USER'S GUIDE

for the

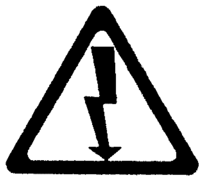
VECTOR

VB75 to VB1100S

FLUX VECTOR

DRIVES FOR STANDARD AC SQUIRREL CAGE INDUCTION MOTORS

0.75 kW to 11 kW



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 this equipment 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, operation or maintenance of the equipment, or adjustment of the optional operating parameters, or from mismatching of the drive to the motor and driven load.

USER'S GUIDE -- VECTOR/VB
Part No. **0433-0001**
Issue No 3 — May 1998
SOFTWARE VERSION V8.X.X

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Contents

Illustrations

FEATURES
of the
VECTOR
RANGE

- ***VECTOR*** drives have been designed in "bookshelf" format to optimise cubicle space when utilised in multiple drive systems.
- ***VECTOR*** drives are designed to operate standard 3-phase induction motors and special high-frequency motors fitted with encoders.
- Insulated gate bipolar transistor (IGBT) inverter output bridge for high speed switching and low power consumption
- Digital control of the output bridge by micro-processor.
- Internal control power provided by switch-mode power supply (SMPS) giving regulated control voltage for a wide range of input voltage.
- Choice of four PWM output switching frequencies to match applications.
- Acceleration and deceleration with programmable ramps.
- Full torque at zero speed.
- Constant-speed control at varying loads.
- Independent control of torque and speed from zero.
- Rapid dynamic response.
- Start on to a spinning motor.
- Full PID control.
- Dynamic braking with on-board power resistor as standard.
- Internal monitoring and protection includes I x t overload, current limit, instantaneous short circuit, earth fault and heatsink overtemperature protection.
- External motor-protection inputs from thermistor and/or thermal relay.
- Parameter and diagnostic data saved during power loss for fault diagnosis and quick restart without reprogramming in the event of a trip.
- Parameter data input fully digital. No potentiometers and no links to adjust.
- A range of analog input and output signals for compatibility with non-digital equipment and systems.
- Control circuits impedance-isolated from power circuits.
- Serial communications interconnection standard RS485. Software protocol standard ANSI x 3.28-2.5-A4.
- Plug-and-socket connection of power and control wiring ensures rapid and reliable disconnection and reconnection of drives.

CONTROL TECHNIQUES WORLDWIDE

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

DECLARATION OF CONFORMITY

The AC variable speed drive product bookcase Vector power range 0.75kW - 2.2kW and 4.0kW-7.5kW, and 11.0kW, has been designed and manufactured in accordance with the following European harmonised, national and international standards:

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

This product complies with the Low Voltage Directive 73/23/EEC and the CE Marking Directive 93/68/EEC.

W. Drury
Technical Director

Newtown
Date: 13 January 1997

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

VECTOR ADDENDUM
for Issue2 Manual

MODULE DIMENSIONS (PAGES 6 AND 10)

.\EW PACKAGE DIMENSIONS (mm)

	VB75 - VB200	VB400 - VB1100S
WIDTH	78.5	127
HEIGHT	352	352
DEPTH	323.5	328.5

EARTHING (PAGE 13)

The Protective Earth connection is now an Earth lug on the top of the drive casing. The connection marked **Y** on the main power connector is now used for connection of varistors to earth for transient voltage protection. This in not recommended for grounded Delta systems **and this terminal is no longer the protective earth**.

EXTERNAL BRAKING RESISTORS (PAGE 18)

VB75 - VB200.

An extra power connector has been added on top of the case to allow access to the DC Link and Dynamic Braking connections for DC bus paralleling and applications requiring external Braking resistors.

The Terminal connections are as follows:-

1 **+DC bus.**
2 **Not Connected.**
3 **INTERNAL braking resistor.**
4 **Not Connected.**
5 **EXTERNAL braking Resistor.**
6 **Not Connected.**
7 **-DC bus.**

VB400 - VB1100S

A removeable Link has been fitted at the bottom of the case to allow disconnection of the internal braking resistor, existing terminals already allow for connection of an external braking resistor and access to the DC bus.

Hardware Addendum For D'Ax 0.75kW to 11kW

Braking Resistor Protection

In applications which require the use of braking resistors, the braking duty cycle must be carefully considered. If the resistor is under-specified for the application, the power dissipated will cause the resistor to overheat, leading to damage to the resistor and the drive increasing the risk of fire. Use of thermal overload protection relays can provide a means of either tripping the power to the system if the duty cycle is exceeded, or sending a signal to a controlling PLC. The relays do not actually try to break the DC current.

Need to specify:

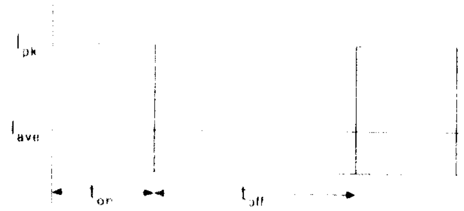
P_{max} - maximum power dissipation
t_{max} - maximum time for P_{max} dissipation
R - total braking resistance
V_{dc} - max d.c. link voltage

During the period of dissipation, the average current through the resistor is given by:

$$I_{ave} = \frac{P_{max}}{V_{max}}$$

where; V_{max} = maximum DC link voltage.

The braking control of the drive actually uses a chopper transistor to switch in the resistor, so the actual current waveform in the resistor similar to that shown below.



where:

$$I_{pk} = \frac{V_{max}}{R}$$

The duty cycle of the transistor is given as:

$$D = \frac{I_{ave}}{I_{pk}} = \frac{t_{on}}{t_{on} + t_{off}}$$

The RMS current in the resistor can now be calculated by:

$$I_{rms} = \sqrt{I_{pk}^{2} * D}$$

The relay should be set up for the expected RMS current in the resistor and the value of t_{max}.

Worked Example 1: Specify a thermal overload for use with a DB140 using its internal resistor. The application is working the resistor close to its maximum specification of 1.5kW for 10 seconds, with 90 seconds cooling time. The nominal resistance is 80Ω.

Data:

P_{max} = 1.5kW
t_{max} = 10 seconds
R = 80Ω
V_{dc} = 750V

Since the continuous rating of the resistor is 150W the average current must be limited to

$$\sqrt{\frac{150}{80}} = 1.369 \quad \text{Amps}$$

$$Ipk = \frac{750}{80} = 9.375 \quad \text{Amps}$$

$$Duty = \frac{1.369}{9.375} = 0.146$$

$$Irms = \sqrt{9.375^2 \cdot 0.146} = 3.582 \text{ Amps}$$

$$Iset = \frac{3.582}{4} = 0.895 \quad \text{Amps}$$

This is the current that must be set on the relay so relay type LR2-D1306 (1.0A to 1.6A) should be used.

The short circuit condition will overload the relay by a factor of 8.5, and this will cause the relay to trip out after approximately 4 seconds.

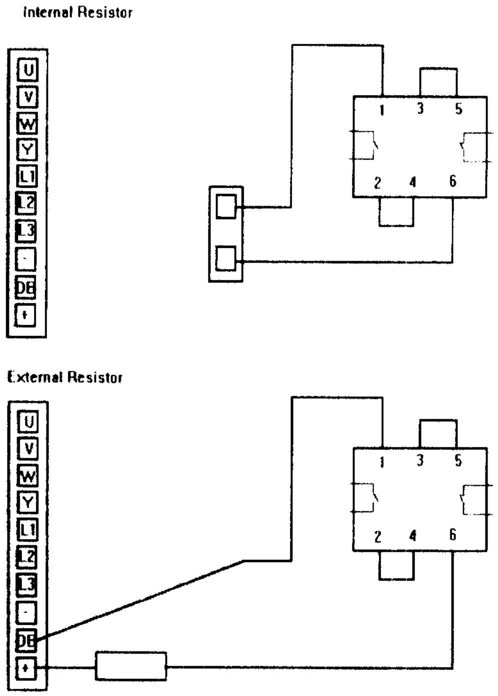
The diagrams below cover the following drives

Vector	CDE	Digitax	Spindax
VBE400	CDE400	DBE420	SA010
VBE550	CDE550	DBE600	SA016
VBE750	CDE750	DBE750	SA022
VBE1100S	CDE1100S	DBE1100S	

Electrical Installation

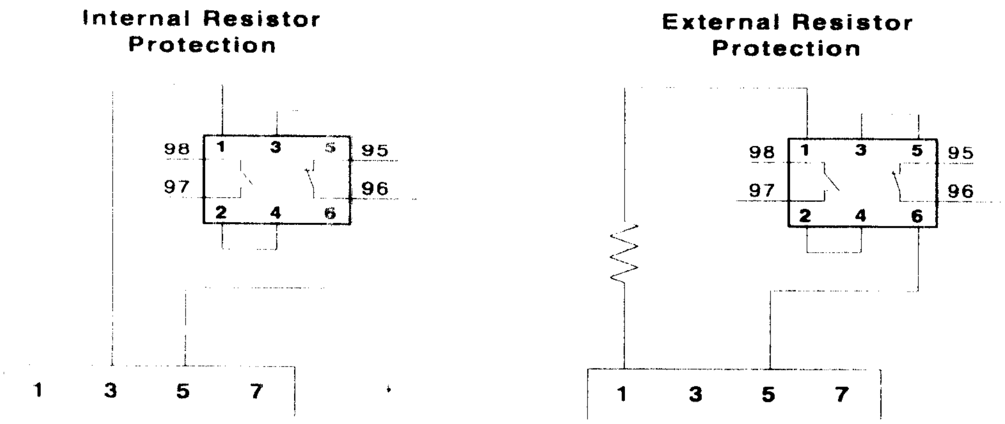
The following diagrams show how to connect the relay to protect the internal resistor for the drives stated, or external resistors if used.

