 frequency becomes the value of the second preset speed when energised from terminal 6 of PL6.

NOTE

The minimum frequency is automatically set to zero 0Hz in this mode.

See **Pr7** description for further details on preset speeds.

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

FREQUENCY RELATIONSHIP

The ULF, the full speed frequency **Pr1**, and the minimum speed frequency **Pr0** are related as follows:—

0Hz ≤ **Pr0** ≤ **Pr1** ≤ ULF

FREQUENCY RESOLUTION

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

Parameter: Pr1
Maximum/Preset 3 frequency:

The value of frequency in Hz above which the motor is not to operate.
Additionally, is the set speed as energised by preset speed 3.

Range:	Pr0 ≤ Pr1 ≤ ULF
Default value:	50Hz
Serial mnemonic:	MX

SPEED

An induction motor runs at a speed which is dependent on the applied frequency, voltage and load. Control of speed is achieved primarily by control of frequency. The drive can supply any frequency up to the maximum for which it is designed (960Hz). It can also reverse the direction of field rotation and so reverse the direction of the motor.

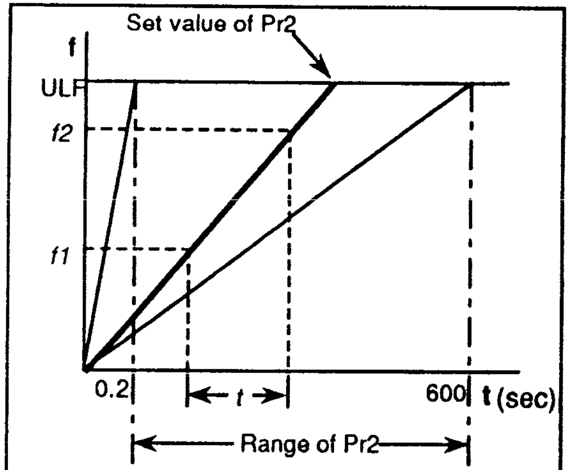
Motor **full speed frequency** is selected by adjusting the value of parameter **Pr1**. For example, **Pr1** = 50 makes the maximum output frequency equal to 50Hz. **Pr1** cannot be greater than ULF, or less than **Pr0**.

Also if terminals 4 and 6 of PL6 are both energised then preset speed 3 is set as per **Pr1**. See parameter 7 description for further details on preset speeds.

6

Parameter: Pr2
Acceleration time: The time to accelerate from 0Hz to the selected value of ULF; determines the slope of the acceleration ramp.

Range:	0.2s to 600s
Default value:	5.0s
Serial mnemonic:	AL



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.

CT/DCP/01/00

Figure 6-1
Acceleration Time Pr2

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 speed change, and to limit DC link voltage during a downward speed change.

Acceleration and deceleration can be regarded as rate of change of frequency since, for a motor controlled by a drive, the speed is nominally proportional to the frequency. If the frequencies at the start and finish of a change of speed are defined, the time to change from one to the other determines the acceleration or deceleration. The values set by Pr2 and Pr3 are the times taken for the drive to change from 0Hz to ULF or vice versa.

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.6-1. A short acceleration time combined with a high inertia load may demand a current higher than the maximum continuous current **Pr5** (CURRENT & PROTECTION) 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** (CURRENT & PROTECTION) were set low would there be a likelihood of an overload trip during acceleration.

Parameter: Pr3
Deceleration time: The time to decelerate from the selected value of ULF to 0Hz; determines the slope of the deceleration ramp.

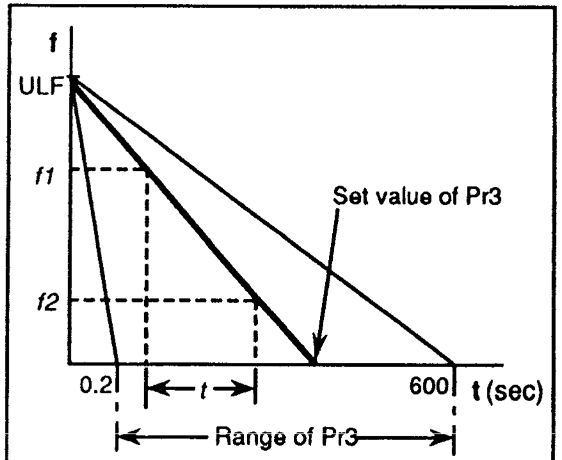
Range:	0.2s to 600s
Default value:	10.0s
Serial mnemonic:	DL

Deceleration time is set by parameter **Pr3** which has a range from 0.2s to 600.0s, Fig.6-2. The effect of deceleration time is, however, not exactly analogous to acceleration time, even though the two characteristics shown in Figs. 6-1 and 6-2 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.

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 dynamic braking mode will have to be utilised with an external resistor to absorb the excess energy. This alternative is discussed further in Chapter 9 "BRAKING".

6



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.

CT/DCP/02/00

Figure 6-2
Deceleration Time Pr3

Parameter: Pr4
Current limit: Maximum level of current overload.

Range:	Pr5 ≤ Pr4 ≤ 150%FLC for Industrial rating drives
Default values:	150% FLC for Industrial rating drives
Serial mnemonic:	TR

CURRENT LIMIT

The level of controlled maximum current output is set by **Pr4**. Its maximum value is 150% of inverter FLC. **Pr4** can be set to any value between **Pr5** and 150%.

OVERCURRENT

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 cable.

The logic responds to transients protecting the motor, the cable 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.

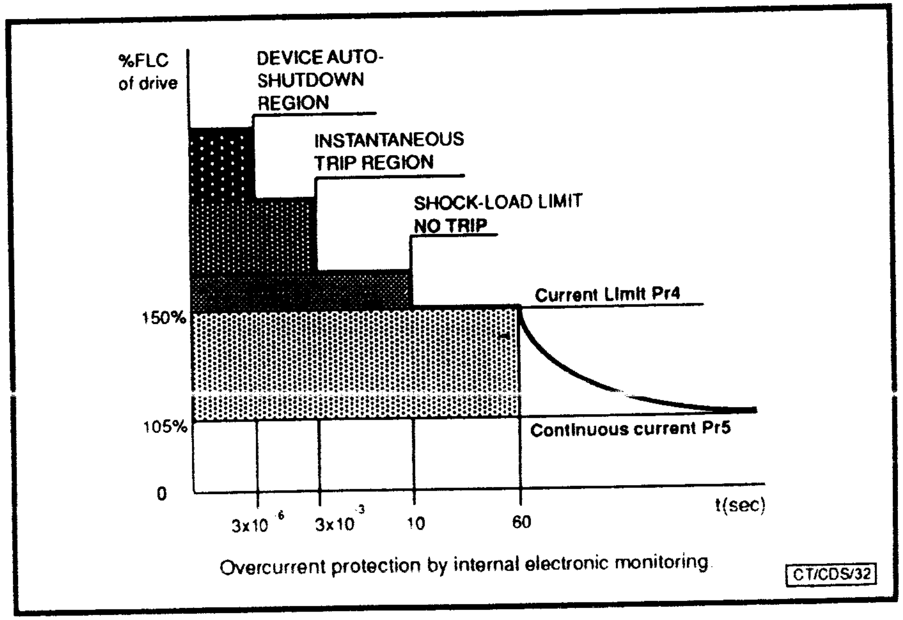


Figure 6-3
Overcurrent Protection

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

CURRENT & PROTECTION

CONTINUOUS CURRENT LIMIT

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 cable. Current in excess of **Pr5** starts the I x t integration and is signalled at the display by flashing of the unused decimal points and will, if sustained, result in tripping of the inverter. Curves are shown in Fig. 6-4.

Trip time = k x **Pr5** / (actual % current - **Pr5**) in seconds,

where k = 25.7

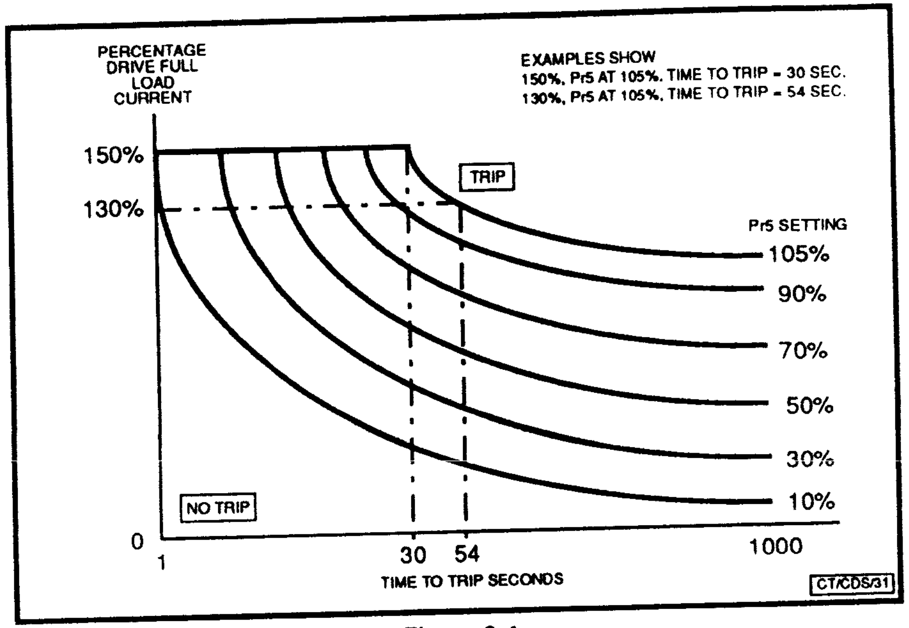


Figure 6-4
I x t Characteristics (NOT TO SCALE)

6

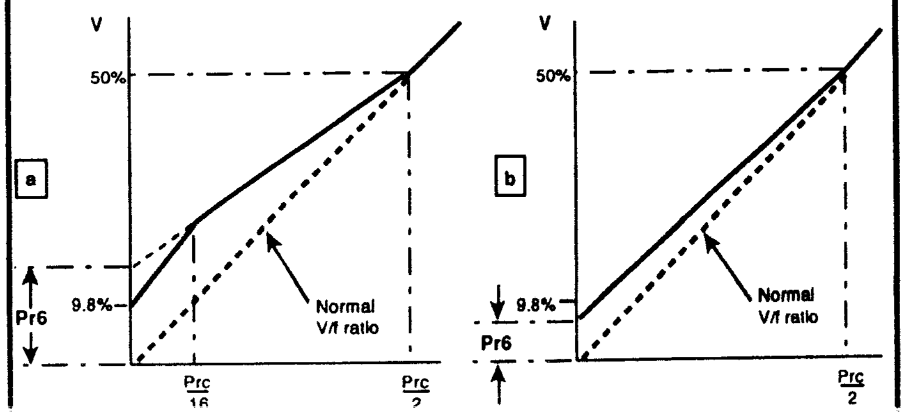
Parameter: Pr6
Voltage (torque) boost: Maximum level of voltage boost at zero frequency.

Range: 0 to 25.5% of main supply voltage
Default value: 9.8%
Serial mnemonic: BO

VOLTAGE (TORQUE) BOOST
To increase the torque available for starting frictional loads and to compensate for the increase in motor losses at low speeds it is useful if torque is boosted (increased) by raising the voltage output above the linear V/f ratio over the lower part of the speed range from 0Hz. The drive offers two alternative ways of applying the boost, selected by parameter **b3**.

AUTO boost is selected by **b3** = 0 — FIXED boost by **b3** = 1.

The degree or amount of boost is determined by paramter **Pr6**, which can be given any value up to 25.5% of main supply voltage.



Voltage (torque) boost Pr6. (a) High level of boost, tapering to 9.8% at 0Hz. Note that boost is maintained at high level down to a frequency of one sixteenth of Prc. (b) Low level of boost — tapers evenly from Pr6 when Pr6 is <9.8% of maximum voltage.

CT/CDS/10

Figure 6-5
Voltage (torque) Boost Pr6

When the value of **Pr6** is set below 9.8% the boost V/f characteristic starts at Pr6% of max output voltage at 0 Hz and tapers linearly to meet the normal V/f characteristic at a frequency of $\frac{Prc}{2}$, Fig. 6-5.

When the value of **Pr6** is set above 9.8% the boost characteristic has a break point at a frequency of Prc/16. The boost tapers from this break point to 9.8% of maximum output voltage at 0 Hz and to the normal V/f characteristic at a frequency of Prc/16, Fig. 6-5.

It is best to choose the lowest effective degree of boost as too high a value may cause the current to reach the current limit level. This has the effect of stopping any increase in frequency, and the motor appears to stall. 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 is selected, the drive applies a voltage increase proportional to the load demand as a percentage of the chosen value of maximum continuous current **Pr5**. If, for example:—

the selected value of **Pr6** is 20%
the selected value of **Pr5** is 105% FLC
and the actual current demand is 90% FLC

then the drive calculates the voltage boost at 0Hz as:—

(0.2 x 0.90 / 1.05) = 17.1%.

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

FIXED boost is the better choice for constant-torque loads requiring a very high starting torque and high inertia loads where rapid acceleration is required i.e. in situations where the machine is more susceptible to stalling. AUTO boost is better for variable-torque loads where the load at starting is also variable i.e. where the machine is less susceptible to stalling.

