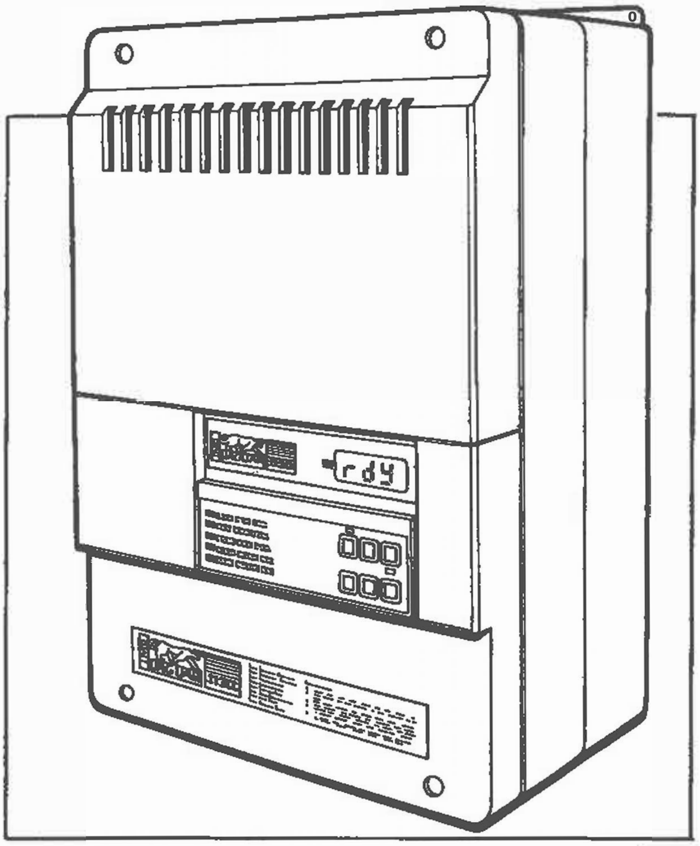


Jaguar AC Variable Speed Drives

Models CDll/30 & CDll/90 HVAC

(Power ratings from 1lkW to 90 kW)

User Manual

"Failure to read these instructions prior to installation and use, may result in damage to the drive and driven equipment and invalidation of the warranty."

IMO JAGUAR

Health and Safety at Work

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

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

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

Special 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 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.

USER'S GUIDE CD11-75 & CDV11-90
Part no 0173-1175
REVISION no 2.0 - July 1991

SOFTWARE VERSION:

WELCOME ...

to the CD11-75 & CDV11-90kW range of inverter drives

Highly versatile yet simple to operate, the CD11-75 & CDV11-90kW range is designed not only to control but also to extend the performance of ac squirrel cage induction motors.

The benefits for the industrial user include close control of the production or manufacturing process, and the potential for increasing productivity, economising the use of power, improving the operating power factor, reducing production down-time, and prolonging the life of the motor.

Apart from the manual or automatic start and stop control facility, the user is able to programme the drive so that the motor will...

- start and stop from external signals
- run at any speed within practical limits
- apply either constant power or constant torque
- run forward and reverse
- accelerate and decelerate at user-variable rates
- apply an increased torque to start difficult loads
- maintain speed against changes of load torque

...and with complete flexibility for rapid adjustment, local, remote or from a computer terminal.

The principal objective of the Guide is to enable the user to exploit the capability of the CD11-75 & CDV11-90kW inverter drive to the full, so as to achieve the optimum benefits in product quality, production rate, economy of operation and, in short, to make the drive really work for its living. To achieve this it is necessary to gain a good understanding of the drive and of its controls.

Getting Started is a chapter designed to help users who are new to this type of equipment to gain familiarity with the basic controls speedily. The Operational Control chapter will then repay study. There the user will find the information which enables the flexibility and responsiveness of the CD11-75 & CDV11-90kW drives to be exploited to the fullest extent.

Becoming expert in operating a CD11-75 & CDV11-90kW drive to the best advantage is made easier and quicker by training. Structured training courses are available, either on-site or in the manufacturer's Training School.

Variable speed ac drives are constantly finding new applications. The CD11-75 & CDV11-90kW range has been designed to meet as many different applications as can be forseen, and is therefore especially well equipped with variable control functions. Some of the options provided may not need to be used for any particular application, but the versatility of the CD11-75 & CDV11-90kW range is its prime advantage and is the feature giving the utmost benefit to the user.

CONTENTS

DIAGRAMS

LOGIC DIAGRAMS

TERMINAL BLOCKS

PREFACE... about this Guide

Introduction to Inverter Drives explains the principles of the induction motor with regard to operation by variable speed drives, and considers the essential and desirable characteristics of an inverter drive, and some application aspects. Technical and operational features of the CD11-75 & CDV11-90kW range of drives are summarised.

Keypad Procedure & Display introduces the procedure for operating the keypad, how the display responds to keyed entries, and what the display shows when the motor is running in various operating conditions.

Getting Started guides the operator step by step through a series of procedures to start and run a motor at variable speed under potentiometer control and alternatively from the keypad. It is a hands-on exercise from the beginning, ideal for gaining familiarity with the controls and their effects, and a foundation for proper understanding of the CD11-75 & CDV11-90kW control logic.

Operational Control is divided into sections covering the purposes of the different kinds of operating parameters and, following a logical sequence, explains the function of each, its relationship to others, and its effect on the dynamic behaviour of the motor, its speed and torque control, acceleration, deceleration and braking. The integral logic for overload, current-limit and short circuit protection is fully described. The chapter ends with a summary of the main dynamic states — stop, start, reset, reverse and trip.

Parameters explains what parameters are, and lists all parameters in alpha-numerical order with a brief description and their values. Operating effects of parameters are illustrated by Logic Diagrams. The chapter also contains indexes to all parameters, in numerical and alphabetical order.

Terminals explains the functions of the circuits provided for hard-wiring from external control devices and to external instrumentation, and is followed by an index of terminals.

Serial Communications explains the principles, the setting up and the standard procedures for data transfer, with examples of the various types of message and command.

Diagnostics covers the malfunction signals ('trip codes') associated with operation of the drive, and also the healthy indications.

Installation Procedures explains the essentials for correct mounting and location, and also gives guidance on the cooling of enclosed drives. Electrical installation covers safety, cabling and wiring, with reference to essential protective devices external to the inverter.

Specifications and Data contains physical dimensions, characteristics, and location specifications; electrical supply specifications; output ratings and derating of the drives. Essential data concerning other equipment is given, including cable, wiring, protective equipment, encoder and communication specifications.

The Glossary provides a useful reference to the meanings of terms used in the book in relation to the CD11-75 & CDV11-90kW range and variable speed ac drives in general.

Induction Motor Characteristics

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

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

the total flux per pole,
the total number of turns per phase of the field winding,
and the rate of field rotation.

This can be expressed as $E = k\O Nf$ (1)

where
E is the induced emf,
Ø is the total flux per pole,
N is the number of turns per pole,
f is the frequency,
and k is a constant.

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

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

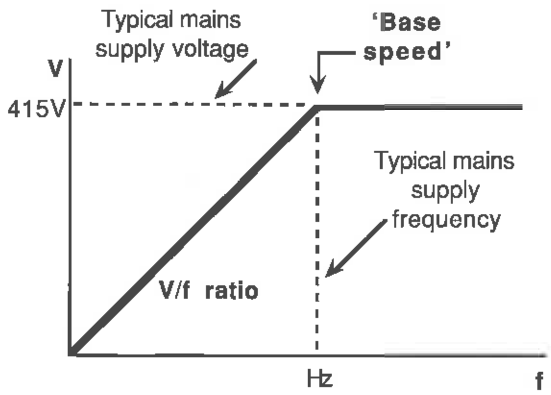
For optimum acceleration, or rapid response to an increase in load torque, Ø should be maximum to maximise the torque, as the designer intended. Equation (1) can be restated as —

$$\O = \frac{E}{kNf}$$

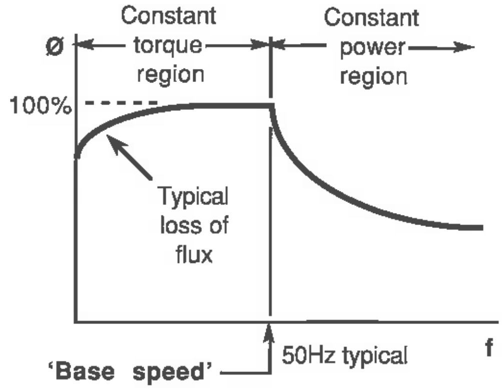
$$\text{or,} \quad \O = \frac{1}{kN} \times \frac{E}{f} \qquad (2)$$

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

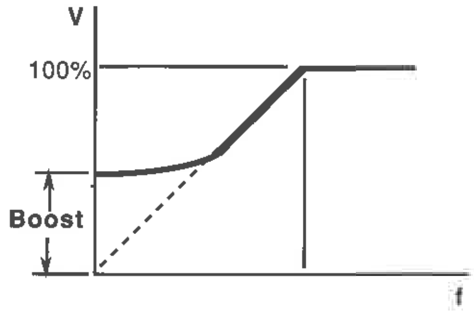
Although constant V/f control is an important underlying principle, departures from it enable the speed range to be extended both above and below the base speed. Operation of the motor at speeds above its base speed is achieved by increasing the output frequency of the inverter above the rated frequency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



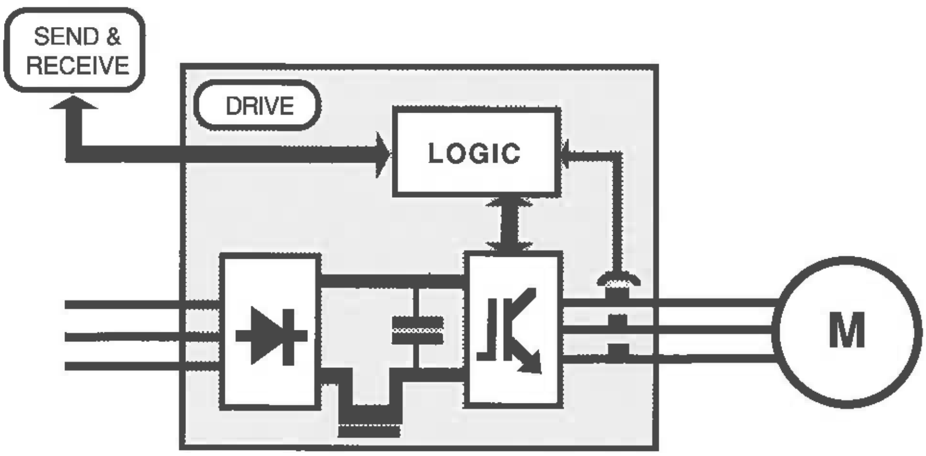
1 Variable motor speed — ideal voltage-to-frequency characteristic.



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



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



4 The principle of a PWM inverter drive system.

characteristic is typically as shown in Fig.1, which also shows the change above base speed. Since V is constant above base speed, the flux falls as the frequency increases, Fig. 2, 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 constant. There are many applications which are well suited by the constant-power characteristic in the region above base speed.

The second operating condition where departure from a constant V/f ratio is beneficial is at low speeds, where the voltage drop arising from stator resistance becomes significantly large. This voltage drop is at the expense of the flux. As the applied frequency approaches zero, the optimum voltage becomes equal to the stator IR drop. To maintain a constant flux in the motor at low speeds the voltage must be increased to compensate for the stator-resistance effect. Compensation for stator resistance is called 'voltage boost', Fig. 3, and most drives offer some form of adjustment so that the degree of boost can be matched to the winding resistance. It is also normal to taper the boost to zero as the frequency increases. A refinement is to increase the degree of voltage boost for loads that impose a high starting torque, since the IR drop will be greater because of the increased current. Automatic load-dependent control of the voltage boost in this manner has practical advantages for many applications.

The CD range of drives comprises two versions — one specifically designed for general industrial applications and the other for heating, ventilation and air-conditioning (HVAC) applications. The industrial range is designated CD11-75kW; the HVAC range is CDV11-90kW.

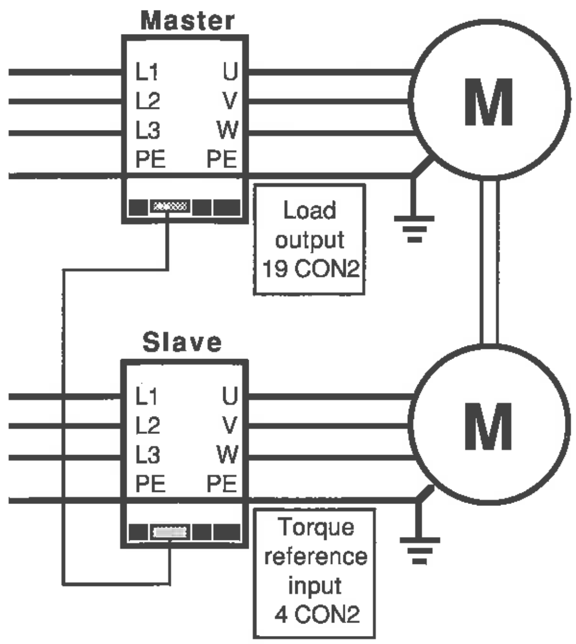
Drive Configuration

To operate an induction motor successfully in all varieties of industrial applications a drive must at least be capable of varying both voltage and frequency, for which it is necessary to separate the input from the output. This is most conveniently done by rectifying the supply and inverting the dc output. Variable output voltage can be obtained by varying the dc bus voltage and maintaining the gain of the inverter constant . The gain is the ratio of ac output to dc input. Alternatively, the dc bus voltage can be uncontrolled and the gain varied. This latter method is usually achieved by pulse-width modulation (PWM) control of the inverter, Fig. 4.

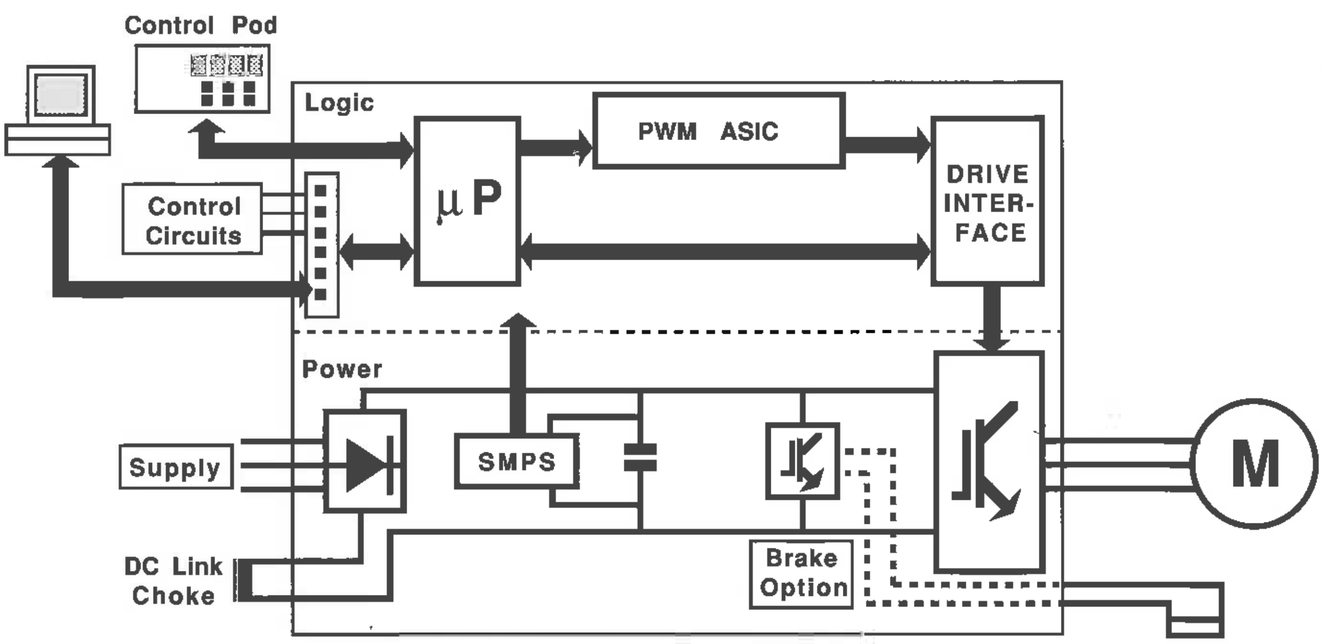
The use of a mathematically-advanced PWM switching strategy to control the latest high power high speed semiconductor switching devices — insulated gate bipolar transistors (IGBT) — in the power output bridge enables the output waveform to be closely approximated to a pure sine wave. The dc input voltage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

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

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



5 Two or more mechanically-coupled motors in master/slave operation by current-slaving.



6 Schematic block diagram of the CD 11-30kW power system and control.

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

MULTIPLE DRIVES AND MOTORS

Where two or more motors are **mechanically coupled**, either directly or by being connected to the same drive train such as a conveyor, the output of the drives is equalised by operating them in master/slave configuration. Three arrangements are possible — frequency slaving, current slaving, and electrical paralleling.

Frequency Slaving

If the available motors are precisely matched, being from the same manufacturer and of identical type, rating and construction, frequency slaving is possible. All drives are then slaves, in which all operating parameters must be identical. The speed command, however derived, is fed to all drives. Electrically, this is the same as operating two or more motors from a common supply.

A digital process controller can always serve to operate multiple drives, since this is one of the common applications of control by serial communications link. Alternatively, several drives can receive a speed control signal from a single speed-control potentiometer.

Current Slaving

If the available motors are not identical, or to improve accuracy of load sharing, current slaving is the preferred solution, Fig. 5. The load reference signal from the output terminal of the drive chosen as the master is connected to the torque reference input terminal of the slave drive or drives. Parameters controlling overload and overcurrent protection must be set to equal values in each of the drives. Both motors then operate with the same load current and share the load equally.

Electrical Paralleling

Two motors can be operated in parallel from the power output terminals of a single suitably-rated drive. This arrangement may be economical, but the following requirements must be observed —

- Both motors must be of identical manufacture, preferably having been specified for this duty. This is necessary to minimise the risk of unequal load-sharing.

- Each motor must be fitted with a motor protection relay, since the drive is not able to protect the motors individually.

DRIVE TECHNOLOGY

- Insulated gate bipolar transistor (IGBT) inverter output bridge for high-speed switching and low power consumption.
- Internal control power provided by switch-mode power supply (SMPS) giving regulated control voltage for a wide range of input voltage.
- Choice of two PWM switching frequencies (CD11-30 & CDV11-37kW range only), user selectable, to match applications.
- Sinusoidal waveform at all output frequencies.
- Variable-frequency output is user-selectable from 0 to 480Hz.
- Choice of voltage/frequency ratios to enable the motor to be precisely matched to the drive and the power supply.
- Maximum and also minimum operating frequencies selectable.
- Maximum flux at all speeds.
- Programmable voltage boost at low speed.
- Acceleration and deceleration with programmable ramp control.
- Slip compensation for accurate speed holding in open-loop speed control.
- Provision for closed loop speed control by encoder feedback.
- Optional injection braking, or dynamic braking with or without dump resistor.
- Capability of starting on to a spinning motor without tripping.
- Ride-through by automatic drive regeneration during mains voltage dip or transient interruption.
- Transient current-limiting by modification of PWM waveform; steady-state current-limiting by frequency control.
- Internal monitoring and protection includes Ixt overload, current limit, instantaneous short-circuit, earth-fault and phase-loss protection, heatsink overtemperature and ambient overtemperature.
- Ambient temperature monitoring.
- Parameter and diagnostic data saved during power loss, for fault diagnosis and quick restart without reprogramming.
- A range of analogue input and output signals for compatibility with non-digital equipment and systems.
- No potentiometers and no links to adjust.
- Demountable control display Keypad.
- Serial communications RS 485, RS422 & RS232 with opto-isolated signal transmission.
- Control circuits opto-isolated from power circuits.

PARAMETER FEATURES

- Parameter data input and read-out fully digital.
- The MENU SELECTOR in the software enables the user to implement the following control options —

  DYNAMIC CONTROLS

  - Skip Frequencies and skip-frequency bands avoid mechanical resonances. This is of particular value in HVAC applications, and may be beneficial in many industrial applications also.
  - Preset Speeds to enable the user to pre-programme a duty cycle of fixed speeds. The cycle is operated by a combination of three digital external commands.
  - Preset Accelerations and Decelerations operate in conjunction with Preset Speeds, enabling a precisely-repeatable dynamic profile to be programmed.
  - 'Inch' ('jog') speeds enable the speed and acceleration of the motor to be preset to match the type of load, so that response to the 'inch' command is smooth and controlled.

  CONFIGURATION OPTIONS

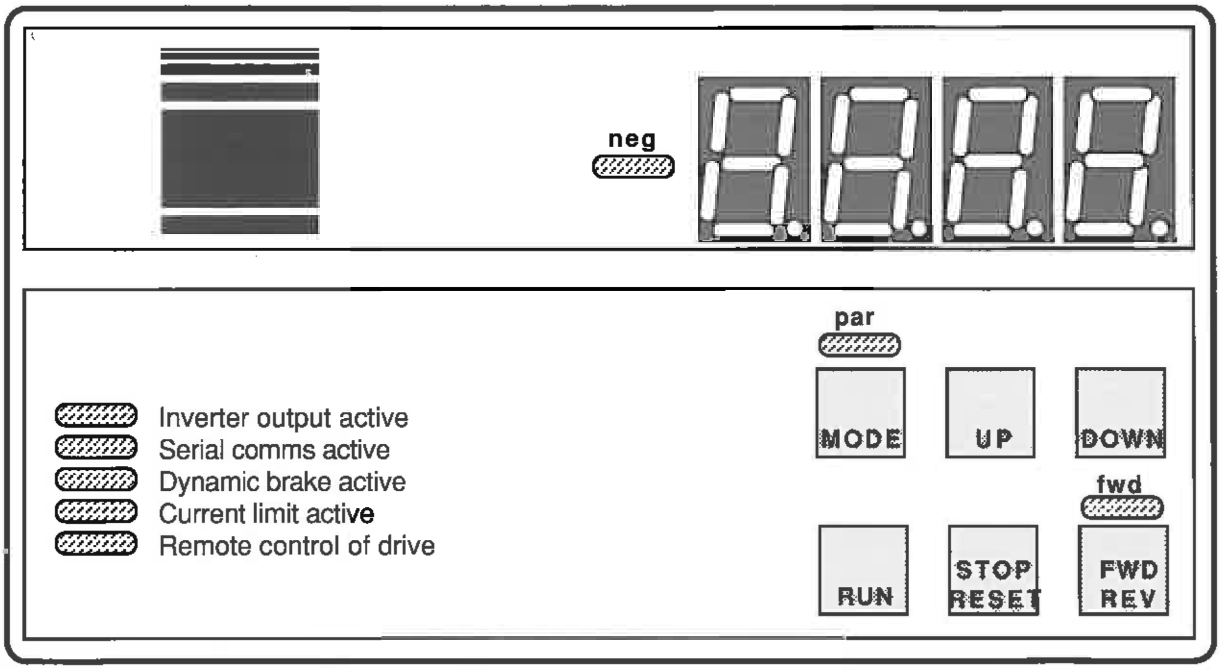
  - Dynamic V/f Ratio. A load-responsive mode for the control of the voltage-to-frequency ratio reduces motor noise and losses under light load.
  - Selectable 'catch a spinning motor'. The drive senses the frequency associated with the motor and auto-synchronises to it without tripping the drive.
  - Auto-restart after a trip. The option permits the user to select the number of times the drive will attempt to restart, and also the time delay between each attempt.

  ADDITIONAL FEATURES

  - Data logging facility includes the last nine drive trips.
  - Selectable zero-speed or at-speed relay functions.
  - Selectable output to signal 'alarm' or 'drive healthy'.
  - Undervoltage protection distinguishes between —
    UU DC link voltage has fallen below the operating range. The drive trips instantaneously.
    AcUU One or more phases of the power supply input to the drive is open-circuited or disconnected.

FEATURES PARTICULAR TO DRIVES EQUIPPED WITH pcb IN40 Issue 2

- Inbuilt dynamic braking option available.
- Short-circuit protection for the motor thermistor input.
- Voltage compensation. This feature improves the system stability in open-loop control, most noticeably effective under light load conditions, and improves torque at low-frequency (speed).



7 The Control Pod. Top right, the four-panel digital display with LED to indicate negative values. Lower left, five LEDs indicate the operational status of the drive. Two LEDs with the keypad illuminate when ('par' LED, upper left) the MODE key is pressed and the display shows a parameter number. The 'fwd' LED is illuminated when the drive is running forward.

The Control Pod, Fig.7, combines keypad and display functions. All operational functions of the drive and motor can be controlled and all parameter values can be changed from the keypad. Parameters and their values are adjusted by the three upper keys. Motor control from the keypad is enabled by setting parameter **b9** = 0.

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

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

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

A feature of the control pod is that it can be demounted from the module simply by pulling it away. This enables the drive module to be located in a secure enclosure and the control pod to be located in an accessible position.

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

The facility to demount the control pod can also be used to provide security, as the pod can be removed completely. Removal of the pod — even while the drive is active — has no effect on the operation of the drive, which continues to function in accordance with the parameter settings already made.

MANIPULATING THE PARAMETERS

To Select a Parameter

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

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

To Read a Parameter

Select a parameter (when the PAR LED is extinguished) by pressing the MODE key once. The LED will illuminate, and the display will show the **Pr** 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 8s, after which it will default to the Present Indication. If a different parameter is required, **select** as explained above. The new parameter will alternate with its value in the display for 8s.

To Change a Parameter

Stop for Bit Parameters!
Bit parameters take the place of the movable links used in analogue drives.
Bit-parameter values can be changed only when

the drive is stopped and the display is showing **rdY,** or
the drive has tripped, when the Trip Code will flash in the display.

In both cases, the Inverter Output Active LED is not illuminated.
To stop the drive, press the STOP/RESET key if the drive is in Keypad control mode (**b9**=0), or open the STOP terminal14 (CON2) in Terminal control mode (**b9**=1). Wait until the display shows **rdY**.

Security Code!
If a Security Code has been assigned (see page 41) it is not possible to **change** any parameter value until the correct code has been entered. Any parameter can be **read** without need for the Security Code.

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

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

Change the parameter value by pressing the UP or the DOWN key. A single keystroke changes the value by 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.

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

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

Negative Values!
Reducing a parameter value past zero makes it negative. A negative value is indicated by the negative LED beside the display becoming illuminated. Parameters which cannot possess a negative value will not reduce beyond zero.

DISPLAY PRESENT INDICATION

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

DRIVE CONDITION	DISPLAY
Healthy and stopped	either: **rdY** (Terminal Mode, **b9** =1) or: **rdY** (Keypad Mode, **b9** = 0)
Healthy and running	either: actual frequency (**b8** = 0, **b9** =1) or: load in % of output FLC (**b8** = 1, **b9** =1) Note that whichever value is displayed, the other canbe viewed by pressing both UP and DOWN keys simultaneously. or: set frequency (**b9** = 0)
Tripped	Trip Code, see page 80 When the drive trips, Trip Code flashes. When the drive is in the process of being reset, Trip Code is steady (not flashing). When the drive completes the reset, either — the display shows **rdY** (Manual Start mode) and the drive waits for a start signal or — the drive automatically starts (Auto Start mode)

DISPLAY FLASHING

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

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

SYSTEM STATUS ANNUNCIATOR

Five red LEDs to the left of the keypad, and the LED above the FWD/REV key, Fig. 7, convey information necessary to ensure a proper appreciation of the status of the drive, especially when it is installed as part of a system with remote control. These indications should always be studied before operating any of the keys on the keypad.

INVERTER OUTPUT ACTIVE indicates that the motor is powered up and healthy, and the output power bridge is active. At any particular time the motor may be stationary in accordance with an operating sequence. When extinguished, this LED indicates that the output is inactive only, for example because it is tripped, NOT because the drive is de-energised.

SERIAL COMMS ACTIVE means that the serial link is actively sending or receiving.

DYNAMIC BRAKE ACTIVE is disabled in the present version of CD11-75 & CDV11-90 drives.

CURRENT LIMIT ACTIVE conveys the information that the drive is in current (torque) limit and that either —

- the load exceeds either the full load of the motor as set by **Pr4**, or —
- the torque limit as set at terminal 7 (CON2), if connected, and signal is less than 10V.

REMOTE CONTROL OF DRIVE is an indication that the control mode is Remote, not Keypad or Local.

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

KEYPAD CONTROL

Control mode **b9** = 0

Note The FWD/REV key defaults to non-functional.

The UP and DOWN keys set the speed. The RUN and STOP/RESET keys start, stop and reset the drive when it has tripped.

With the motor stopped, the display alternates between **rdy** and the set speed value.

Start the motor by pressing RUN to accelerate to set speed.
Press the STOP key to decelerate to rest.

To adjust the speed, press and hold either UP or DOWN. If DOWN is held, the motor will decelerate to minimum speed, when the display will flash. If DOWN is then released , the drive will deliver minimum speed output.

To RESET, press the STOP/RESET key.

The direction of rotation of the motor shaft is selected by the local Forward/Reverse control, terminal 17 (CON2).

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

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

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

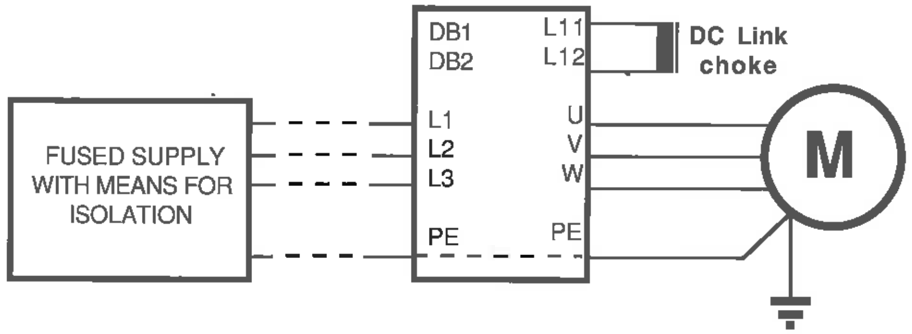
Preliminary

For access to the terminals, first detach the Control Pod — it will come away if pulled — then release the four screws retaining the cover of the drive module. The power and control terminals are located as shown in Fig. 24 on page 84.