Large bookcase package



The internal resistor must be disconnected if an external resistor is being used. The internal resistor is disconnected if there is no connection between the two way terminal block on the bottom of the unit.

Small Bookcase Package Only



NOTE: If external resistors are used, ensure that the internal resistor is disconnected by removing any wire link between terminals 3 and 5.

The previous diagrams refer to the following drives:

Vector	CDE	DigitAx	SpindAx
VBE75	CDE75	DBE140	SA005
VBE110	CDE110	DBE220	
VBE150	CDE150		
VBE220	CDE220		

The normally closed contacts 95 and 96 should be connected in series with the line contactor coil.

1
Introduction

The *VECTOR* Drive
for Standard Squirrel-cage Induction Motors

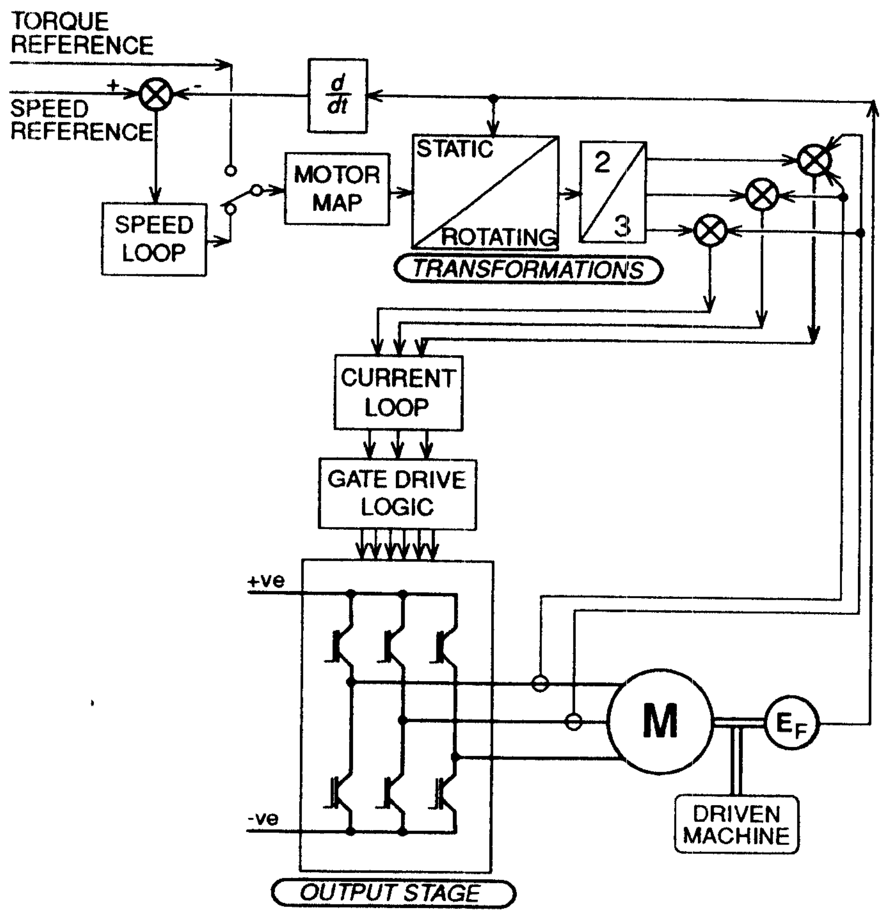
VECTOR has been developed to operate standard run-of-production squirrel-cage motors. The performance of the *VECTOR* with *standard* motors is comparable to the performance achieved with more costly motors specifically designed for flux vector drive control.

True flux vector control requires a feedback so that the rotor position can be monitored continuously. An incremental encoder on the motor shaft is essential for this purpose (E_F in Fig. 1). It is usually fitted at the non-drive end and is a simple modification. The feedback encoder, the *VECTOR* drive and the motor thus become a true closed-loop system, able to give precise control of torque and speed.

Although the function of the feedback encoder is primarily to transmit the rotor position to the drive logic, the same signal is utilised for motor speed sensing by measuring the rate of change of position of the rotor. An additional and separate tacho-generator is not necessary for this purpose.

Standard squirrel-cage induction motors are primarily single-speed machines. The *VECTOR* drive can operate standard motors at speeds from zero up to 6000rpm. Further, *maximum torque* is available from base speed down to zero speed. In applications where motor speeds below base speed will be used, motor cooling must be considered in relation to the speeds and torque outputs involved. For high speed applications above base speed, the quality of rotor balance and bearing type should be specified.

If there is any doubt about an application which is to involve low-speed or high-speed operation, it is advisable to consult the supplier of the motor for practical advice.



1 Schematic representation of the *VECTOR* power circuit and control system.

2
Data

2.1 General Specifications

Physical Dimensions

Refer also to to Figs. 2 and 3.

Module type	*Module height* mm	*Width max* mm	*Depth including heat sink* mm	*Vertical fixing centres* mm
VB75-VB220	340.0	75.0	325.0	357 (372*)
VB400-VB1100S	340.0	125.5	325.0	357 (372*)

**When fixing brackets are positioned for through-panel mounting* — Figs. 2 and 3.

Ingress Protection (IP) Enclosure

VECTOR drives are constructed in accordance with IP20 specification. Internal cooling fans (where fitted) for the heatsinks conform to IP20.

Power Supply

Balanced 3-phase 50Hz or 60Hz, 380V -10% to 460V +10%. Supply frequency tolerance 48Hz to 62Hz.

Inverter Output

The three phase balanced output can produce up to ±6000rpm with 2-, 4-, 6- or 8-pole motors. Maximum output voltage is nominally equal to the input (line) voltage.

Ambient Temperature and Humidity

Ambient temperature range -10°C to +50°C.

Storage temperature range -40°C to +50°C for one year maximum.

Humidity — 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% for each additional 100m.
- The ambient temperature. The drive should be installed where the maximum ambient temperature will not be exceeded due to heat generated by other apparatus nearby.
- Use of the higher PWM switching frequencies — refer to 2.2 Ratings and Derating.

Starts per Hour

Motor according to manufacturer's recommendations. Drive limited to 10 starts per hour if started by switching the supply. If the motor is started only by electronic control of the drive, the number of starts per hour is unlimited for the drive.

PWM Switching Frequencies

Constant switching frequency selectable from four values — 3.0kHz, 6.0kHz, 9.0kHz or 12.0kHz.

2.2 Ratings

Module type	*Motor power* kW	*Maximum continuous current output* A	*Input current* A	*Input at 415V* kVA	*Output at 415V* kVA
VB75	0.75	2.1	3.4	2.4	1.5
VB110	1.1	2.8	4.5	3.2	2.0
VB150	1.5	3.8	5.5	4.0	2.7
VB220	2.2	5.6	8.7	6.3	4.0
VB400	4.0	9.5	13.2	9.5	6.8
VB550	5.5	12.0	13.5	9.7	8.6
VB750	7.5	16.0	16.7	12.0	11.5
VB1100S	11	22*	23.4	17	16

* *See under 2.3 - Derating*

2.3 Derating

- Modules VB75 to VB750 inclusive can achieve the rated output currents shown in the Ratings table above, without derating, in a 50°C ambient temperature and 12 kHz Switching Frequency.
- Module VB1100S at 12 kHz Switching Frequency can only achieve rated output current, without derating, in a 40°C ambient temperature.
- If module VB1100S must operate in a 50°C ambient temperature, derate as follows —

  Switching frequency 9 kHz   20 A *maximum continuous current output*

  Switching frequency 12 kHz   17 A *maximum continuous current output*

2.4 Losses and Cooling

N = Natural circulation
F = Integral cooling fans fitted

Module type	*Losses* *3.0 kHz PWM* W	*12.0 kHz PWM* W	*Cooling*
VB75	45	80	*N*
VB110	50	110	*N*
VB150	60	140	*N*
VB220	90	170	*N*
VB400	130	280	*F*
VB550	170	370	*F*
VB750	220	410	*F*
VB1100S	260	470	*F*

2.5 Ventilation

VECTOR drives do not require external fans. Cooling fans for the heat sinks are built into those modules that require them.