6

Parameter: Pr7
Jog frequency/
Preset frequency:

If Bit parameter b4 = 0

Jog frequency : The frequency that the drive will run at when the jog/preset terminal is active from **rdy** mode (i.e drive will start from **rdy** and attain the frequency set by Pr7).

If Bit parameter b4 = 1

Preset frequency: The frequency that the drive will run at when the preset terminals select this preset speed (only if the drive is already running).

Range: Pr0 ≤ Pr7 ≤ Pr1
Default Value: 0Hz
Serial mnemonic: P1

Preset Speeds (Frequencies)

WARNING: Check the maximum frequency set point (Pr1) before using preset terminals (PL6.4 and PL6.6) as the PL6.4 and PL6.6 = 1 condition selects the maximum frequency set point.

Up to three preset speeds can be selected any of which can then be instantly applied in any direction by configuring the two external switches (mechanical or open-collector) connected to control terminals (PL6.4, PL6.6). (1 = switch on, or input closed). For an example see Chapter 5 (Drive Configurations).

Table 6-1

b4	Drive Status	PL6/6	PL6/4	Frequency reference	Frequency set by	See Note
0	x	x	open	normal	analogue/serial input	
0	rdy	x	closed	jog	Pr7	2
0	running	open	x	normal	analogue/serial input	
x	running	closed	open	preset 2	Pr0	5
x	running	closed	closed	preset 3	Pr1	
1	x	open	open	normal	analogue/serial input	
1	running	open	closed	preset 1	Pr7	

If 'wireproof' mode is selected, SW1E on, there is no jog function only reset speeds. The operation is defined by Table 6-2.

Table 6-2

b4	Drive Status	PL6/6	PL6/4	Frequency reference	Frequency set by	See Note
x	running	open	open	normal	analogue/serial input	
x	running	open	closed	preset 1	Pr7	3
x	running	closed	open	preset 2	Pr0	5
x	running	closed	closed	preset 3	Pr1	

NOTES:

(1) Forward/Reverse Terminal (TB2.6) can be used independently to select the desired direction with the selected preset speed.

(2) In Jog mode, pressing stop will stop the drive, but on release of stop button the drive will restart if PL6.4 is still connected to 0V.

(3) Pr0 contains the minimum frequency set point and the drive speed cannot be set below this frequency by any reference inputs, except with SW1E on: b4 = 0; preset can be below the min frequency set by Pr0.

(4) Pr1 contains the maximum frequency set point and the drive speed cannot be set above this frequency by any reference inputs.

(5) If SW1F is on then the minimum frequency set point is set at 0 Hz and this cannot be changed by any means. Pr0 is then used to adjust the frequency for preset 2.

Acceleration and deceleration during preset frequency approach are controlled by parameters Pr2 and Pr3.

6

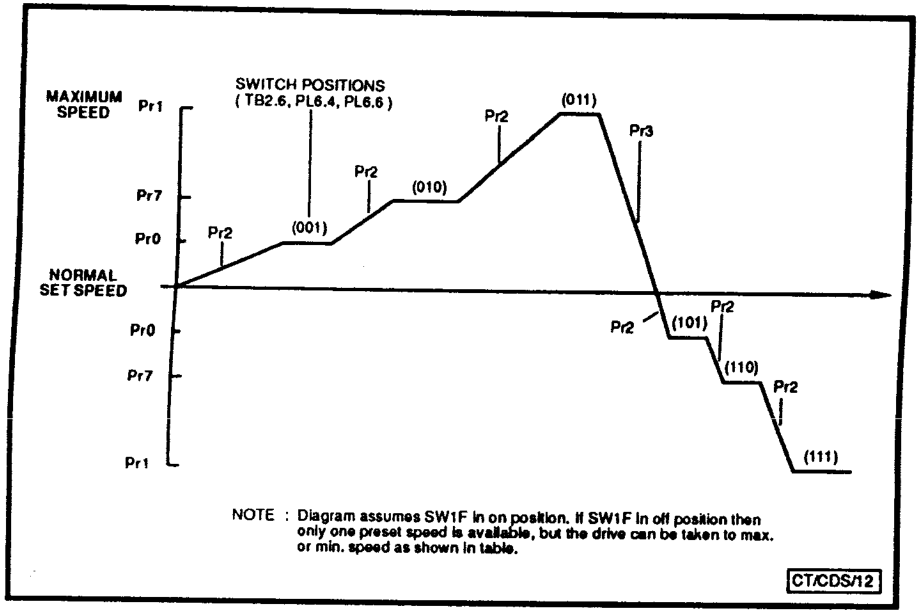


Figure 6-6
Applications of Preset Speed

Parameter: Pr8
DC braking period: The period of injection at 150% of full load current limit.

Range:	0 to 16 seconds
Default value:	1 second
Serial mnemonic:	BR

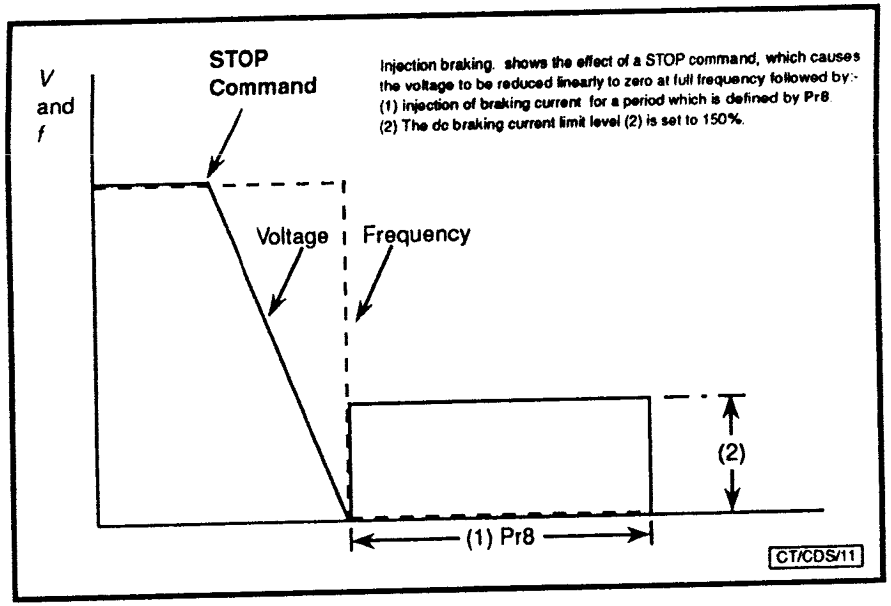


Figure 6-7
Injection Braking

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

Parameter: PrA
Trip Mode: Contains the code for the last trip experienced by the drive

Range:	All trip codes
Default:	Et

LAST TRIP (PrA)

A useful feature for system fault finding is that the reason for the last trip of the drive is available by selecting PrA. This information is not lost even if the drive is powered down and up once after the trip, refer to Chapter 5-3 "DIAGNOSTICS AND FAULT FINDING" for trip codes. The default values for PrA is Et but after the drive has been powered up and down once this will revert to UU as an under voltage trip is inevitable at power down.

NOTE
If the drive is in auto-reset mode and time out (to) occurs then PrA will indicate the trip fault code.

Parameter: Prb
Security code selector Permits the choice of the security code for each inverter. Prb = 0 corresponds to no security code. Values of 100 to 255 can be set via keypad, or 1 to 255 via serial communications.

Range:	0 to 255
Default value:	0
Serial mnemonic:	SC

6.2 Bit Parameters

Parameter: b0

Auto reset:

1 = enabled
0 = disabled

This parameter enables the mode of operation of the drive to be configured to reset and start after a trip (Other than external trip or under voltage), automatically. The auto start function should also be enabled (b1=0) to use this mode of operation. Basically this mode of operation attempts to restart the drive from a trip after 1 second delay. Also the number of identical trips in a specified time window is monitored. If the number of identical trips exceed three, then the drive stays in trip status and disables the auto start operation. So that even after a power interruption drive would not attempt to restart.

Operation

After a trip other than external trip, the drive will attempt to start again after a 1 second delay. Also a trip monitoring period of 8 seconds will be enabled. If the drive trips on any trip other than the previous one during this period then the drive will attempt to start again after a 1 second delay. After the 8 seconds monitoring period any trips will be handled as mentioned above.

If the second trip is the same as the previous trip during the 8 seconds monitoring period then the drive will attempt to restart after 8 seconds delay. Also a further 8 seconds period of trip monitoring will be enabled. If the drive trips on any trip other than the previous one during this period then the drive will attempt to start again after a 1 second delay. After the 8 seconds monitoring period any trips will be handled as mentioned.

If the third trip is the same as the previous trip during the 8 seconds monitoring period then the drive will stay in trip mode. The display flashes "to" for time out in auto reset operation. Also the auto start (Not auto reset) function will be disabled (b1 becomes 1 automatically) to prevent the drive from running if power supply interrupted. Even after power interruption the parameter PrA will show the trip condition which disabled the drive.

After the drive has tripped on timeout 'to' the drive can be reset from the terminal strip with one further life remaining.

In order to totally reset the Auto reset memory the drive will have to be powered down and up again. The drive will then power up in manual start mode (b1=1).

Exceptions:

External Trip	:	No restart available automatically.
Under Voltage Trip	:	Normal power down condition. If power is reapplied then the drive will restart.

Default value:	b0 = 0
Serial mnemonic:	DS

6

Parameter: b1
Auto start or manual start selector:

0 = auto start
1 = manual start

Default value: b1 = 1
Serial mnemonic: DS

In the AUTO-start mode, the inverter starts the motor (delay 100ms) 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 start 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.

RESET

In AUTO start mode and with terminal control mode selected (b9=1): after a trip has occurred, performing a RESET will cause the drive to restart immediately.

In MANUAL start mode and with terminal control mode selected (b9=1): after a trip has occurred, performing a RESET will set the drive to **rdY**. The drive then requires an external START signal to start the motor.

SUMMARY OF STARTING CHARACTERISTICS

AUTO start	When drive is initially energised	100ms delay then auto start
	After stopping due to power supply disturbance	100ms delay then auto start
	When in a TRIP condition	(Trip Code signalled) 1.0s delay to RESET Immediate start after RESET or if in keypad mode (b9=0), waits for UP (▲) or DOWN (▼) key to be pressed.
	When in a STOP condition	(**rdY** signalled) Waits for START signal or if in keypad mode (b9=0), waits for UP (▲) key to be pressed.
MANUAL start	When drive initially energised	(**rdY** Code signalled) Waits for START signal
	When stopped by any signal other than a trip	Signals **rdY**, requires START signal
	When stopped by a trip signal	Signals a Trip Code, waits for RESET, then waits for START signal

Parameter: b2 & b7
Braking method selector:

Parameter b2	b7	Mode
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

STOPPING & BRAKING MODES

Selected by parameters **b2** and **b7**, with **Pr8** additionally for the DC INJECTION option. A STOP command is required to bring the motor to rest regardless of which of the stopping or braking options is chosen.

The CDS range of drives is available with or without the dynamic braking option. Without it, high level ramp (resistive) braking is of no advantage.

In high level ramp, the drive automatically changes to fixed boost on ramp down. This gives fast stopping, even faster than dc brake, but a dynamic brake unit is required.

In standard ramp, the V/F characteristics follow the characteristics set by parameter **b3**.

Resistive braking is preferable for applications where the inertia of the load is high and short stopping times are required. Care must be taken to select a resistor suited to both the motor and the application. The supplier of the drive should be consulted if there is any difficulty about resistor ratings. The options for bringing the motor to a halt are:—

OPTION	KEYPAD DISPLAY during stopping period
coast	**Inh**
ramp	normal— speed or load according to **b8**
injection	**dcb**

RAMP MODE

Ramp brings the motor to rest in a time proportional to the decelerating time parameter **Pr3** (refer to CHANGE OF SPEED RAMPS). Ramp is used if a different stopping time to the natural coasting time is required, or if a linear rate of deceleration is required.

If **b2** = **b7** = 0 (standard ramp) the ramp is halted if the DC link voltage reaches an internal limit and continues when the voltage falls below the limit.

If **b2** = **b7** = 1 (high level ramp) the ramp is continuous. This setting requires the use of the dynamic brake unit, refer to Chapter 9, "BRAKING".

DC INJECTION MODE

Injection braking requires parameter **Pr8** to be adjusted between the limits of 0 and 16 seconds of motor rated FLC. The applied braking voltage is fixed (Refer to Fig. 6-7).

At the STOP command, the output voltage is rapidly reduced at constant frequency, refer to Fig. 6-7, so that the motor is defluxed. A braking voltage is then applied at zero frequency. As the motor comes to rest, direct current is applied for a period as defined by **Pr8**.

Parameter: b3
Low speed torque boost selector:

0 = auto boost
1 = fixed boost

Default value: b3 = 0
Serial mnemonic: DS

VOLTAGE (TORQUE) BOOST

To increase the torque available for starting frictional loads and to compensate for the increase in motor losses at low speeds it is useful if torque is boosted (increased) by raising the voltage output above the linear V/f ratio over the lower part of the speed range from 0Hz. The drive offers two alternative ways of applying the boost, selected by parameter **b3**.