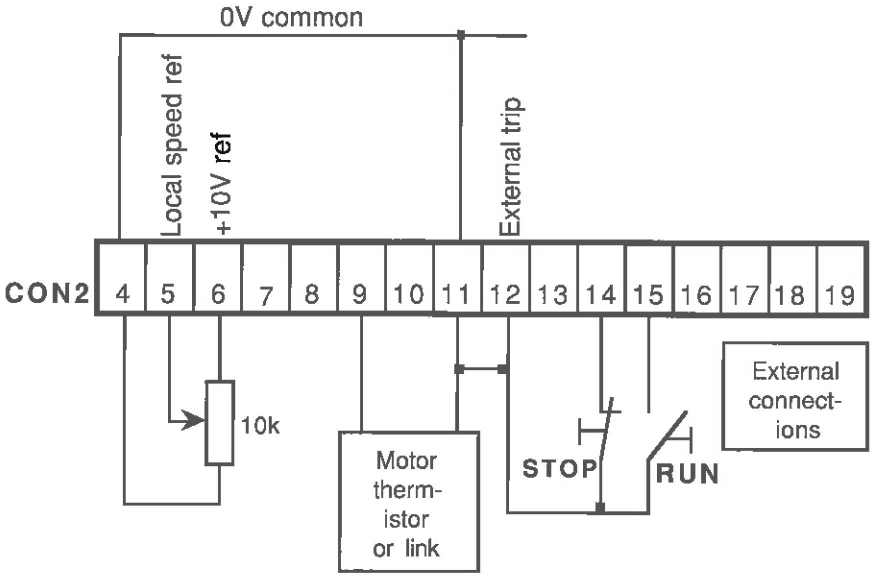
- Electrical supply connections are made in accordance with Fig. 8, and must be earthed in accordance with local industrial safety regulations.
- The specified torque for correct tightening of the power terminals is 8.5Nm. Excessive torque will result in shearing of the power terminal studs.
- The dc link choke must be installed (refer to SPECIFICATIONS & DATA, page 104).
- Protective hrc fuses or a circuit breaker of the correct rating (refer to SPECIFICATIONS & DATA, page 104) must be installed in the supply.

Procedure 'A' requires some simple control wiring to a start and a stop switch, with a potentiometer as shown in Fig. 9, and without alteration of parameters at the keypad. Starting and running the motor in this mode is as simple as with a conventional starter, and the motor is immediately under manual speed control.

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



8 Power supply system. Earth terminals are provided on the input and output terminal boards and permanently connected within the module. **IMPORTANT** A choke (inductor) of the correct rating MUST be fitted — refer to SPECIFICATIONS & DATA.



9 External components and connections to enable the drive to operate in Getting Started mode.

PROCEDURE A

External control, not using keypad.

A1 Install the control wiring connections to terminal board CON2, shown in Fig. 9, as follows:—

Terminals 4, 5, 6.	Connect10k potentiometer. Ensure that the potentiometer is set at the zero volts point.
Terminals 9, 11.	Connect the motor thermistor, if there is one, to terminals 9 and 11. If no thermistor, install a link.
Terminals 11, 12.	Link together to bypass the external trip.
Terminals 11, 14, 15.	Install two control switches —

a RUN switch, normally-open contacts, terminals 11 and 15, and
a STOP switch, normally-closed contacts, terminals 11 and 14.

A2 Energise the system. Observe that the Inverter Active LED illuminates. The keypad display indicates **0**. The motor remains at rest, but is energised at zero Hz.

A3 Turn the potentiometer a small amount to start the motor at low speed. Observe that the keypad display indicates the motor speed. The value shown is the frequency supplied to the motor. Thus if the supply system is 50Hz, the motor is at full speed when the display shows 50.0.

NOTE that it is not advisable to run the motor at low speed for any length of time, especially if it is loaded, unless the motor has a thermistor for over-temperature protection and this is connected to the drive as in paragraph A1, or arrangements have been made for additional cooling.

A4 Use the potentiometer to increase and reduce speed.

A5 Operate the STOP switch.

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

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

At this stage adjustments can be made to some parameters for practice and to observe the effects — go to Select Keypad Control under Procedure B.

Press the RUN switch (terminals 11-15) at any time to restart the drive.

PROCEDURE B

Keypad control, without using external control circuits

B1 Connect the motor thermistor, if there is one, between terminals 9 and 11. If no thermistor, install a link.

B2 Energise the system and observe that the keypad display becomes active and shows **rdY**.

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

SELECT KEYPAD CONTROL b9 = 0

Press the MODE key to enable a parameter to be selected. Observe that the PAR LED illuminates.

Press either the UP or the DOWN key. One key-stroke always changes the display to the next parameter. Choose parameter **b9.** The display alternates between **b9** and its present value, which will be **1**. This is the as-delivered value, and means that the motor is in TERMINAL control mode.

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

Press the MODE key to **enter** the new value.

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

SELECT MAXIMUM SPEED Pr1 = option

Press the MODE key. Press and repeat UP or DOWN to scroll through the parameters. Choose parameter **Pr1**.

Press MODE. The display will show the as-delivered value alternating with **Pr1**. This frequency is the maximum frequency that the drive will attain.

Press MODE again to set and exit the maximum speed adjustment. Wait 8s for the display to return to **rdY**, alternating with the set speed.

RUN AND STOP THE MOTOR

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

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

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

SELECT MINIMUM SPEED Pr0 = option

Press MODE. Use UP/DOWN to change **Pr1** to **Pr0** , and press MODE. The display will show the as-delivered value, **0**Hz.

Press UP to change **Pr1** to some other value, such as 40Hz and press MODE to set and exit.

Note It is impossible to choose a value of **Pr0** higher than the value of **Pr1**. If **Pr0** is raised to **Pr1** value, the display will flash the maximum value.

RUN THE MOTOR

Press RUN. The motor will run up to speed. Press and hold DOWN and the motor speed will ramp down to and settle at the selected minimum speed.

Note If it has not been possible to arrange to run the motor without a load, and if the load torque demand is high at low speeds, the motor should be allowed to run at minimum speed for a short period only unless special cooling arrangements have been made to compensate for the reduced efficiency of the internal cooling fan. At 80% of full speed the internal circulation is reduced to about 60%.

VARY THE MAXIMUM SPEED Pr1 = option

Press UP to raise the speed to rated full speed.

Press MODE, select **Pr1**, and press MODE. The display now shows the frequency being applied to the motor .

Press DOWN, and the motor speed will follow the display to a new value.

Note If **Pr1** is reduced too much, the display will flash when **Pr1** reaches the value of **Pr0** , and will continue flashing when the DOWN button is held.

Press MODE again to set a new value of **Pr1** and exit the adjustment mode.

Wait 8s to allow the display to show the output frequency. Continue adjusting the motor speed.

If further practice is desired, make further adjustments to any of the above.

PARAMETERS and their FUNCTIONS

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

Operating parameters have a real-value range, for example from 0 to 150%, and take the place of variable potentiometer settings. They permit limits to be set to the range or scale of a variable signal.

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

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

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

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

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

Certain parameters form a foundation for the way in which the drive will operate the motor. These are therefore considered first in the following pages, followed by those which refine the performance profile, or are optional, or else concern functions not directly affecting performance — such as the security code, serial address, etc.

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 **Summary of Parameters**, page 47. The values set at the factory ('as-delivered' values) may, for special customer requirements, differ from default values.

The technique for operating the keypad is described under **Keypad Procedure**, page 13.

FOUNDATION PARAMETERS

AUTO START AND MANUAL START

Selected by parameter **b1** —

auto	**b1** = 0
manual	**b1** = 1

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

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

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

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

Summary of Starting Characteristics

AUTO start	When drive is initially energised	120ms delay then auto start
	After stopping due to power supply disturbance	120ms delay then auto start
	After a TRIP signal	(Trip Code signalled) 1.0s delay to RESET Immediate start after RESET
	After a STOP signal	(**rdY** signalled) Waits for RUN or START signal
MANUAL start	When drive initially energised	(**rdY** or Trip Code signalled) Waits for RUN or START signal (after RESET if tripped)
	When stopped by any signal other than a trip	Signals **rdY,** requires RUN or START signal
	When stopped by a trip signal	Signals a Trip Code, waits for RESET, then waits for RUN or START signal

Power Loss and Ride-Through Transient Disturbance of the Supply

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

If the fault persists, that is, if the supply is not restored to normal during the ramping period, the drive will trip, the display will show **UU** or **Ph**, as appropriate, and the drive will switch off.

SPEED CONTROL AND TORQUE CONTROL

Selected by parameter **b0** —

torque control **b0** = 0
speed control **b0** = 1

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

In speed control, **b0** =1, both the speed reference and the torque reference are active. Speed control therefore adds a speed reference, local or remote, to the torque reference input, the torque reference being subject to current limit **Pr4**.

In torque control, **b0** = 0, only the torque reference is active. Speed is limited by **Pr0** and **Pr1**, and direction is determined from the resulting speed input.

It is possible for both or either of the speed and torque references to be driven from external sources.

OPEN LOOP AND CLOSED LOOP

Selected by parameter **b5** —

closed loop **b5** = 0
open loop **b5** = 1

These are two fundamentally-different control modes for a drive and motor. Open loop uses an internal measurement of output frequency as the speed demand signal. Slip compensation can be applied in open loop mode by **Pr7**.

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

ULF (Hz)	120	240	480
Increase above set speed (Hz)	7.5	15	30

PWM SWITCHING FREQUENCY (optional for CD11-55 & CDV11-55KW only)

Selected by parameter **b14** (first entry) — alternative values of 2.9kHz, and 5.9kHz are displayed successively 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 motor performance, and the relationship to the upper limit of inverter output frequency (ULF, see below). Lower PWM switching frequencies improve motor torque at low speed, keep heat losses to a minimum, and would be preferred for applications involving high-inertia loads, repeated acceleration, or frequent start-stop duty. The higher switching frequencies reduce torque ripple and acoustic noise, but increase losses due to inverter heating.

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

UPPER LIMIT OF FREQUENCY (ULF)

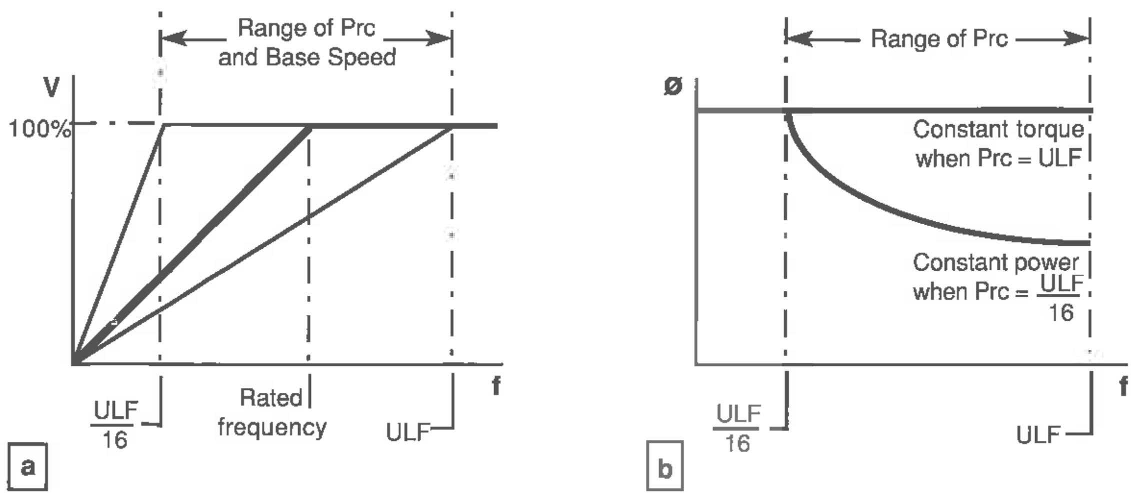
Selected by parameter **b14** (second entry) — integer values of 120Hz, 240Hz or 480Hz are displayed successively by repeated operation of the UP or the DOWN key.

If the selected PWM switching frequency is 2.9kHz, the highest ULF value (480Hz) **is not available**, and cannot be selected.

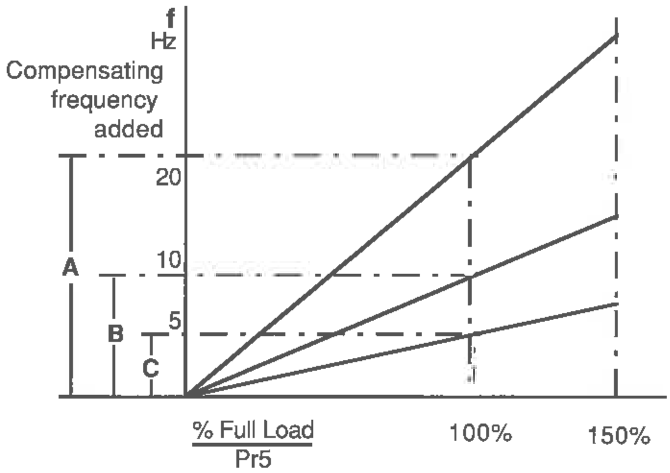
The ULF is the highest frequency of the inverter ac output sinewave. As the behaviour of other control functions is dependent on the ULF value chosen, it is convenient to select a value at this stage. The reasons for choosing one ULF value rather than another will be governed by consideration of the effect on the dependent functions. These functions are:-

- slip compensation — **Pr7**, page 29
- acceleration — **Pr2**, page 29
- deceleration — **Pr3**, page 31
- frequency resolution — page 47

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**.



1 0 Profiling the motor output characteristic by relating the values assigned to Prc and ULF. (a) Prc can be made equal to any value of ULF (minimum one sixteenth). (b) shows how the constant-torque and constant-power profiles are changed according to the selected value of Prc.
Note that ULF is itself selectable from one of three frequenccies.



1 1 Slip compensation Pr7 increases the frequency according to the load. Compensation may be selected within the available ranges —
'A' when ULF = 480Hz; 'B' when ULF = 240Hz; 'C' when ULF = 120Hz.

OPERATIONAL PROFILING

TORQUE-SPEED CHARACTERISTIC

The voltage-to-frequency ratio (V/f) delivered by an inverter is normally held constant up to the maximum (rated) voltage and frequency of the motor — the base speed. Up to this point the motor torque is, in principle, constant. Above base speed, where the voltage can no longer increase, further increase of frequency output produces a constant-power characteristic. (Refer to Figs. 1 and 2, page 6.)

CD11-75 & CDV11-90kW drives permit almost any value of output frequency to be assigned at the rated voltage. In other words, the base speed can, within wide limits, be modified to suit the application.

This facility enables the profile of the inverter output V/f characteristic to be varied. The curves in Fig.10a and 10b show that, 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 most important feature of CD11-75 & CDV11-90kW 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 to be assigned at the rated voltage of the motor is called the **maximum voltage frequency** (MVF) and is adjusted by parameter **Prc.** The MVF is defined by relating **Prc** to the selected value of the upper limit of frequency (ULF), parameter **b14**. The maximum value of the MVF is equal to the ULF (**Prc = b14**). The minimum value is one-sixteenth of the ULF.

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 inverter can supply any frequency up to the maximum for which it is designed (480Hz). It can also reverse the direction of field rotation and so reverse the direction of the motor. The inverter can also supply a compensating frequency for loss of speed through slip when the motor is under load.

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. The maximum speed reference signal (internal or external) is made to equal the value assigned to **Pr1. Pr1** cannot be greater than ULF.

Minimum speed, if required, is set by parameter **Pr0,** which can be any value less than **Pr1**. The logic does not allow the value of **Pr0** to be greater than **Pr1**. The 0 to +10V 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, say, then when the speed reference is 5V the output frequency is —

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

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

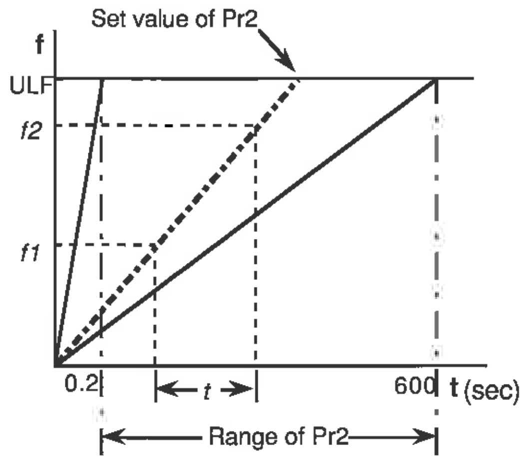
Frequency Relationship

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

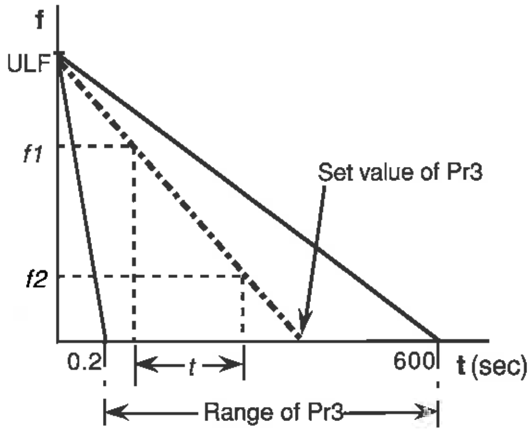
ULF ≥ **Pr1** ≥ **Pr0** ≥ 0Hz

Frequency Resolution

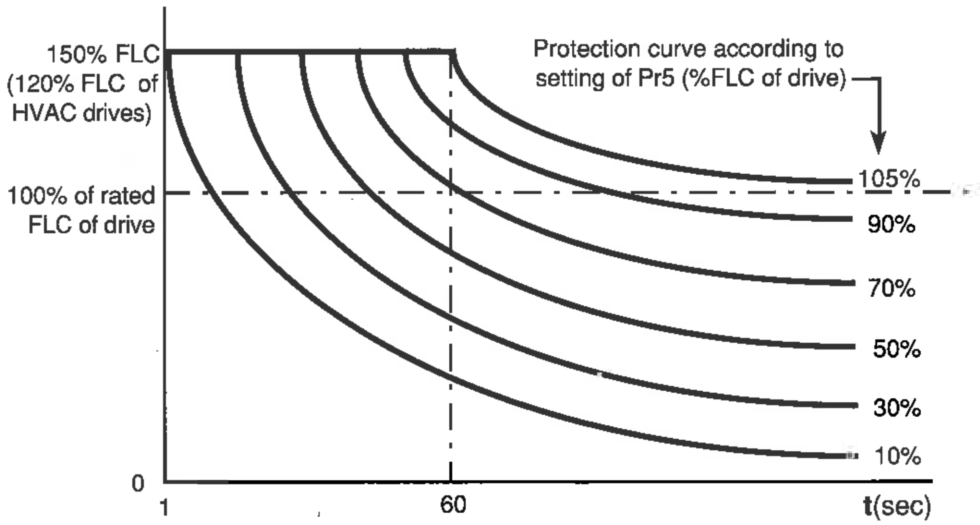
0 to 120Hz	0.1Hz
0 to 240Hz	0.2Hz
0 to 480Hz	0.4Hz



12 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.



13 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.



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

SLIP COMPENSATION

Slip compensation for loss of speed with increasing load due to the slip characteristic of squirrel cage induction motors is applied by parameter **Pr7**, Fig.11. In open loop mode (**b5** = 1) **Pr7** increases the output frequency of the inverter to a value above the frequency demanded by the speed reference. In closed loop mode, **Pr7** has no effect. The available values of slip compensation are —

ULF Hz	Available Range of **Pr7**	Maximum Compensation
120	0 to 5Hz	7.6Hz
240	0 to 10Hz	15.4Hz
480	0 to 20Hz	30.8Hz

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

- The value of ULF selected
- The value of **Pr7** selected from the available range for the ULF
- The actual load as a proportion of the selected value of maximum continuous current **Pr5** (refer to CURRENT & PROTECTION below)

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

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

Slip compensation applies in both forward and reverse operation and gives almost perfect speed holding with fluctuating speed and load.

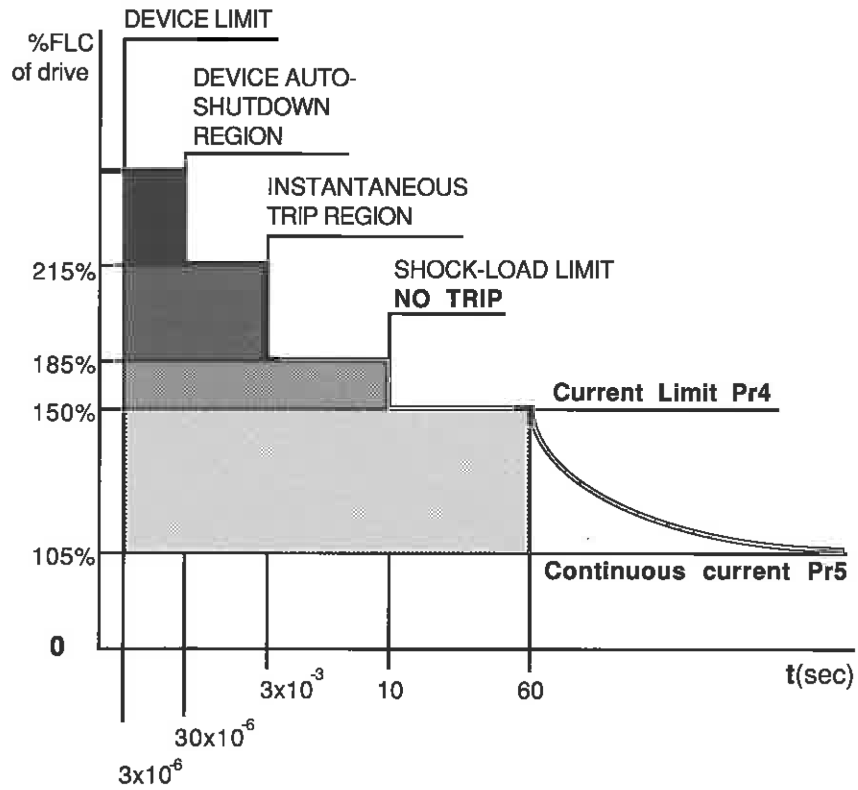
CHANGE-OF SPEED RAMPS

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

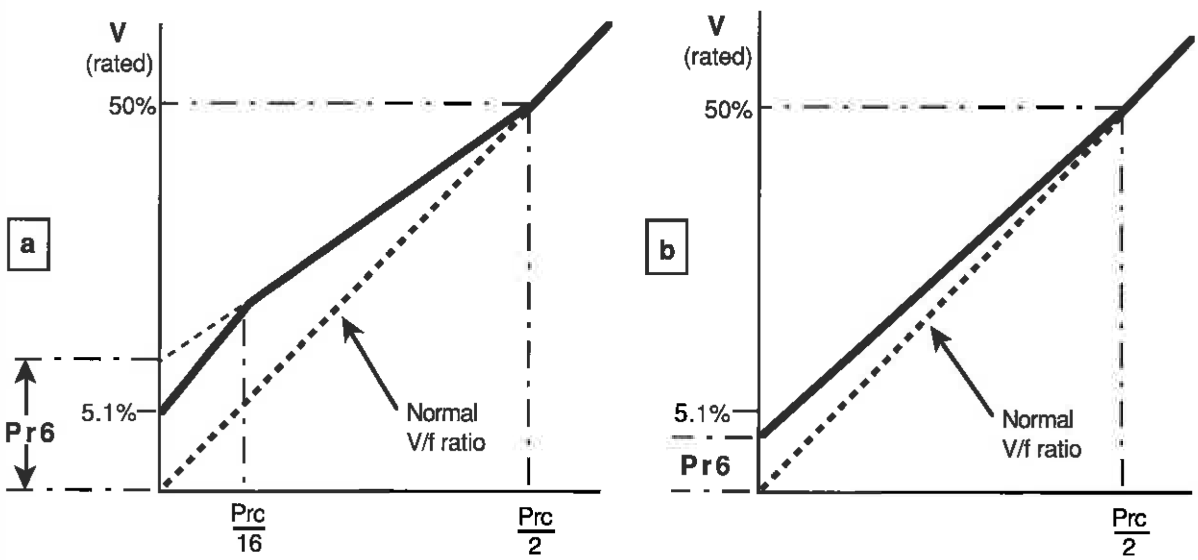
Acceleration and deceleration can be regarded as rate of change of frequency since, for a motor driven by an inverter, the speed is nominally proportional to the frequency. If the frequencies at the start and finish of a change of speed are defined, the time to change from one to the other determines the acceleration or deceleration. The inverter logic uses 0Hz and the selected value of ULF as the frequency set points.

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.12. Acceleration limits are imposed by the maximum and minimum available values of **Pr2** and by the chosen value of ULF (**b14**).

A short acceleration time combined with a high inertia load may demand a current higher than the maximum continuous current **Pr5** (see CURRENT & PROTECTION below) and the current is



1 5 Overcurrent protection by internal electronic monitoring.



1 6 Voltage (torque) boost Pr6. (a) High level of boost, tapering to 5.1% at 0Hz. Note that boost is maintained at high level up to a frequency of one sixteenth of Prc. (b) Low level of boost — tapers evenly from Pr6 when Pr6 is <5.1% of rated voltage.

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**, see CURRENT & PROTECTION below) were set low would there be a likelihood of an overload trip during acceleration.

Deceleration time is set by parameter **Pr3** which has a range from 0.2s to 600.0s, Fig.13. The effect of deceleration time is, however, not exactly analogous to acceleration time, even though the two characteristics shown in Figs.12 and13 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 (Fig. 6 page 37) and by losses within the system, but the dc voltage cannot be allowed to rise without risk of damage to drive components. The dc link protection logic is not adjustable.

If it is found that a chosen deceleration time causes the inverter to trip and indicate a dc link overvoltage, either the deceleration time must be increased or, if this is not possible due to the needs of the driven system, the dynamic braking mode will have to be utilised with an external resistor to absorb the excess energy. This alternative is discussed further under STOPPING & BRAKING, page 37.

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 cabling. Any current value in excess of **Pr5** when integrating in the I x t region is signalled at the keypad display by flashing of the unused decimal points in the display and will, if sustained, result in tripping of the inverter. Curves are shown in Fig.14.

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

where k = 25.7 for CD11-75kW Industrial Drives
and k = 8.57 for CDV11-90kW HVAC Drives

Current Limit

The level of controlled maximum current output is set by **Pr4**. Its maximum value is 150% of inverter FLC for Industrial drives and 120% for HVAC drives. **Pr4** can be set to any value between **Pr5** and the rated maximum for the drive.

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 cabling.

The logic responds to transients as shown in Fig.15, protecting the motor, the cabling and the drive by shutting down the inverter IGBT bridge. The speed of electronic fault detection is greatly superior to the performance of hrc fuses.

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 parameter **Pr6**, which can be given any value up to 25.5% of main supply voltage.

When AUTO boost is selected, the inverter logic 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 applied voltage boost is

$$(20 \times 0.90 \ / \ 1.05) = 17.1\%.$$

This is tapered from 17.1% boost at zero speed 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, as the machine is more susceptible to stalling. AUTO boost is better for variable-torque loads where the load at starting is also variable. The machine is less susceptible to stalling but will not produce as high a starting torque as in fixed boost.

When FIXED boost is selected, **Pr6** is applied by the inverter logic to the constant V/f line at 0Hz, Fig.16a. This has the effect of modifying the gradient of the constant V/f line between 0Hz and 50% MVF. (The gradient of constant V/f depends on the chosen setting for the MVF (**Prc**), refer to Fig 10a & b, page 26).

When the boost value (**Pr6**) is set high, the profile below the set point (one-sixteenth of **Prc**) assumes the gradient of constant V/f provided that the line will intersect the 0Hz axis at a value of 5.1% of mains supply voltage or less. Otherwise, the intercept is made at 5.1%. If the chosen value of **Pr6** is low, the gradient of boost values is constant, Fig.16b.

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

SPEED & TORQUE REFERENCES

SPEED REFERENCE

Active when **b0** = 1. Torque reference, see below, **is always active.**

Select LOCAL or REMOTE mode, controlled by terminal 16 (CON2). Choice of speed reference source is then as follows —

LOCAL Either — **b9** = 0 (Keypad mode)
Speed reference is set by UP/DOWN keys

Or — **b9** = 1 (Terminal mode)
b6 = 0 or 1
terminal 16 (CON2) open circuit

Voltage reference 0V to = +10V at terminal 5 (CON2) provided, for example, by a 10k potentiometer between terminals 4, 5 and 6 (CON2).

When **b4** = 1, FWD/ REV is controlled by terminal 17 (CON2)

Set speed	**Pr0**	**Pr1**
Input voltage	0V	+10V

When **b4** = 0, terminal 17 (CON2) is not functional

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

REMOTE **b9** = 1
terminal 16 (CON2) closed = 0V

There are three choices of input for the remote speed reference —

Either — **b11** is set to 4.20, 20.4 or 0.20, and **b6** = 0

Current loop reference at terminal 8 (CON2), for which the input is 4 to 20mA, 20 to 4mA or 0 to 20 mA (0.1k impedance) as appropriate to the installation.

FWD/REV is controlled by terminal A9 (CON4)

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

Or — **b11** = **Ur**, and **b6** = 0

Voltage reference 0V to +10V at terminal A7 (CON4) is provided, for example, by a 10k potentiometer between terminals A6, A7 and A8 (CON4).

When **b4** =1, FWD/REV is controlled by terminal A9 (CON4)

Set speed	**Pr0**	**Pr1**
Input voltage	0V	+10V

When **b4** = 0, terminal A9 (CON4) is not functional

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

Or — **b6** = 1 (slave)

Control by Serial Communications Link. Speed reference is adjusted by mnemonic SP.

TORQUE REFERENCE

Active whether **b0** = 0 or 1. (Speed reference **is not active** when **b0 =** 0.)

Select LOCAL or REMOTE mode, controlled by terminal 16 (CON2) . Choice of speed reference source is then as follows —

LOCAL or REMOTE **b6** = 0 (Master mode)

This mode enables the drive to operate the motor within speed limits while controlling its torque output and is especially useful for applications such as winding and spooling. The torque reference input is 0V to +10V to terminal 7 (CON2). Zero volts sets the minimum torque at 10% FLC, and +10V sets maximum torque to the value of **Pr4**. If the terminal is left open-circuited the terminal is internally pulled up to +10V to set the torque demand equal to the **Pr4** value.