VECTOR drives may be installed in an enclosure, but care must be taken to ensure that —

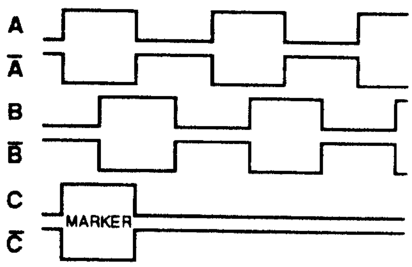
- the drive module is mounted vertically;
- adequate air space is provided within the enclosure to allow for correct air flow over the heatsink cooling fins.
- adequate clearance for air flow is provided above and below each module, Fig. 4, page 11.

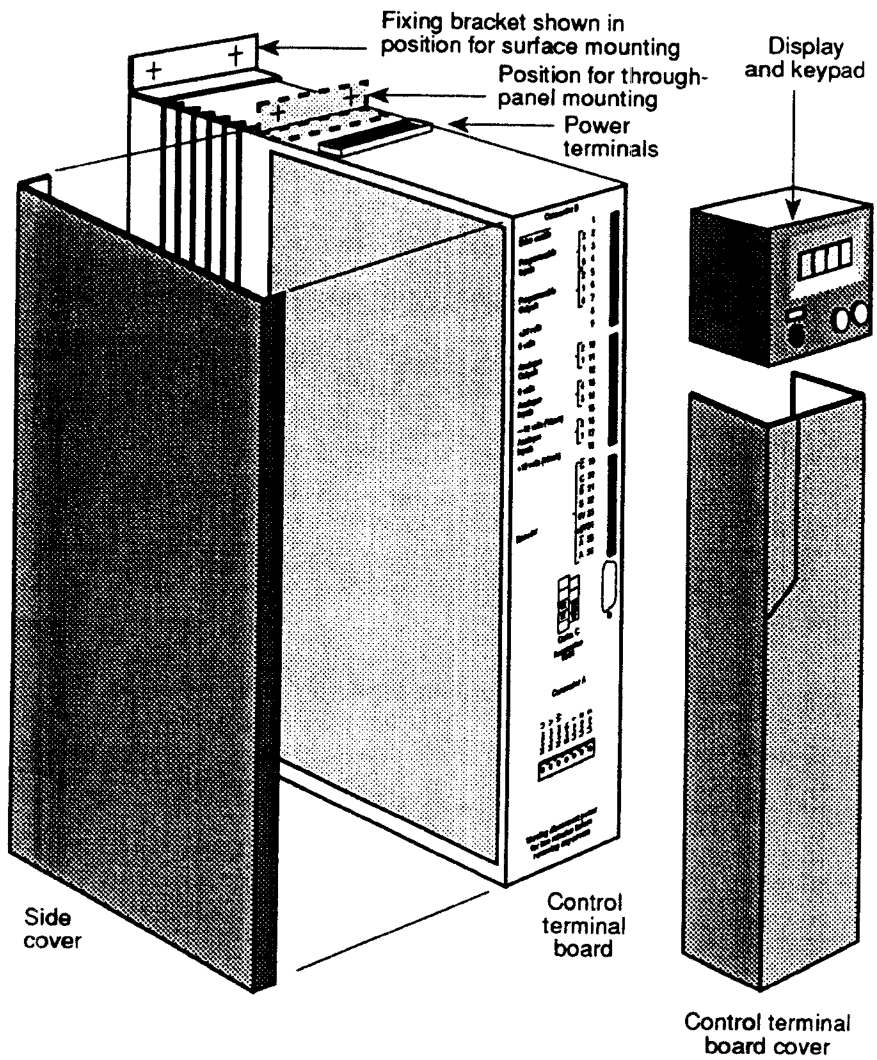
2.6 Encoder Specification

Incremental shaft position encoder, 5V, 200mA, 1024 pulses per revolution (ppr), TTL differential line driver.

It is recommended that the encoder is connected by overall-screened cable having individually-screened pairs.

For a cable exceeding 150m in length it will probably be necessary to arrange an external supply for the cable because of the voltage drop due to the cable length. It may also be necessary to arrange a local power supply close to the encoder.





2 Locations of the principal components of the *VECTOR* variable speed drive.

3
Installation — Mechanical

3.1 Mounting

VECTOR drives are to be installed only in a vertical position, to ensure the best flow of air for the cooling fins of the heat sink. Installation vertically above other drives or any heat-producing equipment may result in overheating.

Location

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

Care must also be taken to avoid condensation of vaporised liquids, including atmospheric moisture. If the drive is to be located where condensation is likely to occur when the drive is not in use, a suitable anti-condensation heater must be installed. The heater must be switched OFF when the drive is energised. An automatic changeover switching arrangement is recommended.

VECTOR drives are not to be installed in classified hazardous areas unless correctly mounted in an approved enclosure and certified. (Refer also to HAZARDOUS AREAS, Chapter 4 Section 1.)

Fixing brackets

Two alternative arrangements are provided for in the design of *VECTOR* drives:

Either —

- the drive may be mounted on an open panel or wholly within a cubicle, in which case the fixing brackets are located in position A, Fig. 3 Page 10,

or —

- the heat sink may project through the mounting panel into a free air space behind, in which case the fixing brackets are located in position B.

The fixing brackets are attached to the material of the heat sink or to the frame of the drive by two screws each. Self-tapping screws are provided, to ensure good earth connection to the supporting framework or cubicle which should itself be bonded to earth in accordance with good practice.

Where two or more drives are to be installed side-by-side there must be a gap, 3mm minimum, between adjacent modules to facilitate removal of the the front terminal cover, Fig. 4 page 11.

3.2 Cooling and Ventilation

The Drive Enclosure

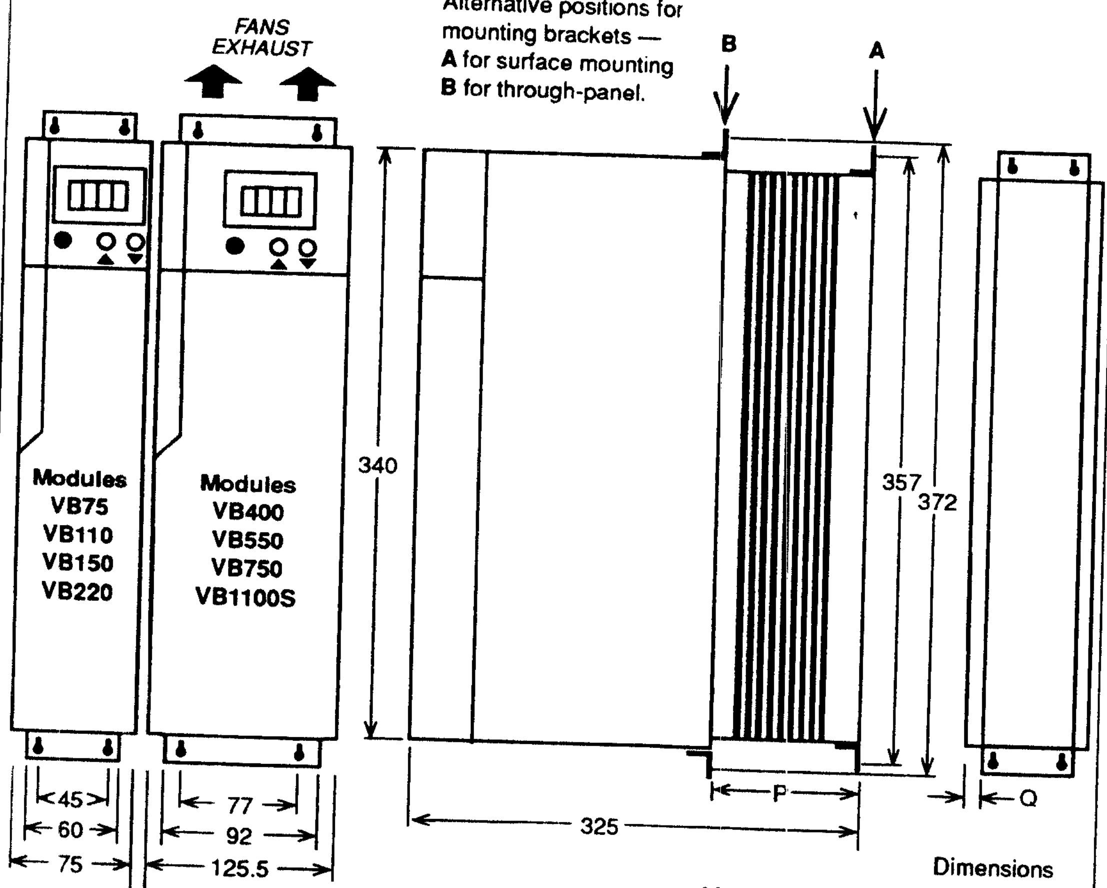
VECTOR drives are protected from damage caused by overheating. A thermal sensor is mounted on the heat sink. If the temperature rises to 95°C, the drive trips automatically. This setting is not adjustable.