Parameter: b4
Jog/preset selector:

1 = preset
0 = jog

Default value: b4 = 1
Serial mnemonic: DS

JOG FREQUENCY/PRESET FREQUENCY

Either jog or preset frequency can be selected using **b4** with **Pr7** setting the frequency.

When jog is selected and with the drive in **rdy** mode, closing terminal PL6/4 will start the drive and will ramp up to the frequency set by **Pr7**, opening PL6/4 will cause the drive to ramp down and stop.

When preset is selected the drive must be already running for the command from PL6/4 and/or PL6/6 to have any effect. When PL6/4 and/or PL6/6 is closed the drive will ramp from its existing frequency to the frequency set by **Pr7**.

See **Pr7** for more information.

Parameter: b5
Catch spinning motor selector: 1 = enabled
0 = disabled

Default value: b5 = 0
Serial mnemonic: DS

Enables the drive to be energised onto a motor whose shaft is rotating, without causing a trip. On receiving a start signal, the drive scans the motor frequency and connects itself at a synchronising value. During the scanning period the keypad displays 'Scn'. 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.

Parameter: b6
Analogue Input/ serial comms mode :

0 = controlled by analogue input
1 = controlled by serial comms link

Default value: b6 = 0
Serial mnemonic: DS

See b11 and LK5 for more information.

NOTE
Drive data can be read at any time independently of b6.

LK5	PL6/9 Local/ Remote	b6	b11	Frequency reference source
in	x	0	Ur	voltage input
in	x	0	0-20 4-20 20-4	current input
in	x	1	x	serial communications input
out	L	x	x	voltage input
out	R	0	Ur	voltage input
out	R	0	0-20 4-20 20-4	current input
out	R	1	x	serial communications input

Parameter: b7
See b2
Serial mnemonic: DS

Parameter: b8
Indicate frequency or load current value: 0 = frequency (Hz)
1 = load (%FLC)

Default value: b8 = 0
Serial mnemonic: DS

NOTE
The analogue output (terminal 13 on TB2) can either indicate the value of the displayed quantity or the quantity of the non-displayed function, see SW1C.

Parameter: b9
Keypad or terminal mode selector: 0 = keypad
1 = terminal

Default value: b9 = 1
Serial mnemonic: DS

NOTES

(1) Keypad must NOT be disconnected/connected when the drive is energised.

(2) Keypad Control b9 = 0
This method of control is recommended for commissioning purposes rather than for normal drive control. By changing b9 to a '0', control of speed, stop/start, and reset, can be achieved using the keypads alone. All control inputs are inhibited, except for the serial link, reverse input TB2/6 and the motor thermistor input PL6/2.

If auto start, b1 = 0, has been selected, the drive will, on power-up, accelerate to the last speed set. If manual start, b1 = 1, has been selected, the drive will, on power-up, display [rdY]. To start the drive, just press either the UP or DOWN keys, and the drive will accelerate to the last speed set. The output frequency can be increased or decreased by using the UP or DOWN keys. The display shows the set point frequency, and not the actual frequency, (which is indicated in TERMINAL control).

Parameter: b10
Parity selector: 0 = even parity
1 = odd parity

Default value: b10 = 0
Serial mnemonic: DS

Parameter: b11
Analogue speed reference:

0 to +5V = Ur
0 to 20mA = 0.20
4 to 20mA = 4.20
20 to 4mA = 20.4

Default value: b11 = Ur
Serial mnemonic: DS

See b6 and LK5 for more information.

Parameter: b12
Baud rate selector:

4.8 = 4800 baud
9.6 = 9600 baud

Default value: 4.8
Serial mnemonic: DS

Parameter: b13
Reset parameters to default values:

0 = inactive
1 = set default values

Default value: 0
Serial mnemonic: CW

NOTE
The action of setting default values will set b13 back to '0'.

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 — Upper Limit Frequency - 120 = 120Hz
240 = 240Hz
480 = 480Hz
960 = 960Hz @ 11.7kHz

Default values: - PWM 2.9kHz
- ULF 120Hz

Serial mnemonic: FQ

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PWM SWITCHING FREQUENCY

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

The alternating sinewave output of the inverter is synthesised from the DC bus by a pattern of on-off switching applied to the control gates of the IGBT bridge. This method of producing an alternating output from a DC source is called pulse width modulation (PWM). The pulsed switching pattern is generated by an application-specific integrated circuit (ASIC) which is itself controlled by a microprocessor.

In making a choice of PWM switching frequency, the factors to be considered are the effect on the drive and motor, and the relationship to the upper limit of inverter output frequency (ULF, see below).

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

UPPER LIMIT 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.

If the selected PWM switching frequency is 2.9kHz, the high ULF values (480Hz and 960Hz) **are not available**, and cannot be selected. If 960Hz is required then the PWM switching frequency must be set at 11.7kHz.

The ULF is the highest frequency of the inverter AC output sinewave and is an upper limit for **Pr1**. If the motor is a standard 50Hz or 60Hz machine, the ULF will normally be set to 120Hz. If the motor is a special high speed machine one of the higher ULF values would be chosen.

The behaviour of the other control functions is dependent on the ULF value chosen:-

- acceleration — **Pr2**
- deceleration — **Pr3**
- frequency resolution

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 set the ULF without entering a value for PWM first, press MODE twice after adjusting the parameter code to **b14**.

NOTE

After changing b14 ensure **Pr0** , **Pr1**, **Pr2**, **Pr3** and **Prc** are set correctly before running.

Parameter: Prc
Max. voltage frequency: Defines the frequency at which the drive delivers the rated voltage.

Range:	50Hz < Prc < ULF
Default value:	50Hz
Serial mnemonic:	BS

TORQUE-SPEED CHARACTERISTIC

The voltage-to-frequency ratio (V/f) delivered by a drive 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.

CDS drives permit a wide range of output frequencies to be assigned at the rated voltage. In other words, the base speed can, within wide limits, be modified to suit the application and motor.

This facility enables the profile of the inverter output V/f characteristic to be varied. Curves in Fig. 6-8 show this at one extreme the whole of the V/f characteristic is a constant torque output, whereas at the other extreme almost the entire speed range is constant power. This feature of CDS drives enables the user to adjust the V/f profile to match the motor characteristic to a wide variety of applications.

The value of the frequency when the drive reads its maximum output voltage is called the **maximum voltage frequency** (MVF) and is adjusted by parameter **Prc**. The maximum value of the PrC is equal to the ULF. The minimum value is 50Hz.

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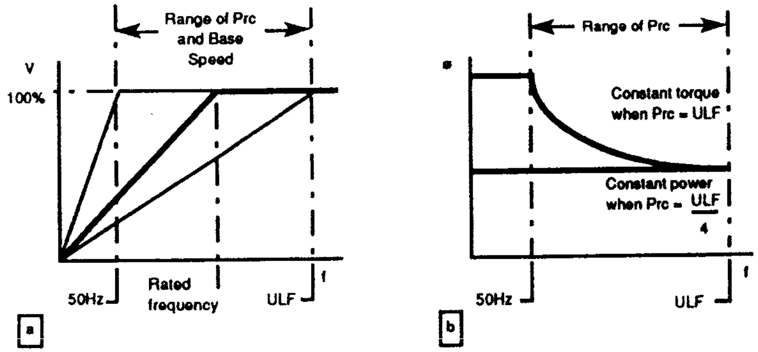

Profiling the drive & motor output characteristic by relating the values assigned to Prc.

(a) Prc can be made equal to any value between 50Hz & ULF

(b) shows how the torque profile changes according to Prc.

Note that ULF is itself selectable from one of four frequencies.

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Figure 6-8
Inverter Output Profiling - Prc and ULF

6.3 DIL Switch

DIL switch settings cannot be adjusted via the serial link and are only read when the drive is powered up.

DIL switch must not be adjusted when the drive is energised.

SW1A, B
Relay Selector:

Default value: Off.

		Drive status when:	
SW1A	SW1B	Relay energised	Relay de-energised
off	off	healthy	tripped
off	on	running	stopped (rdy)
on	off	above min speed	at min speed
on	on	at set speed	not at speed

When the relay is configured as "at speed", "min speed", or "zero speed" there is a 0.5 Hz hysteresis to prevent chatter. Relay is also de-energised when there is no mains power to the drive.

SW1C
Analogue Output Selector:

Off = as quantity indicated on 3 digit LED display
On = alternate quantity

Default value: Off

When the analogue output is configured to be alternate to the displayed quantity, it is possible to have a displayed quantity of frequency while the load signal is presented at the analogue output (TB2/13).

LED Display

b8	SW1C	Information on LED display	Information at analogue output TB2/13
0	off	frequency	frequency
0	on	frequency	load
1	off	load	load
1	on	load	frequency

SW1D
V/f Characteristic Selector:

Off = fixed V/f
On = dynamic V/f (load dependent)

Default value: Off

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.

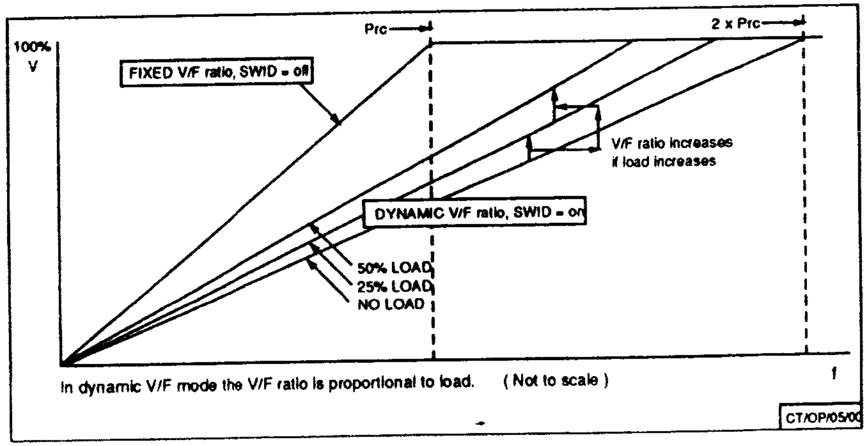

Figure 6-9
Fixed/Dynamic V/f Ratio

SW1E 'Wireproof' Control Selector

SW1E = Off — START, STOP, REVERSE, RESET (terminals have their normal functions)

SW1E = On — 'Wireproof' input selected (this redefines the functions of ther terminals)

Default value = off

START TB2/4, STOP TB2/5, FORWARD/REVERSE TB2/6 and RESET TB2/10, so that only permanent status of the inputs cause the drive to run. (In normal mode a momentary contact closure, starts the drive).

Other differences are:—

At 0Hz the drive output stage is completely off and therefore the motor is not energized.

If autostart **b1** = **1** is enabled and there is a brief interuption in the mains supply, but not long enough to completely shut it down, the drive will restart if either run forward or run reverse is selected.

If manual start **b1** = **0** is selected the same brief interuption will cause the drive to show UU trip and a reset will be required to restart.

TERMINAL NUMBER	TB2/10	TB2/5	TB2/4	TB2/6		
NEW DESIGNATION	inhibit	run/stop	run forward	run reverse	ACTION	See Note
	open	x	x	x	drive inhibited. i.e. if running coasts to a halt, 'Inh' displayed	2,3
	closed	open	x	x	stop according to b2 and b7	2
	closed	closed	open	open	stop after 65ms delay * according to b2 and b7	1, 2
	closed	closed	open	closed	run in reverse	
	closed	closed	closed	open	run in forward	
	closed	closed	closed	closed	stop according to b2 and b7	3

NOTES

(1) The 65ms delay is to allow the run forward and run reverse contacts to change over via this state without actually putting the drive into stop mode.

(2) If this stop mode is activated first and then TB2/10 is opened second the drive will stop according to b2 and b7.

If this stop mode is activated second and then TB2/10 is opened first the drive will inhibit.

(3) If this stop mode is activated and TB2/10 is opened either first or second the drive will inhibit.

Reset

In this mode to reset after a trip, open inhibit, TB2/10, and then close it again. The drive will start after a 1 second delay if, it is in a run state.

6

SW1F
Pr0 Function Selector:

SW1F - off Pr0 functions as minimum speed. and preset speed 2. Both are the same.
SW1F - on Minimum speed is set to zero, value in Pr0 becomes preset speed 2. See parameter Pr7 for further information on preset speeds.

Default value = off.

6.4 Links

LK4 Motor Themistor Input Enable

In = input disabled (prevents tripping on th when a thermistor is not used).
Out = output enabled.
Default value = In.

LK5 Local/Remote Input Enable

In = input disabled (effectively remote selected)
Out = output enabled
Default value = in.

See b6 and b11 for more information.