REMOTE and **b6** = 1 (Slave mode)

Control by Serial Communications Link. Torque reference is adjusted by mnemonic TP.

BIPOLAR/UNIPOLAR REFERENCE SELECT

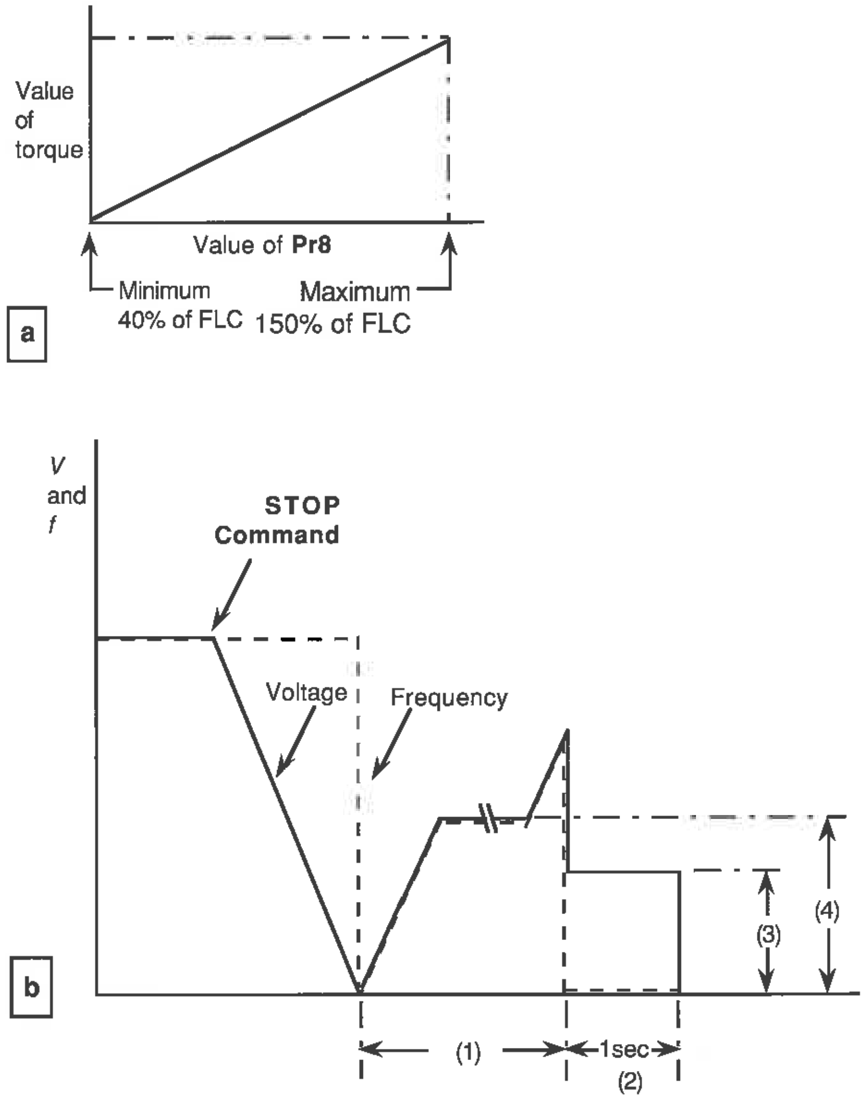
Unipolar reference **b4** = 1
Bipolar reference **b4** = 0

Permits the drive to accept a bipolar reference to control forward and reverse operation as the alternative to a unipolar reference with a forward/reverse signal. Applies to local and remote voltage references at terminals 5 (CON2) and A7 (CON4).

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

*Direction immaterial

In bipolar reference mode, terminals 17 (CON2) and A9 (CON4) **are not functional.**



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

STOPPING & BRAKING

STOPPING & BRAKING MODES

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

The CD11-75 & CDV11-90kW range of drives is available with or without the DB braking circuit (Fig. 6). Without it, high level ramp (resistive) braking is not available.

Resistive braking is preferable for application 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 as **b8** = 0 or 1
injection	**dc**

*With or without external resistor

Ramp Mode

Ramp brings the motor to rest in a time proportional to the decelerating time parameter **Pr3** (refer to CHANGE OF SPEED RAMPS, page 29). Ramp is used if longer stopping times than the natural coasting time are required. The rate of deceleration is linear.

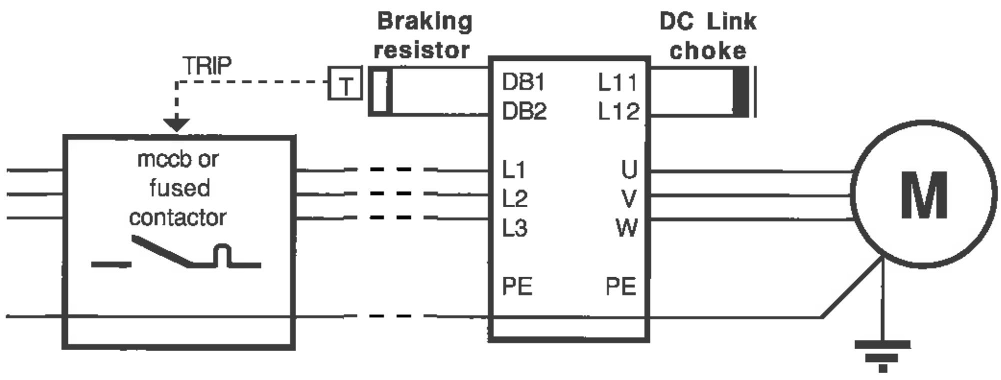
If **b2** = **b7** = 0 (standard ramp) the ramp is halted if the dc link voltage reaches the voltage limit and continues when the voltage falls below the limit.

If **b2** = **b7** = 1 (high level ramp) the ramp is continuous. This setting requires the use of an external resistor.

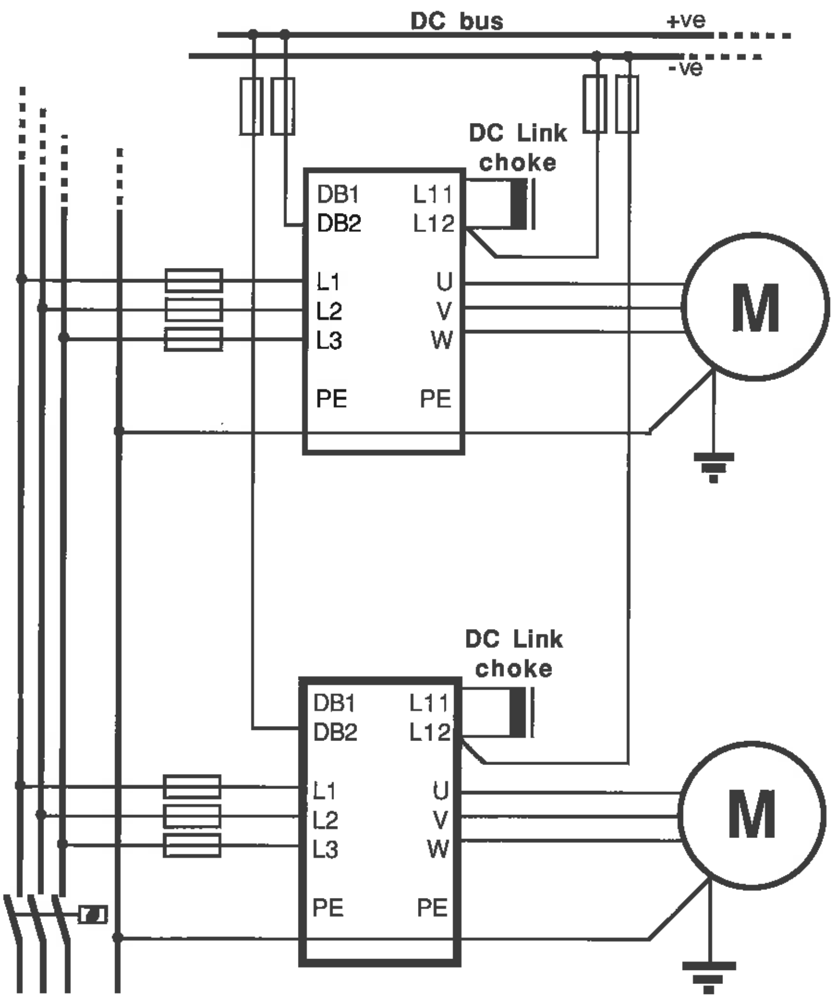
Stopping Mode

There are four possible states —

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



1 8 Drive with external braking resistor, equipped with thermal overload trip to operate contactor or mccb.



1 9 Multiple independent drives and motors with the dc link of each drive connected in parallel with the other, avoiding the need for braking resistors. A single contactor controls the power supply to all drives. Individual drives are protected by fuses. DC connections must use semiconductor fuses.

Injection Mode
Injection braking requires parameter **Pr8** to be adjusted between the limits of 40% and 150% of motor rated FLC. The applied braking torque depends on the value of **Pr8.** Higher values produce shorter stopping times, Fig.17a.

At the STOP command, the output voltage is rapidly reduced at constant frequency, Fig. 17b, so that the motor is defluxed. A braking current is then applied at low frequency. The value of **Pr8** determines the level of current injected. As the motor comes to rest, direct current is applied for one second. During the stopping sequence described, any RUN command is inhibited until after the one-second dc injection period.

Resistive Braking Operation
The resistive braking option with the current CD11-75 & CDV11-90kW range of drives requires a braking control card installed internally to the drive. For further information please refer to User's Guide, Dynamic Braking Units & Resistors for CD11-75kW & CDV11-90kW Drives (part no. 0174-1175).

It is essential that a braking resistor is equipped with thermal overload protection and that the trip circuit is wired to a contactor or circuit breaker installed on the supply side of the drive, Fig.18.

Drives in Parallel
It is possible to operate two or more CD11-75 & CDV11-90kW drives with their dc buses connected in parallel, Fig.19. This is a convenient arrangement in certain applications where, due to the nature of the load, intermittent overvoltage tripping of a drive occurs during deceleration. By paralleling dc buses, current regenerated by one drive can be absorbed by another or others. This may avoid the necessity to fit a braking resistor. It is not necessary for the motors concerned to be mechanically coupled, or even to be operating in the same process application.

However, if the characteristics of the loads of all the drives are such that frequently-repeated brsking is expected, the correct solution would be to fit braking resistors if overvoltage tripping is experienced.

The paralleling of dc buses is applicable **only to drives of equal rating** to ensure correct sharing of currents in the rectifier diode bridges.

All drives paralleled in this way must be powered-up simultaneously to avoid damage to the rectifier diode bridges. Supply should be from a common busbar, with a single switch to control all drives, and fuse protection in the feeders to individual drives as shown in Fig.19. The dc links are also paralleled, as shown. Semiconductor fuses are essential protection in the dc connections.

REVERSING & RESET

REVERSING

Reversing is controlled by the polarity of the local or remote speed reference when **b4** = 0. Negative polarity produces a reverse operation.

If **b4** =1, a logic signal applied to terminal 17 (CON2) or terminal A9 (CON4) operates as follows —

open circuit	=	forward
0V (contact closed)	=	reverse

The signal may be switched by any convenient device, including a push button switch, a relay contact or an open-collector semiconductor.

RESET

A trip condition may be reset by one of the following means —

- Switch the main power supply off and on. An undervoltage (**UU**) trip will be displayed.
- In KEYPAD mode, press the STOP/RESET key
- Operate the RESET input, terminal 13 (CON2)

The signal may be switched by any convenient device, including a push button switch, a relay contact or an open-collector semiconductor.

For a complete summary of procedures, refer to the Stop, Start, Reset, Reverse, Trip summary, page 43.

COMMUNICATIONS PARAMETERS

DISPLAY VALUE

Selected by parameter **b8**. During normal operation, and when the drive is **not** in Keypad mode, the keypad display can show either the motor speed or the load. Speed is shown in Hz, and is thus related to the local standard supply frequency and the number of motor poles. 50Hz or 60Hz is base speed according to locality. Load is displayed as a percentage of full load current.

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

A quick way of changing the displayed value from speed to load or from load to speed is to press both the UP and DOWN keys simultaneously.

SECURITY CODE

Selected by parameter **Prb**. Prevents unauthorised access to all read-write parameters.

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

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

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

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

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

As delivered, **Prb** = 0. If desired, the code can be left at this so that access is available without a code. It is convenient to do this during commissioning, and to assign a security code after the operating parameter settings are satisfactory.

As an alternative or additional security, the keypad can be demounted from the drive; refer to page 105 and Fig 31.

SERIAL ADDRESS

Selected by parameter **Pr9**. Any one- or two-digit number from 0 to 99 can be set.

A serial address is essential if the Serial Communication Link is to be used, even if only one drive is connected.

SERIAL COMMUNICATIONS

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

- Parity bit to be adjusted to suit the host

  b10 = 0 even parity
  b10 = 1 odd parity

- Baud rate to suit the host

  b12 = 4.8 4800 baud
  b12 = 9.6 9600 baud

- Serial address

  Pr9 = 0 to 99

- Master/slave selector to be set as follows —

  b6 = 1 **and** terminal 16 (CON2) in REMOTE mode (ie closed) if parameters are to be adjusted by the host.

  b6 = 0 **or** terminal 16 (CON2) in LOCAL mode (ie open) allows parameters only to be read by the host.

DEFAULT PARAMETERS

The drive logic contains a set of default values which are retrieved by **b13.**

Parameter **b13** is normally set at 0. Setting **b13** = 1 changes changes all parameters to their default values, which are given in the Summary of Parameters, page 47. Note that the Security Code **Prb** will become 0, so that security is lost.

Ordinarily, drives are delivered with all parameters at their default values. Exceptionally, by arrangement with the supplier, parameters may be set to values other than default values for delivery.

STOP

Keypad mode b9 = 0

Press the STOP key. Observe the display as the speed reduces. The drive will stop, and the display will change to **rdY** alternating with the set speed.

Terminal mode b9 = 1

PARAMETER STATUS	PROCEDURE
b6 = 0 (Master mode)	Momentarily open the STOP input, terminal 14 (CON2)
b6 = 1 (Slave mode)	Momentarily open the STOP input, terminal 14 (CON2), or — using Serial Comms, momentarily set bit **1** of mnem CW to **0**

ANY Control Mode	Disconnect main power supply

START

Manual Start Mode b1 = 1, or Auto Start Mode b1 = 0

PARAMETER STATUS		PROCEDURE
b9	**b6**	
0 (Keypad mode)	**0 or 1**	Display shows **rdY** alternating with the set speed Press RUN key Drive will accelerate to the set speed
1 (Terminal mode)	**0** (Master mode)	Momentarily close the RUN input, terminal 15 (CON2)
	1 (Slave mode)	Either — Momentarily close the RUN input, terminal 15 (CON2) Or — using Serial Comms, momentarily set bit **0** of mnem CW to **1**

Auto Start Mode b1 = 0

The drive will start automatically when

- power supply is first connected
- drive is RESET after a Trip
- power supply is restored after temporary loss

RESET

PARAMETER STATUS			
b9	**b6**	**b1**	PROCEDURE
0 (Keypad mode)	**0** or **1**	**1** = Manual	Display shows a Trip Code (flashing) Press STOP/RESET key Display shows **rdY** alternating with set speed
		0 = Auto	Display shows a Trip Code (flashing) Press STOP/RESET key Drive will accelerate to the speed set prior to trip
1 (Terminal mode)	**0** (Master mode)	Momentarily close the RESET input, terminal 13 (CON2)	
	1 (Slave)	Momentarily close the RESET input, terminal 13, (CON2), or — using Serial Comms, momentarily set bit **5** of mnem CW to **1**	
ANY			Disconnect and reconnect main power supply

REVERSE

A REVERSE command from any source causes the drive to decelerate (ramp down) to zero speed at a rate determined by parameter **Pr3**, and to accelerate (ramp up) in the reverse direction at a rate determined by **Pr2**.

Keypad mode b9 = 0

PARAMETER **b6**	TERMINAL 16 (CON2) (Local/Remote)	PROCEDURE
0 (Master mode)	Open or closed	Close the Local FWD/REV input, terminal 17 (CON2)
1 (Slave mode)	Open = LOCAL	Close the Local FWD/REV input, terminal 17 (CON2)
	Closed = REMOTE	Using Serial Comms, set mnem SP to a negative value

Terminal mode b9 = 1

PARAMETER STATUS		TERMINAL 16 (CON2) (Local/Remote)	PROCEDURE
b6	**b4**		
0 (Master mode)	**1** (Unipolar reference)	Open = LOCAL	Close the Local FWD/REV input, terminal 17 (CON2)
		Closed = REMOTE	Close the Remote FWD/REV input, terminal A9 (CON4)
	0 (Bipolar reference)	Open = LOCAL	Reverse the polarity of the Local speed reference input, terminal 5 (CON2)
		Closed = REMOTE	If **b11** = **Ur** Reverse the polarity of the Remote speed reference input, terminal A7 (CON4)
			If **b11** = 4.20, 20.4, or 0.20 Close the Remote FWD/REV input, terminal A9 (CON4)
1 (Slave mode)	**1** (Unipolar reference)	Open = LOCAL	Close the Local FWD/REV input, terminal 17 (CON2)
		Closed = REMOTE	Using Serial Comms, set mnem SP to a negative value
	0 (Bipolar reference)	Open = LOCAL	Reverse the polarity of the Local speed reference input, terminal 5 (CON2)
		Closed = REMOTE	Using Serial Comms, set mnem SP to a negative value

TRIP

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

For particulars of internal trips and the Trip Codes refer to page 80.

An external trip **Et** can (in Terminal Mode only) be forced by the operator, whether any external protection is connected to the drive or not.

PARAMETER STATUS		PROCEDURE
b9	**b6**	
1 (Terminal mode)	0 (Master mode)	Momentarily open the external trip input, terminal 12 (CON2)
	1 (Slave mode)	Either — Momentarily open the external trip input, terminal 12 (CON2) Or — Using Serial Comms, momentarily set bit **4** of mnem CW to **0**
0 (Keypad mode)	Forced trip not possible	

RESOLUTION

When parameters are set from the Keypad or the serial communications link, resolution is ±0.1 unit **except** for the following —

value >100 units	±1.0 unit, Keypad mode ±0.1 unit, Serial Comms mode
Pr2 and **Pr3**	resolution becomes coarser towards 600s
Pr0 , **Pr1**, **Pr7**	±0.2Hz for ULF = 240Hz ±0.4Hz for ULF = 480Hz
Pr6	±0.4%

OPERATING PARAMETERS

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

Pr0	**Minimum frequency**	The lower limit of inverter output frequency, determining the minimum speed of the motor.
	Range Default value 0Hz	$0Hz \leq Pr0 \leq Pr1$
Pr1	**Maximum frequency**	The value of speed in Hz above which the motor is not to operate.
	Range Default value 50Hz	$Pr0 \leq Pr1 \leq ULF$
Pr2	**Acceleration time**	The time to accelerate from 0Hz to the selected value of ULF; determines the slope of the acceleration ramp.
	Range Default value 5.0s	0.2s to 600s
Pr3	**Deceleration time**	The time to decelerate from the selected value of ULF to 0Hz; determines the slope of the deceleration ramp.
	Range Default value 10.0s	0.2s to 600s

Pr4	**Timed current limit**	Maximum level of inverse time-current overload.

Range Pr5 ≤ Pr4 ≤ 150%FLC for Industrial rating drives
Pr5 ≤ Pr4 ≤ 120%FLC for HVAC rating drives
Default values 150% FLC for Industrial rating drives
120% FLC for HVAC rating drives

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	
Pr6	**Voltage (torque) boost**	Maximum level of voltage boost at zero frequency, but tapered to 5.1% max at 0Hz.
	Range	0 to 25.5% of main supply voltage
	Default value 5.1%	
Pr7	**Slip compensation**	Increases inverter output frequency as load increases; scaled by the ratio of actual current to the selected value of **Pr5**, up to the frequency increase selected.
	Range	0 to 5Hz — ULF 120Hz 0 to 10Hz — ULF 240 Hz 0 to 20Hz — ULF 480Hz
	Default value 0Hz	
Pr8	**Injection braking**	Maximum level of injection braking current; value as a percentage of rated FLC.
	Range	40% to 150%FLC
	Default value 150%FLC	
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	

Pr A — **Failure mode parameter**

Contains the Trip Code for the last trip. Does not hold **UU** unless there was an undervoltage **trip**. Holds the last trip code even when power disconnected.

Default value Et, external trip

Pr b — **Security code selector**

Permits choice of the security code for each individual inverter. **Prb** = 0 corresponds to no security code. In keypad adjustment mode, values of 100 to 255 and zero can be set. In serial comms control mode, values of 0 to 255 can be set.

Range 0 to 255
Default value 0

Pr d — **Menu selector**

For access to the menus which extend the dynamic control features of the drive.

SUMMARY of PARAMETERS Pr d

Parameter		Serial mnemonic	Factory setting
Skip frequencies	**Pr10 - Pr12**	S1 - S3	0Hz
Skip bands	**Pr13 - Pr15**	B1 - B3	±0.5Hz
Preset speeds	**Pr20 - Pr26**	P1 - P7	0Hz
Jog speed	**Pr27**	PJ	1.5Hz
Preset speed accelerations	**Pr30 - Pr36**	A1 - A7	as **Pr 2**
Jog speed acceleration	**Pr37**	AJ	0.2sec
Preset speed decelerations	**Pr40 - Pr46**	D1 - D7	as **Pr3**
Jog speed deceleration	**Pr47**	DJ	0.2sec
Auto restart	**Pr50**	RN	zero
Auto restart delay timer	**Pr51**	RD	1sec

bit parameters

Jog & 3 preset speeds, or 7 preset speeds	**b20**	C1	0 = jog & 3 presets
Standard or selected acceleration times	**b21**	C1	0 = Standard
Terminal or preset reverse	**b22**	C1	0 = Terminal
Run or At Speed relay	**b50**	C1	0 = Run
Disable or enable FWD/REV key at keypad	**b51**	C1	0 = Disable
Enable 'Catch spinning motor' software	**b52**	C1	0 = Disabled
Alarm/Drive Healthy output	**b53**	C1	0 = I x t active
Fixed or dynamic V/f ratio	**b54**	C1	0 = Fixed V/f ratio

BIT PARAMETERS

b0 **Speed reference or torque reference selector**

0 = torque reference
1 = speed reference

Default value b0 = 1

b1 **Auto start or manual start selector**

0 = auto start
1 = manual start

Default value b1 = 0

b2 & b7 **Braking method selector**

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

Default values b2 = 0
b7 = 0

b3 **Low speed torque boost selector**

0 = auto boost
1 = fixed boost

Default value b3 = 0

b4 **Bipolar/unipolar reference selector**

1 = unipolar
0 = bipolar

Default value b4 = 1

b5 **Feedback selector**

0 = encoder
1 = open loop

Default value b5 = 1

b6 **Master/slave selector** (when in Remote mode)

0 = Master (current loop, remote analogue reference)
1 = Slave (serial comms link)

Default value b6 = 0

b7 See **b2**

b8 **Display frequency or load current value**

0 = frequency (Hz)
1 = load (%FLC)

Default value **b8** = 0

b9 **Keypad or terminal control selector**

0 = keypad
1 = terminal

Default value b9 = 1

b10 **Parity selector**

0 = even parity
1 = odd parity

Default value b10 = 0

b11 **Remote reference selector**

Input 4 to 20mA = 4.20
20 to 4mA =20.4
0 to 20mA = 0.20
remote 0 to +10V = **Ur**

Default value b11 = 4.20

b12 **Baud rate selector**

4.8 = 4800 baud
9.6 = 9600 baud

Default value 4.8

b13 **Reset parameters to default values**

0 = inactive
1 = set default values

Default value 0

b14 **Define PWM switching frequency and ULF**

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

NOTE — 5.9kZ available on CD11-30kW and CDV11-37kW drives only.

Second entry — Upper limit of frequency -
120 = 120Hz,
240 = 240Hz,
480 = 480Hz

Default values - PWM 2.9kHz
- ULF 120Hz

Prc **Max. voltage frequency** Defines the frequency at which the inverter delivers the rated voltage.

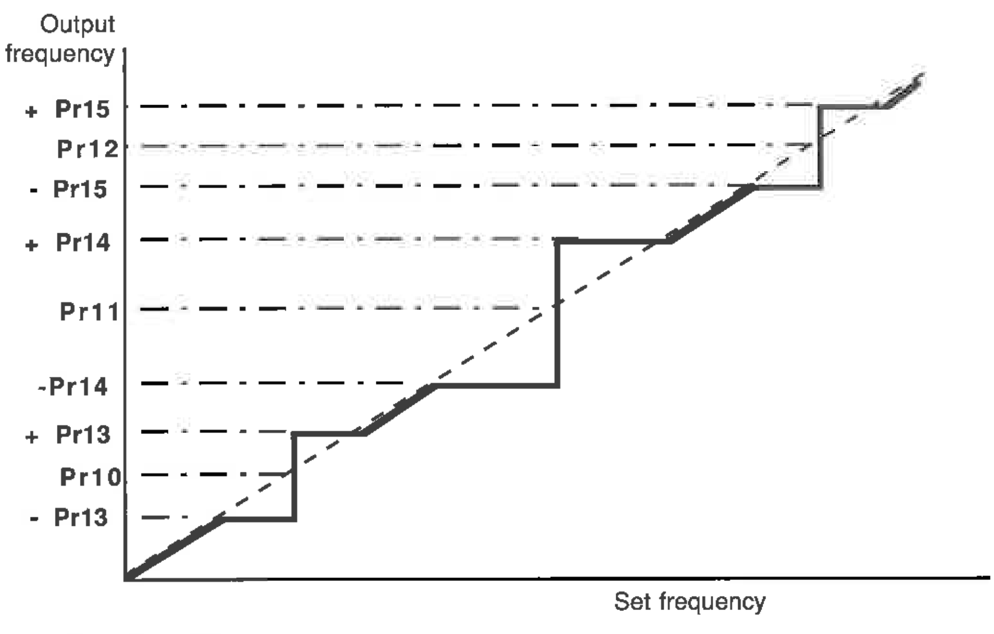
Range ULF/16 < Prc < ULF
Default value 50Hz

Prd = 10 SKIP FREQUENCY

For an application in which the mechanical system resonates at one (or at more than one) particular frequency of drive output it is desirable to eliminate continuity of change of speed through a certain frequency band or bands . With a Skip Frequency in operation, the drive will continue to change speed but makes a step change on reaching the limits of the skip-frequency band, Fig. 20.
Up to three Skip Frequencies can be selected, and each may have a different band width. The Skip Frequencies operate when the drive is accelerating and when it is decelerating.
After selecting **Prd** = 10, proceed as shown in the example, Fig. $, then enter the desired value of skip-frequency in Hz, press MODE, and set half the desired value of total skip-band in Hz; this automatically applies both the lower and upper limits.

Pr	Skip (value in Hz)	Mnemonic	Range	Default
10 **11** **12**	frequency 1 frequency 2 frequency 3	S1 S2 S3	**Pr0** to **Pr1** Refer to User's Guide, page 27	0Hz
13 **14** **15**	band 1 band 2 band 3	B1 B2 B3	±0.5 to ±5.0Hz giving a range of band width from 1.0Hz to10Hz	±0.5Hz

Parameters **Pr10** through to **Pr15** are Real, Read-write



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

Prd = 20 PRESET SPEEDS

(Refer also to menus30 & 40 below, Preset Acceleration & Preset Deceleration)
Up to seven speeds can be selected, any of which can then be instantly applied by configuring the three external switches (mechanical or open-collector) connected between control terminals A10, A11, A12 and A1 (0V) of terminal block CON4. Refer to Logic Diagram 5a, page 68.
The purpose is to enable a profiled duty cycle to be constructed for any application, such as that shown in Fig. 21. Acceleration and deceleration between Preset Speeds may either be controlled by Presets (refer to menus 30 and 40 below) or by parameters **Pr2** and **Pr3** (refer to page 29).
Preset speeds are always available by connecting any of terminals A10, A11, A12, to zero volts, as shown in Table-A below. If all terminals are open-circuit, the drive will use any source of speed reference that is currently valid. (Refer to page 33.) When any of the three terminals is at 0V, the Preset Speeds take precedence over all other speed references.

TABLE-A

Table of Preset Speed Control Configurations

A12	A11	A10	PRESET SPEED
0	0	0	'Normal' set speed reference
0	0	1	**1**
0	1	0	**2**
0	1	1	**3**
1	0	0	**4**
1	0	1	**5**
1	1	0	**6**
1	1	1	**7**

In the table, 0 = open circuit; 1 = 0V, ie 'closed' **provided that** the logic has not been inverted. Refer to page 77 'Logic Inversion' and Fig. 23, page 76.