Cubicle-mounted *VECTOR* drives can be mounted either wholly enclosed, or with the heat sink projecting though the rear panel. Through-panel mounting allows for physical segregation between the control section of the drive and the power electronics, enabling the heat-producing (power) section to dissipate heat without affecting the temperature within an enclosure.

This may be an advantage when a number of drives are to be enclosed in a single cubicle. In any case, cubicle size must be verified by calculation to ensure that there is adequate space to allow free circulation of the air within an enclosure. All equipment in the enclosure must be taken into account in calculating the internal temperature. Installation vertically above other drives or any heat-producing equipment may result in overheating.

As standard, all models of *VECTOR* drives are equipped with an on-board braking resistor. For special applications, some servo systems may require braking capacity in excess of the standard. **A larger braking resistor can be connected** (models VB400, VB550, VB750 and VB1100S only) **externally to the drive. The on-board resistor must be disconnected (it is essential to consult the supplier of the drive in this case).**

When an external resistor is fitted it is vitally important to take account of the increase in heat generated. It is recommended that the external resistor should be mounted where its heat losses cannot affect the drive.



Module type VB...	P	Q
75, 110, 150, 220	95	8
400, 550, 750, 1100S	100	7

3 Dimensions of *VECTOR* drives.

To find the dimensions of an 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 to ensure adequate clearance for air circulation.

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

The effective surface area A_e for an enclosure, Fig. 5, containing equipment which generates heat is calculated from the following equation —

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

where

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

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

T = Maximum permissible operating temperature of the drive module in °C.

T_{amb} = Maximum external ambient temperature in °C.

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

The effective heat-conducting area of a cubicle typically located on the floor and against one wall, is —

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

where A is the cubicle height, B is the depth, front to back, and C the width, Fig. 5.

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 can be found, and 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 —

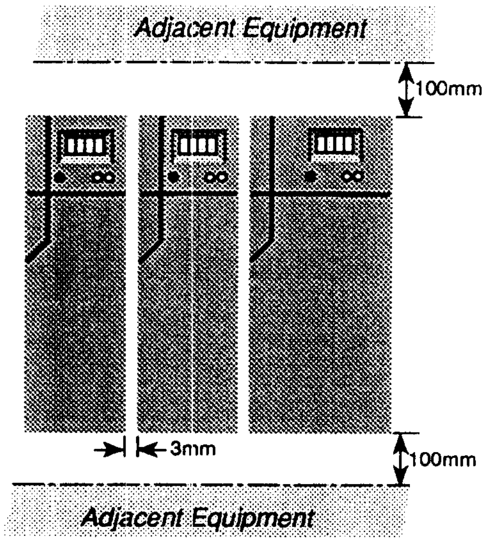
$$A_e - 2AB = C(A + B)$$

or —

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

If an enclosure is to be selected from a stock catalogue, 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, or to installing internal 'stirrer' fans with drive modules which have no fans of their own to ensure air-circulation.



4 Minimum clearances for air circulation — 100mm from the nearest adjacent equipment. Clearance for access, 3mm.

Enclosure ventilation

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

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

$$V = \frac{3.1 \times P_l}{T - T_{amb}}$$

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

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 = Maximum permissible operating temperature of the drive module in °C.

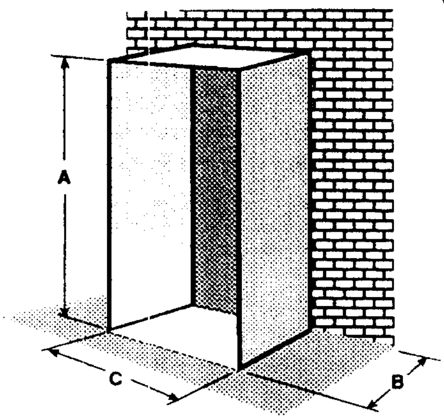
T_{amb} = Maximum external ambient temperature in °C.

The Motor

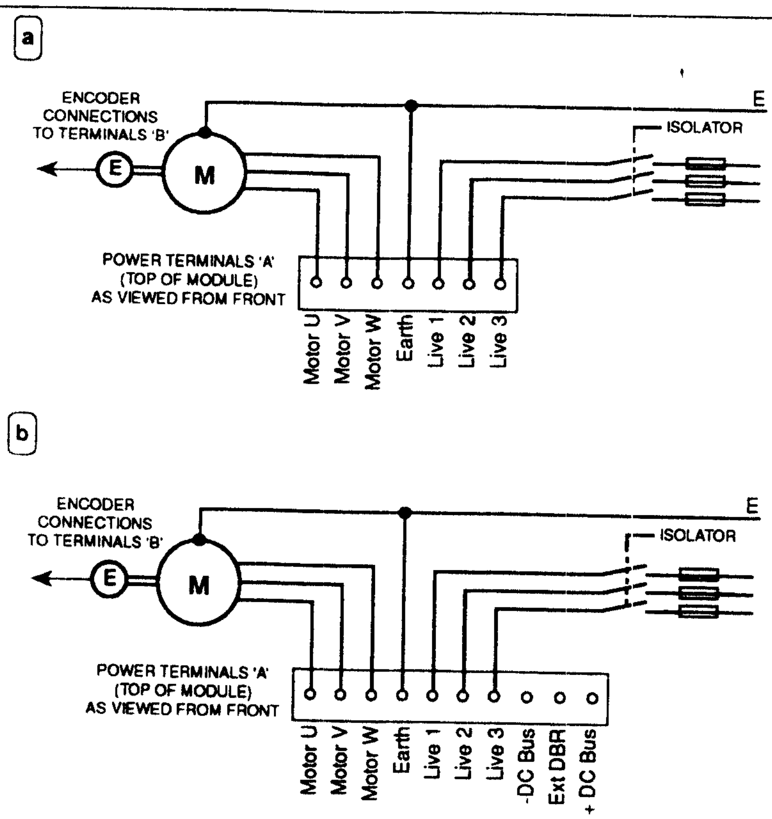
The *VECTOR* range of drives is capable of operating induction motors at speeds below the speed for which they are intended when driven from a fixed-frequency supply. Normally, the cooling of the motor is dependent on a shaft-mounted internal fan. This rapidly loses its effectiveness when operating at speeds below the normal near-synchronous speed of operation.

Designers intending to make full use of the benefits of variable speed control should give careful consideration to the possible need for supplementary cooling (by an external air supply, for example) if the application is one that requires periods of operation at reduced speed, or prolonged acceleration times at full torque.

Most manufacturers of standard induction motors are able to provide guidance, as is the supplier of *VECTOR* drives.



5 Enclosure with, typically, two surfaces unable to disperse heat.



6 Power connections at Connector 'A' for
(a) *VECTOR* modules VB75 to VB220 and
(b) modules VB400 to VB1100S.

4
Installation — Electrical

4.1 Introduction

SAFETY

The voltages present in the supply cables, the output cables and terminals, the externally-mounted DC link choke, the external 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 IP20. 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. (Please refer also to LOCATION, Chapter 3 Section 1.)

Earthing

The drive must be connected to the system earth by the earth terminal provided on the power terminal block, Fig. 6.

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

Control cable screens should be terminated to a 0V terminal, Connector B, *at the drive end only*, to minimise the possibility of interference.

4.2 Power Connections

Refer to Figs. 6 and 8.

The power terminals are located on the upper surface of the module. The terminals for the control circuits are on the front, protected by a removable cover. This arrangement enables the power cables to by run in from above the module and the control wiring from below, with the advantage that the two are well-separated, for the avoidance of interference with control signals. For cable sizes, refer to page 14.

Protection

The drive must be protected on the supply side either by hrc fuses (refer to 4.3 below and Fig.6) or by suitably-rated MCB or MCCB switches equipped with thermal and magnetic trips.

Power Circuit Earthing

Earth cable runs should be as short as possible. Earth loop impedance should be verified in accordance with the applicable approved code of practice and local regulations.

Screened cable may be used for the output cabling to the motor. Screening should be connected to earth at Connector 'A'.

4.3 Fuses and Power Cabling

Module type	**Recommended fuse ratings at 380V* A	*† Typical cable size* mm²
VB75	6	1.0
VB110	6	1.0
VB150	10	1.5
VB220	10	1.5
VB400	16	2.5
VB550	16	2.5
VB750	20	2.5
VB1100S	35	4.0

* As a current peak may appear at power-on because of the effect of the DC link capacitor, the use of 'slow' fuses is recommended. As an alternative to fuses, mcbs or mccbs may be used if equipped with adjustable thermal and magnetic trip devices of a suitable rating.