6.5 Parameter Quick Reference

Par.	Function	Units	Min.	Max.	Def.	Mnem.
Pr0	min speed; preset 2 speed	Hz	0	Pr1	0.0	MN
Pr1	max speed; preset 3 speed	Hz	Pr0	1ULF	50.0	MX
Pr2	accel time (0 to ULF)	sec	0.2	600	5.0	AL
Pr3	decel time (ULF to 0)	sec	0.2	600	10.0	DL
Pr4	current limit	%FLC	Pr5	150	150	TR
Pr5	max continuous current	%FLC	10.0	105 or Pr4	100	TH
Pr6	voltage (torque) boost	%supply V	0	25.5	9.8	BO
Pr7	jog speed; preset 1 speed	Hz	0	ULF	0	PI
Pr8	DC braking period	sec	0	16.0	1.0	BR
Pr9	serial comms address		0	99	11	SE
PrA	last trip				Et	SW
Prb	security code (0=none)		100	255	0	SC
b0	0=not auto-reset 1=auto-reset enable		0	1	0	DS
b1	0=auto-start en. 1 = manual start enable		0	1	1	DS
b2	braking b2, b7 = 00 = standard ramp 01 = coast 10 = inject DC 11 = high level ramp (resistive)		0	1	0	DS
b3	0 = auto boost 1 = fixed boost		0	1	0	DS
b4	0 = jog speed en. 1 = preset speeds enable		0	1	1	DS
b5	0 = not catch 1 = catch spinning motor		0	1	0	DS
b6	0 = analogue 1 = serial comms control		0	1	0	DS
b7	braking [see b2]		0	1	0	DS
b8	0 = freq display 1 = load display		0	1	0	DS
b9	0 = keypad mode 1 = terminal mode		0	1	1	DS
b10	0 = even parity 1 = odd parity		0	1	0	DS
b11	current-loop speed ref	mA	0f, 0.20, 4.20, 20.4			DS
b12	serial comms rate	kbaud	4.8; 9.6		4.8	DS
b13	0 = no action 1 = set defaults		0	1	0	CW
b14	PWM switching frequency	kHz	2.9;5.9;8.8;11.7		2.9	FQ
b14	ULF (upper limit of freq) (max 240 @ 2.9; 480 @ 5.9 & 8.8)	Hz	120;240;480;960		120	FQ
PrC	MVF (max voltage frequency)	Hz	50.0	ULF	50.0	BS

		Drive status when:	
SW1A	SW1B	Relay energised	Relay de-energised
off	off	healthy	tripped
off	on	running	stopped (rdy)
on	off	above min speed	at min speed
on	on	at set speed	not at speed

SW1C freq or load o/p	Off = same as display; On = opposite
SW1D	Off = fixed v/f; On = dynamic v/f ratio
SW1E	Off = normal; On = wireproof
SW1F	Off = Pr0 min spd; On = 0 min spd, Pr0 preset 2
LK4 Thermistor input;	In = disable
LK5 Local/Remote input;	In = remote.

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7 Serial Communications

7

Serial Communications

7.1 Introduction

A communications link is standard in all CDS 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. CDS 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. 7-3, and up to 99 if line buffers are used.

The communication port of the drive module is the four terminals 1, 3, 5, 7 (PL6), and the 0V terminal 10 (PL6). The standard connection is five wire RS485, or RS422 (refer to Fig. 7-2), three wire RS232 can be used in some systems (refer to Fig. 7-1).

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

7.2 Connecting Serial Communications

7.2.1 Serial Communication connections

Serial communications:-

RS485 cable type:	braid screened, 120 Ohm characteristics impedance dual twisted pair and 0V.
Termination:	Cable terminated at each end by 120 Ohm resistor.
Maximum cable length:	1200 metres
Operation:	multidrop, equipment can be connected along the cable.
RS422 cable type:	braid screened, 100 Ohm characteristics impedance dual twisted pair and 0V.
Termination:	Cable terminated at receiver end by 100 Ohm resistor.
Maximum cable length:	1200 metres.
Operation:	one transmitter can drive 10 receivers at the end of the cable.
RS232 cable type:	braid screened, 3 core.
Termination:	None.
Maximum cable length:	5 metres.
Operation:	one transmitter can drive one receiver.

Voltage levels:-
Maximum + voltage with respect to 0V at any terminal = +12V
Maximum - voltage with respect to 0V at any terminal = -7V

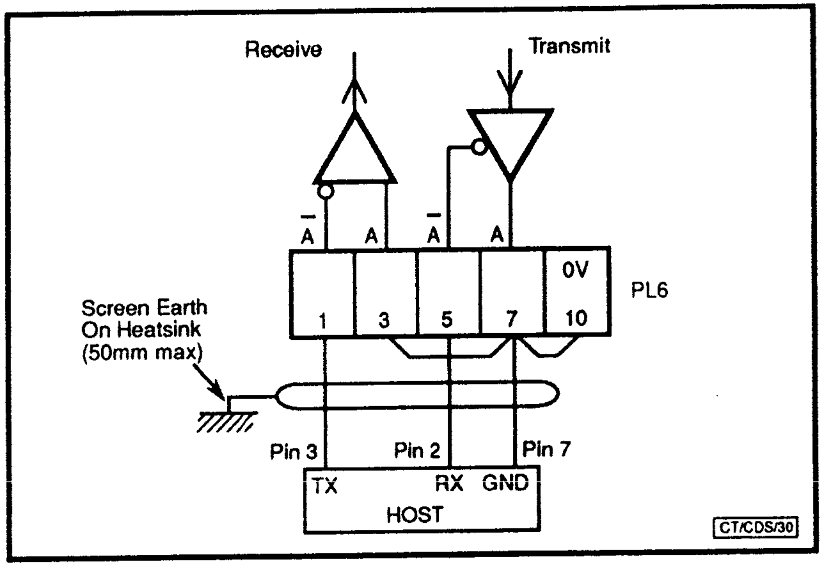

Figure 7-1
RS232 Serial Communications Link Connections

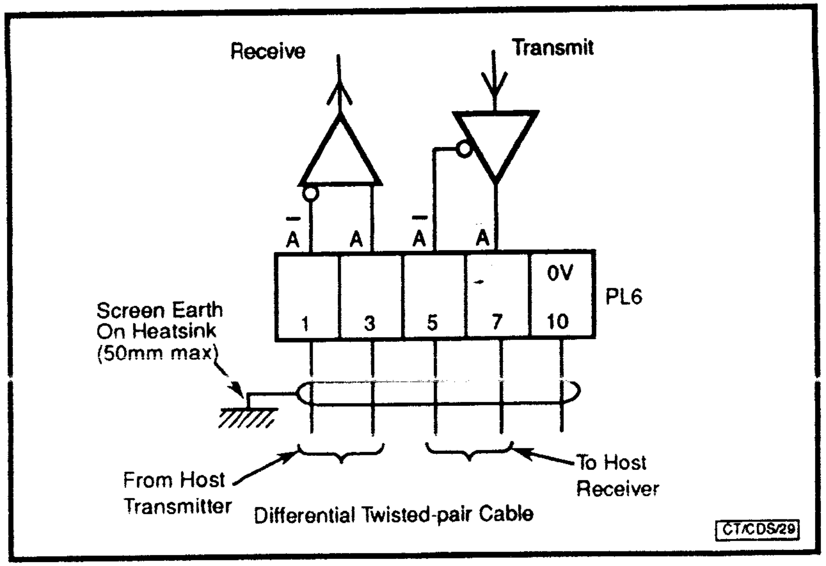

Figure 7-2
RS422/485 Communications Link Connections

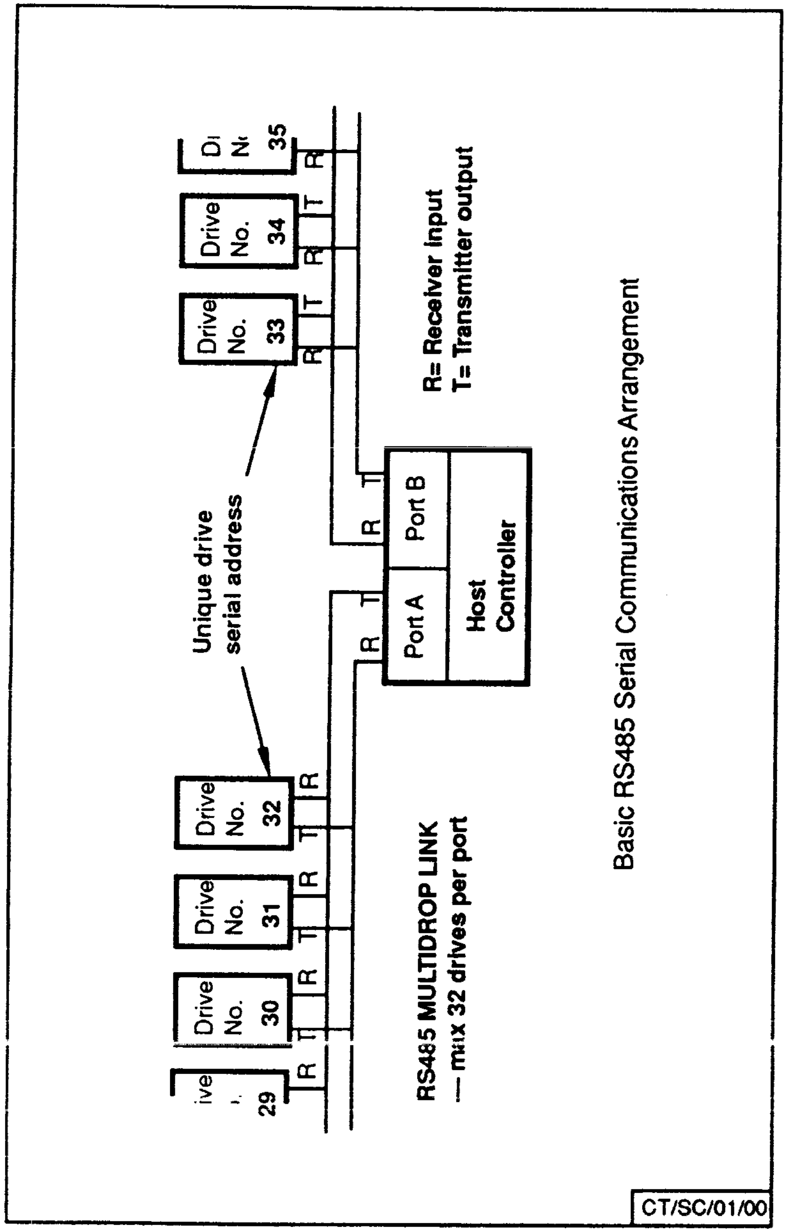

Figure 7-3
RS485 Multidrop Link Connections

7.2.2 RS422 Connection

Refer to Figs. 7-2 and 7-4.

Using a RS422 standard limits the number of receivers to a maximum of 10, also all receivers must be connected at the end of the cable and NOT along its length. The cable must be braided screen, 100 Ohm, twisted pair, terminated at the receiver end by a 100 Ohm resistor.

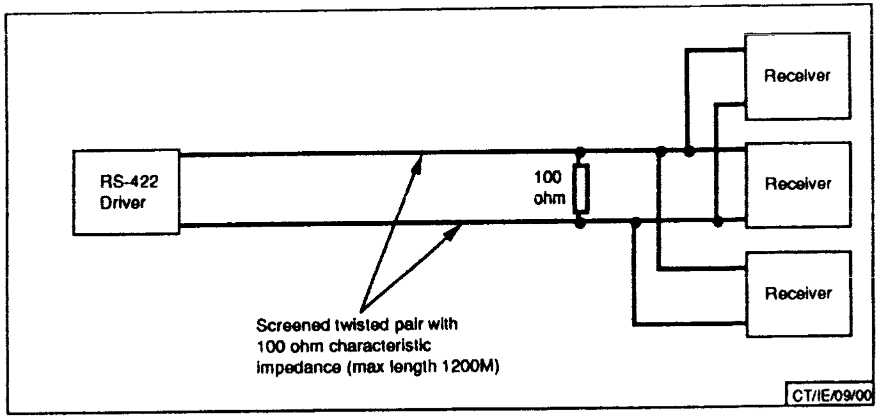

Figure 7-4
Standard RS422 Connections

NOTE

The 100 Ohm terminating resistor (R113) can be fitted into one of the CDS Drives.

For Serial Port pin connections, refer to Fig. 7-2.

7.2.3 RS485 Connection

Refer to Figs. 7-2, 7-3 and 7-5.

The standard connection used is RS485 which must use a braided screened 120 Ohm twisted pair cable, terminated at each end with a 120 Ohm resistor.

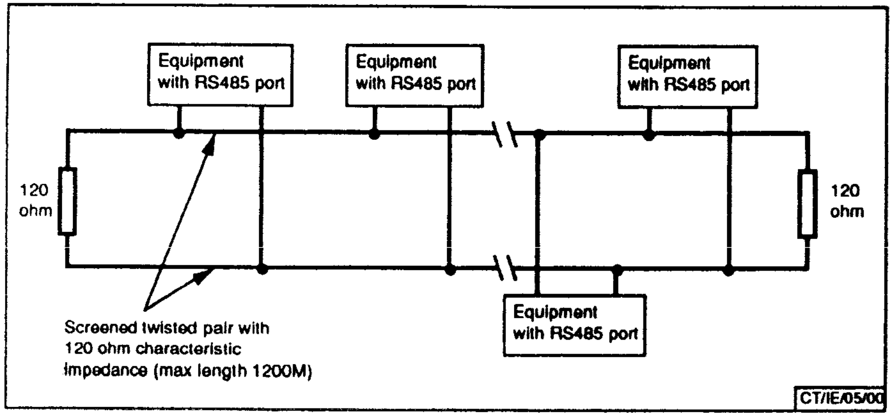

Figure 7-5
Standard RS485 Connections

Stub connections to the equipment from the main cable must be as short as possible. If a CDS Drive is connected at the end of a cable the terminating resistor can be fitted into the CDS Drive (R113).