TABLE-B

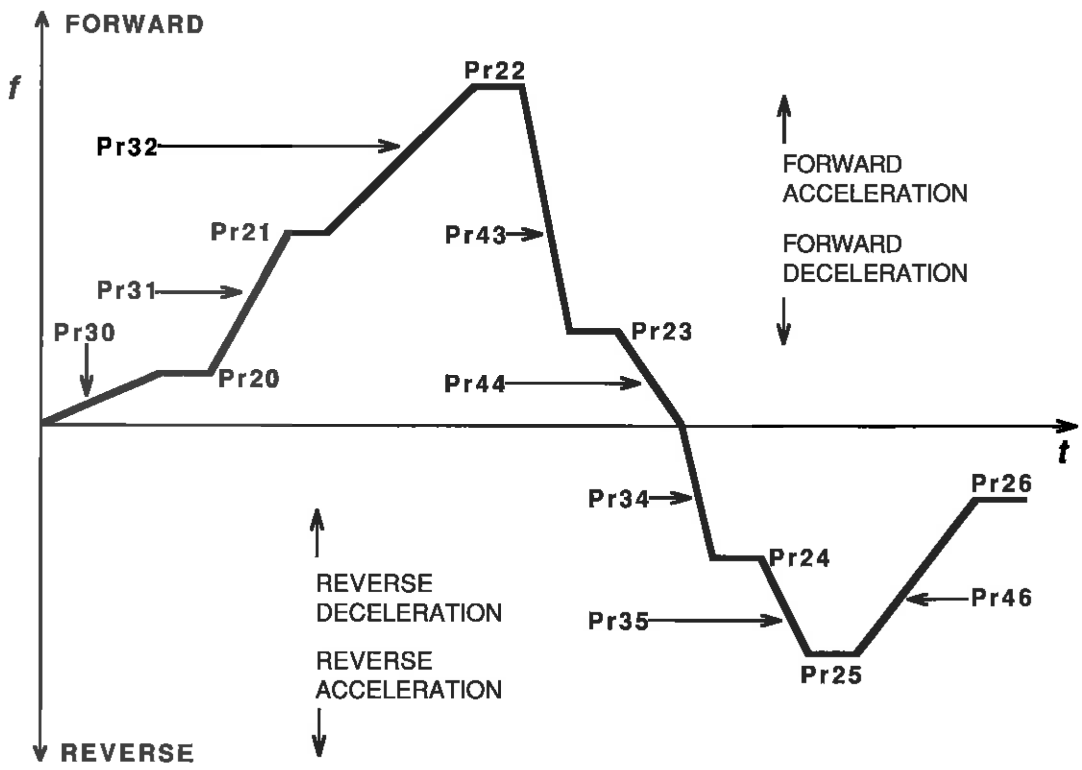
Pr	Preset Speed (value in Hz)	Mnemonic	Range	Default
20	**1**	P1	**Pr0** to **Pr1**	0Hz
21	**2**	P2		
22	**3**	P3		
23	**4**	P4		
24	**5**	P5		
25	**6**	P6		
26	**7**	P7		
27	Jog	PJ	0 -15Hz	1.5Hz

Parameters **Pr20** through to **Pr27** are Real, Read-write.

The speed values corresponding to Preset Speeds **1** through to **7** in Table-A are written (in Hz) by assigning values to parameters **Pr20** through **Pr27** as shown in Table-B and Logic Diagram 5a, or though Serial Communications. Information relevant to **Prd** is in Configuration through Serial Communications, page 58.
Thereafter, any Preset speed, or 'normal' speed, can be applied at will by the terminal switching configurations of Table-A.

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

1 Bit parameter **b20** = 0 (default) enables only terminals A10 and A11 for Preset Speeds. In this mode, Preset Speeds **1, 2** and **3** are available, Table-B, with Jog (otherwise called 'inch', meaning that the motor is under momentary on-off control). The Jog facility is thus



2 1 Application of Preset Speeds (**Pr20...**), Acceleration Times (**Pr30...**), and Deceleration Times (**Pr40...**). NOTE that acceleration and deceleration parameter numbers maintain a logical sequence of unit-digits independent of the tens-digits. Thus, the change-of-speed parameter between the Preset Speeds **Pr21** and **Pr22** must be **Pr32** if accelerating, or **Pr42** if decelerating. If the motor is driven directly into reverse without any Preset Speed at zero speed (as illustrated) the successive forward-deceleration and reverse-acceleration parameters have the same unit-digit, though different tens-digits. Rate of change of speed can change at zero speed (as illustrated) or can be the same, as required.

controlled by applying 0V at terminal A12 — in other words, the switch controlling the voltage at terminal A12 becomes a Jog control.
From **rdY**, the drive will run at set Jog frequency for as long as terminal A12 is connected to 0V. The acceleration and deceleration rates of the Jog operation are controlled by **Pr37** and **Pr47** (refer to menus 30 and 40 below).

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

3 Bit parameter **b21** = 0 (default) puts **Pr2** and **Pr3** in control of acceleration and deceleration.

4 Bit parameter **b21** = 1 enables the individual profiling accelerations and decelerations available in menu **Prd** = 30... and = 40... (refer to parameters 30 and 40 below).

5 Bit parameter **b22** = 0 (default) enables reversing to be controlled from terminal 17 CON2 while the motor is running.

6 Bit parameter **b22** = 1. The direction of rotation is preset by parameters **Pr20** to **Pr26**, refer to Fig.21.

Reverse Rotation

To programme any Preset Speed parameter to operate the motor in reverse, set the value of speed required but, before pressing MODE, press the FWD/REV key to toggle the negative LED of the display (Fig. 7, page 12).

Prd = 30 PRESET ACCELERATIONS

Accelerations between Preset Speeds can be preset. If **Prd** bit 21 = 0, acceleration is controlled by **Pr2.** Note the logic of the sequence of the acceleration (and deceleration) parameter numbers — the 'unit' digit of the number must always correspond with the 'unit' digit of the *second* of the two Preset Speeds which it connects. Application of **Prd** = 30 is illustrated in Fig. 21.

TABLE-C

Pr	Preset Accel. (value in seconds)	Mnemonic	Range	Default
30	**1**	A1	as Pr2	as Pr2
31	**2**	A2		
32	**3**	A3		
33	**4**	A4		
34	**5**	A5		
35	**6**	A6		
36	**7**	A7		
37	Accel Jog	AJ		0.2s

Parameters **Pr30** through to **Pr37** are Real, Read-write.

Prd = 40 PRESET DECELERATIONS

Decelerations between Preset Speeds can be preset. If **Prd** bit 21 = 0, deceleration is controlled by **Pr3.** Note the logic of the sequence of the deceleration (and acceleration) parameter numbers — the 'unit' digit of the number must always correspond with the 'unit' digit of the *second* of the two Preset Speeds which it connects. Application of **Prd** = 40 is illustrated in Fig. 21.

TABLE-D

Pr	Preset Decel. (value in seconds)	Mnemonic	Range	Default
40	**1**	D1	as **Pr3**	as **Pr3**
41	**2**	D2		
42	**3**	D3		
43	**4**	D4		
44	**5**	D5		
45	**6**	D6		
46	**7**	D7		
47	Decel Jog	DJ		0.2s

Parameters **Pr40** through to **Pr47** are Real, Read-write.

NOTE — The external STOP input at terminal 14 CON2 will override the Jog function.

Calculating Acceleration or Deceleration Time
To determine the required value of a Preset Acceleration or Deceleration parameter —

Example

Referring to Fig. 21, to find the value to enter for **Pr43**, in seconds,

$$\mathbf{Pr43} = t \times \frac{\text{ULF}}{\mathbf{Pr22} - \mathbf{Pr23}} \text{ (seconds)}$$

NOTE — for the explanation of ULF, refer to page 25.

Prd = 50 AUTO RESET or RESTART

This menu enables the mode of operation of the drive to be configured to reset and start after a trip, automatically. The facility provides for selection of the time delay before reset/restart, and for selecting the number of attempts before the auto reset/restart facility is disabled and the drive remains tripped. With the drive in AUTO-start mode (**b1** = 0), when this function is enabled any user-resettable trip other than **Et** will be automatically reset and the drive will restart.
If the trip condition persists after the selected number of start attempts, the drive will latch the trip. If the trip condition clears within the selected number of start attempts, the restart count is reset to the value of **Pr50.** The restart count is also reset on power-up, or whenever **Pr50** (RN) is given a new value. When the drive trips in this mode, the keypad display shows the trip code and the remaining restart count.

TABLE-E

Pr	Function	Mnemonic	Range	Default
50	Number of attempts	RN	up to 5 attempts	0 (disable)
51	Start delay	RD	1sec to 5sec	1sec

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

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.

CONFIGURATION OPTIONS

Within the **Pr d** = 50 menu, four bit parameters are available to select the configuration options listed below.

To change a bit parameter the drive must be at **rdY**. Status can be read at any time.

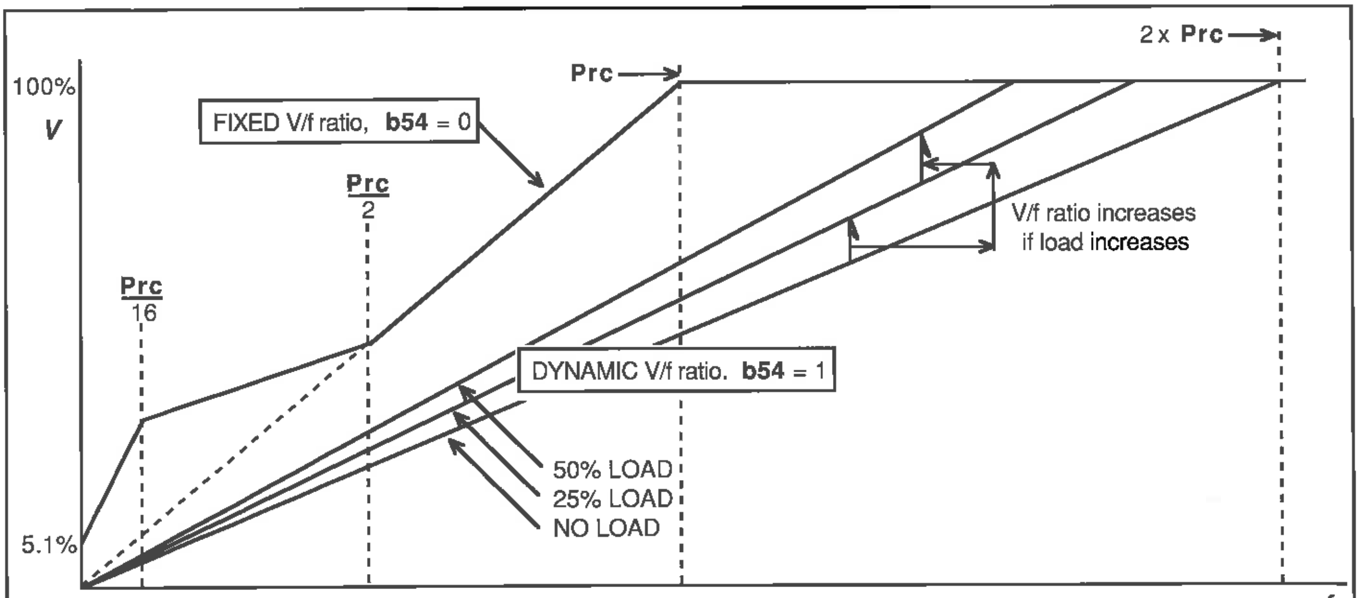
b50 = 0 Relay RL202 indicates Run (default)
b50 = 1 Relay RL202 indicates At Speed
Allows the user to choose the relay signal appropriate to the installation.

b51 = 0 DISABLE keypad FWD/REV key (default)
b51 = 1 ENABLE keypad FWD/REV key
Enhances security by making the FWD/REV key inactive. For example, to reverse a moving conveyor during operation could be dangerous.

b52 = 0 Not catch spinning motor (default)
b52 = 1 Catch spinning motor
Enables the drive to be energised onto a motor whose shaft is rotating, without causing a trip. On receiving a RUN signal, the drive scans the motor frequency and connects itself at a synchronising value. During the scanning period the keypad displays **SCAN.** On systems where there is no mechanical load on the motor when it is over-running, a change of speed may be observed during the scanning operation. Dependent on the system and the dynamic conditions, there may be a delay of up to 5 seconds before the drive resumes normal operation.

b53 = 0 Open-collector output = I x t protection active (default)
b53 = 1 Open collector output = Drive Healthy
Overload alarm outputs. An alarm output is active (at terminal A3 CON4) when the actual percentage load output of the drive exceeds the maximum continuous current (**Pr5**). If the percentage falls below the value of **Pr5** and the drive is not integrating in the I x t region, the alarm output returns to the inactive state. If the alarm output trips on overload (I x t integrated to the limit) the alarm output latches in the active state.

b54 = 0 FIXED V/f ratio (default)
b54 = 1 DYNAMIC V/f ratio
Provides the option of load sensitive voltage response, Fig. 22, 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.



22 In dynamic V/f mode the V/f ratio is proportional to load. [Not to scale}

DATA LOGGING

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

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

To access the last nine trips through the Serial communications link, nine mnemonics are used —

Function	Mnemonic
PrA	T0
PrA - 1	T1
PrA - 2	T2
PrA - 3	T3
PrA - 4	T4
PrA - 5	T5
PrA - 6	T6
PrA - 7	T7
PrA - 8	T8
PrA - 9	T9

CONFIGURATION THROUGH SERIAL COMMUNICATIONS

Serial communications may be used to access any of the foregoing parameters. All parameters can be read at any time. **Pr** parameters can be changed at any time, but for bit parameters to be changed the drive must be at **rdY**. All parameters to be changed are subject to use of the security code. Bit-parameter data is Integer, Read-Write. To read or write bit parameters, mnemonic C1 provides the access to a a 2-byte hex-value word of four characters as shown in Table-F.

EXAMPLES

To select a Preset Speed, Acceleration or Deceleration, the required Preset number is written to the mnemonic PS. This is a one-byte hex-value word of two characters — refer to the User's Guide, page 79. The data is Integer, Read-Write.

If a value above the valid range is transmitted by PS, the highest valid value will be entered, as determined by bit parameter **b20.**

Preset Speeds are adjusted by mnemonics P1 to P7; preset acceleration by A1 to A7; preset deceleration by D1 to D7.

COMMUNICATIONS NOTES

Data types —

R R/W	= Real, read or write	Real numbers displayed
R RO	= Real, read only	Real numbers displayed
I R/W	= Integer, read or write	Hex code displayed
i RO	= Integer, read only	Hex code displayed

TABLE-F

bit	= 0 (Default)	=1	Function
1st Character			
—	—	—	—
b54	Fixed	Dynamic	V/f ratio
b53	I x t active	Drive healthy	Open collector output
b52	Not catch	Catch	Spinning motor sync.
2nd Character			
b51	Disabled	Enabled	FWD/REV key
b50	Run	At Speed	Run/At speed relay RL202
b21	Standard	Preset	Accel/Decel
b20	3 Preset + Jog	7 Preset, no Jog	Preset Speed inputs
3rd Character			
b22	Terminal	Preset	Preset reverse
Not used			
Not used			
Not used			
4th Character			
Not used			
Not used			
Not used			
Not used			

BIT PARAMETERS — Numerical

KEY	DESCRIPTION	0	1
b0	Control mode — torque or speed	Torque	Speed
b1	Start mode — auto or manual	Auto	Manual
b2	with b7 — Stopping mode	See table Stopping Mode	
b3	Boost mode — Auto or Fixed	Auto	Fixed
b4	Unipolar or bipolar reference selector	Bipolar	Unipolar
b5	Encoder or open loop feedback	Encoder	Open Loop
b6	Master or slave remote speed reference	Master	Slave
b7	with b2 — Stopping mode	See table Stopping Mode	
b8	Display frequency or load	Frequency	Load
b9	Control mode — keypad or terminal	Keypad	Terminal
b10	Parity bit — even or odd	Even	Odd
b11	Remote speed-reference selector	*	
b12	Baud rate selector	*	
b13	Set parameters to default	*	
b14	ULF and PWM switching frequency	*	
Prc	MVF (maximum voltage frequency)	*	

* Refer to Summary of Parameters, page 51

Stopping Mode

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

BIT PARAMETERS — Alphabetical

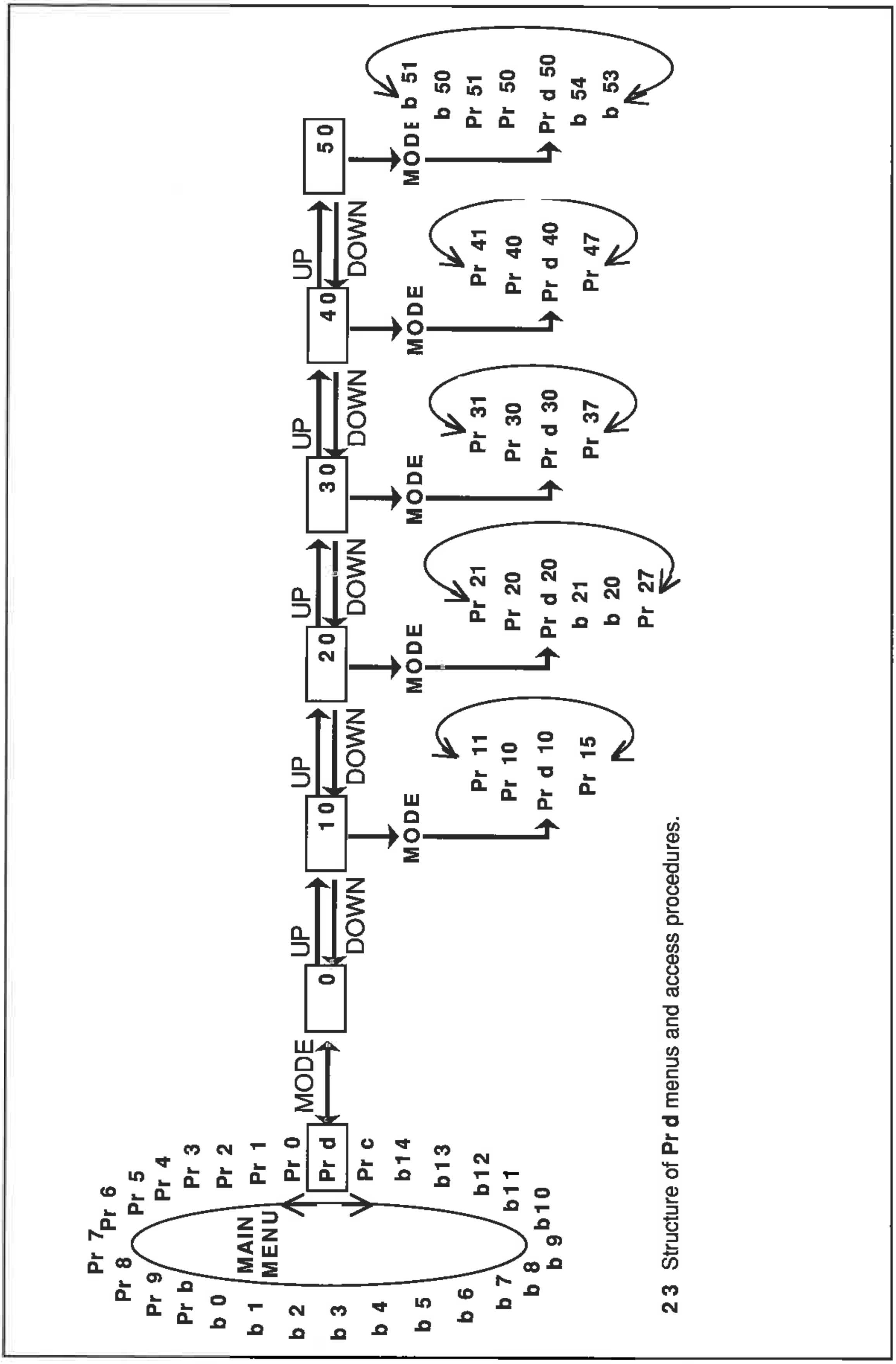
SUMMARY of PARAMETERS Pr d

Parameter		Serial mnemonic	Factory setting
Skip frequencies	**Pr10 - Pr12**	S1 - S3	0Hz
Skip bands	**Pr13 - Pr15**	B1 - B3	±0.5Hz
Preset speeds	**Pr20 - Pr26**	P1 - P7	0Hz
Jog speed	**Pr27**	PJ	1.5Hz
Preset speed accelerations	**Pr30 - Pr36**	A1 - A7	as **Pr 2**
Jog speed acceleration	**Pr37**	AJ	0.2sec
Preset speed decelerations	**Pr40 - Pr46**	D1 - D7	as **Pr3**
Jog speed deceleration	**Pr47**	DJ	0.2sec
Auto restart	**Pr50**	RN	zero
Auto restart delay timer	**Pr51**	RD	1sec

bit parameters

Jog & 3 preset speeds, or 7 preset speeds	**b20**	C1	0 = jog & 3 presets
Standard or selected acceleration times	**b21**	C1	0 = Standard
Terminal or preset reverse	**b22**	C1	0 = Terminal
Run or At Speed relay	**b50**	C1	0 = Run
Disable or enable FWD/REV key at keypad	**b51**	C1	0 = Disable
Enable 'Catch spinning motor' software	**b52**	C1	0 = Disabled
Alarm/Drive Healthy output	**b53**	C1	0 = I x t active
Fixed or dynamic V/f ratio	**b54**	C1	0 = Fixed V/f ratio

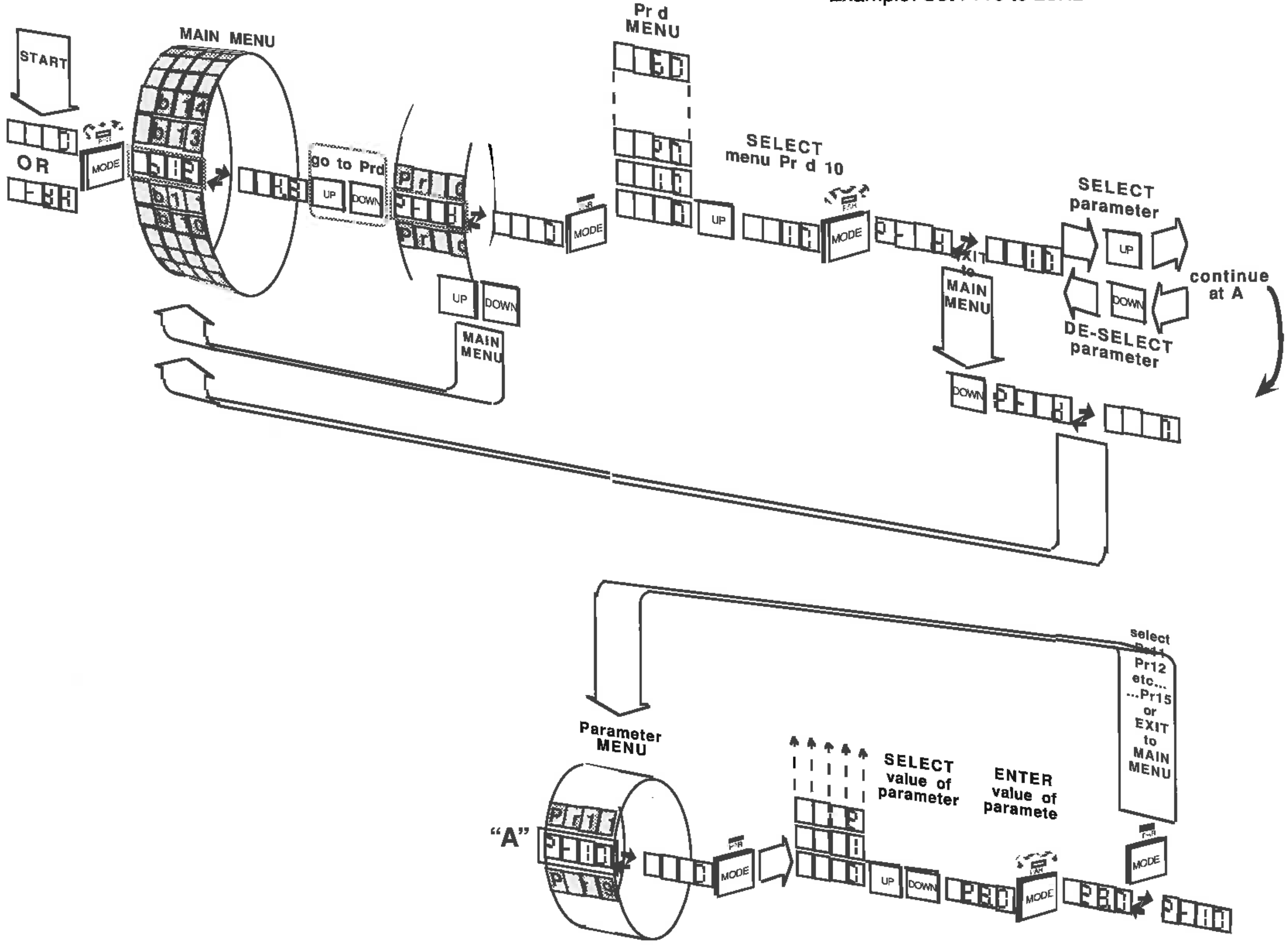
Parameters are accessed at the keypad by the same methods as for standard CD parameters, as described in the User's Guide. The structure of the **Pr d** menus is shown in Fig. 23. A detailed example of access and parameter-value change is shown in Fig. 24. The example shows the procedure to access Skip Frequencies, parameter **Pr10**, and set a new value of 28Hz.

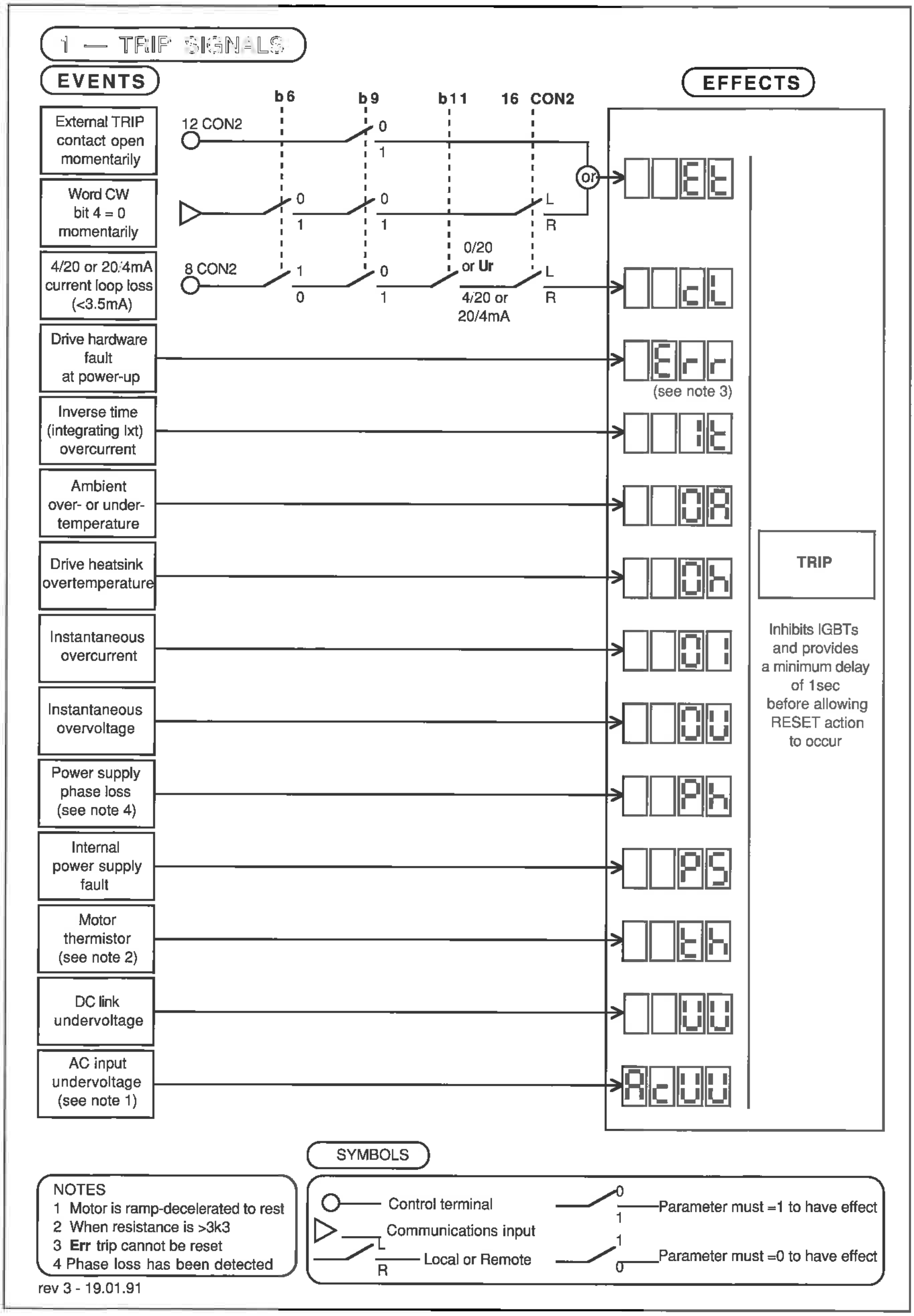


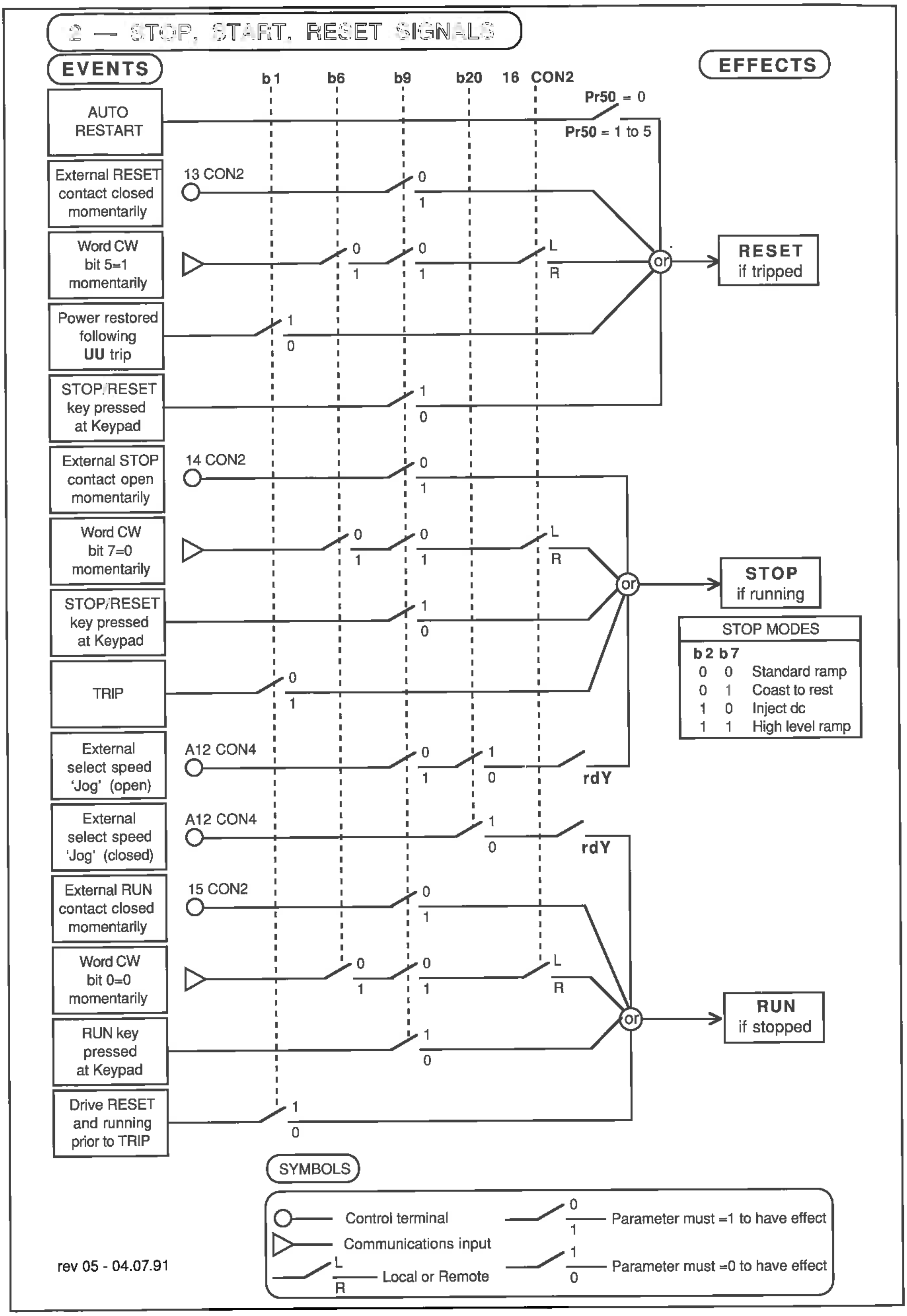
23 Structure of **Pr d** menus and access procedures.