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

4.4 Guide to Line Choke Size

Installations with long cable runs to the motor may require the addition of line chokes (inductors) to prevent spurious overload tripping of the drive.

The table shows cable lengths above which chokes of 1mH or 2mH, rated according to motor size, may be typically required.

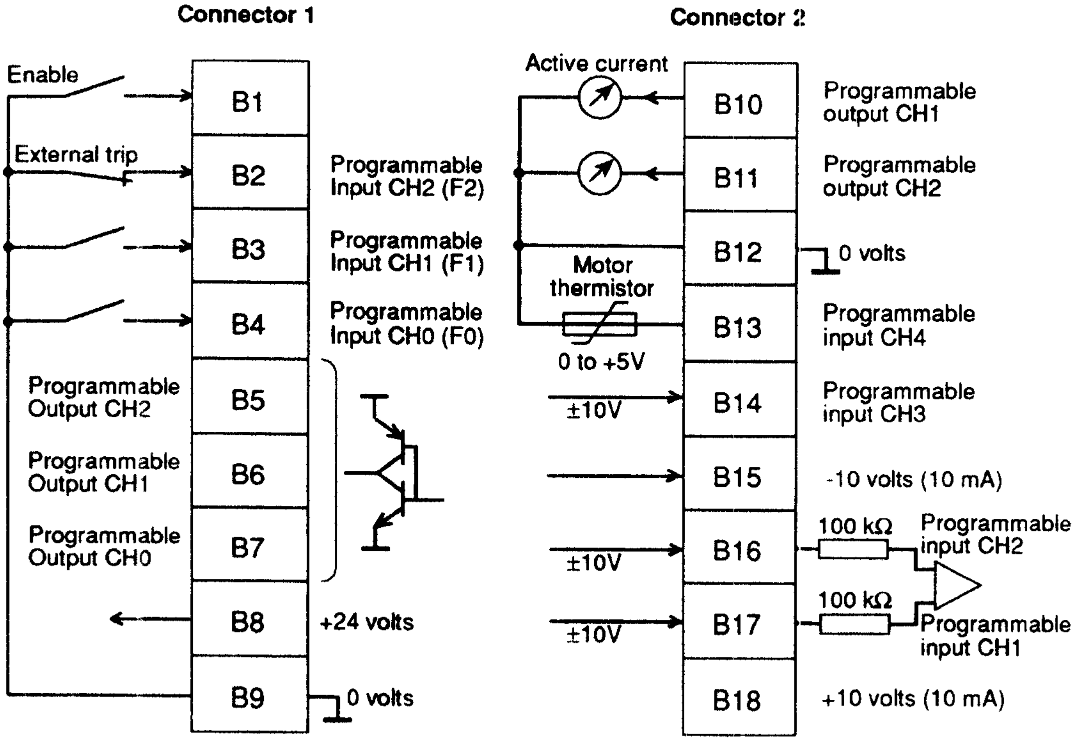
Module type	*Choke Value* *1mH* m	*2mH* m	*Current Rating* A
VB75	30	90	5
VB110	40	125	5
VB150	50	145	5
VB220	60	165	9
VB400	80	200	9
VB550	140	300	20
VB750	140	300	20
VB1100S	200	400	25

4.5 Control Connections

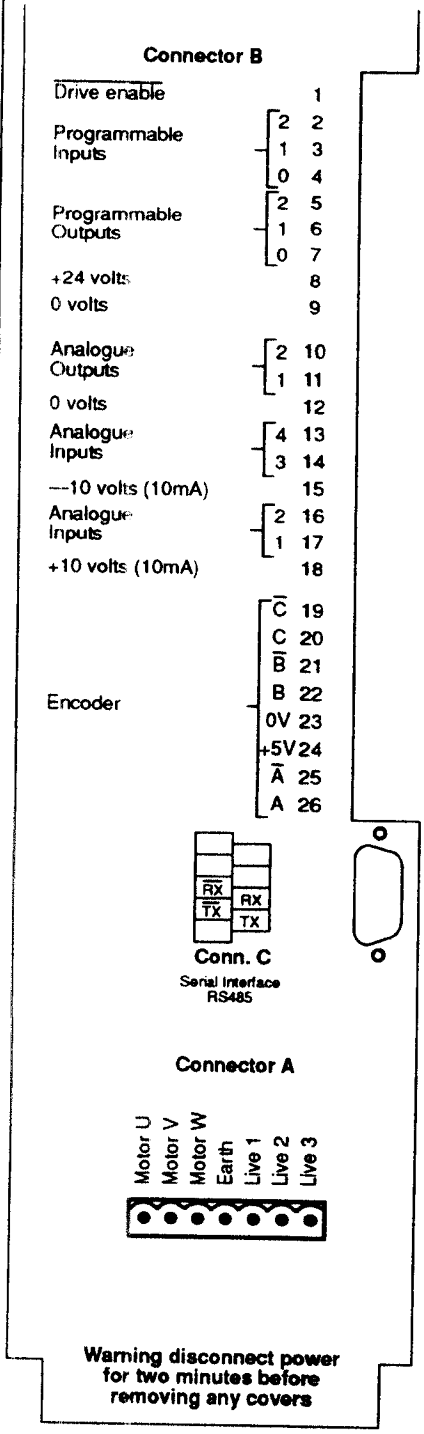
Refer to Figs. 7 and 8.

The control system wiring should be 0.5mm^2, screened overall. The screen should be connected to 0V at the drive end only. Control cables and encoder and digital reference cables should be segregated from the power cables. If they have to cross, they should do so at right-angles. Contactor, solenoid and brake coils should be fitted with RC suppressors or the equivalent. Please refer also to to Encoder Specification, page 8, and Electromagnetic Compatibility, Chapter 10.

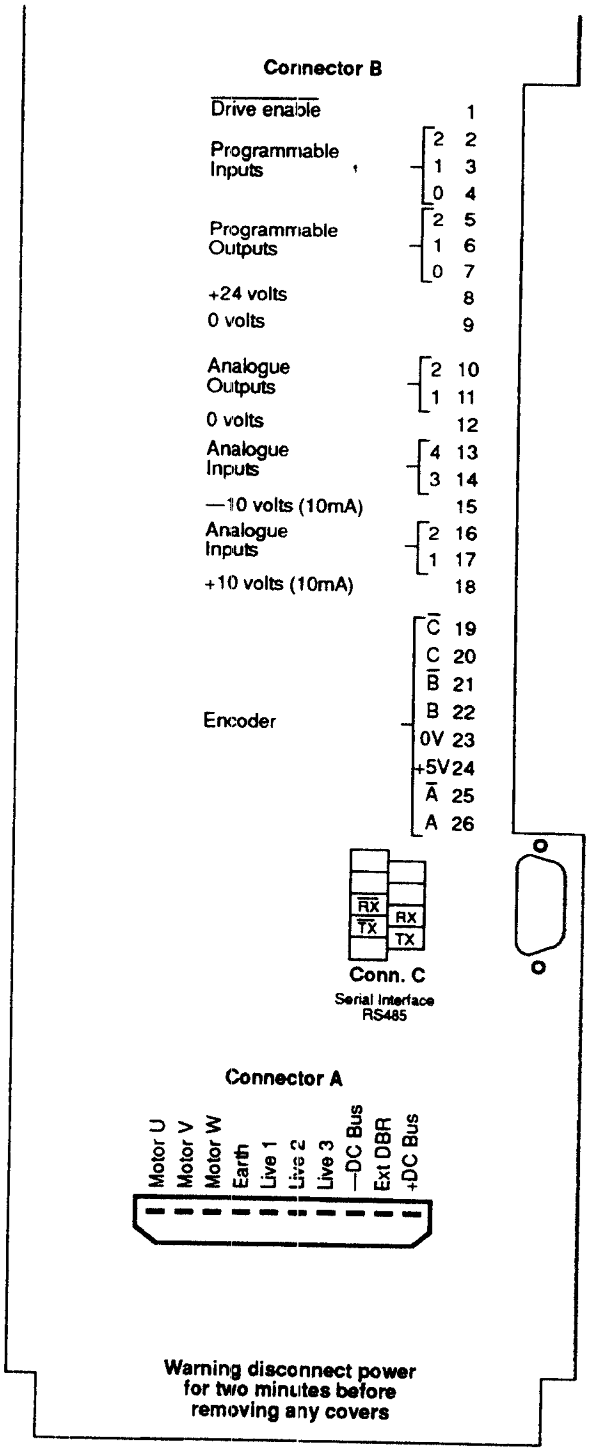
For the RS485 serial link, twisted-pair cables should be used. Serial link connections are illustrated in Figs. 14 and 15, page 52.



7 Control Terminals 'B', connectors 1 and 2.
Typical external connections, terminals B1 to B18.
Terminals B19 to B26 are Encoder connections.