NOTE
Resistor Value: 120 Ohm 0.25Watt.

7.2.4 RS232 Connection

Refer to Fig. 7-1.

The serial port on the CDS Drive can be configured to interface with an RS232 link. Using this configuration only one drive and receiver can be connected together. A terminating resistor is not used.
The user should note that the CDS is not specified to be compatible with RS232. Some PLC's or computers generate and accept voltage levels outside of the specification of this product.
For users requiring reliable connection RS485 or RS422 should be used.

7.3 Components of Messages

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 contains 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 CDS 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 Table 7-2.

The first 32 characters in the ASCII set (hex 00 to IF, 'NUL' to 'OS') are used to represent special codes. These are the Control Codes, each of which has a particular meaning refer to Table 8-1. 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 is the binary byte 0000 0010. The drive is programmed to know that this character signals that a command will follow:

Table 7-1 details the only control codes that the CDS drive will respond to, other control codes and the 'space' character (20h) should not be used when communicating with the CDS drive.

Table 7-1 Control Characters in CDS Drives

Character	Meaning	ASCII code hex —	Keyed as... Control-
EOT	Reset	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 CDS 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 seconds).

7.3.1 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 (refer to Table 7-3), which is a simple two-character code. When data is being communicated, it is preceded by the appropriate mnemonic. The data mnenonic 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.

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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

Data	-	0	9	5	.	0
Character Number	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.

Table 7-2 "Low" ASCII Character Set

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

NOTE

Control characters also marked as (^D).

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Table 7-3 Data Mnemonics in Alphabetical Order

Mnemonic	Name	Type of Data	Read - only	Write, only when rdy or tripped	Parameter
AC	Actual frequency	numeric (Hz)	•		-
AL	Acceleration time	numeric (s)			Pr2
BO	Boost level	numeric (% of Vmax)			Pr6
BR	DC Brake time	numeric (s)			Pr8
BS	Base speed	numeric (Hz)		•	Prc
C1	Configuration	hex code	•		SW1A to SWIF
CW	Command word	hex code			-
DL	Deceleration time	numeric (s)			Pr3
DS	Drive set-up	hex code		•	b0 to b12
FQ	Frequency (switching frequency & ULF)	hex code		•	b14
LD	Load	numeric (% of FLC) with sign	•		-
MN	Minimum frequency	numeric (Hz)			Pr0 also preset 2
MX	Maximum frequency	numeric (Hz)			Pr1 also preset 3
P1	Preset/jog frequency	numeric (Hz) with sign			Pr7
SC	Security code	hex number			
SE	Serial address	hex number	•		Pr9
SP	Set point frequency	numeric (Hz) with sign			-
SW	Status word	hex code	•		PrA
TH	Thermal current limit	numeric (% of FLC)			Pr5
TR	Transient current limit	numeric (% of FLC)			Pr4

NOTE

Parameters associated with serial communication are also read-only, b6, b10, b12. It is not possible to read or write to b13.

7.4 Structure of Messages

7.4.1 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:-

NOTE

Local/Remote must be in remote to enable serial comms to write to parameters.

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

- Analogue input/serial communications mode to be set as follows —

  b6 = 1 if parameters are to be adjusted by the host.

  b6 = 0 allows parameters to be read by the host.

7.4.2 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
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	BCC
EOT Control-D	1	1	4	4	STX Control-B	S	P	-	0	4	7	.	6	ETX Control-C	&

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** and **b12** (contained in DS), AC, C1, LD, SE, SW.

7.4.3 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	BCC
STX Control-B	S	P	+	0	1	1	.	2	ETX Control-C	'

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 at 11.2Hz" in this example.

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

i) **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

ii) **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 ⟶ AC ⟶ LD, MN, MX, AL, DL, TR, TH, BO, PI, BR, SE, SC, SW, DS, FQ, BS, CW, C1

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

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

Each of the nine separate 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 decimal (20 hex). As the ASCII characters from hex 00 to IF 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.

7.5 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 or four hexadecimal code digits:-

SE	Serial Address **(Pr9)**
SC	Security Code **(Prb)**
SW	Status Word, SW
DS	Drive Setup
FQ	PWM Switching Frequency and ULF **(b14)**
CW	Command 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 hexadecimal '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.

7.5.1 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.

7.5.2 SC - Security Code

7.5.3 SW — Status Word (4 Hexidecimal Digits)

This is a 2-byte hex value word 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:—

Last trip — Error Flag — Trip Flag — Run/Ready status

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		>	0	E	1	C	ETX Control-C	> (BCC)

The four characters following the > symbol are treated as hex digits 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

0 means not tripped on any of the trips defined by the 1st hex digit.
E last trip was overvoltage trip.
1 tripped flag indicating a fault.
C drive tripped; indicating RESET and trip code flashing on keypad display.

Status Word SW — **Example**

Digit Position	Flags and Trip Code		ok	fault	Hex	Binary
1st	Not used		—	—	0	0(msb)
	Drive over-temperature	Ot	0	1		0
	Motor over-temperature	th	0	1		0
	I x t overload	It	0	1		0(lsb)
2nd	Current peak trip	OI	1	0	E	1(msb)
	Power supply failure	PS	1	0		1
	Undervoltage trip	UU	1	0		1
	Overvoltage trip	OU	1	0		0(lsb)
3rd	Not Used		—	—	1	0(msb)
	Current loop loss	cL	0	1		0
	Error flag	Err	0	1		0
	Tripped flag		0	1		1
4th	Run flag, 1 = set to run		See Ready Table	Run/ Status	C	1(msb)
	Ready flag, 1 = drive ready					1
	Not Used		—	—		0
	Not Used		—	—		0(lsb)

Run / Ready States

Run	Ready	Status Indicated
0	0	Drive stopping on ramp control
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 trip itself, however, continues to exist only if the tripped flag equals 'fault'.

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

7.5.4 DS — Drive Setup (4 Hexadecimal Digits)

This is a 2-byte hex-value word 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 digits, and decode to binary as follows:—

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

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

speed control mode — auto start mode — coast to stop — fixed boost — jog input — catch spinning motor disabled — serial mode — frequency (speed) display — keypad control — even parity bit — 4/20mA speed reference — Baud rate 4800.

To write to drive number 11, sending the same parameter settings as in the previous example, 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 Setup DS / **Example**

Digit Position	Bit parameter		0	1	Hex	Binary
1st	Not Used		—	—	0	0(msb)
	Auto reset	b0	enabled	disabled		1
	Start mode	b1	auto	manual		0
	Stopping mode	b2	see Stopping Mode table			0(lsb)
2nd	Boost mode	b3	auto	fixed	F	1(msb)
	Jog/Preset	b4	jog	preset		1
	Catch spinning motor	b5	disabled	enabled		1
	Analogue input/serial comms	b6	analogue	serial		1(lsb)
3rd	Stopping mode	b7	see Stopping Mode table		8	1(msb)
	Display	b8	frequency	load		0
	Control mode	b9	keypad	terminal		0
	Parity bit	b10	even	odd		0(lsb)
4th	Analogue reference — a	b11	see Analogue Reference table		4	0(msb)
	Analogue reference — b	b11	see Analogue Reference table			1
	Not Used		—	—		
	Baud rate	b12	4800	9600		0(lsb)

There are four possible states of **Analogue Reference**

Analogue Reference		Speed Reference Input
a	**b**	
0	0	0/20mA
0	1	4/20mA
1	0	20/4mA
1	1	Ur

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

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

7.5.5 FQ — PWM Switching Frequency & ULF (2 Hexadecimal digits)

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

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)

FQ codes

Word FQ	PWM Switching Frequency	MVF
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

7.5.6 CW — **Command Word** (2 Hexadecimal Digits)

This is a one-byte hex-value word enabling the drive to be controlled through the serial link. It is important to note that some of the terminal inputs are **not disabled**, even when b6=1 they remain operative (START, STOP, RESET, EXTERNAL TRIP, LOCAL/REMOTE).

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

RESET, TRIP (external), STOP, START

CW allows the drive to state the direction of rotation as set by the control terminal Forward/Reverse (TB1/6) 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).

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 :—

not reset — emergency stop/external trip input closed — direction set to forward — jog/preset terminal closed — not stop — not run

Command Word CW **Example**

Digit Position	Function	Terminal input status 0	Terminal input status 1	Hex	Binary
1st	Not Used	—	—	1	0(msb)
	Not Used	—	—		0
	Reset	open	closed (reset)		0
	Emergency stop/ External trip	open (tripped)	closed		1(lsb)
2nd	fwd/rev *	open (fwd)	closed (rev)	6	0(msb)
	local/remote*	open (local)	closed (remote)		1
	Stop	open (stop)	closed		1
	Start	open	closed (run)		0 (lsb)

* Cannot be changed through the Serial Communications Link using CW

Typical Values of Command Word CW

Function option selected	**CW values during ...** Power -up	Start	Stop	Reset	Ext Trip	**Not start Not reset Not 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

7.5.7 C1 — Drive Configuration Word 1 (2 Hexadecimal Digits)

This is a one byte hex value word (two hexadecimal digits) enabling the state of the dil switch and internal link 0 to be read. (It is read only). The two digits following the > symbol decode into binary states to indicate the state of the dil switch and link 0. 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		>			0	7	ETX Control-C	H (BCC)

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

0 — 0000, 7 — 0111

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

Lk0 in — SW1F ON — SW1E ON — SW1D ON — SW1C OFF — SW1B OFF — SW1A OFF (see Chapter 6 for full definition of the switch functions).

C1 — CONFIGURATION WORD

Digit Position	Function	0	1	Example Hex	Example Binary
1st	Not Used	-	-	0	0 (Msb)
	Lk0	IN	OUT		0
	SW1F	ON	OFF		0
	SW1E	ON	OFF		0 (lsb)
2nd	SW1D	ON	OFF	7	0 (Msb)
	SW1C	ON	OFF		1
	SW1B	ON	OFF		1
	SW1A	ON	OFF		1 (lsb)

8 Logic Diagrams

To be issued

9 Braking

9

Braking

(Dynamic Brake, IBD-2)

9.1 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 CDS. If the regenerated power is less than the losses of the system, the drive will perform satisfactorily. If the regenerated power is more than the losses of the system, the drive 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 is in watts
a is in rad/s^2
s is in rad/s
I is in kg.m^2

For a drive with a given deceleration time (set in Pr3) and a certain speed in Hz the above equation becomes:

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$$P = 120\, w\, I \left(\frac{4\pi}{P}\right)^2 / t$$

where w = speed in Hz
P = number of machine poles (e.g. 2, 4, 6 etc)

t = deceleration time set in Pr3 for 120 Hz upper limit frequency. (If b14 set for upper limit frequency other than 120 Hz, 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 '0' the internal ramp is stopped whenever the drive's DC bus voltage exceeds about 30V 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 bus 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 bus 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 '1' the internal ramp is maintained at the set rate even if the drive's DC bus voltage exceeds the 30V margin above the normal working value. In this mode of operation as the DC bus 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 bus 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 over current if the current exceeds 150% of the drive rating during regeneration. Therefore the drive rating determines the maximum regenerative capability of the drive.

9.2 Operation of the Braking Unit

The IBD-2 is effectively a power switch which controls the current in the braking resistor. When the DC bus exceeds a preset level the braking resistor is connected across the DC bus and when the DC bus drops by 5V the resistor is disconnected. The power dissipated in the resistor is automatically regulated to match the regenerated power.

The IBD-2 has a LED to indicate when the braking transistor is switched on. It takes its power supply and control signals from the CDS.

9.3 Specification

Maximum continuous braking power dissipation = 439W (derived from RMS transistor rating and minimum braking resistance)

Instantaneous power dissipation capability = 3.5kW (for a maximum time of 2 milliseconds derived from 47, -10%, ohms across 385VDC.

Temperature Range

The operating ambient temperature range is 0^oC to 50^oC.

Braking Resistor

Minimum resistance = 47 ohms (-10%)

Indication

The IBD-2 has one LED to indicate when the unit is operating

CONNECTIONS

POWER

DC - VE	connection to drive - DC BUS
DC + VE	connection to drive +DC BUS
D.B. RES + VE	connection to brake resistor
D.B. RES - VE	connection to brake resistor

CONTROL

0V signal 0V from drive (isolated wrt 0VG)
DB control signal from drive (isolated wrt 0VG)
+15VG +15V supply from drive
0VG 0V supply from drive

BRAKING DUTY

10% duty cycle at 2.2 kW with a braking time of 30s, ie the brake is on for 30s followed by a 270s off time. See Fig 9-1 for duty cycle at other powers.
(based on using the minimum braking resistance of 47R - 10%)

PROTECTION

Thermal protection of the IBD-2 must be provided by the user, typically by using a thermal circuit breaker with auxiliary contacts.
eg Weber Series T12, type T12-221SN 2.5A rated.