MANIPULATION of the **Pr d** MENU

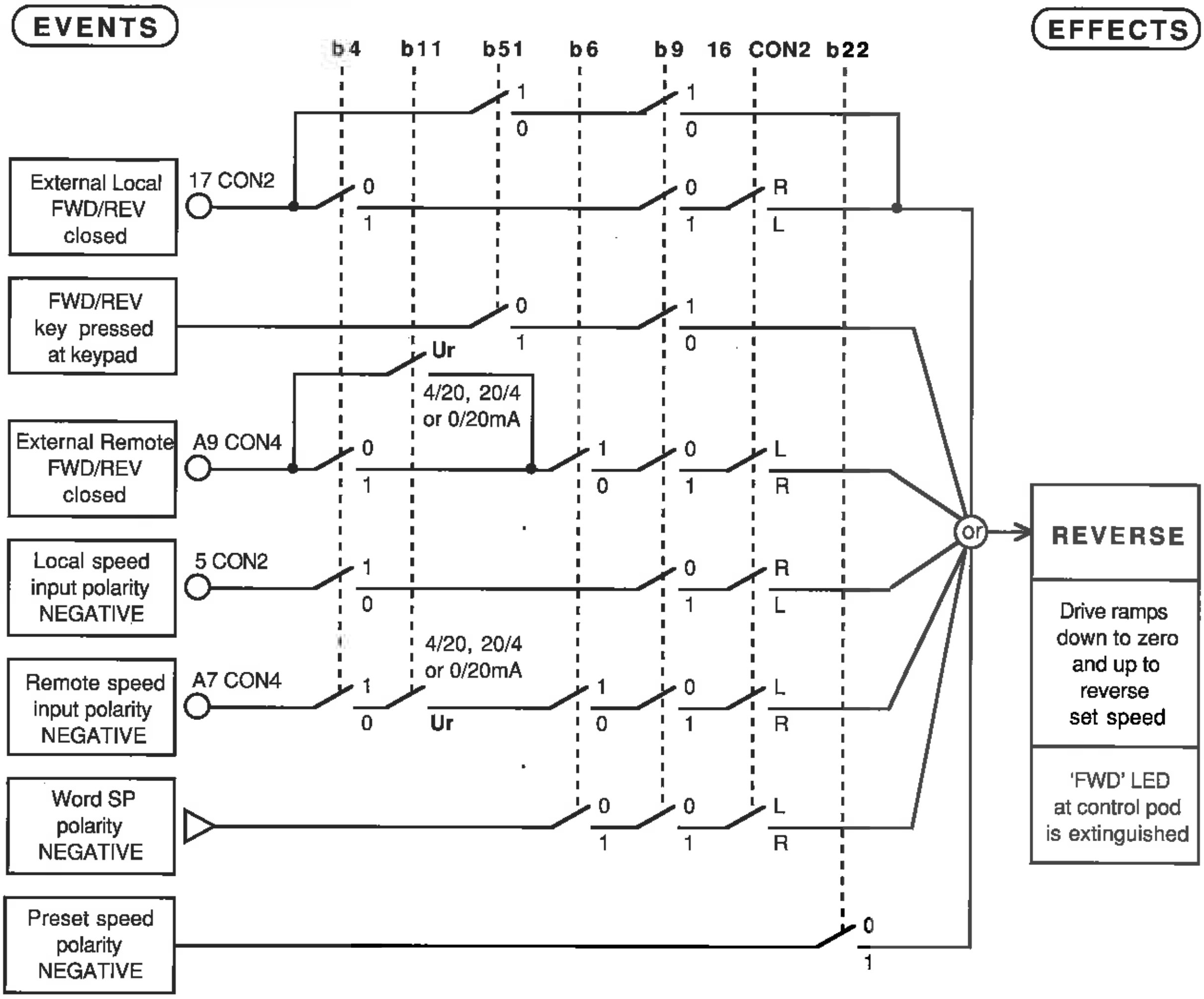
Example: Set Pr10 to 28Hz

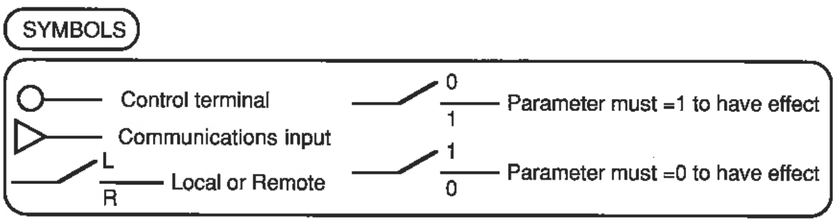



1 — TRIP SIGNALS
EVENTS
EFFECTS
b6
b9
b11
16 CON2
12 CON2
0
1
L
R
0/20
or Ur
4/20 or
20/4mA
8 CON2
or
External TRIP contact open momentarily
Word CW bit 4 = 0 momentarily
4/20 or 20/4mA current loop loss (<3.5mA)
Drive hardware fault at power-up
Inverse time (integrating Ixt) overcurrent
Ambient over- or under-temperature
Drive heatsink overtemperature
Instantaneous overcurrent
Instantaneous overvoltage
Power supply phase loss (see note 4)
Internal power supply fault
Motor thermistor (see note 2)
DC link undervoltage
AC input undervoltage (see note 1)
Et
cL
Err
(see note 3)
It
OA
Oh
OI
OU
Ph
PS
th
UU
AcUU
TRIP
Inhibits IGBTs and provides a minimum delay of 1sec before allowing RESET action to occur
SYMBOLS
Control terminal
Communications input
Local or Remote
Parameter must =1 to have effect
Parameter must =0 to have effect
NOTES
1 Motor is ramp-decelerated to rest
2 When resistance is >3k3
3 Err trip cannot be reset
4 Phase loss has been detected
rev 3 - 19.01.91

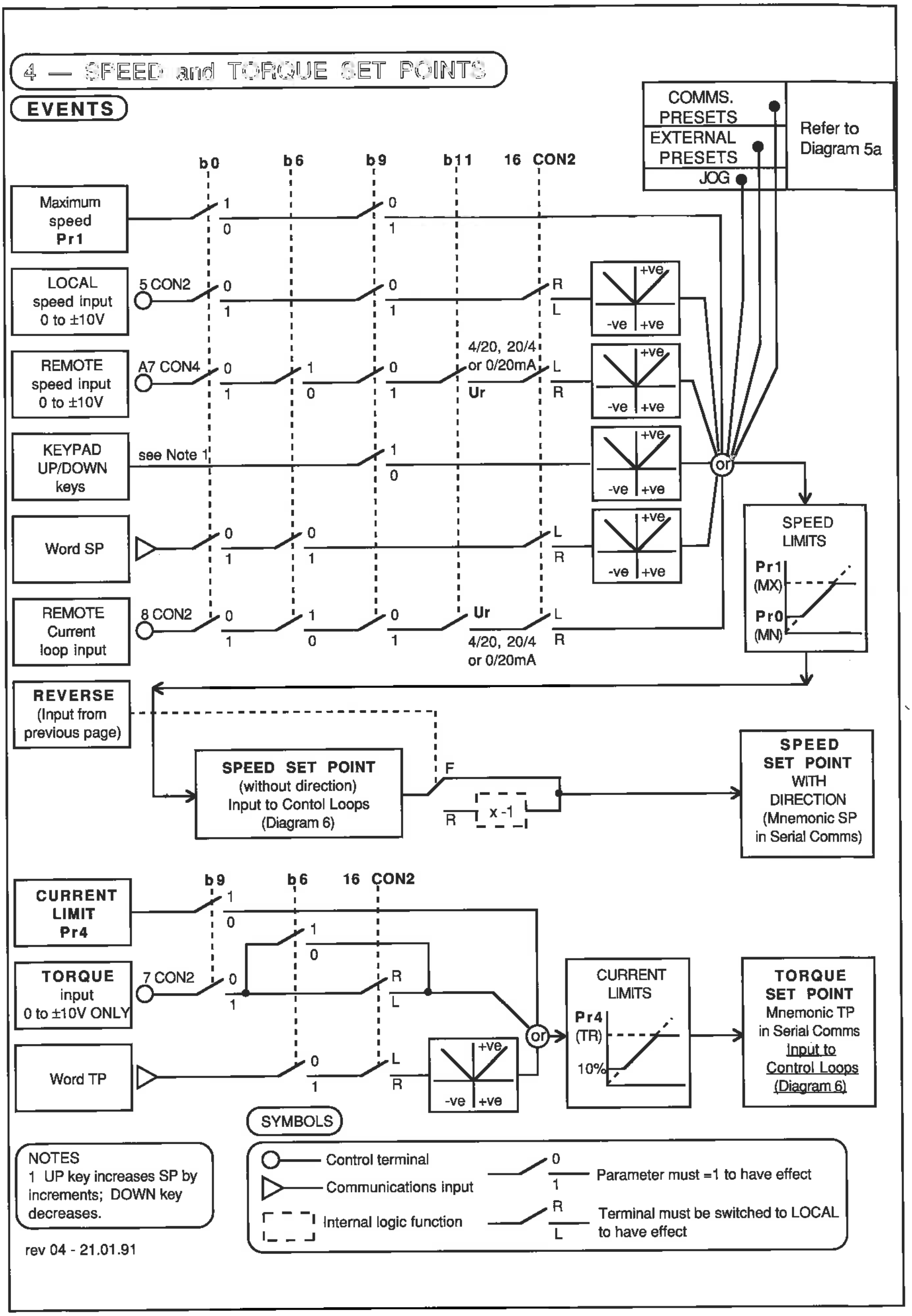

2 — STOP, START, RESET SIGNALS
EVENTS
EFFECTS
b1
b6
b9
b20
16 CON2
Pr50 = 0
Pr50 = 1 to 5
AUTO RESTART
External RESET contact closed momentarily
13 CON2
Word CW bit 5=1 momentarily
Power restored following UU trip
STOP/RESET key pressed at Keypad
RESET if tripped
External STOP contact open momentarily
14 CON2
Word CW bit 7=0 momentarily
STOP/RESET key pressed at Keypad
TRIP
STOP if running
STOP MODES
b2 b7
0 0 Standard ramp
0 1 Coast to rest
1 0 Inject dc
1 1 High level ramp
External select speed 'Jog' (open)
A12 CON4
rdY
External select speed 'Jog' (closed)
A12 CON4
rdY
External RUN contact closed momentarily
15 CON2
Word CW bit 0=0 momentarily
RUN key pressed at Keypad
Drive RESET and running prior to TRIP
RUN if stopped
or
L
R
SYMBOLS
Control terminal
Communications input
Local or Remote
Parameter must =1 to have effect
Parameter must =0 to have effect
rev 05 - 04.07.91

8 — REVERSE SIGNALS

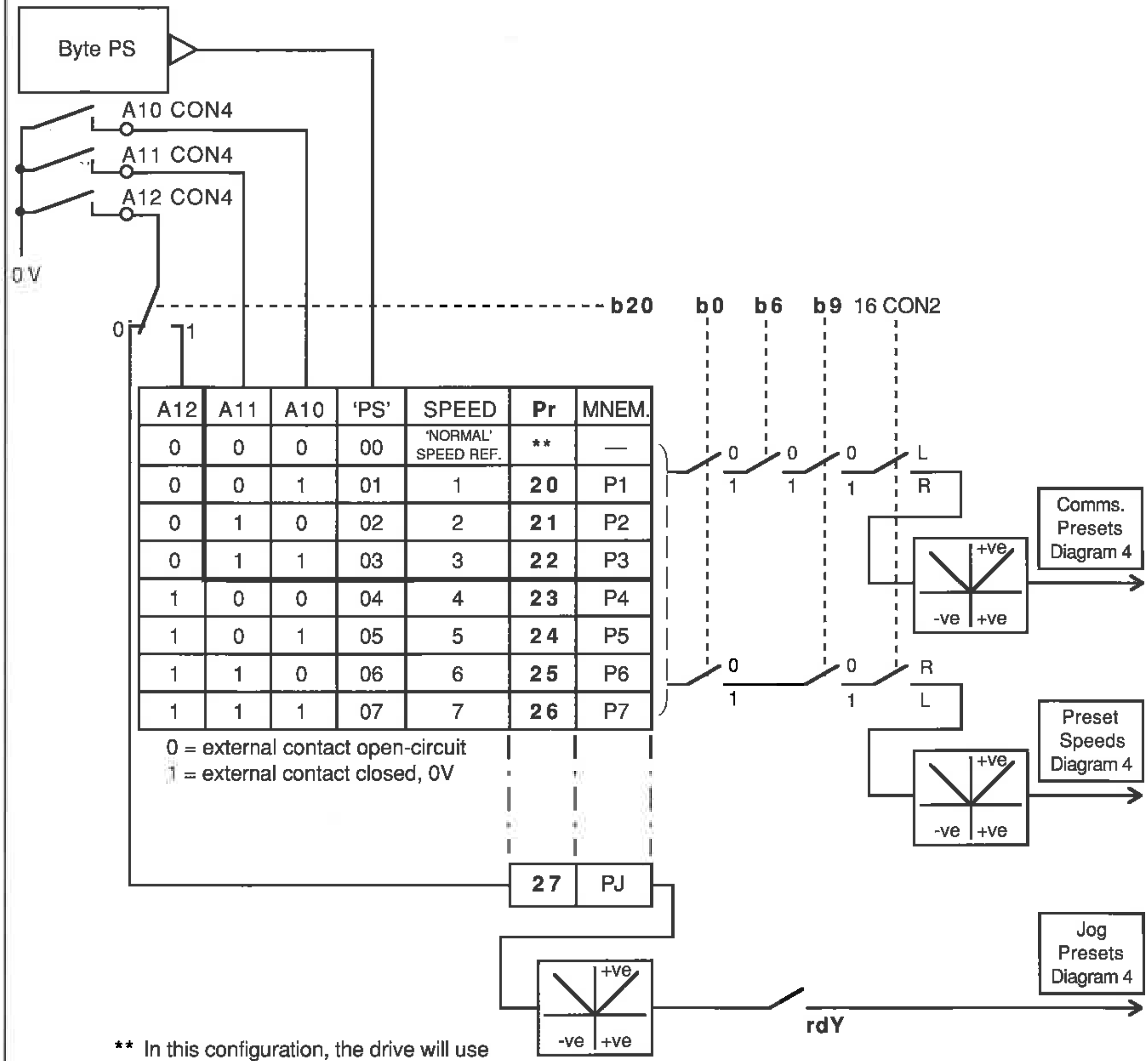




rev 05- 04.07.91


4 — SPEED and TORQUE SET POINTS
EVENTS
COMMS. PRESETS
EXTERNAL PRESETS
JOG
Refer to Diagram 5a
b0
b6
b9
b11
16 CON2
Maximum speed Pr1
LOCAL speed input 0 to ±10V
5 CON2
REMOTE speed input 0 to ±10V
A7 CON4
4/20, 20/4 or 0/20mA
Ur
KEYPAD UP/DOWN keys
see Note 1
Word SP
REMOTE Current loop input
8 CON2
4/20, 20/4 or 0/20mA
+ve
-ve
or
SPEED LIMITS
Pr1 (MX)
Pr0 (MN)
REVERSE (Input from previous page)
SPEED SET POINT (without direction) Input to Contol Loops (Diagram 6)
F
R
x -1
SPEED SET POINT WITH DIRECTION (Mnemonic SP in Serial Comms)
b9
b6
16 CON2
CURRENT LIMIT Pr4
TORQUE input 0 to ±10V ONLY
7 CON2
Word TP
CURRENT LIMITS
Pr4 (TR)
10%
TORQUE SET POINT Mnemonic TP in Serial Comms Input to Control Loops (Diagram 6)
SYMBOLS
Control terminal
Communications input
Internal logic function
Parameter must =1 to have effect
Terminal must be switched to LOCAL to have effect
NOTES
1 UP key increases SP by increments; DOWN key decreases.
rev 04 - 21.01.91

5a — SPEEDS: PRESET & JOG



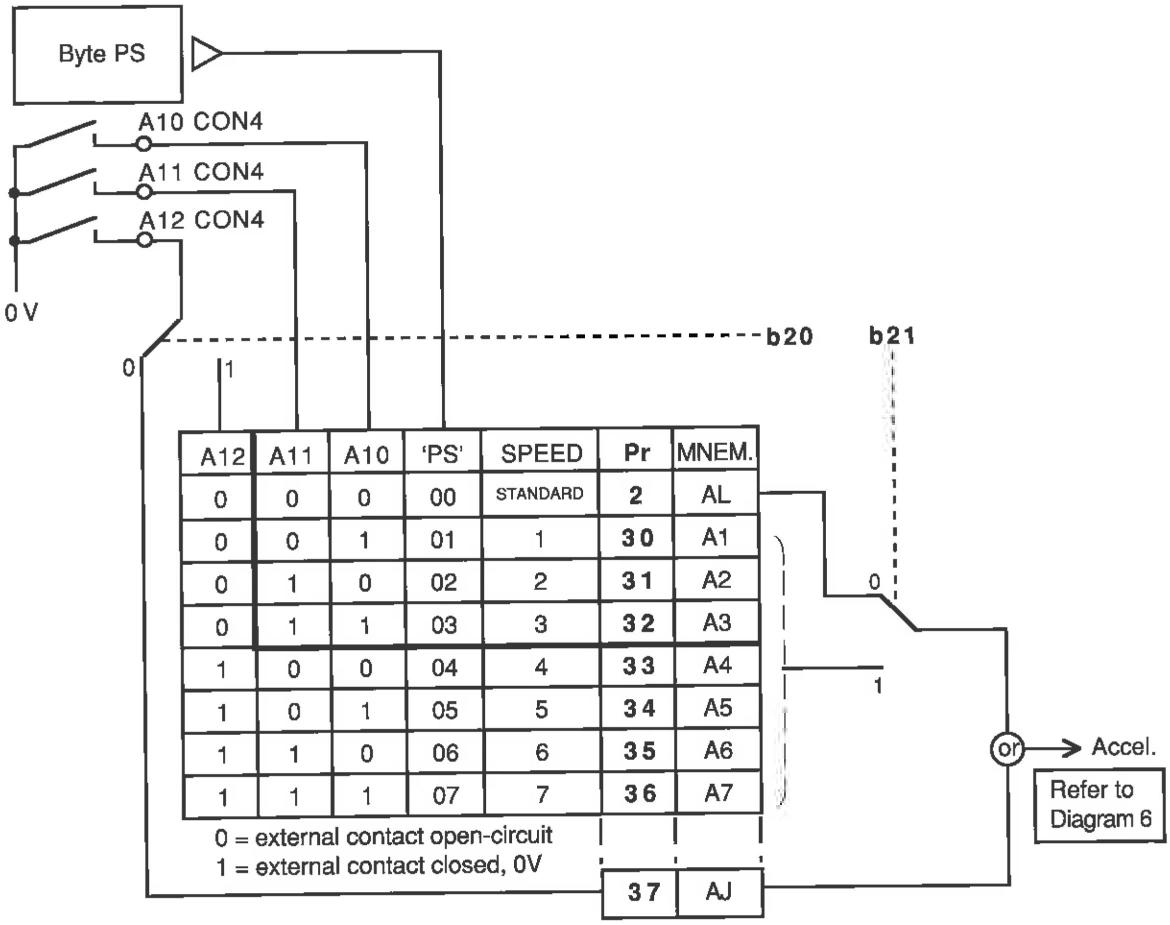
A12	A11	A10	'PS'	SPEED	Pr	MNEM.
0	0	0	00	'NORMAL' SPEED REF.	**	—
0	0	1	01	1	**20**	P1
0	1	0	02	2	**21**	P2
0	1	1	03	3	**22**	P3
1	0	0	04	4	**23**	P4
1	0	1	05	5	**24**	P5
1	1	0	06	6	**25**	P6
1	1	1	07	7	**26**	P7

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

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

rev03 - 24.01.91

5b — ACCELERATION

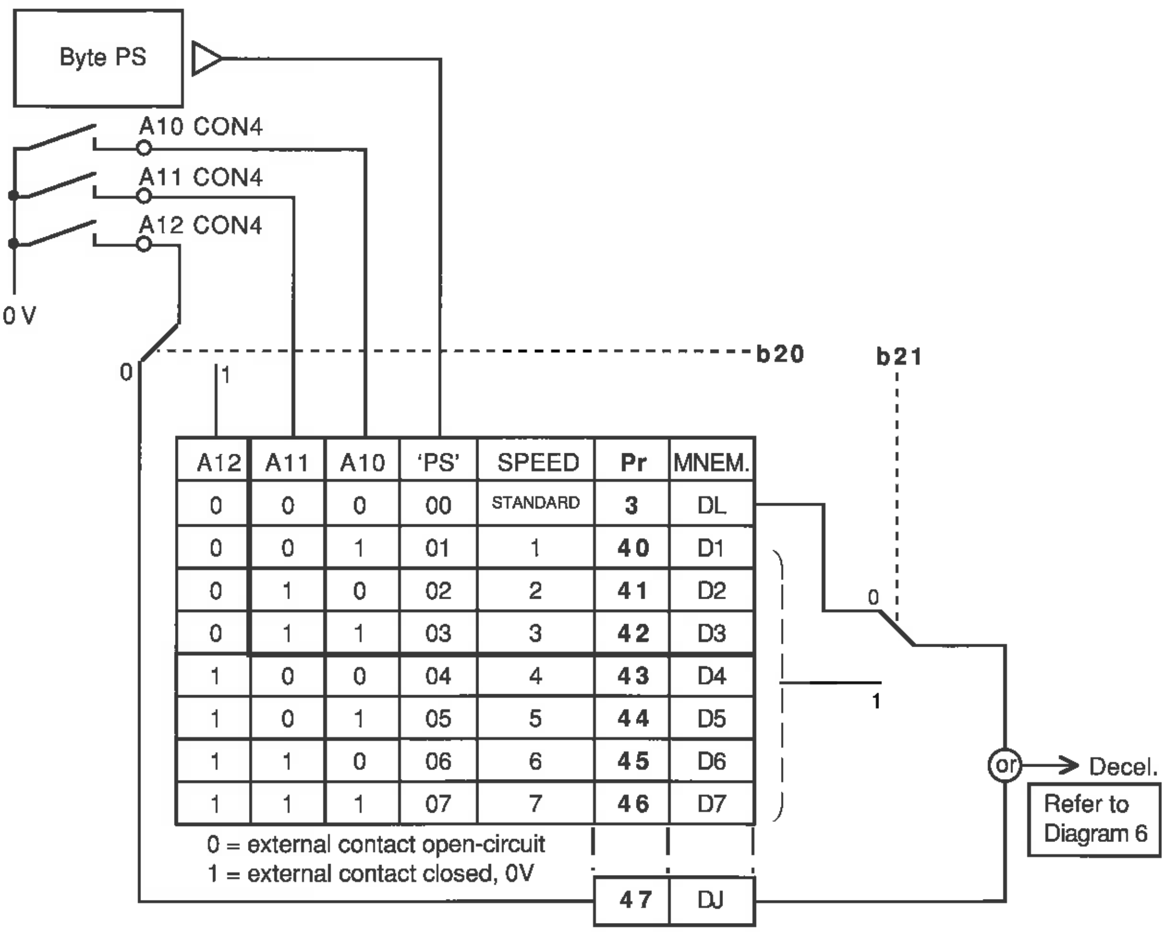


A12	A11	A10	'PS'	SPEED	Pr	MNEM.
0	0	0	00	STANDARD	**2**	AL
0	0	1	01	1	**30**	A1
0	1	0	02	2	**31**	A2
0	1	1	03	3	**32**	A3
1	0	0	04	4	**33**	A4
1	0	1	05	5	**34**	A5
1	1	0	06	6	**35**	A6
1	1	1	07	7	**36**	A7
					37	AJ

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

rev 01 - 22.01.91

5c — DECELERATION

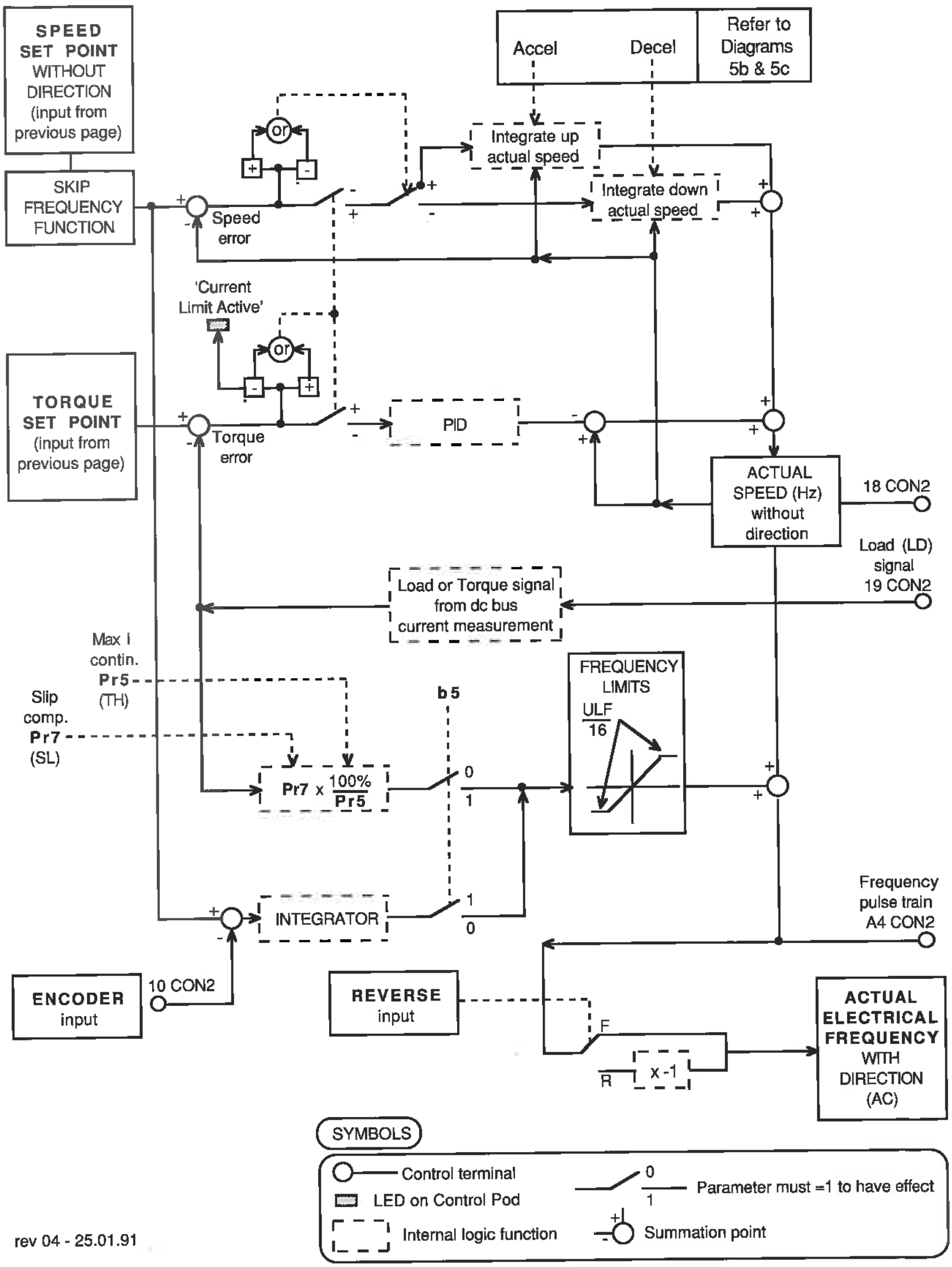


A12	A11	A10	'PS'	SPEED	Pr	MNEM.
0	0	0	00	STANDARD	**3**	DL
0	0	1	01	1	**40**	D1
0	1	0	02	2	**41**	D2
0	1	1	03	3	**42**	D3
1	0	0	04	4	**43**	D4
1	0	1	05	5	**44**	D5
1	1	0	06	6	**45**	D6
1	1	1	07	7	**46**	D7
					47	DJ