Panel layout for modules...
VB75, VB110, VB150, VB220



Panel layout for modules...
VB400, VB550, VB750, VB1100S

8 Layout of Power Terminals 'A', Control Terminals 'B' and Communications Terminals 'C'. The power terminal block is located in the upper face of the drive module.

4.6 Terminals

Refer to Fig. 8.

Power Terminals Models VB75, VB110, VB150, VB220

No	Function	Type	Description
A1	Phase U	out	Output to motor
A2	Phase V	out	
A3	Phase W	out	
A4	Earth		Frame earth common
A5	Line 1 (R)	in	Power supply input
A6	Line 2 (S)	in	
A7	Line 3 (T)	in	

Power Terminals Models VB400, VB550, VB750, VB1100S

No	Function	Type	Description
A1	Phase U	out	Output to motor
A2	Phase V	out	
A3	Phase W	out	
A4	Earth		To system earth
A5	Line 1 (R)	in	Power supply input
A6	Line 2 (S)	in	
A7	Line 3 (T)	in	
A8	DC bus negative pole		
A9	External braking resistor		
A10	DC bus positive pole		

Control Terminals

No	Name & Function	Description
B1	ENABLE	0 to 24V at 1mA — Connect to 0V to RUN
B2	Programmable channel 2	INPUTS 0 to 24V at 1mA
B3	Programmable channel 1	
B4	Programmable channel 0	
B5	Programmable channel 2	OUTPUTS 0 to 24V at 1mA with 50mA sink and source capability
B6	Programmable channel 1	
B7	Programmable channel 0	
B8	24V 50mA	OUTPUT
B9	0V	
B10	Analog channel 2	OUTPUT channels 5mA maximum
B11	Analog channel 1	
B12	0V	
B13	Analog channel 4	INPUT, 10-bit resolution channels, 100kΩ impedance
B14	Analog channel 3	
B15	-10V 10mA	
B16	Analog channel 2	INPUT , 12-bit resolution channels, 100kΩ impedance
B17	Analog channel 1	
B18	+10V 10mA	

Encoder Terminals

No	Name	Description
B19	C	MARKER PULSE
B20	C̄	
B21	B	B CHANNEL
B22	B̄	
B23	0V	
B24	5V 200mA	
B25	A	A CHANNEL
B26	Ā	

Serial Link Terminals, RS485

Please refer also to Figs. 13 and 14 Chapter 8.

Connector C

1	0V
2	$\overline{TX}$
3	$\overline{RX}$
4	
5	
6	TX
7	RX

4.7 Braking Resistors

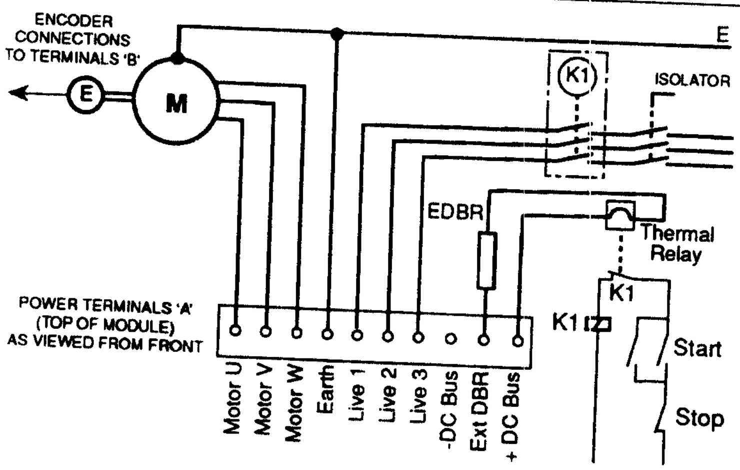
Module type	*Resistor size*	*Maximum regenerative power*
VB75 VB110 VB150	80Ω, 150W	1.5kW for 10s, continuous rating, with a minimum cooling time of 90s.
VB220 VB400 VB550 VB750 VB1100S	40Ω, 300W	3.0kW for 10s, continuous rating, with a minimum cooling time of 90s.

External Braking Resistor Connections

Refer to Fig. 9.

ON the larger *VECTOR* drives, (VB400, VB550, VB750 and VB1100S), provision is made to fit an external resistor of higher rating that the standard on-board resistor for increased dynamic braking performance. To protect the installation from the risk of damage it is essential that —

- The internal resistor is disconnected. For this it is essential to consult the supplier of the drive.
- The external resistor is fitted with a thermal protection relay, wired to trip the supply contactor.



9 A thermal trip relay wired to trip the drive supply circuit automatically is essential protection for an External Dynamic Braking Resistor (EDBR).

5
Operating Procedures

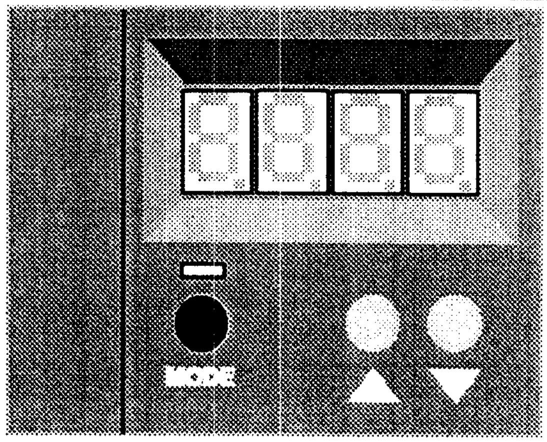
5.1 Keypad and Display

The Control Pod, Fig.10, 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 keys, which control the parameters in two modes —

selecting a parameter number (mode LED illuminated)

and

changing a parameter value (mode LED illuminated).



10 *VECTOR* keypad.

Motor start, stop and reverse operations can be directly controlled from the keypad, which holds all control parameters.

Parameter identity numbers or parameter values, as appropriate, are shown in the four-window display. The display indicates when a value is negative by a negative sign in a display window.

When parameters are not being read or changed, or after 8 seconds without a keystroke, the display defaults to the Present Indication. The following description of the method of manipulation of the parameters is illustrated by Fig. 11.

5.2 Manipulation of Parameters

Refer to Fig. 11

To SELECT a Parameter Number

The MODE key enables a parameter number to be selected. When the MODE key is pressed the green LED above the MODE key is illuminated and the **number** of the last parameter to have been read or changed is displayed. The parameter number alternates with its present **value**. If a keystroke is not made within 8 seconds, the display will default to the Normal Indication of the output of the drive, as shown in Fig. 11.

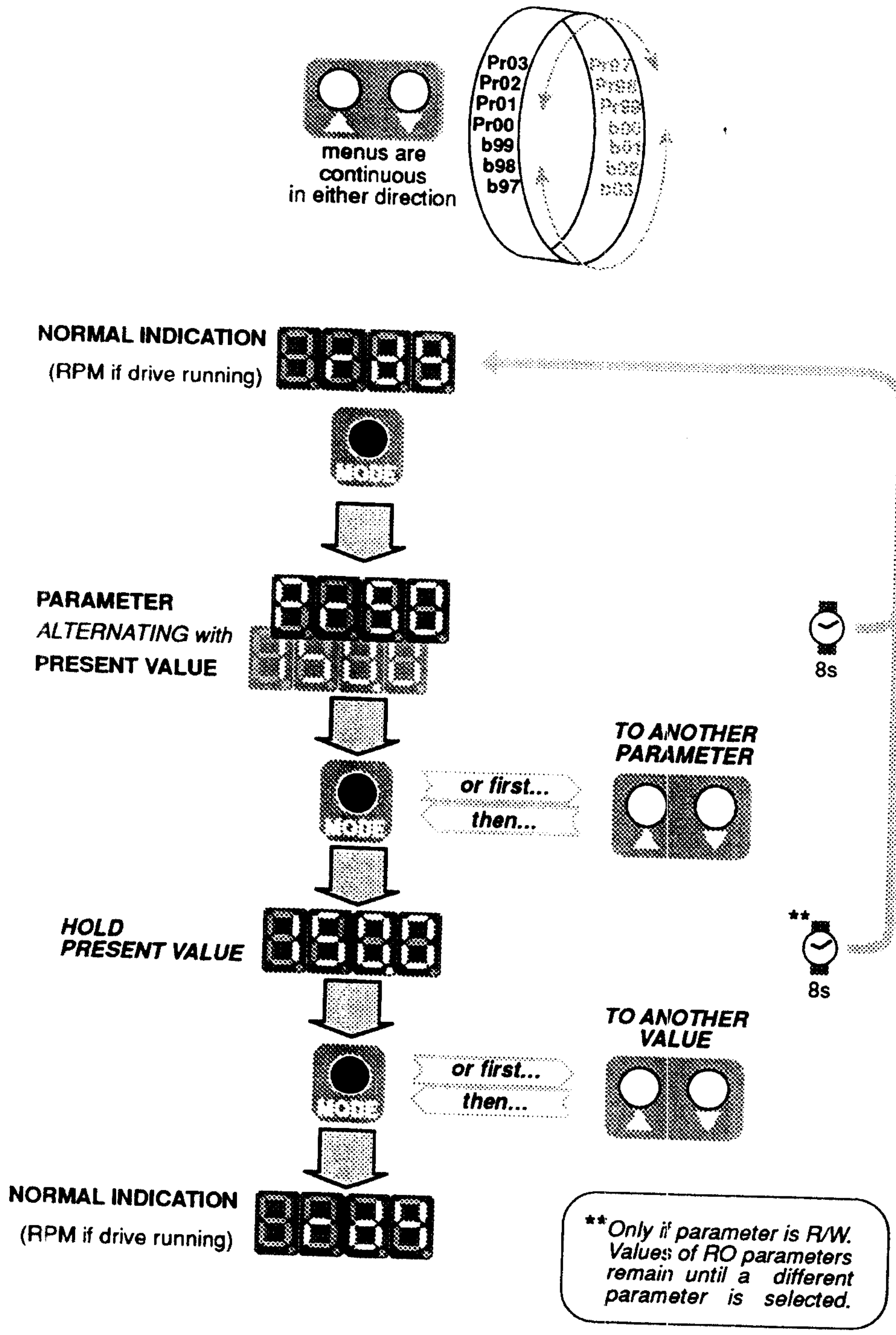
With the Mode LED illuminated, press the UP or the DOWN key once to **select** the NEXT parameter. To scroll through parameter numbers either press UP or DOWN repeatedly, or press and hold for fast scrolling.