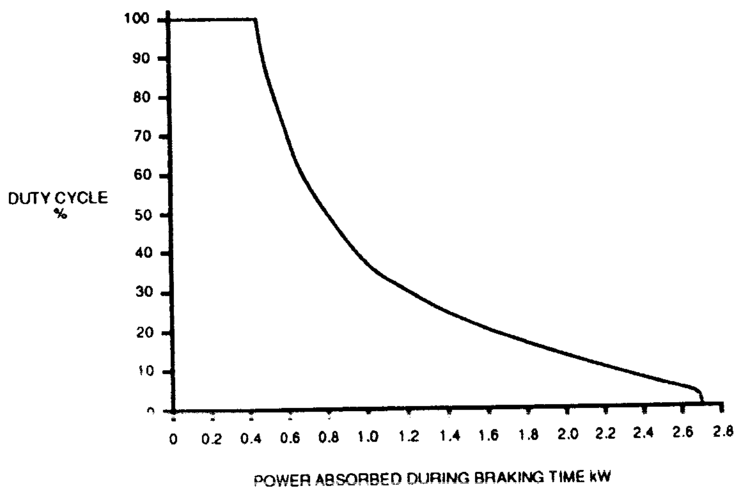

Figure 9-1
IBD-2 Braking Duty with 30 Second Ti--

9.4 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 time. From the previously stated equation, but modified for maximum conditions:

$$P_{max} = 120\, W_{max}\, I\left(\frac{4\pi}{P}\right)^2 / tmin$$

where w_{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 set for upper limit frequency other than 120 Hz, modify constant of 120 to correct upper limit frequency).

Pmax must be less than 1.5 times the drive rating to ensure the drive can handle the braking duty.

Pmax must also be less than the peak power dissipation of the braking resistor when applied to the maximum DC link voltage level of 385VDC:

$$Pmax <= (385)^2/R$$

where R = Braking resistor value in ohms

Secondly the average power rating of the braking resistor must be determined. (We currently know its resistance value and peak power dissipation capability). The average 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:

$$E_{loss} = (0.5)\, I\left(\frac{4\pi}{P}\right)^2 . [W_1{}^2 - W_2{}^2]$$

where w_1 = highest operating speed in Hz

w_2 = speed decelerated to in Hz (possibly 0 Hz if the machine is stopping or reversing)

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If this event takes t_1 seconds to occur and repeats after t_2 seconds, ie the cycle time is $t_1 + t_2$, the average power dissipation in the braking resistor is:

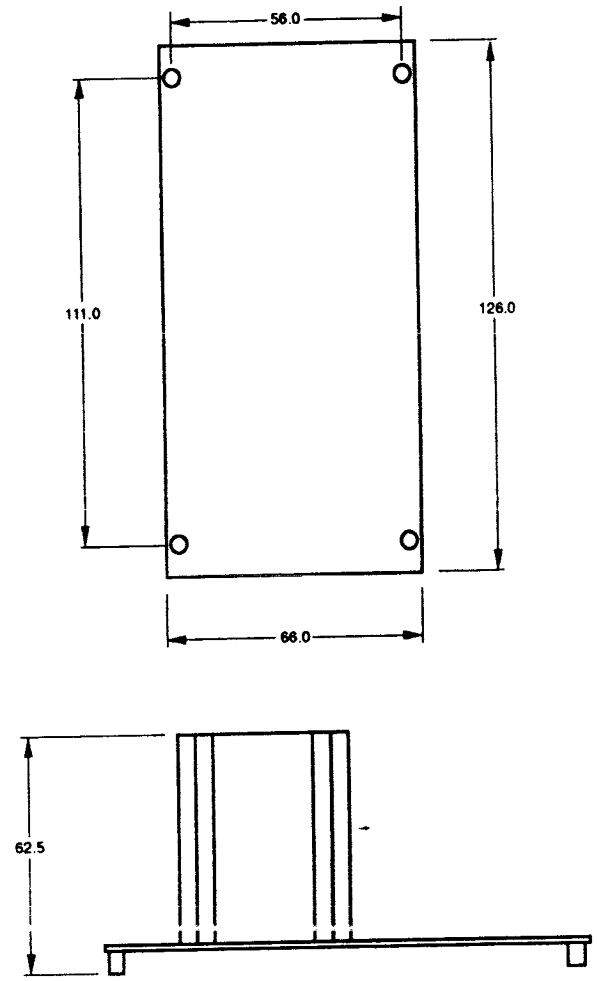
$$P_{avloss} = E_{loss}/(t_1 + t_2)$$

P_{avloss} defines the average power loss in the braking resistor.

Provided the braking resistance value satisfies the above three equations, and is greater than the minimum resistance of 47 ohms, the resistor will meet the power requirements of the application.

9.5 Mechanical Installation

The overall dimensions and fixing holes are shown in Fig 9-2.



DIMENSIONS IN mm
NOTE : Mounting pillars are M4 clearance

CT/CDS/15

Figure 9-2
Mounting dimensions

The IBD-2 board is mounted external to the CDS, either to the left hand side of the CDS or above the left hand corner of the CDS, see Fig 9-3. The limitation on the mounting position is governed by the length of the two power connections, DC + VE and DC - VE, from the IBD-2 to the CDS.

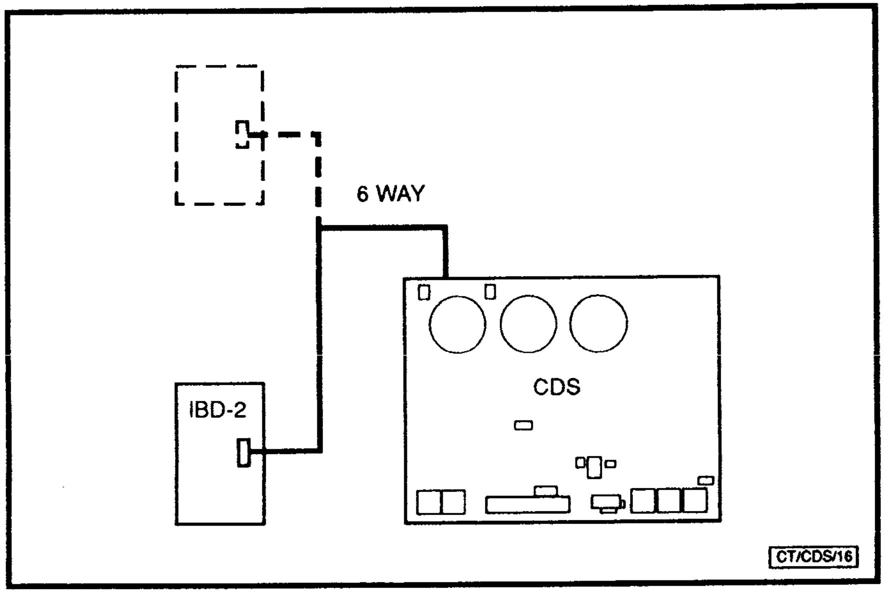


Figure 9-3
Mounting Position

9.6 Electrical Installation

9.6.1 Safety

WARNING:
The voltages present in the power cables, the 0VG and the +15VG cables and most of the parts of the circuit board are at mains potential and are capable of causing severe electric shock and may be lethal.

ELECTRIC SHOCK RISK!
If the CDS has been energised before installation of the IBD-2 it MUST be ISOLATED before work may continue. A period of ten minutes MUST elapse after isolation to allow the internal capacitors to discharge fully. Until the discharge period has passed, dangerous voltages may present within the CDS.

Thermal protection of the braking resistor must be provided by the user. This is necessary to avoid the resistor causing a fire hazard if the braking transistor fails in the on condition. Any thermal protection must disconnect the AC supply to the drive and braking unit.

9.6.2 Connections

The IBD-2 unit makes use of internal plugs on the CDS PL3, PL4, +DC BUS and -DC BUS. To gain access to the internal plugs, release the four screws securing the cover taking care to disconnect the cable from PL2. The leads to the IBD-2 board are routed underneath the cover when it is re-fitted.

The positions of PL3, PL4, +DC BUS , -DC BUS are shown in Fig 9-4.

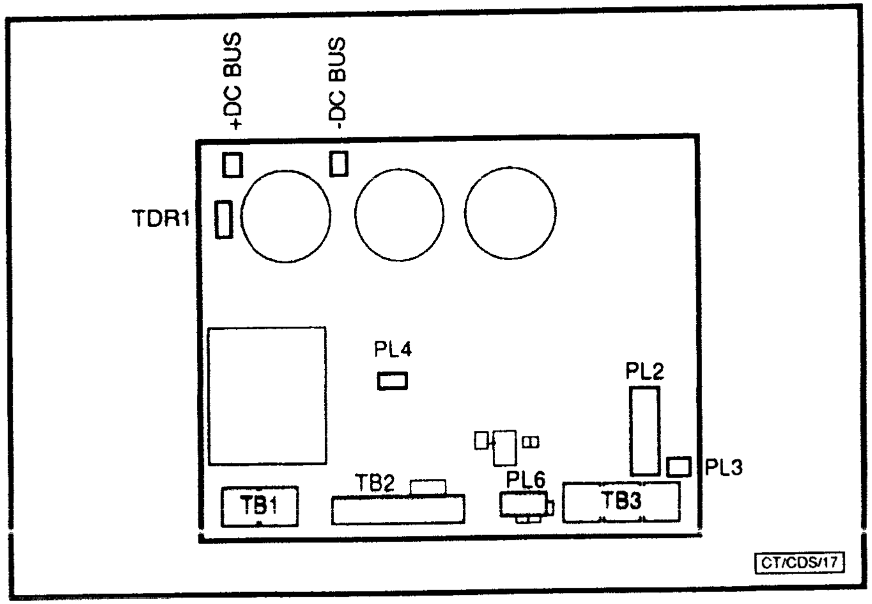


Figure 9-4
Position of CDS connectors for use with IBD-2

PL1 on the IBD-2 has two connectors which plug into the CDS, the 2-way one connectors to PL3 and the 3-way one connects to PL4, refer to Fig. 9-4.

DC + VE on the IBD-2 plugs onto the +DC BUS faston tab on the CDS and DC + VE plugs onto -DC BUS, refer to Fig. 9-5.

Ensure no wires come into contact with TRD1, the big black disc at the top left hand corner of the CDS circuit board.

Connect the leads D.B. RES + VE and D.B. RES - VE of the IBD-2 to the power resistor, via a thermal trip, refer to Fig. 9-5.

Ensure the leads do not touch the surface of the power resistor. The heat generated by the power resistor can burn the insulation of the wires if they come into contact. Note that the power resistor is not polarity sensitive.

The IBD-2 is not short circuit protected between the braking resistor connections "+" and "-" or between the braking connections to earth. (A short circuit would cause damage to the unit). The IBD-2 is not thermally protected and should always be used in conjunction with a suitable thermal trip. Operating outside specification could damage the inverter and braking card.

Fig 9-5 shows the position of the connections and the layout of the IBD-2.