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

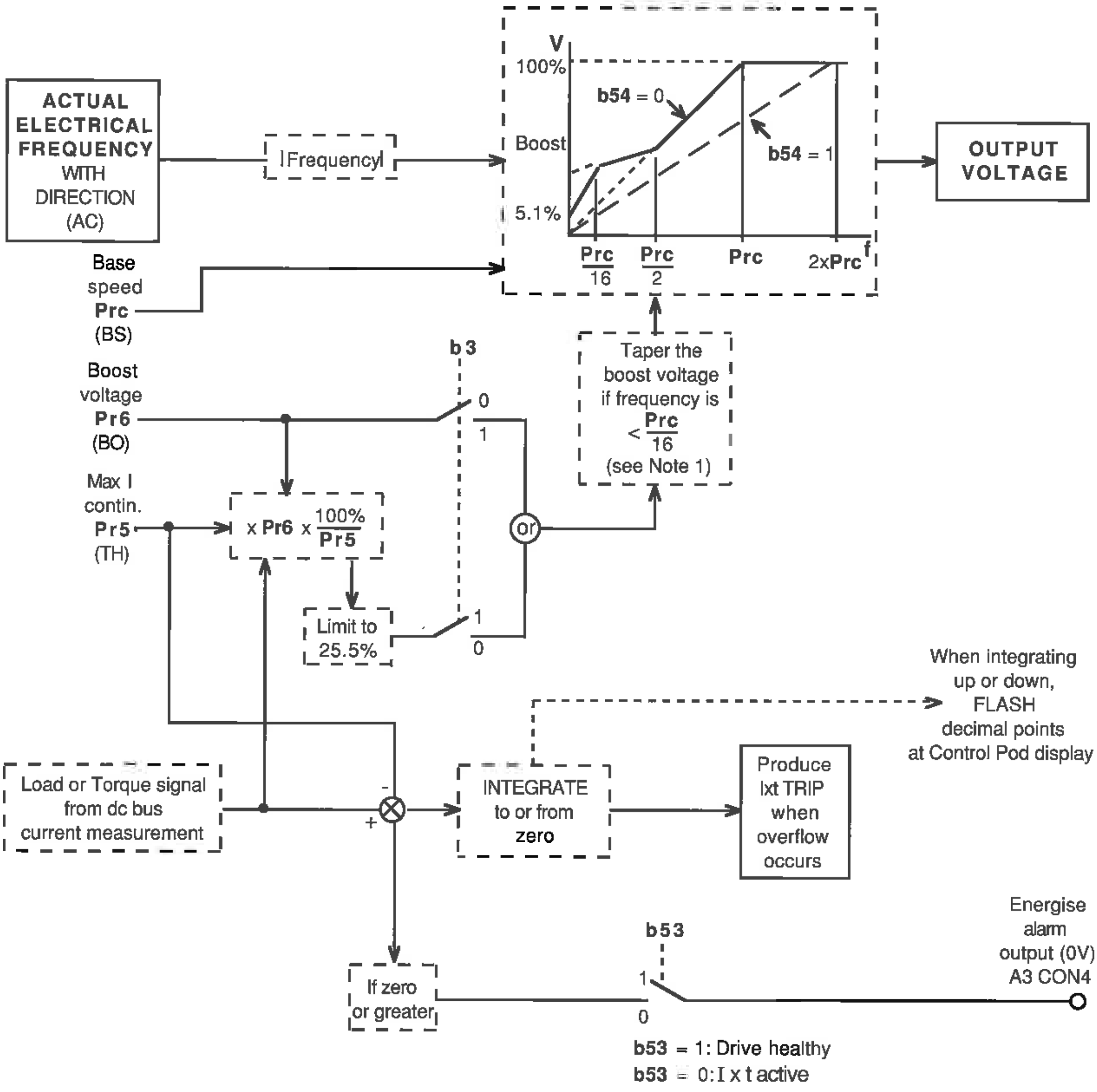
rev 01 - 22.01.91

6 — SPEED LOOP



rev 04 - 25.01.91

7 - VOLTAGE LOOP

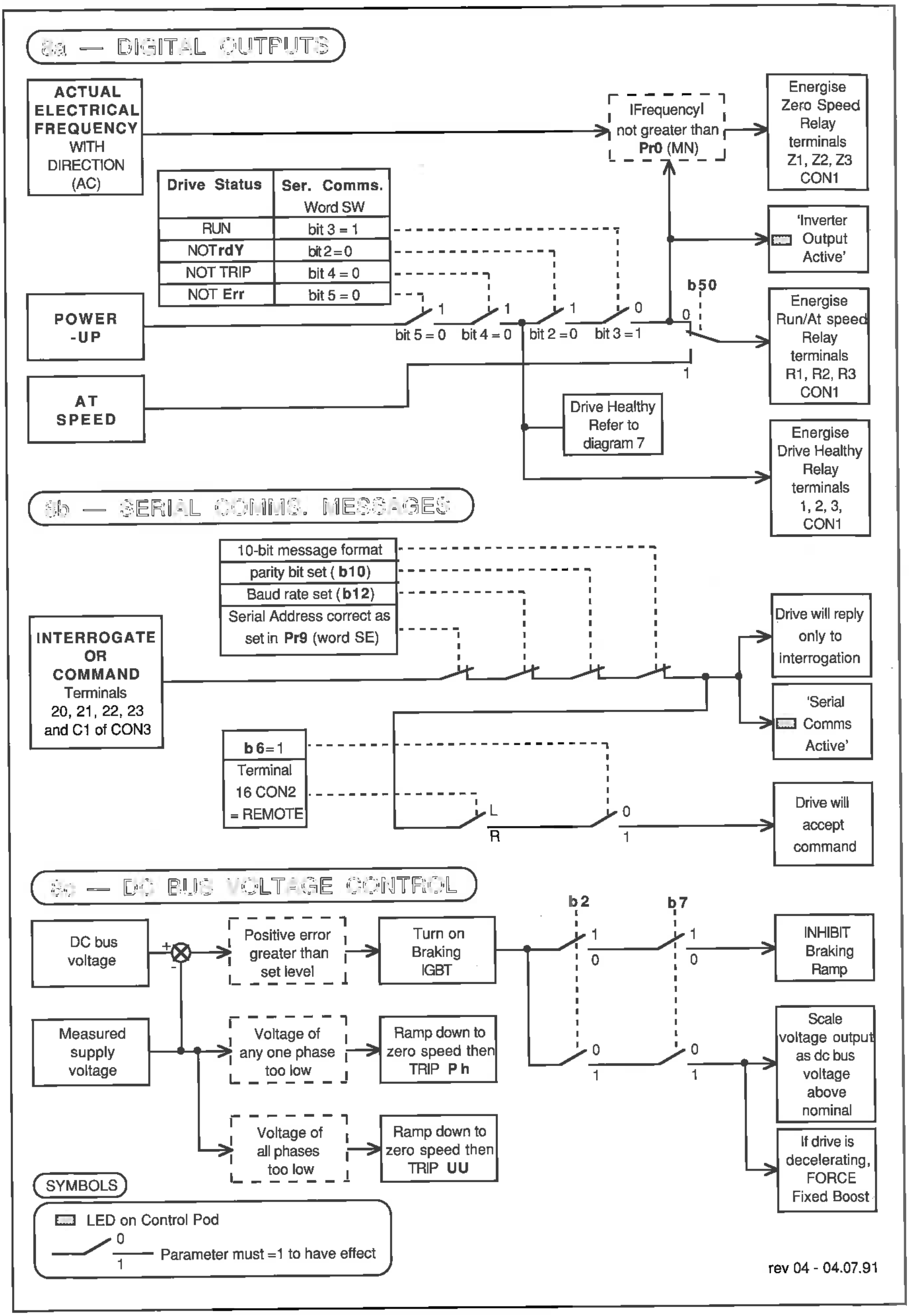


SYMBOLS

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

Control terminal	Parameter must =1 to have effect
Internal logic function	Summation point

rev 06- 04.07.91


8a — DIGITAL OUTPUTS
ACTUAL ELECTRICAL FREQUENCY WITH DIRECTION (AC)
|Frequency| not greater than Pr0 (MN)
Energise Zero Speed Relay terminals Z1, Z2, Z3 CON1
Drive Status
Ser. Comms. Word SW
RUN
bit 3 = 1
NOTrdY
bit 2 = 0
NOT TRIP
bit 4 = 0
NOT Err
bit 5 = 0
'Inverter Output Active'
b50
Energise Run/At speed Relay terminals R1, R2, R3 CON1
POWER -UP
bit 5 = 0
bit 4 = 0
bit 2 = 0
bit 3 = 1
AT SPEED
Drive Healthy Refer to diagram 7
Energise Drive Healthy Relay terminals 1, 2, 3, CON1
8b — SERIAL COMMS. MESSAGES
10-bit message format
parity bit set (b10)
Baud rate set (b12)
Serial Address correct as set in Pr9 (word SE)
INTERROGATE OR COMMAND Terminals 20, 21, 22, 23 and C1 of CON3
Drive will reply only to interrogation
'Serial Comms Active'
b6=1
Terminal 16 CON2 = REMOTE
L
R
Drive will accept command
8c — DC BUS VOLTAGE CONTROL
DC bus voltage
Positive error greater than set level
Turn on Braking IGBT
b2
b7
INHIBIT Braking Ramp
Measured supply voltage
Voltage of any one phase too low
Ramp down to zero speed then TRIP Ph
Scale voltage output as dc bus voltage above nominal
Voltage of all phases too low
Ramp down to zero speed then TRIP UU
If drive is decelerating, FORCE Fixed Boost
SYMBOLS
LED on Control Pod
Parameter must =1 to have effect
rev 04 - 04.07.91

DISPLAY FEATURES

			DISPLAY	'PAR' LED
1	Hardware fault at power-up		Err ↔ 1 (Error Number)	illuminated or off
2	Parameter number and its value. MODE key pressed once.		Pr 2 (Parameter Number) ↔ 43.0 (Parameter Value)	illuminated
3	Adjusting a parameter value. MODE key pressed twice.		50.6 (Parameter Value)	off
4	Drive TRIPPED		0I, flashing (Trip Code)	off
5	Drive TRIPPED and RESET. (Only for 1s)		OU (Trip Code)	off
6	Drive STOPPING	1 Ramp mode	88.8 (Actual Frequency)	off
		2 Coast to rest	Inh (Inhibited)	off
		3 Injection brake	dc (dc braking mode)	off
7	Drive STOPPED	1 Keypad mode **b9** = 0	rdY (Ready) ↔ 88.8 (Set speed — change by use of UP/DOWN keys)	off
		2 Terminal mode **b9** =1	rdY (Ready)	off
8	Drive RUNNING	1 Keypad mode **b9** = 0	52.4 (Set speed — change by use ofUP/DOWN keys)	off
		2 Terminal mode **b9** =1 UP and DOWN keys pressed simultaneously	103.9 (If **b8** =0, shows LOAD, steady or ramping. If **b8** =1, shows actual FREQUENCY, steady or ramping.)	off
		3 Terminal mode **b9** =1	18.0 (If **b 8** = 0, shows actual frequency etc. If **b 8** =1, shows LOAD)	off

SYMBOLS

- **1, 2...** Priority for display
- ⇄ Display alternating
- 'PAR' LED illuminated
- 'PAR' LED off
- 3 Steady
- 3 (dotted) Flashing

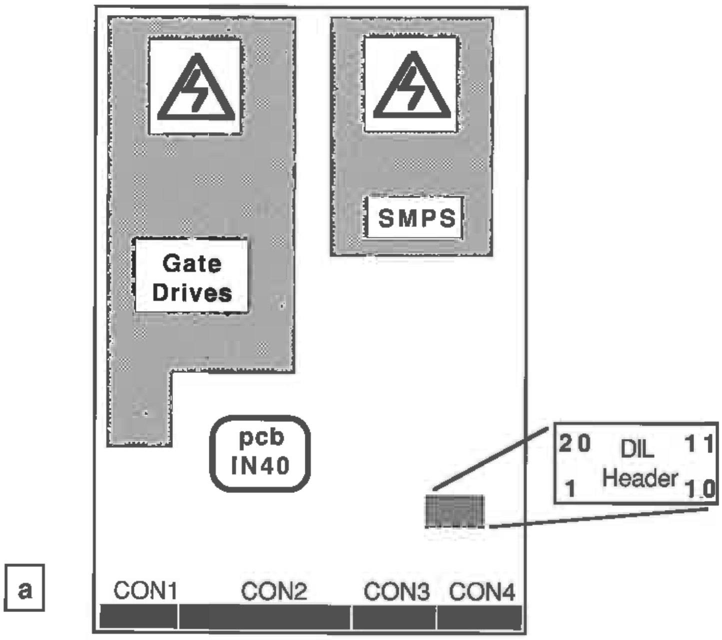
rev 03 - 20.01.91

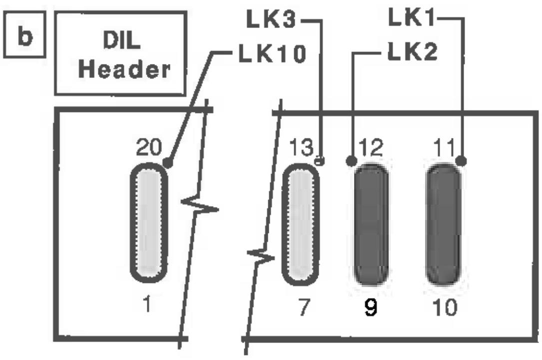
For the purpose of external control and for monitoring the status and performance of the inverter and the motor, the following terminals are provided —

- external operating signal inputs
- status signal outputs
- analogue signal outputs for measurement instrumentation

SCHEDULE of TERMINALS ACCORDING to FUNCTION

Operating Signals	Terminal		Analogue or Digital
Protection			
Motor thermistor input	CON2	9	A
Control			
Analogue/Digital common	CON2	4, 11	A
	CON4	A1, A6	A
External trip	CON2	12	D
Reset	CON2	13	D
Stop	CON2	14	D
Run	CON2	15	D
Local/Remote	CON2	16	D
Local Forward/Reverse	CON2	17	D
Remote Forward/Reverse	CON4	A9	D
Local analogue speed reference	CON2	5	A
Remote analogue speed reference	CON4	A7	A
Local +10V reference	CON2	6	A
Remote +10V reference	CON4	A8	A
Remote 4-20mA speed reference	CON2	8	A
Encoder input	CON2	10	D
24V supply	CON4	A2	A
Torque reference input	CON2	7	A
RS485 serial comms	CON3	20, 21, 22, 23, C1	D
Status Signal Outputs			
Minimum speed relay	CON1	Z1 Z2 Z3	D
Motor running relay	CON1	R1 R2 R3	D
Status - power off or trip relay	CON1	1 2 3	D
Alarm	CON4	A3	D
Instrument Signal Outputs			
Analogue frequency	CON2	18	A
Frequency (x1)	CON4	A4	D
Load	CON2	19	A





LK1 and LK2 are user-adjustable

LK1	LK2	Logic
IN	OUT	**Negative***
OUT	IN	Positive

*As delivered

LK3 to LK10 are factory-adjusted and NOT to be altered

23 DIL header. (a) Location and orientation of the DIL header on pcb IN40. (b) Positions of links LK1 and LK2 for negative (as delivered) and positive input logic. Links LK3 to LK10 are not to be adjusted.

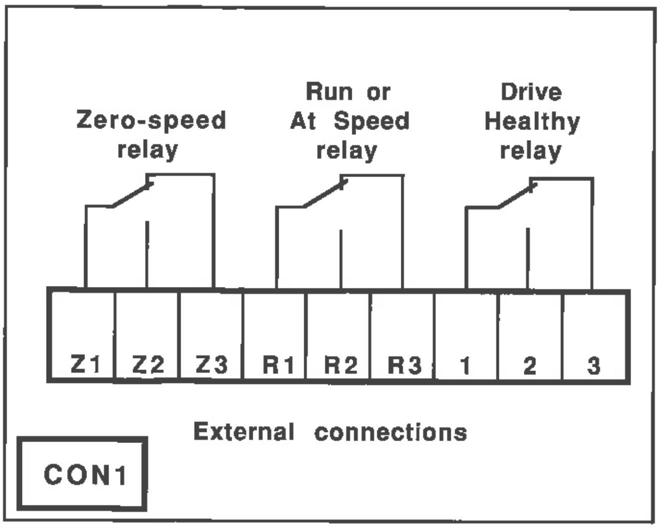
1 The status of contacts is with the drive de-energised or in fault condition.
2 Terminal 9 (CON2) requires a link connected between it and terminal 11 (CON2) if not used.
3 Terminals 12 and 14 (CON2) must be linked to 0V if not to be used.
4 Terminals A5, A10, A11 and A12 (CON4) are not for use at present.
5 The logic of terminals 12 to 17 (CON2) inclusive and A9 (CON4) can be inverted if required — see Logic Inversion, below — to match the output of certain types of PLC; when inverted, the ON state corresponds to +24V. To invert, a link is repositioned on the circuit board, Fig. 23.
Observe the safety warning!
6 All terminals on CON3 are optically isolated from all other control terminals.

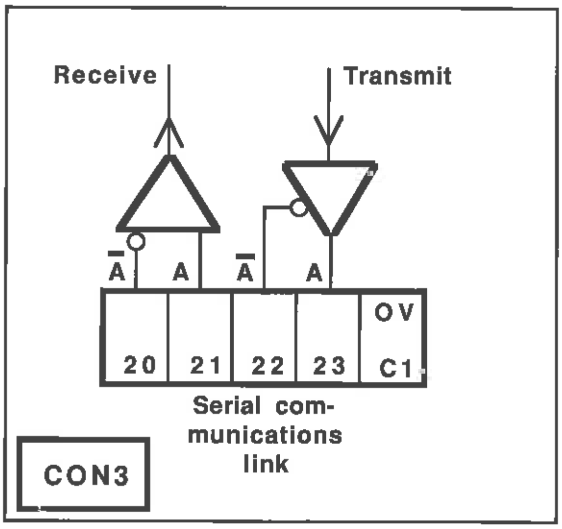
LOGIC INVERSION
By altering the position of a link in the DIL header on pcb IN40, Fig. 23, the logic of the digital inputs is inverted, so that the 'on' state corresponds to +24V instead of the standard 0V (as delivered). This is necessary to match the outputs of certain types of programmable controller.

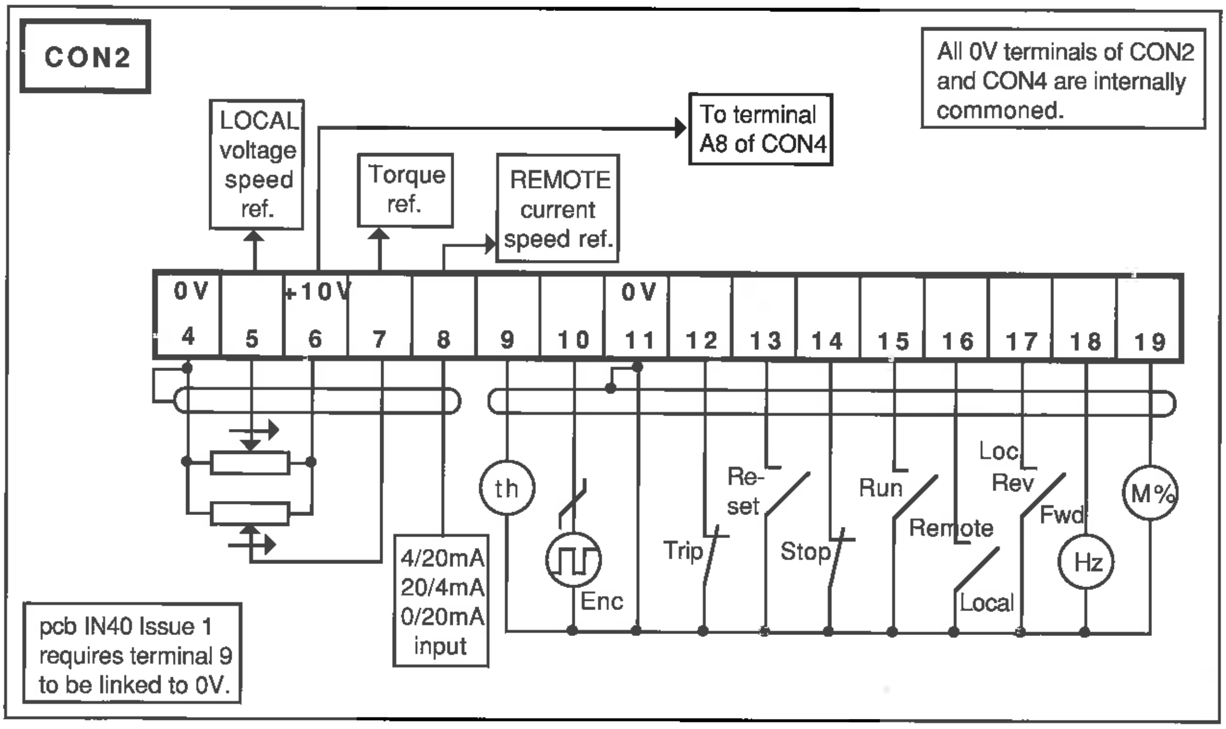
ELECTRIC SHOCK RISK!
If the drive has been energised, it MUST be ISOLATED before any work is attempted. A period of 7 minutes MUST elapse after isolation to allow the dc link choke and internal capacitors to discharge fully. Until the discharge period has passed, dangerous voltages may be present at the terminals and within the module.

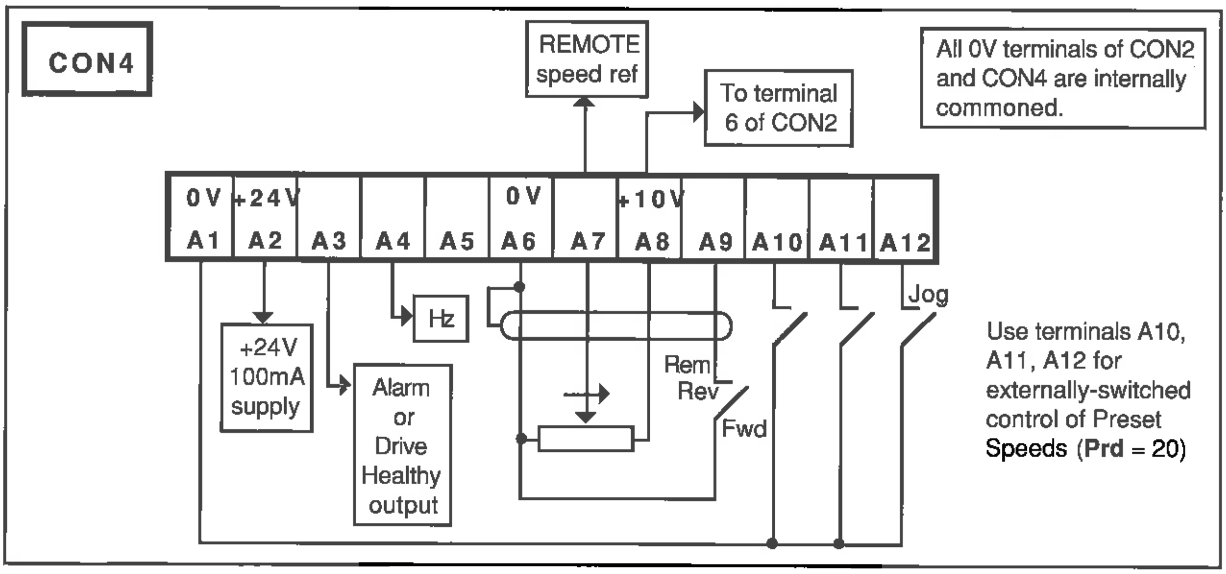
TERMINAL BOARD CON1

Terminal Number	D/A	Description	
Z1	D	Minimum speed relay —common	Volt-free change-over contact 240V ac 7A resistive load Relay energised, not at minimum speed
Z2	D	Minimum speed relay —normally-open	
Z3	D	Minimum speed relay —normally-closed	
R1	D	Run/At Speed relay —common	Volt-free change-over contact 240V ac 7A resistive load Relay energised when motor running or at speed
R2	D	Run/At Speed relay —normally-open	
R3	D	Run/At Speed relay —normally closed	
1	D	Drive Healthy relay —common	Volt-free change-over contact 240V ac 7A resistive load Relay energised when drive healthy
2	D	Drive Healthy relay —normally-open	
3	D	Drive Healthy relay —normally-closed	


Zero-speed relay
Run or At Speed relay
Drive Healthy relay
Z1
Z2
Z3
R1
R2
R3
1
2
3
External connections
CON1


Receive
Transmit
$\bar{A}$
A
$\bar{A}$
A
0V
20
21
22
23
C1
Serial communications link
CON3


CON2
LOCAL voltage speed ref.
To terminal A8 of CON4
Torque ref.
REMOTE current speed ref.
All 0V terminals of CON2 and CON4 are internally commoned.
0V
4
5
+10V
6
7
8
9
10
0V
11
12
13
14
15
16
17
18
19
th
Enc
Trip
Re-set
Stop
Run
Remote
Loc
Rev
Fwd
Local
M%
Hz
4/20mA 20/4mA 0/20mA input
pcb IN40 Issue 1 requires terminal 9 to be linked to 0V.


CON4
REMOTE speed ref
To terminal 6 of CON2
All 0V terminals of CON2 and CON4 are internally commoned.
0V
A1
+24V
A2
A3
A4
A5
0V
A6
A7
+10V
A8
A9
A10
A11
A12
Hz
Jog
+24V 100mA supply
Alarm or Drive Healthy output
Rem
Rev
Fwd
Use terminals A10, A11, A12 for externally-switched control of Preset Speeds (Prd = 20)

TERMINAL BOARD CON2

Terminal Number	D/A	Description	
4	A	0V common	
5	A	Local set speed potentiometer input	10k potentiometer or voltage signal 0V to +10V or -10V to +10V 110k input impedance
6	A	+10V reference voltage	10mA maximum loading (Connected to A8 CON4)
7	A	Torque reference input	10k potentiometer, or voltage signal 0V to +10V, 110K impedance
8	A	Remote set speed current input	4/20mA or 20/4mA or 0/20mA, 100R input impedance
9*	A	Motor thermal protection (thermistor) input	Resistance input — 100Ω < no trip <3kΩ
10	D	Encoder input	0V to +5V at 16mA open collector Square wave, mark:space 60:40 or 40:60, up to 24V
11	A	0V common	
12	D	External trip	n/c contact, 0V. Impulse open to trip
13	D	Reset	n/o contact, 0V. Impulse close to reset
14	D	Stop	n/c contact, 0V. Impulse open to stop
15	D	Run (start)	n/o contact, 0V. Impulse close to start
16	D	Local/Remote	n/o contact, 0V. Close to select remote reference
17	D	Local fwd/rev	n/o contact, 0V. Close to select reverse
18	A	Frequency output signal	0V to +10V, 5mA. Accuracy ±2% 0V at Pr0, 10V at Pr1
19	A	Load output signal	0V to +10V, 5mA 0V = no load +10V = 150%FLT motoring -10V = 150%FLT regenerating

*IN40 Issue 1 requires terminal to be connected to 0V by a solid link. IN40 Issue 2 does not require any link.

TERMINAL BOARD CON3

All terminals in CON3 are optically isolated from CON1, CON2, and CON4

Terminal Number	D/A	Description	
20	D	Serial link receive $\overline{A}$ or B	Two lines for differential receive
21	D	Serial link receive A	
22	D	Serial link transmit $\overline{A}$ or B	Two lines for differential transmit
23	D	Serial link transmit A	
C1	A	Serial link 0V common	

TERMINAL BOARD CON4

Terminal Number	D/A	Description	
A1	A	0V common	
A2	A	+24V supply, 100mA	General purpose
A3	D	Alarm or Drive Healthy	Open collector output Source, 30mA from +24V Sink, 250mA to 0V
Alarm relay 24V coil may be optionally connected directly between A2 & A3			
A4	D	Frequency output x1	+24/0V, ±10mA
A5	D	Frequency output x30	+24/0V, ±10mA
A6	A	0V common	
A7	A	Remote speed reference	0V to +10V or -10V to +10V 110k input impedance
A8	A	+10V reference voltage	10mA maximum loading (Connected to 6 CON2)
A9	D	Remote fwd/rev	n/o contact, 0V. Close to select reverse
A10	•	For externally-switched control of Preset Speeds (**Pr d** = 20)	
A11	•		
A12	•		

A communications link is standard in all CD11-75 & CDV11-90kW drives. It is a machine-machine link, enabling one or more drives to be used in systems controlled by a host such as a process logic controller (PLC) or computer. CD11-75 & CDV11-90kW 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, Fig. 24, and up to 99 if line buffers are used.

The communication port of the drive module is the four terminals 20 to 23 (CON3), and the 0V terminal C1 (CON3). The standard connection is the RS485, Fig. 25, or RS422 four-wire link; the 3-wire RS232 can be connected also, Fig.26.

Protocol is ANSI x 3.28 - 2.5 - A4, as standard for many industrial interfaces.

FUNDAMENTALS

Logic processors, such as computers, PLCs, and the communications systems of Control Techniques drives 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. In CD11-75 & CDV11-90kW drives, the on-state is represented by a positive voltage, and the off-state by zero volts. The two different voltages thus represent two distinct units of data, each being a binary digit ('bit'), either 0 or 1.

By fixing a time duration for each bit, a series of bits transmitted can be recognised by a receiver. If, also, a series or group always 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.

The scope of the data that can be represented is much increased if two hexadecimal characters are combined to make a simple code. Since there are 16 hex characters, two in combination will produce 16 x 16 = 256 possible different characters. Using this as the basis of a code, it becomes possible to represent a large number of symbols, or units of data, by means of only two hex characters, each of four bits, making eight bits in all and known as a 'byte'.

Early in the development of computer technology it was recognised that a long stream of bits without, so to speak, any punctuation marks would be unmanageable and at risk of transmission errors passing unrecognised. The byte was adopted as a standard unit. To ensure that each byte is distinct, a start bit and a stop bit are added. The convention is that the start bit is a 0 and the stop bit a 1.

Each byte, therefore, occupies a finite time in transmission, but the interval between successive bytes is of no importance. Only the 'framing' or 'character format' of the byte is significant. There is more than one convention for 'framing' the character. The format in CD11-75 & CDV11-90kW drives is ten bits as shown digrammatically —

<table>
<tr><td></td><td colspan="7">'Low' ASCII character byte</td><td></td><td></td></tr>
<tr><td colspan="4">First hex character</td><td colspan="4">Second hex character</td><td></td><td></td></tr>
<tr><td>Start bit</td><td colspan="7">Seven data bits, variable</td><td>Parity bit</td><td>Stop bit</td></tr>
<tr><td>0</td><td>lsb</td><td></td><td></td><td></td><td></td><td></td><td>msb</td><td></td><td>1</td></tr>
</table>

The parity bit is used by the receiver of the message to check the integrity of the data byte.