If a further keystroke is not made within 8 seconds, the display will default to the Normal Indication. To return to the parameter previously selected, press MODE again.

The sequence of parameters is continuous, as shown in Fig. 11, to facilitate quick selection. For example, if the last parameter selected was **b80** and the next required is **Pr10**, is is not necessary to scroll all the way down though **b00**; scroll *up*, through **b99** and **Pr00**.

To READ a Parameter Value

Select a parameter as above. The display will show the number, alternating with the present value, of whichever parameter was last read or changed. (If a further keystroke is not made within 8 seconds, the display will default to Normal Indication.) If a different parameter is required, press UP or DOWN.



11 Parameter manipulation

To CHANGE a Parameter Value

Parameter values cannot be changed from the keypad if the drive is in the TRIP condition. The display must show either **rdY**, if the drive is stopped, or the present value of speed if it is running.
NOTE — If a Security Code has been assigned it is not possible to **change** any R/W parameter values until the correct code has been entered. Write the correct security code number and press MODE, then continue. (Any parameter can be **read** without need for the Security Code.) For the procedure for assigning and changing a Security Code, see below.

Select a parameter as above. When the required parameter is seen in the display, press MODE once. The display will hold the parameter value steady. If a further keystroke is not made within 8 seconds **and** if the parameter is read/write (R/W), the display will default to Present Indication.

Change the parameter value by pressing the UP or the DOWN key. A single keystroke changes the value by plus or minus one unit. Press either key repeatedly, or press and hold, to increase or decrease the parameter value to the maximum or minimum available.

For most parameters, a change of value acts immediately on the internal setting. For others, the drive must be powered-down and up again to give effect to a new value, or a Software Trip (**b01**) performed; these parameters are marked by the symbol » in the parameter descriptions starting at page 31, and in the Indexes of Parameters, pages 49 and 50.

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 **Pr13** is +0.1 to +8.0pu. The display will therefore show all values between 0.1 and 8.0 with a resolution of 0.1. The range of **Pr44** is +3.50 to +31.99 rad s^{-1}. The values displayed will therefore range from 3.50 to 31.99, with a resolution of 0.01.

Negative Values
Reducing a parameter value past zero makes it negative. A negative value is indicated by a negative sign '-' appearing in the window to the left of the value displayed. Any parameter which cannot possess a negative value will not reduce below zero.

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 or	**rdY** any selected R-O parameter value.
Healthy and running	Either or	speed in rpm (**Pr70**). any selected R-O parameter value.
Tripped	Trip Code(flashing), refer to Chapter 6 page 23.	

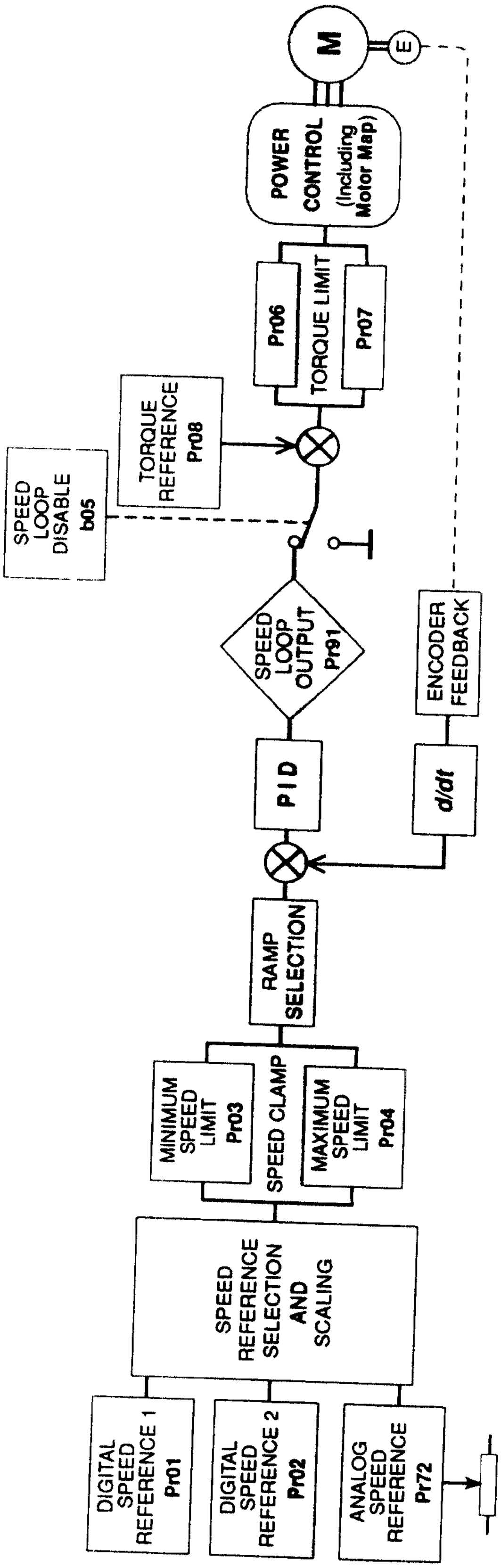
DISPLAY FLASHING

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

- The drive has tripped. A Trip Code is displayed.
- All unused decimal points flash to indicate when the drive output has entered the I x t overload region.
- During installation and commissioning a flashing display may indicate that the feedback encoder connections are incorrect relative to the direction of rotation of the motor.

5.3 Security Code

To assign or to change a code number, select **b21** and change to **b21** = 0. Press MODE. This permits access to write a code number. Select **Pr25**. Enter any number from 100 to 9999. Set **b26** = 0 to store (save) the code number.



12 System Control Overview

12 System Control Overview

6
Commissioning

6.1 Commissioning — Safety

Before proceeding with commissioning of the drive, the user MUST...

- ENSURE THAT mechanical installation is complete.
- ENSURE THAT electrical installation is complete.
- ENSURE THAT the motor is of the correct size and rating, and is securely fixed on its mountings.
- ENSURE THAT the feedback encoder connections are correct.
- ENSURE THAT the 'Drive Enable' control connection, terminal B1, is disconnected at this stage, Figs. 7 and 8, AND that the motor is **disconnected and isolated**.

6.2 The Motor Map

Before a *VECTOR* Drive can be used, values must be assigned to the five parameters of the Motor Map, **Pr41**, **Pr42**, **Pr43**, **Pr44** and **Pr45**. These are the parameters that programme the drive to know the fundamental characteristics of the motor it will operate. This information must be entered, and should be accurate to 10% or better, otherwise the power control will be inappropriate and the motor response may be affected adversely.

Motor full load current (FLC), **Pr41**, is obtained from the motor rating plate. It is the vector sum of the fixed magnetising current and the variable, torque-producing active current.

Motor magnetising current, **Pr42**, is the current drawn by the motor for excitation of the field. If the value entered is not correct, the motor will either be wastefully over-excited or, if under-excited, will be unable to produce full torque. The magnetising current value is best obtained from the manufacturer of the motor. Alternatively, it is possible to measure it directly if the motor can be mechanically disconnected and run at no load and at the voltage and frequency stated on the rating plate.