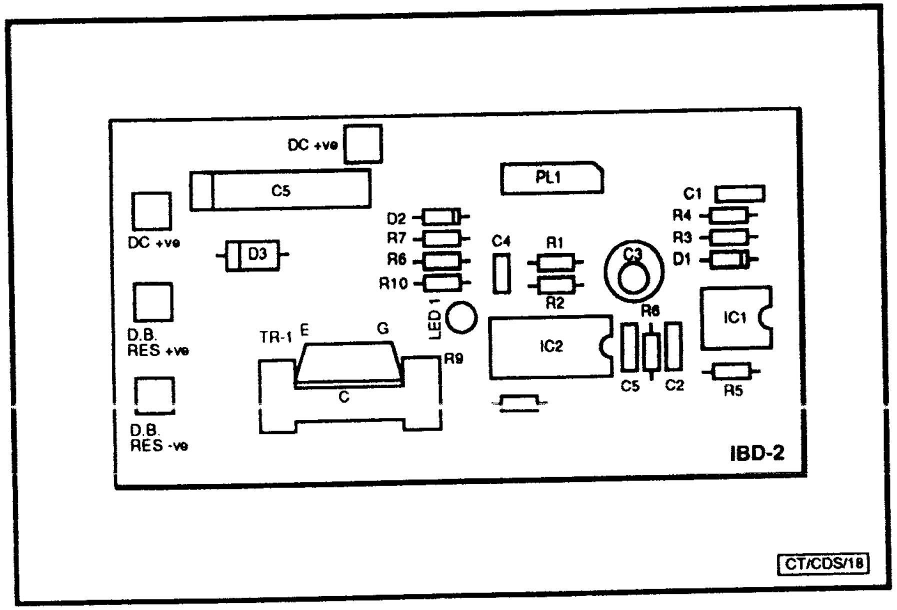


Figure 9-5
Component Layout on IBD-2

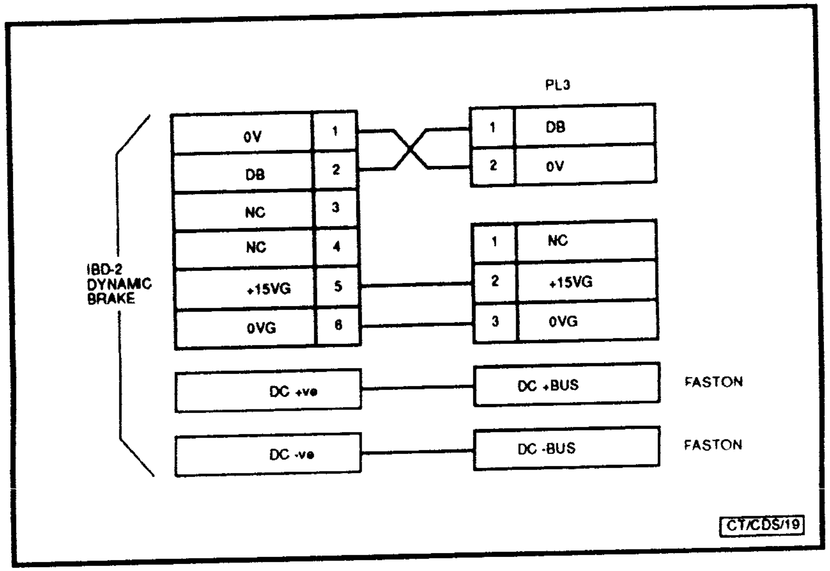


Figure 9-6
Interconnection of IBD-2 and CDS

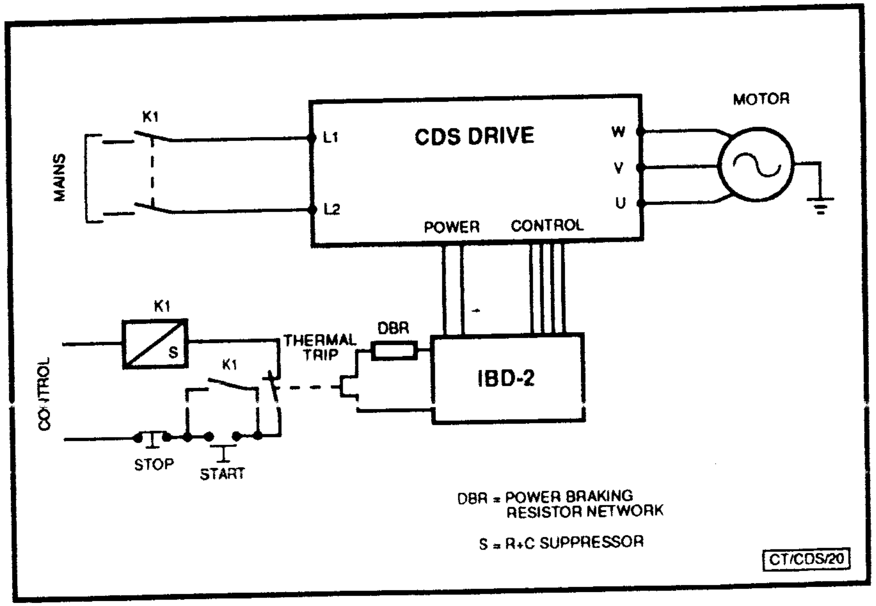


Figure 9-7
Typical connections

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9.7 Operating Procedures

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 bus 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 bus. 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 be illuminated.

10 Electromagnetic Compatibility (EMC)

10

Electromagnetic Compatibility (EMC)

10.1 EMC

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

10.2 Immunity

Meets IEC801 without significant disturbance to operation at the following levels:

Part 4 (Transient Burst)   Level 4 all terminals

The immunity of drives to externally generated interference is very good. Usually no special precautions are required beyond normal good practice. It is recommended particularly that the coils of DC-energised contactors associated with drives be suppressed with a diode or similar device since they can generate very 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. 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 1-30kHz in AC and servo drives. Because the switching is fast, harmonics may be generated up to frequencies of several MHz. The most important frequency 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 the drive there are quite high electric and magnetic fields, but these diminish by an inverse cube law with distance and are insignificant at 300mm.

The main mechanism for propagation of RF energy out of the drive is by conduction through its connections. Fig. 10-1 illustrates the main routes.

The connections in order of emission level are:

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.

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, and 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 from the drive. If the motor cable exceeds about 50m then the supply emission will be particularly severe.

THE EARTH SYSTEM

The drive earth wire carries the RF current returning from the motor. Because the inductance of the wires 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.

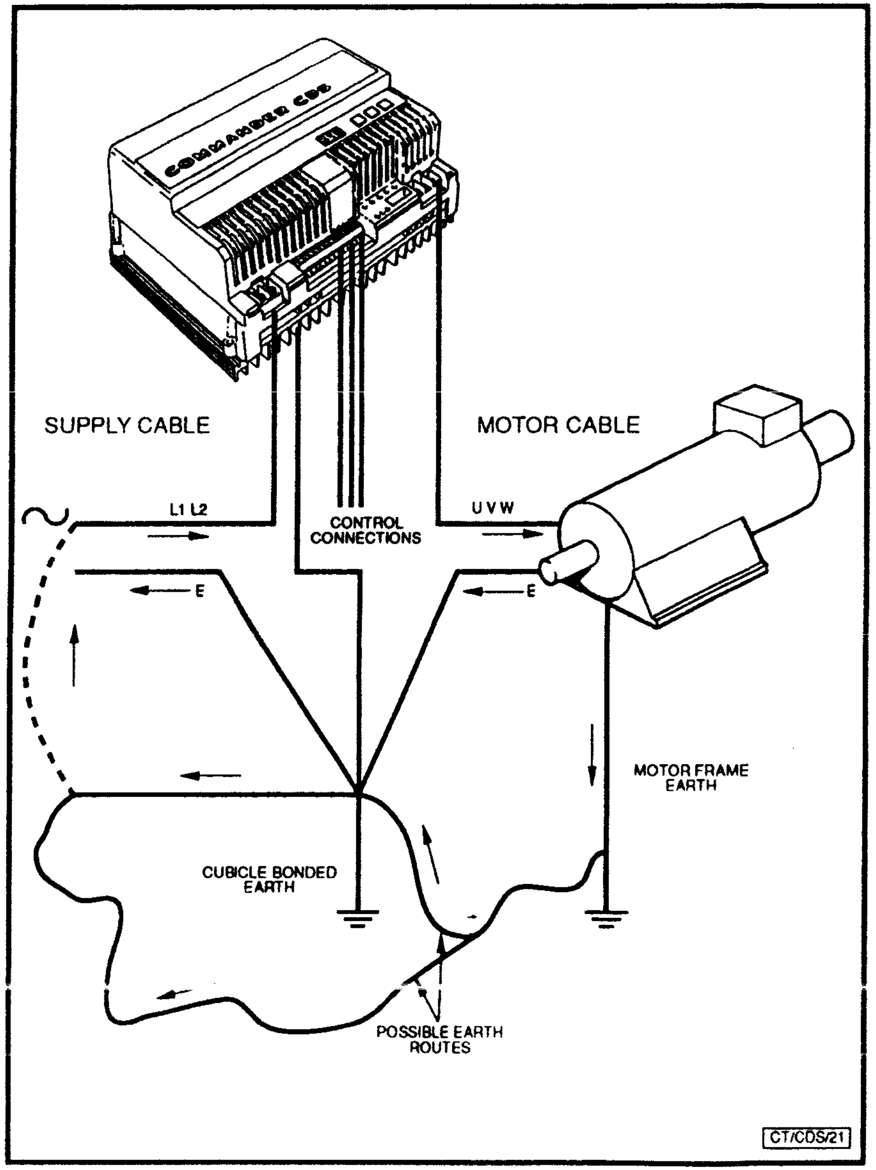

Figure 10-1
RF Current Paths - Drive with No Special Precautions

THE CONTROL CONNECTIONS

Inside the drive the control circuits have stray coupling 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.

The drive may be thought of as a source of RF current which leaves its output terminals. The capacitance of the output cable and the motor windings to earth present quite a low impedance to the RF frequencies, so 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 well-defined, low impedance path then 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 installations there are either no sensitive circuits vulnerable to disturbance, or else the sensitive circuits have been designed by the manufacturer to have good immunity. To avoid unnecessary cost 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 a variety of electronic circuits and systems. The list cannot cover all possibilities, and some degree of judgment will be required in assessing a given situation.

10.4.1 Not sensitive

Purely electrical circuits, relays, contactors, 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 category 10.4.3 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 very long and/or unscreened.

Analogue measuring circuits using high levels (over 1V), only if the connections are very long and/or unscreened or they are required to give very high resolution (better than 1 in 1000).

Analogue circuits which have very fast response or wide band-width, eg audio circuits. (Most industrial systems have intentionally slow response to minimise disturbance by transient effects.)

Video circuits, such as closed circuit TV and possibly computer monitors.

Digital data links, 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 Wave and Medium Wave only).
Inductive-loop pagers and communications systems.
Through-mains communication systems.

But **not** televisions, VHF radio receivers, mobile telephones, radio remote-controllers or other modern radio-based equipment which uses very high frequencies.

10.5 Precautions for Drive Installation

10.5.1 Routing Precautions

These are precautions which cost little to implement, and are recommended for any installation. They are illustrated in Fig. 10-2.

SEGREGATION

No signal circuit should 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 the spacing should be 1.2m.

No signal circuit should pass within less than 0.3m of the drive itself. If this is unavoidable then an earthed aluminium screen should be erected between the circuit and the drive. (This constraint obviously does not apply to signal connections to the drive itself. The immunity of the drive to external interference is compatible with its emissions.)

EARTHING

In any cubicle a single low impedance earth point or busbar should be established, to which circuits are earthed independently 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 at the drive end should be connected **directly to the drive earth termination, not to the cubicle busbar.**

The motor cable should have four cores, the earth core being connected to the drive earth and the motor frame. (This is in any case normally done for electrical safety).

If the drive control connections are to be linked to any electronic circuit, then if possible the common or "0V" line should be earthed at that circuit and at no other point.

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) then 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.

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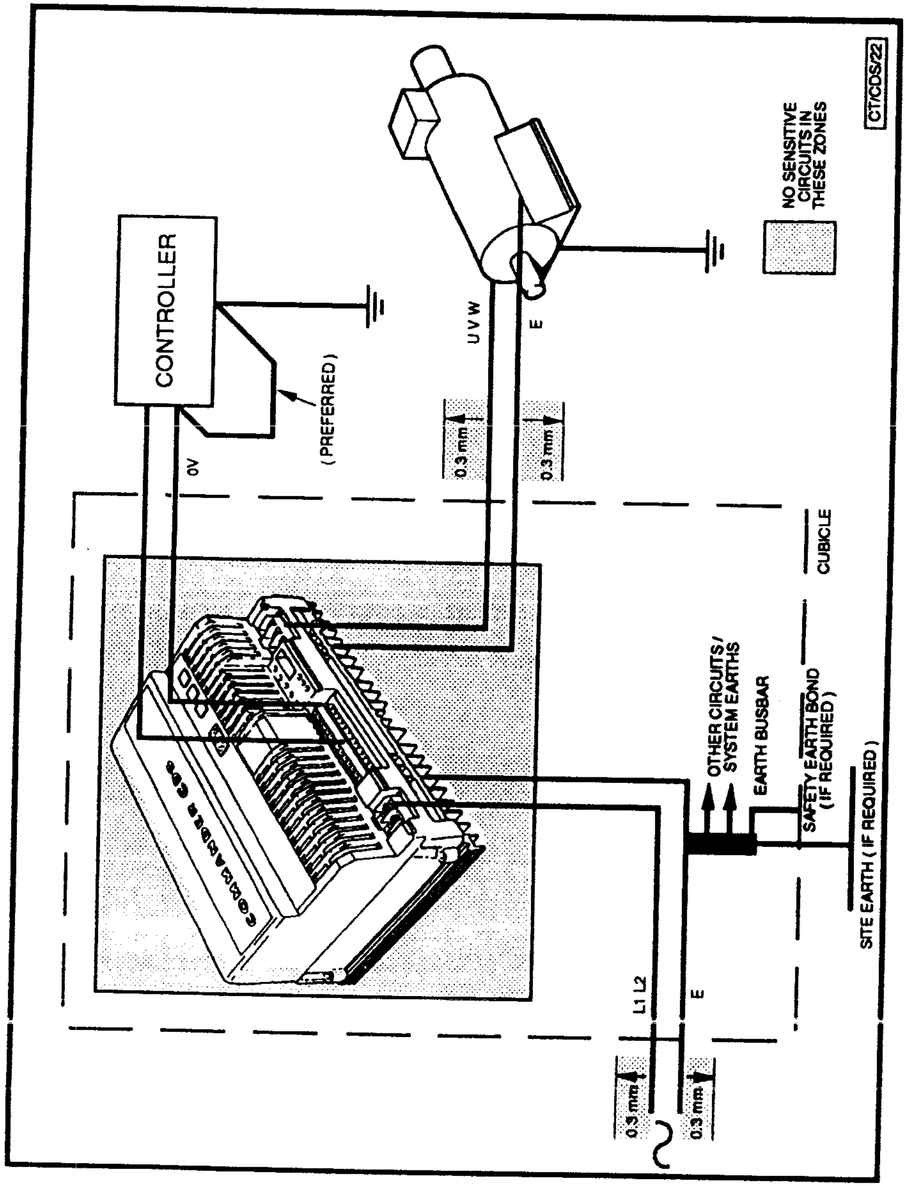

Figure 10-2
Wiring and Layout for Non-Sensitive Systems

The recommended RFI Filters are:-
RS 11 CT, for the CDS75, and
RS 19 CT, for the CDS150
and are available from the supplier of the drive.

10.5.2 Additional Precautions for Sensitive Systems

If the drive is associated with sensitive systems then further precautions are advisable. They are illustrated in Fig. 10-3.

SWITCHING FREQUENCY

The emitted energy is proportional to the switching frequency. It is preferable therefore to use the lowest acceptable switching frequency.