'Low' ASCII Character Set

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

The character set used in Control Techniques drives is the 'low' American Standard Code for Information Interchange (ASCII), comprising 128 characters, decimally numbered 0 to 127. In the low ASCII set, the first hex character extends only from decimal 0 to 7, binary 0000, 0001 etc to 0111. This being so, the first bit is always 0 and can be the start bit. The remaining three bits of the first hex character and the four bits of the second hex character are available to denote any of the 128 characters in the low ASCII set. The parity bit, and the stop bit,1, are attached at the end.

The first 32 characters in the ASCII set (hex 00 to 1F and the 'space' character, decimal 32) are used to represent special codes. These are the Control Codes, each of which has a particular meaning. For example, 'start of text' is STX, and, from a keyboard, is made by holding down the Control key and striking B once (Control-B). This is hex 02, and the actual transmission is the binary byte 0000 0010. The drive is programmed to know that this character signals that a command will follow, whereas EOT (Control-D) will be followed by information or a request. If a host has a vdu screen, control characters appear on it in their ASCII format— ETX, EOT etc.

The components of all messages between the host and a CD11-75 & CDV11-90kW drive are formed ofASCII characters. The format of a message, ie the sequence in which the characters appear, is standardised for messages of each different kind, and is explained under Structure of Messages, page 86.

PRELIMINARY ADJUSTMENTS of the DRIVE

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. To enable the host to control the drive or to change parameter settings, the drive mode must be adjusted as follows —

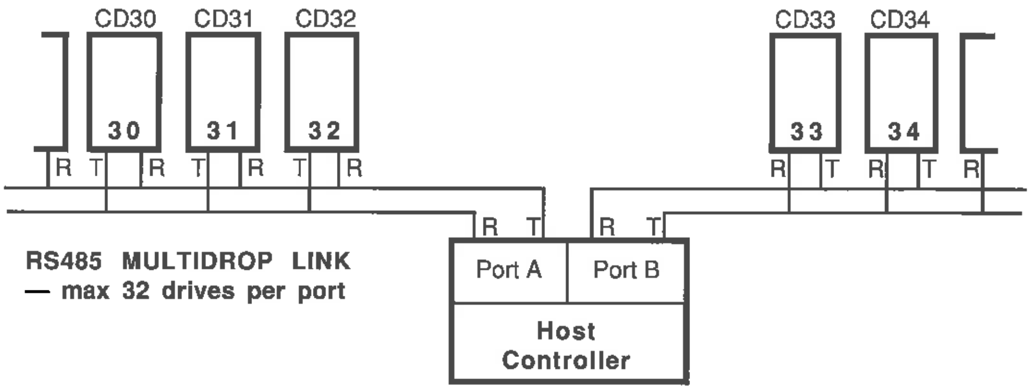
- external control switch set to REMOTE, or terminal 16 (CON2) at 0V
- parameter **b6** = 1, ie the drive is in SLAVE mode

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 that parameters **Pr9** (serial address), **b10** (parity bit) and **b12** (Baud rate) are correctly set.

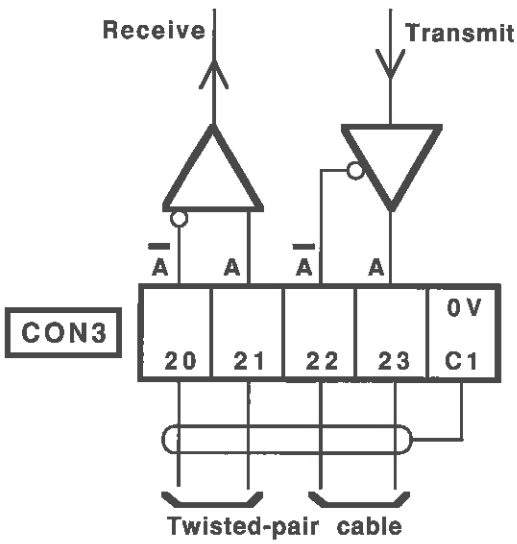
COMPONENTS OF MESSAGES

Control Characters

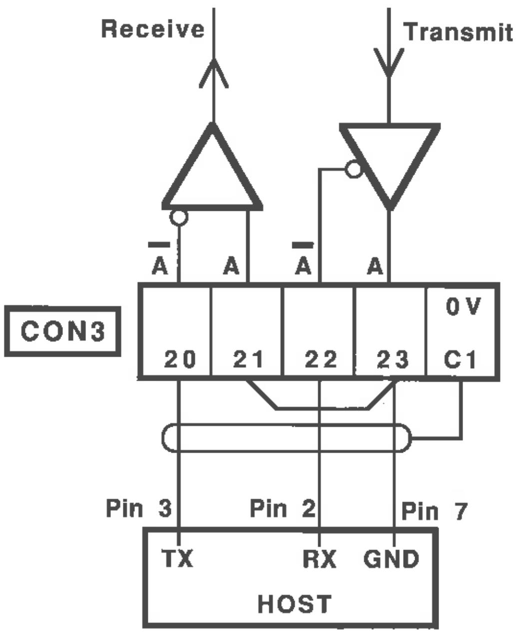
To conform to the standard structure of a message, the stages of a message are signalled by control characters. Each character has a specific meaning, a standard mnemonic abbreviation, and is transmitted and received in ASCII code. If a message is initiated from a keyboard, the control characters are keyed by holding the Control key down while making a single-letter keystroke. Of the 32 control characters in the ASCII set, six are used in CD11-75 & CDV11-90kW serial communications.



2 4 Serial address Pr9. Unique identity code for up to 32 drives per communications port at the host.



2 5 RS485 or RS422 serial communications link connections. Cable must be screened.



2 6 Connections for RS232 link.

CONTROL CHARACTERS in CD11-75 & CDV11-90kW DRIVES

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

Serial Address
Each drive is given an identity or address (**Pr9**, Fig.24) so that only the drive that is concerned will respond. For security, the format is that each digit of the two-digit drive address is repeated, thus the address of drive number 23 is sent as four characters—

2	2	3	3

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

Data Mnemonics
To identify which operating parameter a message relates to, the parameters are represented by a data mnemonic, which is a simple two-character code. When data is being communicated, it is preceded by the appropriate mnemonic. Table of Data Mnemonics, page 87.

Data
Data to be sent or requested occupies the next six characters after the data mnemonic. Data is handled in two different forms —
as a plain numerical value, or
as a Hex Code Word.
Most of the operating parameters of the drive, as shown by the Data Mnemonics table, are **numerical** data, such as a value of frequency, load, current, etc. For example, speed is given as frequency in the range +480 to - 480Hz. The value '95Hz in a reverse direction' is sent as

-	0	9	5	.	0

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 variable states of some 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 interrogatives and acknowledgement are terminated by a block checksum character (BCC, page 89).

STRUCTURE OF MESSAGES

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, or —
a command

Both must start with the control character EOT (Control-D) to indicate the kind of message being sent. This is followed by the serial address of the drive receiving the message. The format of the data and the choice of control character to terminate the message is different for the two kinds.

For an **information request**, a Data Mnemonic (table, page 87) instructs a particular drive to supply data defined by the mnemonic. The data mnemonic is a two-character 'word' naming one of the 20 operational conditions of the drive, for example its speed or load or level of slip compensation, etc. A data request message is terminated by the control character ENQ to indicate that the drive is to transmit data in reply.

For a **command**, a control character after the serial address tells the drive that the message is to be an instruction concerning its operational parameters, and that the next part of the message will be the instruction data. The instruction data occupies six characters. An instruction message is terminated by control character ETX followed by a block checksum (BCC, page 89).

Drive to Host

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

a reply to a data request, or —
acknowledgement of a message.

In **reply** to a data request, the start control character is STX, and is followed by the data mnemonic to confirm the request from the host, and then the six characters of data. The message is terminated by the control character ETX and a block checksum (BCC).

A message is **acknowledged** by the control character ACK if understood, or NAK if invalid, wrongly formatted or corrupt.

SENDING DATA

Data can be sent by the host when the following conditions are satisfied —

- external control switch set to REMOTE, or
  terminal 16 (CON2) at 0V
- parameter **b6** = 1, ie set to SLAVE mode

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** state, that is with the motor stopped or tripped. (If tripped, the Trip Code will be flashing in the control pod display.)

Host command —
reset - address - start of text - mnemonic - 6 characters - end - BCC

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

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

The drive will reply with an acknowledgement, either —

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

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

TABLE of DATA MNEMONICS in Protocol Sequence

Mnem	**Para-meter**	**Name**	**Value Displayed**	**Read Only**
SP		Set frequency	Hz	
TP		Set torque	% of FLC	
AC		Actual frequency	Hz	*
LD		Load	% of FLC	*
MN	Pr0	Minimum frequency	Hz	
MX	Pr1	Maximum frequency	Hz	
AL	Pr2	Acceleration time	seconds	
DL	Pr3	Deceleration time	seconds	
TR	Pr4	Current limit	% of FLC	
TH	Pr5	Max continuous current (I x t)	% of FLC	
BO	Pr6	Voltage (torque) boost	% of V_{max}	
SL	Pr7	Slip compensation	Hz	
BR	Pr8	DC braking level	% of V_{max}	
SE	Pr9	Serial address	00 to 99 in hex	*
SC	Prb	Security code	code in hex	
SW		Status word	code in hex	*
DS	**b0** to **b12**	**Drive configuration**	code in hex	
FQ	**b14**	**PWM switching frequency**	code in hex	
BS	**Prc**	**MVF** (max voltage frequency)	Hz	
CW		Command word	code in hex	

NOTES Parameters which cannot be written to, additional to the read-only parameters above, are **b6, b10, b12** and **b13**.

Parameters which can be written to only when the drive is in the **rdY** state or tripped are shown in bold type.

READING DATA

The drive will send any data to the host, provided that the request is valid. The format of a data request message is —

Host request —

reset - address - mnemonic - end

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

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

The drive replies in the following form —

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

For example —

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

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

Repeat Enquiry
The negative acknowledgement NAK (Control-U) can be used at a keyboard to cause the drive to send data repeatedly for the same mnemonic. It saves time when wanting to know if or how a value is changing over a period.

Next Parameter
To obtain data from the same drive for the next mnemonic in the list (see Table of Data Mnemonics) send the positive acknowledgement ACK (Control-F). The drive will respond by transmitting the data relating to the next mnemonic in sequence.

Invalid Mnemonic
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 characters - reset

Thus—

STX Control-B	X	Y	EOT Control-D

BLOCK CHECKSUM (BCC)

To ensure that data received can be verified, a block checksum is attached to the end of each command or data response. The BCC is automatically calculated by the sending logic 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..

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

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

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

6 + 32 = 38 decimal,

for which the ASCII character is &.

Thus the complete message to set the speed of drive number 14, say, 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)

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

CONFIGURING THE DRIVE THROUGH SERIAL COMMUNICATIONS

Reference to the Table of Data Mnemonics on page 87 will show that of the total of 20 there are 14, ie the first 13 plus BS (the mnemonic for **Prc**, the maximum voltage frequency), which have a simple numerical value in seconds, Hz, or percentages of voltage or current.

These values can readily be expressed in six digits or less. The remaining six items, however, express information of greater complexity. In protocol sequence, the six are —

SE	Serial Address (**Pr9**)
SC	Security Code (**Prb**)
SW	Status Word, SW
DS	Drive Configuration
FQ	PWM Switching Frequency (**b14**)
CW	Command Word

The drive configuration (DS), for example, must express the state of each of the 13 parameters b0 to b12 inclusive. A process control programme may require to make alterations to several of these, possibly at quite frequent intervals. To simplify the programming of such changes and to enable blocks of relatively complex data to be delivered by means of few and simple signals and in the least time, these six make use of one- and two-byte 'word' codes.

Hex Code Words are transmitted in ASCII format, but are always preceded by the symbol > which enables the receiving programme to decode them in a special way. This is best explained by an illustration. (Refer to the table of ASCII characters, page 82.)

The ASCII character E, for example, would ordinarily decode as hex 45 but because it is in relation to the Status Word SW and is preceded by the > symbol the programme treats it as if it were hex E, not ASCII. The table of ASCII characters shows that hex E is binary 1110. This binary number might indicate the status of four trip circuits, all of which are of course two-state, healthy or tripped. The following paragraphs give the code systems for all six Hex Code Words, and illustrate the decoding by an example in each instance.

SE — SERIAL ADDRESS

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

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

The drive will reply —

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

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

SC — SECURITY CODE

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

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

The drive will reply, for example —

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

The data following the > symbol is hex 57, which is 87 decimal.

The security code for drive number 11 is 87.

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

SW — STATUS WORD

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

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

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

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

The drive replies, for example —

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

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

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

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

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

STATUS WORD SW — with example

Flags and Trip Code		ok	fault	Example Hex	Example Binary
NOT USED		—	—	O	0(msb)
Drive over-temperature	**Ot**	0	1	(1st char)	0
Motor over-temperature	**th**	0	1		0
I x t overload	**It**	0	1		0(lsb)
Current peak trip	**OI**	1	0	E	1(msb)
Power supply failure	**PS**	1	0	(2nd char)	1
Undervoltage trip	**UU**	1	0		1
Overvoltage trip	**OU**	1	0		0(lsb)
Phase loss	**Ph**	0	1	1	0(msb)
Current loop loss	**cL**	0	1	(3rd char)	0
Error flag	**Err**	0	1		0
Tripped flag (status relay)		0	1		1
Run flag, 1 = set to run				C	1(msb)
Ready flag, 1 = drive ready				(4th char)	1
Status of terminal 16, 0 = LOCAL, 1 = REMOTE					0
Ambient over-temperature	**OA**	0	1		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 (status relay) equals 'fault'.

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

DS — DRIVE CONFIGURATION

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

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

The drive replies, for example —

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

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

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

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

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

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

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

To write to drive number 11, sending the same parameter settings as in the example on page 83, 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 addressed 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 then when interrogated about the drive configuration.

DRIVE CONFIGURATION DS — **Example**

Bit parameter		0	1	Hex	Binary
NOT USED		—	—	4	0(msb)
Control mode	b0	torque	speed	(1st char)	1
Start mode	b1	auto	manual		0
Stopping mode	b2	see table page 76			0(lsb)
Boost mode	b3	auto	fixed	F	1(msb)
Uni- or bipolar speed reference	b4	bipolar	unipolar	(2nd char)	1
Feedback	b5	encoder	open loop		1
Master or slave	b6	master	slave		1(lsb)
Stopping mode	b7	see table page 76		8	1(msb)
Display	b8	frequency	load	(3rd char)	0
Control mode	b9	keypad	terminal		0
Parity bit	b10	even	odd		0(lsb)
Current loop — a	b11	see table below		4	0(msb)
Current loop — b	b11	see table below		(4th char)	1
NOT USED		—	—		
Baud rate	b12	4800	9600		0(lsb)

There are four possible states of
Current Loop

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

FQ — PWM SWITCHING FREQUENCY & MVF

FQ is a one-byte, ie two-character, word. The status of PWM switching frequency and MVF are expressed by five hex words which cover all permissible combinations of the two frequency parameters shown in the table Status Word FQ.

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

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 MVF is set at 120Hz.

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

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

CW — COMMAND WORD

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

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

RESET, TRIP (external), STOP, RUN.

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

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

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

The drive replies, for example —

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

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

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

COMMAND WORD CW / **Example**

Function	**Terminal input status 0**	**Terminal input status 1**	**Hex**	**Binary**
NOT USED	—	—	1	0(msb)
Remote FWD/REV *	open	closed (rev)	(1st char)	0
Reset	open	closed (reset)		0
External trip	open (tripped)	closed		1(lsb)
Local FWD/REV *	open	closed (rev)	6	0(msb)
Local/Remote *	open (local)	closed (rem)	(2nd char)	1
Stop	open (stop)	closed		1
Run	open	closed (run)		0

* Cannot be changed through the Serial Communications Link

For Typical Values of Command Word CW refer to the table on page 98.

TYPICAL VALUES of COMMAND WORD CW

Function option selected	CW values during ...					Not start Not reset Not trip
	Power -up	Start	Stop	Reset	Trip	
remote forward local forward remote	16	17	14	36	06	16
remote forward local reverse remote	1E	1F	1C	3E	0E	1E
remote forward local forward local	12	13	10	32	02	12
remote forward local reverse local	1A	1B	18	3A	0A	1A
remote reverse local forward remote	56	57	54	76	46	56
remote reverse local reverse remote	5E	5F	5C	7E	4E	5E
remote reverse local forward local	52	53	50	72	42	52
remote reverse local reverse local	5A	5B	58	7A	4A	5A

Configuration of Pr d Menus

For details of procedure for configuring the **Pr d** menus through the serial communications link, refer to page 58.

FAULT FINDING

DISPLAY does not illuminate and drive does not run

CHECK control pod is connected to drive module
CHECK mains supply, supply fuses or circuit breaker
Replace supply fuses if blown, or reclose circuit breaker, but if supply fuses blow or breaker trips again contact the supplier of the drive.

MOTOR does not start, display shows **rdY**

Drive is in MANUAL start mode.
Operate RUN key, or START pushbutton
CHECK the control wiring, and that external stop/run/trip contacts and circuits are in order.

MOTOR does not start, display shows **0.**

CHECK wiring of speed reference, and that the correct mode (REMOTE/LOCAL) has been selected. CHECK that KEYPAD mode is not selected.

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

Note that:

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

MOTOR fails to turn the load, and is noisy

Fixed boost setting too high (**Pr6**).
Also check the settings of current limits **Pr4** and **Pr5.**

DRIVE fails to respond to serial communications

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

DRIVE appears to be set to an unusable state

If the security code is known—
Enter the security code (**Prb**) to gain access to **b13**.
Set **b13** = 1 to reset all parameters to default values.

If the code is not known —
the code can be accessed from the communications link. See page 72.

Alternatively, at the keypad —
Press MODE + DOWN at power-up to force **Err 6** to set all parameters to the default settings. Disconnect the power supply from the drive, and re-energise when the display becomes blank.

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

Any trip, internal or external, immediately de-energises 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. Refer to page 46.

INTERNAL FUSES If an internal fuse fails, under NO circumstances should a replacement be fitted without first consulting the supplier of the drive. *Serious damage could occur.*

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.

Et External trip has operated (terminal 12 CON2) 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.

OA Ambient temperature fault. The ambient temperature within the drive module has reached its upper or lower safe working limit (50^{O}C to -10^{O}C).

Oh Heat sink overtemperature. The heatsink has reached its upper safe working limit due to loss of cooling air or cooling air too hot.
CD37-75kW & CDV45-90kW models only —
The **Oh** trip code is also used to indicate that the (internal) inrush contactor has failed to close. If this occurs, the drive can be reset by powering down and up (disconnecting and reconnecting mains supply).

OI Instantaneous overcurrent trip. Excess current flowing in the IGBT inverter bridge, caused by short circuit, low impedance earth fault or excessive shock load.

OU DC bus overvoltage. Caused by main supply overvoltage (even if momentary), or high impedance earth fault, or excessive regeneration due to a high rate of deceleration.

Ph Input phase failure or imbalance, causing voltage in one phase to be less than 380V-15% phase equivalent.

PS ** Internal power supply fault.

th Motor thermistor (if fitted) impedance high due to sensing excess temperature.

UU DC link voltage has fallen below the operating range. The drive trips instantaneously.

AcUU The display remains as long as the condition persists. The condition does not trip the drive if running, but causes it to ramp down to zero speed. If corrected before zero speed is reached, the drive will ramp up to whatever speed reference applies and operate normally. If zero speed is reached before the condition is corrected, the drive will trip. The trip code indication is **Ph**.

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

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

HEALTHY INDICATIONS

rdY	Motor stopped, drive energised.
Numerical value displayed	Motor speed (Hz) or load (%FLC) dependent on the setting of **b8.** (Set speed is displayed only in Keypad mode).
dc	dc braking active.
Inh	Motor coasting to rest; IGBT bridge inhibited.

MECHANICAL INSTALLATION

LOCATION

The installation should be located in a place free from dust, corrosive vapours, gases and 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.

CD11-75 & CDV11-90kW drives are not to be installed in classified hazardous areas unless correctly mounted in an approved and certified enclosure. (Refer also to HAZARDOUS AREAS, page 110.)

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 of the motor manufacturer is consulted first.

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

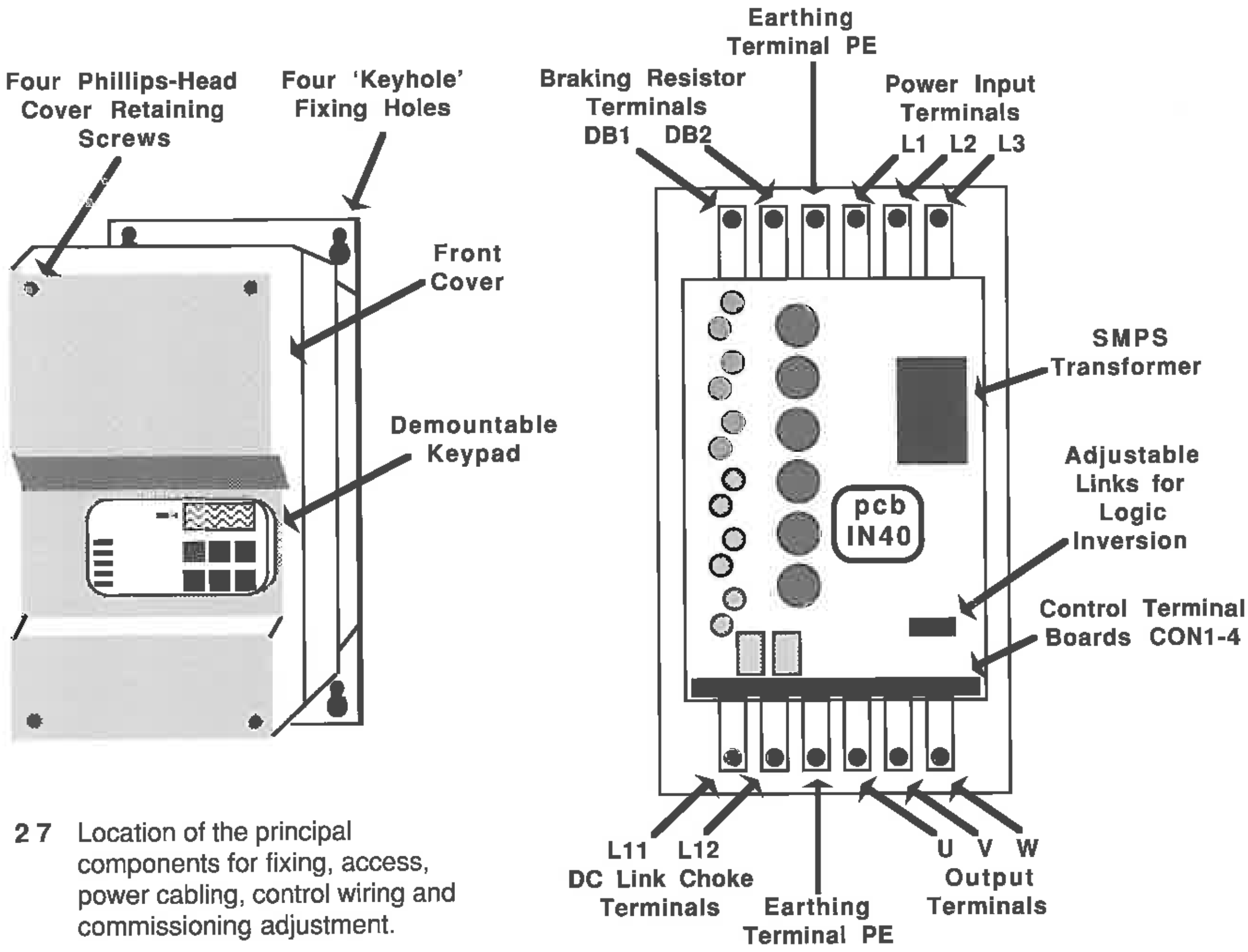
Low speed is liable to result in overheating of the motor because the effectiveness of the internal cooling fan reduces in proportion to the square of the reduction of speed. Motors should be equipped with thermistor protection, and if full benefit of the use of low speeds is to be gained from a variable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

MOUNTING OF THE DRIVE

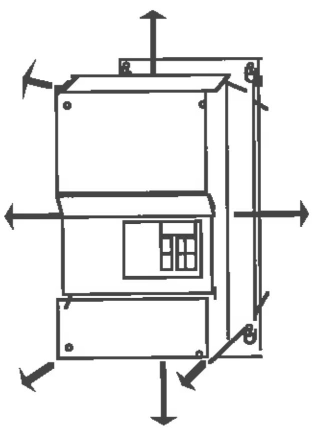
The CD11-75 & CDV11-90kW drive is supplied as a stand-alone unit in a protective casing which conforms to IP00 enclosure specification.The cooling fans for the heatsink conform to IP20. Locations of the principal components of the drive are shown in Fig.27.

The drive module must be fixed in an upright position, and with adequate spacing from adjacent equipment so as to allow free flow of cooling air, Fig. 28.

All modules can be either surface-mounted by the back-plate of the heat sink shroud, or through-panel mounted, as preferred. There is no need to remove the shroud for through-panel mounting, as it is designed to enable it to pass though a cut-out of the correct size, Fig. 29.



27 Location of the principal components for fixing, access, power cabling, control wiring and commissioning adjustment.

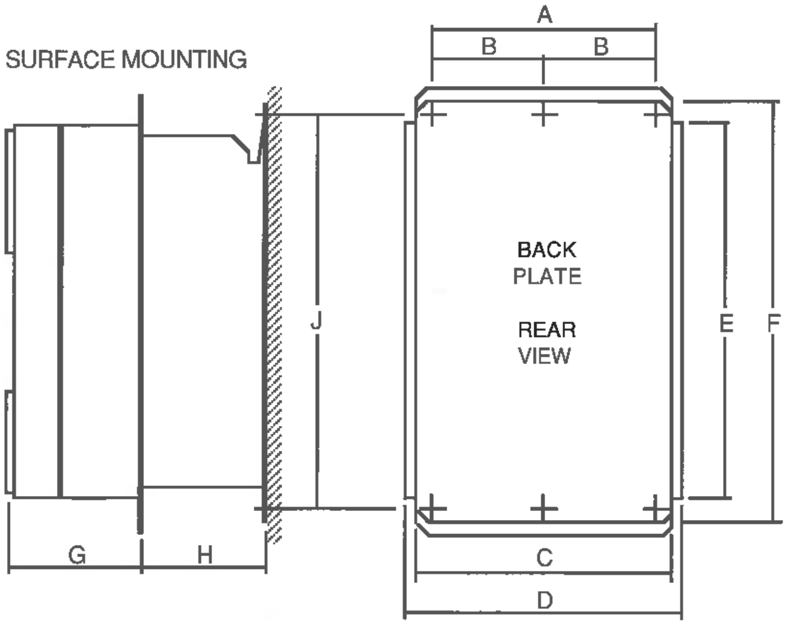


28 A minimum distance of 100mm from adjacent contactors, relays and other types of heat-producing equipment to allow free circulation of cooling air.

Modules CD1100 to CD3000, and CDV1100 to CDV3700 — drill panel for M6 fixing screws
Modules CD3700 to CD7500, and CDV4500 to CDV9000 — drill panel for M8 fixing screws

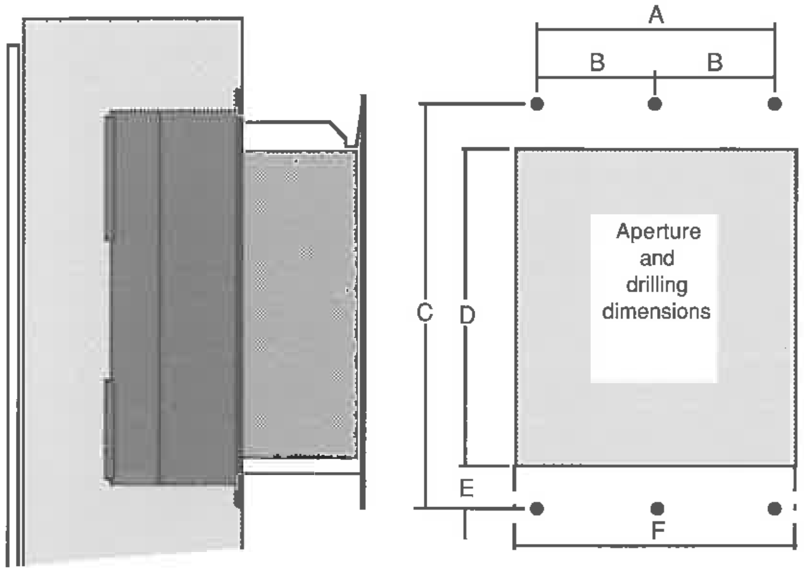
Not to scale
Dimensions in mm

SURFACE MOUNTING



DIMENSIONS (mm)		
	CD1100 to CD3000 CDV1100 to CDV3700	CD3700 to CD7500 CDV4500 to CDV9000
A	248.0	—
B	—	180.0
C	295.2	464.5
D	330.0	490.0
E	490.0	765.0
F	522.0	843.5
G	145.0	170.0
H	138.4	135.0
J	490.0	798.0

THROUGH-PANEL MOUNTING



DIMENSIONS (mm)		
	CD1100 to CD3000 CDV1100 to CDV3700	CD3700 to CD7500 CDV4500 to CDV9000
A	248.0	—
B	—	180.0
C	502.0	815.0
D	466.0	780.0
E	18.0	25.0
F	296.0	467.0

2 9 Principal dimensions and mounting arrangements, CD11-75 & CDV11-90kW.

The CD11-75 & CD11-90kW range of drives is designed to accept two alternative mounting arrangements. Either the module can be mounted by the backplate of the heatsink shroud or, if it desirable that the heatsink should not be within the enclosure, the module can be mounted with the heatsink projecting through the enclosure back panel, into a cooling duct if appropriate. Fig. 29 shows mounting details and dimensions.

If the module is to be mounted with the heatsink projecting beyond the enclosure, and if the IP20 protection of the cooling fans is inadequate, the fans can either be replaced, or removed if an adequate cooling air supply is provided for the heat sink. The drive module is equipped with overtemperature trip protection, so that if external separate cooling is inadequate or fails, the drive cannot overheat but will trip.