SUPPLY FILTER

A filter must be fitted in the mains supply line. The filter should be of a type recommended by the drive supplier.

MOTOR CABLE

The only certain way of preventing emission from the motor cable is to screen it. However screened cable is more expensive than conventional cable and may be inconvenient. For many installations, conventional cable is adequate provided that it can be segregated from sensitive circuits. As an approximate guide, allow a spacing of 1m for every 10m run, but avoid long parallel runs.

If in doubt, the motor cable should be screened, with the screen connected to both the drive earth and the motor frame. It is important that the connection be made at both ends to minimise the external magnetic field.

Screened cable is also very 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 drive cubicle penetration, then screened cable should be used internally to continue as far as possible the coaxial arrangement of power cable and earth. 10

If it is not possible to screen the cable - for example where it is an existing installation - fit an output inductor of the kind recommended for use with long motor cables. Your drive supplier will be able to advise you.

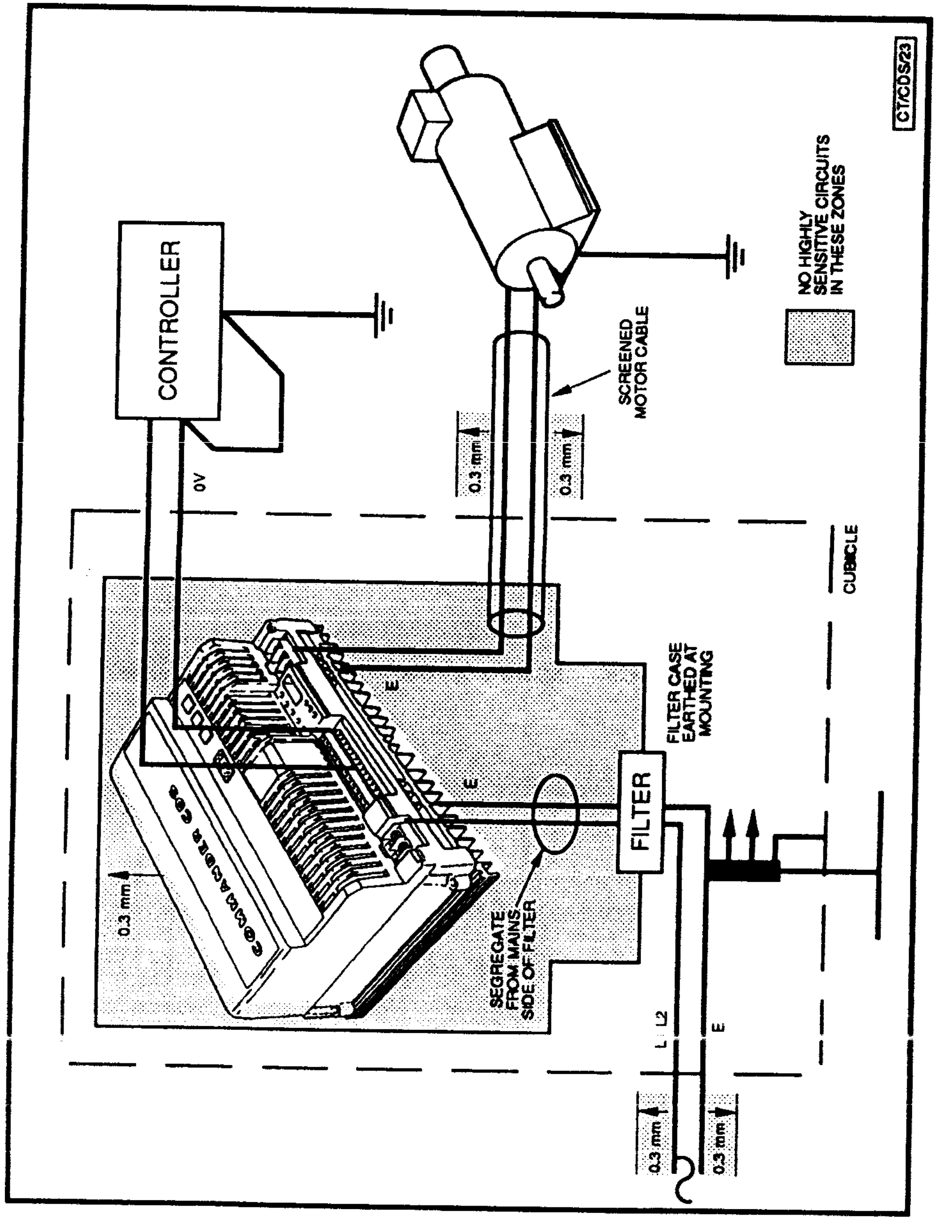

Figure 10-3
Wiring and Layout for Sensitive Systems

In some hazardous environments it is not permissible to earth both ends of the cable armour because of the risk of high 50Hz circulating currents if the earth loop is cut by strong magnetic fields. This only applies in the proximity of very powerful electrical machinery. In this case, the earth connection at one end may be made with a capacitor of 1.0µF, which will block the 50Hz current but present a low impedance to RF. Because of the high pulsed current, a 250VAC type must be used.

EARTHING

Care must be taken with the earthing arrangements. **The essential objectives are to define firmly the paths through which 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. 10-4. The bold lines show the desired paths, and the dashed lines show the stray paths which the layout is intended to minimise. The drive RF current paths are kept compact, and the earth shared with other circuits at one point only (except for the inevitable motor frame attachment).

The arrangement 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 the segregation of current-carrying earth wires must be maintained, ie a signal earth conductor should not run close and parallel to a drive earth conductor.

CONTROL CIRCUIT

Most Drives have electrically isolated control circuits. The control circuit should preferably be earthed at one point in the user's system, remote from the drive. This means that the "0V" connection 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 a 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 (note this is different from the instructions given in the drive manual, where the screen is required to be connected to "0V". These instructions are intended to maximise the immunity of the drive to external disturbance).

If the control connections are short and contained inside a cubicle which contains no sensitive circuits, then these precautions are not necessary.

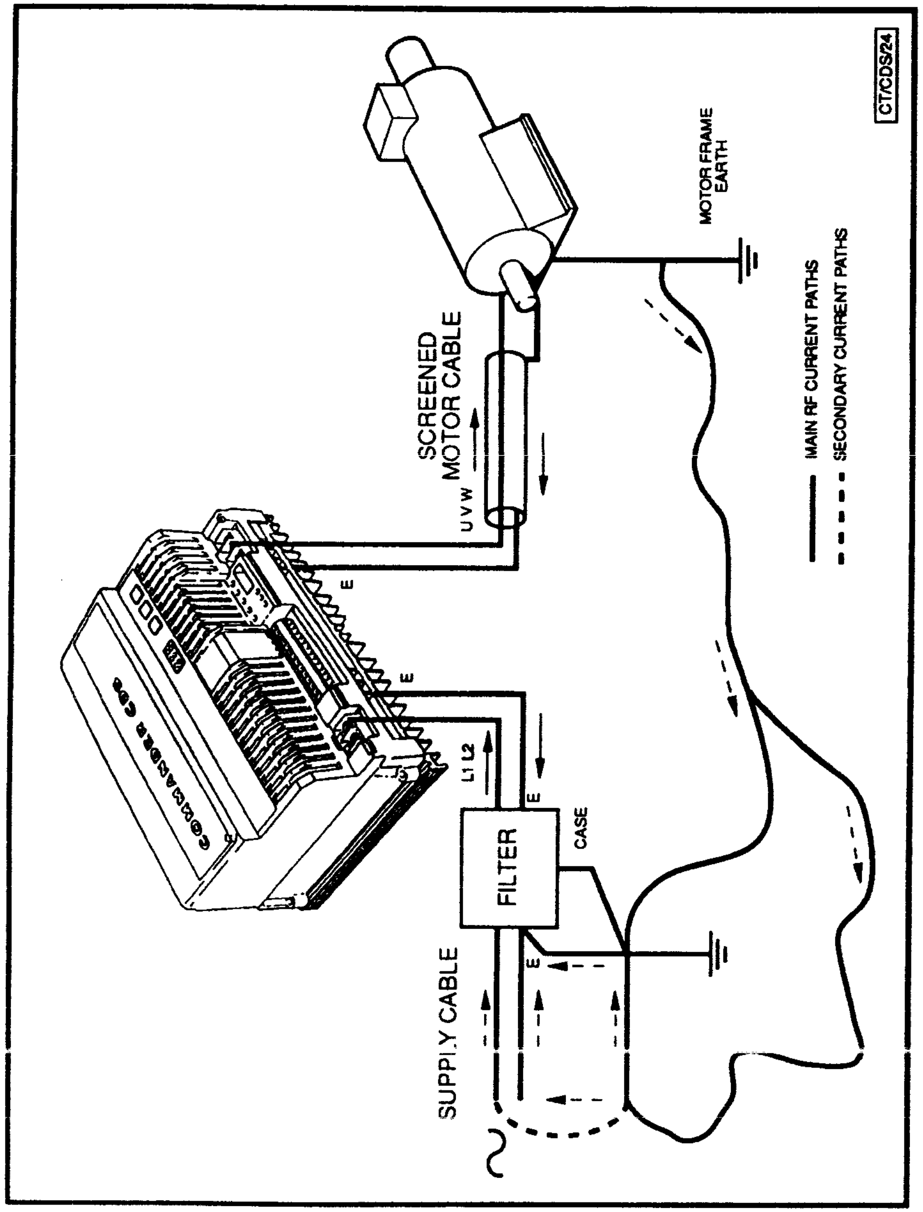

Figure 10-4
Current Paths with Supply Filter and Screened Motor Cable

10.5.3 Very Sensitive Systems, Radio Receivers etc.

Very careful attention is required if radio reception is required in the LW and MW bands close to the equipment. 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 very weak station, may be disturbed to some extent. It can be very difficult to achieve operation of a long/medium wave radio actually standing on the cubicle of equipment containing a drive. On the other hand, following the guidance given here clear reception of the main stations is usually achieved at distances of 1-2m.

All of the precautions given in Section 10.5.2 must be observed, as well as those following.

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 judgment is required here.

An obvious error to avoid is of combining the filter input and output wires in the same wiring loom. The output wires must go by a short, direct route to the drive, and be segregated from all circuits on the "clean" side of the filter.

The "clean" wires must also be strictly segregated from the motor cable.

If the cubicle does not contain other power circuits associated with the motor or other drives, then the filter should be located close to the drive with short, preferably screened wires connecting it 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, then it is best to locate the filter at the cubicle power incomer. The disadvantage of this arrangement is that other wires leaving the cubicle may carry RF energy picked up from the internal power cables.

In complicated multi-drive installation, fit the recommended filters close to each drive, and a further general purpose filter at the cubicle incoming supply connections to attenuate the stray pickup on the "clean" wires.

SCREENING

The motor cable must be screened, unless it is extremely short - no greater than 1m outside the cubicle. Armouring is sufficient provided both ends are earthed. Metallic trunking may be adequate, but it is important 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 with filter to EN55014 does not guarantee the conformity of the complete installation, although the standard is unlikely to be seriously infringed if these guidelines are adhered to. If strict conformance with EN55014 is required then it is necessary to carry out measurements on the complete installation.

11 Parameter Setting Record

11.1 Parameter Setting Record

11

Parameter Setting Record

11.1 Parameter Setting Record

Parameter		Factory Default Settings	First Change			Second Change		
				Date	Set by		Date	Set by
Pr0	Min freq/Preset 2	0Hz						
Pr1	Max freq/Preset 3	50Hz						
Pr2	Acceleration time	5 seconds						
Pr3	Deceleration time	10 seconds						
Pr4	Current limit	150%						
Pr5	Continuous current	100% FLC						
Pr6	Voltage boost	9.8%						
Pr7	Jog frequency/ Preset 1 frequency	0Hz						
Pr8	DC braking Period	1s						
Pr9	Serial address	11						
PrA	Trip	Et						
Prb	Security Code	0						

Parameter		Factory Default Settings	First Change	Date	Set by	Second Change	Date	Set by
b0	Auto reset	0 = disabled						
b1	Auto/Manual start	1 = manual start						
b2	Stop mode with b7	0 = standard ramp						
b3	Auto/fixed boost	0 = auto						
b4	Jog/Preset	1 =preset						
b5	Catch spinning motor	0 = disabled						
b6	Analogue/Serial comms	0 = analogue						
b7	Stop mode with b2	0 = standard ramp						
b8	Freq/Load display	0 = frequency						
b9	Keypad/Terminal	1 = terminal						
b10	Even/Odd parity	0 = even						
b11	Analogue speed ref	U_r voltage input						
b12	Baud rate	4.8 kb						
b13	Reset defaults	0 = inactive						
b14	PWM/ULF	2.9 kHz/120Hz						
PrO	MVF	50 Hz						

DIL Switch		Factory Default Settings	First Change	Date	Set by	Second Change	Date	Set by
SW1A	Relay function	Off = trip relay						
SW1B	Relay function	Off = trip relay						
SW1C	Analogue output of speed or load	Off = same as display						
SW1D	Fixed/dynamic V/F	Off = fixed V/F						
SW1E	Normal or 'Wireproof' mode	Off = normal						
SW1F	Pr0 = Min speed or Pr0 = Preset 2	Off = Pr0 is min speed						

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