The control pod is a plug-in unit which can be detached from the inverter module (even when in operation) for location elsewhere. For details of fixing dimensions see Fig. 30. The connecting cable may be 100m maximum length, and should be screened data cable. The pod plugs into a standard 9-pin D-type panel-mounted data communications socket.

A choke (inductor), Fig. 31, for the dc link is mounted externally to the inverter module, though it may be in the same enclosure.

ENCLOSURE 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. All equipment in the enclosure must be taken into account in calculating the internal temperature.

Effective Heat-conducting Area

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

$$A_e = \frac{P_l}{k\,(T_i - T_{amb})}$$

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

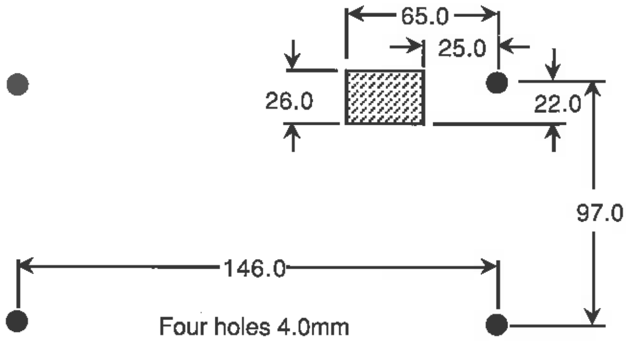
P_l = Power loss of all heat-producing equipment in Watts.

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

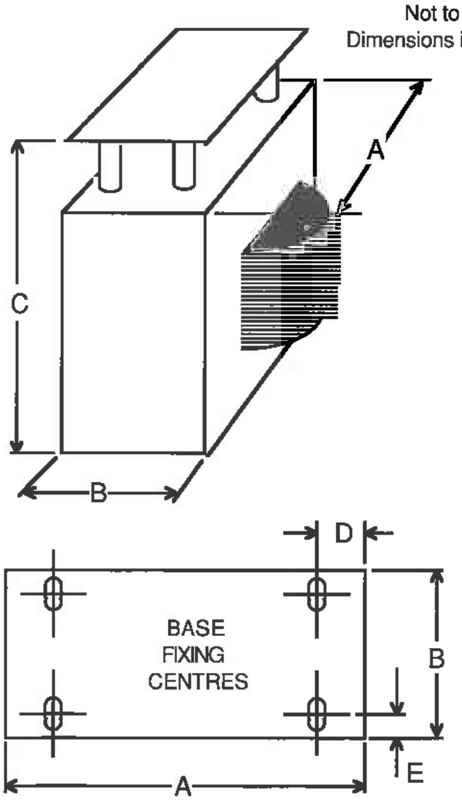
T_{amb} = Maximum external ambient temperature in ^oC.

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

3 0
Remote-mounting of Control Pod. Fixing and cut-out dimensions.



Not to scale
Dimensions in mm



MODULE **CD/CDV**	A	B	C	D	E	Termination stud
1100	118	70	155	27	7	M8
1500	118	82	155	27	7	M8
1850	137	84	175	24	10	M8
2200	118	95	155	27	7	M8
3000	137	116	175	24	10	M8
3700	167	132	200	39	8	M8
4500	167	119	197	39	8	M8
5500	195	138	230	46	11	M10
7500	215	166	254	51	13	M10
9000	215	177	254	51	13	M10

Overall width will be larger than dimension B because the bobbin extends slightly beyond the fame

3 1 Dimensions of dc link chokes (inductors).

EXAMPLE

Calculation of the size of an IP54 cubicle for a CD1100 drive

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

- The drive is to be operated at 5.9kHz PWM switching frequency (**b14** first entry = 5.9).
- The installation is to conform to IP54, which means that the drive module and its heat sink are to be mounted wholly within the cubicle, and that the cubicle is virtually sealed and without any ventilation of the air inside. Heat can escape only by conduction through the skin of the cubicle, which is cooled by radiation to the external air.
- The cubicle is to stand on the floor and against a wall, Fig.32, so that its base and back surfaces cannot be considered to play any part in the cooling process. The effective heat-conducting area, A_e, is provided by the top, front, and two sides only.
- The cubicle is to be made of 2mm sheet steel, painted.
- The maximum ambient temperature is 25°C.

To Find the Effective Heat-conducting Area :—

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

P_l = 440W (from the table of losses for CD 11-30kW drives, page 117. CD1100 module operating at 5.9kHz PWM switching frequency)

T_i = 50°C (for all CD11-75 & CDV11-90kW drives)

T_{amb} = 25°C

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

$$A_e = \frac{440}{5.5(50 - 25)}$$

$= 3.2m^2$

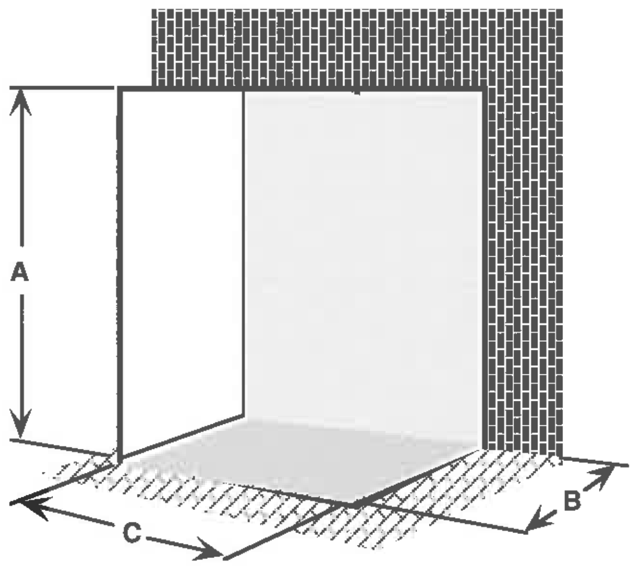
Note — It is essential to include any other heat-generating equipment in the value for P_l.

To Find the Dimensions of the Enclosure :—

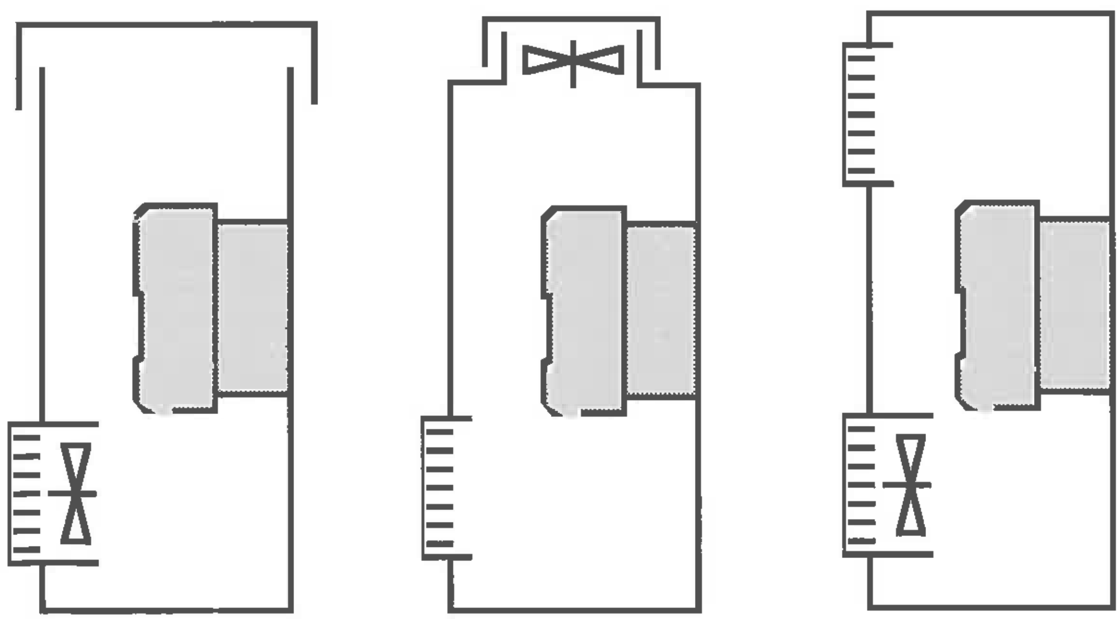
If a cubicle is to be fabricated to suit the installation, there is a free choice of dimensions. Alternatively, it may be decided to choose a cubicle from a range of standard products.

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. 28 page 103.

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.



3 2 Enclosure with typically two surfaces unable to disperse heat.



3 3 Typical arrangements of fan-ventilated enclosures

The effective heat-conducting area of a cubicle located on the floor and against one wall as shown in Fig.32 is —

$$Ae = 2AB + AC + BC$$

Suppose the cubicle height A is 1.8m, and the depth B is 0.5m, as a first estimate. The actual figures chosen in practice will be guided by available space, perhaps, or standard enclosure sizes. Since A_e, A, and B are known, the dimension to be calculated is C. The equation needs to be rearranged to enable C to be found, thus —

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

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

$$C = \frac{3.2 - (2 \times 1.8 \times 0.5)}{1.8 + 0.5}$$

$$C = \frac{3.2 - 1.8}{2.3}$$

$$C = 0.61 \text{ approx.}$$

Clearance on either side of the inverter module must be checked. The width of the module is 330mm, Fig 28. 100mm is required on either side. So the minimum internal width of the enclosure must be 530mm, or 0.53m. This is within the calculated width, and therefore acceptable. However, it allows no space for any equipment to either side of the inverter, and this may be a factor in deciding the proportions of a suitable enclosure. If so, modify the calculated value of C to allow for other equipment, and re-calculate either of the other two dimensions by the same method.

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 dimensions of the top at the expense of the height.

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. Three typical arrangements are shown in Fig. 33.

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

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

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

To Find the Ventilation Required for a CD1100 Drive :—

If, P_l = 440W (table of Losses, page 117)

T_i = 50^oC (for all CD11-75 & CDV11-90kW drives)

Then $$V = \frac{3.1 \times 440}{50 - 25}$$

$$V = 54.56\,m^3\,h^{-1}$$

T_{amb} = 25^oC (for example)

or, say $55m^3\,h^{-1}$ minimum

ELECTRICAL INSTALLATION

SAFETY

The voltages present in the supply cables, the output cables and terminals, the externally-mounted dc link choke, the braking circuit if fitted, and within certain parts of the inverter, are capable of causing severe electric shock and may be lethal.

IP Rating

The drive enclosure conforms to international enclosure specification IP00. It is therefore necessary to consider the location of and access to the module in the light of local safety regulations applicable to the type of installation.

ELECTRIC SHOCK RISK!

Whenever the inverter has been energised, it MUST be ISOLATED. A period of seven minutes MUST elapse after isolation to allow the dc link choke and internal capacitors to discharge fully. Until the discharge period has passed, dangerous voltages may be present at the terminals and within the module.

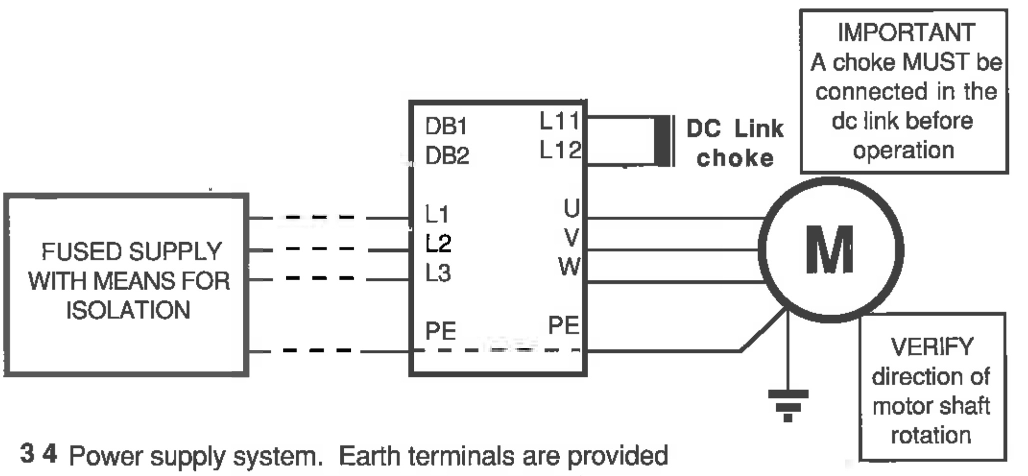
Persons supervising and performing electrical installation or maintenance must be suitably-qualified and competent in these duties.

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. (Refer also to LOCATION, page 102.)

POWER TERMINALS — TIGHTNESS

The specified torque for correct tightening of the power terminals is 8.5Nm. Excessive torque will result in shearing of the power terminal studs.



3 4 Power supply system. Earth terminals are provided on the input and output terminal boards and permanently connected within the module.

EARTHING

System Earthing

Earth connections must be made in accordance with Fig. 34. Earthing cable must have at least 50% of the current rating of the supply cabling.

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

CD11-75 & CDV11-90kW drive modules are equipped with an earthing terminal (PE) on both the input and the output power terminal boards. These two terminals are connected within the module, thus enabling the motor frame earth to be solidly connected through the drive module to a system earth, and providing ample flexibility to accommodate any installation requirements.

Control System Earthing

Five analogue and digital common terminals on control terminal boards CON1, CON2, and CON4 are interconnected internally. They are at zero volts potential relative to the drive control circuits (refer to Terminals, page 75 and Terminal Blocks diagram page 78). It is recommended that these 0V terminals should **not** be connected to an external system earth, for the avoidance of electrical noise.

The Serial Communications 0V Common terminal C1 (CON3) is not connected to any of the other five 0V terminals internally, for the same reason.

POWER CIRCUITS

Connect the drive to the motor and the supply, and the dc link choke to the drive by cable rated as shown under SPECIFICATIONS & DATA, page 114, and as shown in Fig. 34. As a minimum, the supply should be equipped with a means of proper isolation, and must be fitted with protective hrc fuses or circuit breaker of the recommended rating.

Cable and protective-device ratings will be found under SPECIFICATIONS & DATA.

Access to the power terminals is gained by removing the front cover of the drive module, which is secured by four captive screws, one at each corner (Fig. 27, page 103).

Make earthed connections from the power supply to the PE input terminal of the drive and from the PE output terminal to the motor frame.

Unusually-long cable runs (in excess of 200m) between the drive and the motor may give rise to spurious tripping due to transmission line effects. As a result, an overcurrent fault would be indicated (**OI** or **Oh**). It may be necessary to fit chokes (inductors) in the output cables.

A general guide to sizes for motor line chokes is shown in SPECIFICATIONS & DATA. In case of any uncertainty, the supplier of the drive should be asked to advise.

If the drive is to operate with resistive braking (optional) the supply circuit must be fitted with a contactor, circuit breaker, or other switchgear equipped with an external-trip relay. Refer to Fig.18, page 38.

DC Link
A choke (inductor) MUST be connected in the dc link (terminals L11 and L12) before the inverter is operated. The choke is located externally to the inverter module. For choke dimensions refer to Fig. 31, page 106.

Resistive Braking
The drive must be equipped with the externally-mounted IB-2 Braking Option card.
Connect the braking resistor to terminals DB1 and DB2 of the drive by cables rated in accordance with the ratings of the resistor.

Motor Rotation
Check that the direction of rotation is correct as soon as the drive is first energised. If not, interchange any two phase connections on the output side of the drive. Alternatively, use the drive control options to reverse the direction of rotation.

CONTROL CIRCUITS

The wiring for control circuits should be segregated from the power circuit cables to minimise the possibility that high frequency interference may corrupt digital control signals. Control cabling is standard for all circuits: 0.5mm^2, screened overall. Use screened twisted-pair cable for RS485 serial link.

Screening should be bonded to the regulated 0V terminals. For the best immunity from noise it is advisable not to connect the screen to earth.

There are four terminal blocks for control wiring as shown in the diagram on page 78. The diagrams also illustrate typical interconnections with other equipment.

Resistive Braking
A protective device must be fitted to prevent thermal overloading of the braking resistor. This device must be interconnected to tripping contacts of a contactor or circuit breaker controlling the supply to the inverter as shown in Fig.18, page 38.

ELECTROMAGNETIC COMPATIBILITY (EMC)

Immunity

If the instructions in this Guide are observed, CD11-75kW and CDV11-90kW drives exhibit excellent immunity to interference from external sources. In accordance with normal good practice, relays, contactors and switches in power circuits adjacent to the drive should be fitted with suppressors if they control inductive loads.

Emission

Because of the fast semiconductor switches used to ensure high electrical efficiency, PWM drives emit some radio-frequency energy, mainly by conduction through the power cables. It is possible for this energy to distrub nearby communications or measuring systems if they are sensitive in the frequency range 100kHz to 10MHz.

Emission can be minimised by using the lowest programmable switching frequency.

The power cable from the drive to the motor carries the highest radio-frequency voltage and current. The electric and magnetic fields associated with the cable diminish very rapidly with increasing distance. Sufficient attenuation can usually be achieved by ensuring the segregation of signal-carrying cables. Physical separation should be at least 0.3m, and parallel runs of signal and power cables should not exceed about 10m, but should preferably be avoided altogether.

Emission from the motor cable is greatly reduced by using screened or armoured cable. The best effect is obtained if the screen is earthed at both ends — to the motor frame and to the drive earth terminal PE.

If emission into the supply cable is troublesome, a suitable filter must be fitted. The supplier of the drive should be asked to advise.

Control wiringto the drive carries a small radio-frequency potential because of stray capacitance in the drive. Control wiringshould be earthed at a single point in the user's system. If this is impractical and if the control wiring is connected to sensitive apparatus, it is recommended that a small capacitor, 100nF and suitable voltage rating, should be connected between the 0V common terminal and the earth at the user equipment.

PHYSICAL DIMENSIONS
Inverter modules in the CD11-75 & CDV11-90kW range have the following nominal overall dimensions —

Inverter Module	Height mm	Width mm	Depth mm	Backplate Height mm
CD11-30 and CDV11-37	490.0	330.0	283.4	522.2
CD37-75 and CDV45-90	795.0	490.0	305.0	843.5

INGRESS PROTECTION (IP) ENCLOSURE
The CD11-75 & CDV11-90 is constructed in accordance with IP00 specification. The internal cooling fans for the heat sink conform to IP20. The dc link choke (inductor) and the (optional) braking resistor are installed external to the drive module.

POWER SUPPLY
Balanced 3-phase 50Hz or 60Hz, 380V -10% to 460V +10%.

INVERTER OUTPUT
The three phase balanced output can be adjusted to either 120Hz, 240Hz or 480Hz maximum frequency. Maximum output voltage is nominally equal to the input voltage.

AMBIENT TEMPERATURE & HUMIDITY
Ambient temperature range -10°C to +50°C.
5% to 95% relative humidity at 40°C, non-condensing.

DERATING
Nominal ratings are affected by —

- The altitude of the installation. Where the site is above 1000m, reduce the normal full load current by 1.0% for each additional 100m.
- The ambient temperature. The inverter should be installed where its ambient temperature will not be affected by heat from any other apparatus nearby.

STARTS PER HOUR
Unlimited for the drive.
Motor according to manufacturer's recommendations.

PWM SWITCHING FREQUENCIES
CD11-55kW and CDV11-55kW — choice of 2.9kHz or 5.9kHz.
CD75kW, CDV75kW and CDV90kW — 2.9kHz only.

VIBRATION
All modules in the CD11-30kW Industrial and the CDV11-37kW HVAC ranges conform to the requirements of IEC 68-2-61:1982 and BS2011 part 2.1 Fc:1983, up to a level of 0.5g.

ENCODER
15 pulses per motor pole per revolution.

INVERTER RATINGS

Power ratings are for 3-phase 6-pole motors

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

CD11-75kW Industrial Inverter, 380V supply

Inverter Model	OUTPUT	MOTOR RATING		INPUT			
	100% rms current			100% rms current		!00% fundamental	
	A	kW	HP	A	kVA	A	kW
CD1100	25	11	15	26.5	17.4	22.1	14.5
CD1500	31	15	20	29.5	19.4	25.6	16.8
CD1850	38	18.5	25	36.4	24.0	33.4	22.0
CD2200	46	22	30	49.1	32.3	40.5	26.7
CD3000	59	30	40	57.9	38.1	51.1	33.6
CD3700	76	37	50	72.7	47.8	66.9	44.0
CD4500	91	45	60	90.1	59.3	79.2	52.1
CD5500	110	55	75	106.1	69.8	96.7	63.6
CD7500	150	75	100	144.0	94.8	132.5	87.2

CD11-75kW Industrial Inverter, 460V supply

Inverter Model	OUTPUT	MOTOR RATING		INPUT			
	100% rms current			100% rms current		100% fundamental	
	A	kW	HP	A	kVA	A	kW
CD1100	25	15	20	26.5	21.1	22.1	17.6
CD1500	31	18.5	25	29.5	23.5	25.6	20.4
CD1850	38	22	30	36.4	29.0	33.4	26.6
CD2200	46	30	40	49.1	39.1	40.5	32.3
CD3000	59	37	50	57.9	46.1	51.1	40.7
CD3700	76	45	60	72.7	57.9	66.9	53.3
CD4500	91	55	75	90.1	71.8	79.2	63.1
CD5500	110	55	75	106.1	84.5	96.7	77.0
CD7500	150	90	120	144.0	114.7	132.5	105.6

INVERTER RATINGS continued

CDV11-90pkW HVAC Inverter, 380V supply

Inverter Model	OUTPUT	MOTOR RATING		INPUT			
	100% rms current			100% rms current		100% fundamental	
	A	kW	HP	A	kVA	A	kW
CDV1100	25	11	15	25.6	16.8	21.1	13.9
CDV1500	32	15	20	31.8	20.9	28.2	18.6
CDV1850	38	18.5	25	35.2	23.2	32.0	21.1
CDV2200	46	22	30	49.1	32.3	40.5	26.7
CDV3000	62	30	40	61.3	40.3	54.6	35.9
CDV3700	70	37	50	67.7	44.6	61.6	40.5
CDV4500	91	45	60	90.5	59.6	79.5	52.3
CDV5500	110	55	75	106.0	69.8	96.7	63.6
CDV7500	144	75	100	138.7	91.3	127.1	83.7
CDV9000	180	90	120	173.4	114.1	158.3	104.2

CDV11-90kW HVAC Inverter, 460V supply

Inverter Model	OUTPUT	MOTOR RATING		INPUT			
	100% rms current			100% rms current		100% fundamental	
	A	kW	HP	A	kVA	A	kW
CDV1100	25	15	20	25.6	20.4	21.1	16.8
CDV1500	32	18.5	25	31.8	25.3	28.2	22.5
CDV1850	38	22	30	35.2	28.0	32.0	25.5
CDV2200	46	30	40	49.1	39.1	40.5	32.3
CDV3000	62	37	50	61.3	48.8	54.6	43.5
CDV3700	70	45	60	67.7	53.9	61.6	49.1
CDV4500	91	55	75	90.5	72.1	79.5	63.3
CDV5500	110	55	75	106.0	84.5	96.7	77.0
CDV7500	144	90	120	138.7	110.5	127.1	101.3
CDV9000	180	110	150	173.4	138.2	158.3	126.1

LOSSES

CD11-75kW Industrial Inverter

Inverter Model	Total Heat Loss 2.9kHz (100%)W	Total Heat Loss 5.9kHz (100%)W	Inverter Efficiency 380V 2.9kHz	Inverter Efficiency 380V 5.9kHz	Inverter Efficiency 460V 2.9kHz	Inverter Efficiency 460V 5.9kHz
CD1100	358	440	97.6	97.1	98.0	97.6
CD1500	404	498	97.7	97.1	98.1	97.6
CD1850	490	615	97.8	97.3	98.2	97.7
CD2200	572	724	97.9	97.4	98.3	97.8
CD3000	698	886	98.0	97.4	98.3	97.9
CD3700	934	—	97.9	—	98.3	—
CD4500	1106	—	97.9	—	98.3	—
CD5500	1322	—	98.0	—	98.3	—
CD7500	1897	—	97.9	—	98.2	—

CDV11-90kW HVAC Inverter

Inverter Model	Total Heat Loss 2.9kHz (100%)W	Total Heat Loss 5.9kHz (100%)W	Inverter Efficiency 380V 2.9kHz	Inverter Efficiency 380V 5.9kHz	Inverter Efficiency 460V 2.9kHz	Inverter Efficiency 460V 5.9kHz
CDV1100	368	455	97.4	96.8	97.9	97.4
CDV1500	442	544	97.7	97.2	98.1	97.6
CDV1850	491	606	97.7	97.2	98.1	97.7
CDV2200	593	742	97.8	97.3	98.2	97.8
CDV3000	761	961	97.9	97.4	98.3	97.8
CDV3700	834	1068	98.0	97.4	98.3	97.9
CDV4500	1124	—	97.9	—	98.3	—
CDV5500	1357	—	97.9	—	98.3	—
CDV7500	1774	—	97.9	—	98.3	—
CDV9000	2323	—	97.8	—	98.2	—

SUPPLY FUSES & CIRCUIT-BREAKERS
CABLE SIZES,
DRIVE WEIGHT
DC LINK CHOKE WEIGHT

Fuses or a circuit breaker must be installed in the supply to protect the cables.
Fuse specification IEC 269 Parts 1 & 2, type **gl** characteristic and BS 88 Parts 1 & 2, HRC fuses.Fuses described as 'motor starting' are not suitable.
Circuit breaker type K characteristic.

NOTE — INTERNAL FUSES — If an **internal** fuse ruptures, do NOT replace it without first consulting the supplier of the inverter.

Inverter Module **CD/CDV**	Fuse/Circuit-breaker Rating **A**	Cable Size **mm^2**	Drive Module Weight **kg**	DC Link Choke Weight **kg**
1100	35	6.0	22.3	3.5
1500	40	10.0	22.3	4.5
1850	50	10.0	22.3	6.4
2200	60	16.0	24.0	5.4
3000	70	25.0	24.0	8.4
3700	80	25.0	*	16.5
4500	100	25.0	56.0	14.5
5500	125	50.0	56.0	22.5
7500	160	70.0	56.0	32.0
9000	200	95.0	58.0	35.0

* CD3700, 54.0kg
CDV3700, 24.0kg

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.

DC LINK CHOKE RATINGS

Ripple frequency = 6 x supply frequency.
Ratings and values quoted are suggested minima.

Inverter Module CD/CDV	Choke Ratings		
	mH	A_{rms}	A_{pk}
1100	1.25	32.5	65
1500	1.35	39	72
1850	1.50	45	85
2200	0.65	60	128
3000	0.70	75	143
3700	0.80	89	167
4500	0.45	111	224
5500	0.5	130	251
7500	0.4	176	352
9000	0.3	212	350

GUIDE to MOTOR LINE CHOKE SIZES

For dimensions of chokes refer to Fig. 31 page 106.
Unusually-long cable runs (in excess of 200m) between the drive and the motor may give rise to spurious tripping due to transmission line effects. If in doubt, please consult the supplier of the drive.

GLOSSARY

As-delivered Customised departure from the standard default value of a parameter.

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

Customised Modified or adapted to suit the requirements of a particular installation or system.

Default A single pre-determined value tp which a parameter is set during manufacture

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

Drive The set of equipment designed to operate an electric motor, complete with the means of controlling speed and torque.

FLC Full load current. The value of the current which apparatus draws or delivers when supplied at rated voltage and subjected to the normal full value of the load for which it is designed.

HVAC Heating, ventilating and air-conditioning.

Inverter The output bridge of a drive, provided with means to synthesise an alternating voltage output.

Isolation The separation of parts of an electrical circuit by an insulating medium, permanent or temporary, adequate in withstand value to prevent the voltage potential of one part being experienced by another.

Latch Characteristic of operation of a device which causes it to remain in one state until released by an external agency.

Loss (1) Of an electrical supply — the failure of the supply to an installation, usually as a result of a fault. (2) The difference between the energy delivered and the energy converted into useful work or product.

MVF Maximum voltage frequency (of a CD11-30kW drive): the frequency selected to be delivered to the motor when the voltage output is equal to the rated voltage.

Optical isolation The coupling of electrically-isolated circuits by means of signals in the form of modulated visible light or infrared radiation.

Parameter Data, usually adjustable in value, relating to a particular variable characteristic.

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

Power-down Disconnection of the mains power supply.

Power-up Application of mains power supply to the drive (not power from the drive to the motor). Enables all internal systems of the drive to be operated.

PWM Pulse width modulation. A technique for synthesising a sinusoidal or other controlled output from a dc input, realised by one of several practical stategies of switching semiconductor devices.

Ramp Movement of a reference signal from one value to another in accordance with a specified rate of change.

Read-only A unit of data in a which can be interrogated but not changed.

Read-write A unit of data in a which can be changed and interrogated as to its value.

Reference Data or parameter value of one part of a system used for controlling another part.

Reset Restore the values and conditions obtaining prior to (usually) an interruption or disturbance.

Set point The value of an operating parameter, often adjustable, controlling an operating condition. See also 'Reference'.

Set-up The particular configuration of the controls of a system or item of equipment chosen for specific conditions.

SMPS Switch-mode power supply. A means of deriving a secondary electrical supply, usually at a different potential, from a dc source.

ULF Upper limit of frequency (of a CD11-30kW drive). The frequency beyond which demand is not permitted to increase.

Word A grouping of hexadecimal or other characters based on binary numerals and representing a specified state or value.

USER'S RECORD of DRIVE SETTINGS

Parameter		Setting			First Change			Second Change		
			Date	Set by		Date	Set by		Date	Set by
b0	Torque or speed									
b1	Auto/Manual start									
b2	Stop mode with b7									
b3	Auto/fixed boost									
b4	Uni/bipolar ref									
b5	Open/Closed loop									
b6	Master/Slave									
b7	Stop mode with b2									
b8	Freq/Load Display									
b9	Keypad/Terminal									
b10	Even/Odd parity									
b11	Remote speed ref									
b12	Baud rate									
b14	ULF/PWM									
Prc	MVF									
Pr0	Min frequency									
Pr1	Max frequency									
Pr2	Acceleration time									
Pr3	Deceleration time									
Pr4	Current limit									
Pr5	Max contin I x t									
Pr6	Voltage boost									
Pr7	Slip compensation									
Pr8	DC braking level									
Pr9	Serial address									
Prb	Security code									