As a first estimate, the magnetising current can be derived from the motor power factor, cosϕ, using the formula —

$$I_m = I_{FLC} \times \sqrt{[1 - (\cos\phi)^2]}$$

where I_m = motor magnetising current

and I_{FLC} = motor full load current

Base frequency, **Pr43**, is the frequency at which full (rated) voltage is delivered to the motor. In a conventional installation without a variable speed drive this is the frequency of the supply for which the motor was designed.

Motor full load slip, **Pr44**, in radians per second, is calculated from the full-load speed and the no-load speed. It is recommended that the manufacturer of the motor should supply the figures, but measured values can be used if the measurements can be made with reasonable accuracy. The value of **Pr44** is calculated from —

$$\mathbf{Pr44} = 0.0525p\,(N_o - N_f)$$

where N_o = motor speed at no load
N_f = motor speed at full load
and p = number of poles

Number of motor poles, Pr45, allows for the operation of motors of two, four, six, and eight-pole construction. A default value, 4-pole, is installed in the software.

> *IMPORTANT NOTE*
> To implement (save) new or changed values written for parameters **Pr41**, **Pr42**, **Pr43**, **Pr44** and **Pr45**, set **b26** = 0.

EXAMPLE

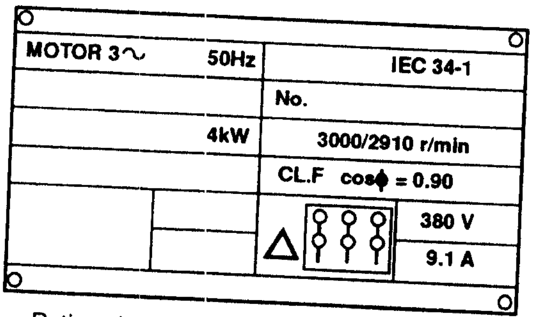
Calculation of values for the Motor Map

NOTE — ANY INTENDED EXTERNAL 'ENABLE' CONTROL CIRCUIT MUST BE DISCONNECTED FROM TERMINAL B1, Figs. 7 and 8.

Power the drive up. Set Keypad Display Mode Selector **Pr49** = 1 to enable the Motor Map parameters to be displayed and accessed.

For this example, the following are assumed to be the operational data —

- Power supply 415V
- Motor data as shown in the typical rating plate below



Rating plate (typical) showing essential data for the Motor Map.

Pr41 **Motor Full Load Current**

From rating plate, 380V delta connection, FLC = 9.1A

Scroll to 9.1

Pr42 **Motor Magnetising Current**

Using the formula —

$$I_m = I_{FLC} \times \sqrt{[1 - (\cos\phi)^2]}$$
$$I_{FLC} = 9.1A$$
$$I_m = 9.1 \times \sqrt{[1 - (0.90)^2]}$$
$$= 9.1 \times 0.4395$$
$$= 4.0A$$

Scroll to 4.0

Pr43 **Motor Base Frequency**

The drive is to be supplied at 415V, but the motor is rated 380V. To avoid over-fluxing the motor the V/f ratio must be adjusted to compensate.

$$\mathbf{Pr43} = \frac{\text{Supply Voltage}}{\text{Motor Voltage}} \times \text{Motor Base Frequency}$$

$$= \frac{415}{380} \times 50$$

$$= 54.6\text{Hz}$$

Scroll to 54.6

Pr44 **Motor Full Load Slip**

The slip frequency is given by —

$N_s = N_o - N_f$

where N_o = base speed

and N_f = full load speed

From the motor rating plate, N_o = 3000rpm, N_f = 2910rpm, so that

N_s = 90rpm

The value must be entered in radians per second. Using the expression—

Pr44 = $0.0525 . p . N_s$

Pr44 = 0.0525 x 2 x 90

= 9.45 rad s^{-1}

Scroll to 9.45

Pr45 **Number of Motor Poles**

Typically —	2-pole machines run at	3000rpm 50Hz	3600rpm 60Hz
	4-pole machines run at	1500rpm 50Hz	1800rpm 60Hz
	6-pole machines run at	1000rpm 50Hz	1200rpm 60Hz
	8-pole machines run at	750rpm 50Hz	900rpm 60Hz

Scroll to 2 (for this example)

SAVE and implement the Motor Map parameters entered by setting **b26** = 0.

This completes the Motor Map settings. The further procedures required are —

- To verify the encoder connections
- To verify the direction of rotation of the motor shaft

VERIFICATION PROCEDURES

To CHECK the encoder connections —

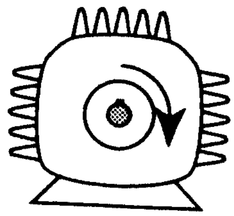
- ENSURE that the 'enable' circuit is disconnected at terminal B1 **AND** that the motor terminals are **disconnected and isolated** so that there is no possibility that the drive can turn the motor.
- Power-on the drive.
- *Slowly* rotate the motor shaft *clockwise* by hand and watch for a positive count on the display.
- *If the display reads negative,* exchange the leads to terminals B22 and B26, and also exchange leads B25 and B21. Rotate the motor shaft again to prove a positive reading.
- *If there is a null display,* suspect lack of encoder power. Check across terminals B23 AND B24; there should be a +5V reading.
- *Before proceeding,* power-off the drive and ISOLATE THE POWER SUPPLY (in accordance with any specified safety procedures as appropriate).
- WAIT TWO MINUTES to ensure that capacitive circuits are discharged.

To CHECK the direction of rotation of the motor —

- ENSURE that there is no risk of injury or damage when the motor shaft rotates.
- Reconnect the motor cables from the drive, observing safety procedures.
- Connect the 'enable' circuit at terminal B1.

conyinurd...

- Power-on the drive.
- Set **b22** = 0. This enables the drive to run an *unloaded* motor without encoder feedback.
- If the motor speed is too great for accurate observation, set **Pr01** to a low value, eg 10rpm, temporarily.
- The direction of rotation should be *clockwise* as viewed from the drive end of the motor. If incorrect, power-off the drive and ISOLATE THE POWER SUPPLY (in accordance with any specified safety procedures as appropriate).



Front view (at drive shaft end) clockwise rotation.

- WAIT TWO MINUTES to ensure that capacitive circuits are discharged.
- Exchange any two motor phase connections.
- Set **b22** = 1.

TEST RUN

The drive is now ready to be test-run at 100rpm (default speed reference).

Make the following parameter settings —

b02 = 0 — drive enable
Pr06 = 50 — torque limit, motoring
Pr07 = 50 — torque limit, regenerating

Also, connect the external 'Drive Enable' circuit to terminal B1 (refer to Figs. 7 and 8).

The motor should now run at 100rpm in clockwise rotation.

If the motor does not turn, or turns at a very slow speed, then either—

the motor phase connections are incorrect
or —
the encoder A and B connections are incorrect.

The final preparation is to set other drive parameters as appropriate to the application and duty of the motor and drive. Note that **Pr49, Keypad** Display Mode, is at present set to 1; it may be necessary or convenient to choose a different setting.

A number of parameters may now be monitored, for example —

Speed reference	**Pr01**
Motor speed	**Pr70**
Line Current	**Pr82**
Active current	**Pr75**
etc...	

The user may also wish to try the effect of adjusting certain parameters, for example —

Acceleration Rates	**Pr09, Pr10**
Deceleration Rates	**Pr11, Pr12**
Torque Limits	**Pr06, Pr07**

By setting **b07** = 0, the drive speed can be controlled by the analog speed reference potentiometer.

The remaining procedures are, if necessary, the fine tuning of the functioning of the motor and its driven load, by adjustment of the PID parameters of the *VECTOR*. The procedures are explained on the following pages.

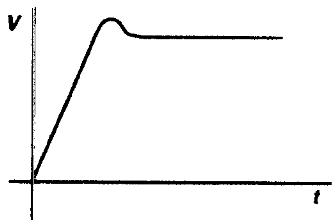
6.3 Fine Tuning

The *VECTOR* drive employs a forward-compensation speed loop. The response of the speed loop can therefore be optimised to a high degree. To achieve this, the user has control of proportional, integral and derivative (PID) shaping of the speed loop output.

PID Parameters

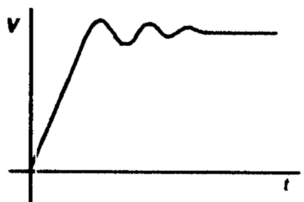
The characteristics and effects of these three gains is summarised as follows —

Proportional Gain The greater the value of the proportional gain, the smaller will be the instantaneous speed error (overshoot) in response to a step change of load. (This, however, shows poor derivative effect.)



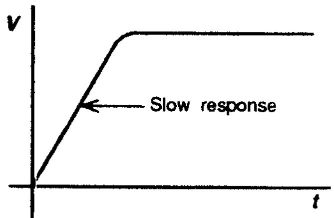
Overshoot.

Integral Gain The greater the value, the quicker the speed recovers from the effect of a step change of load, and is necessary to eliminate speed-following error. Will tend to cause instability if set too high.



Instability.

Derivative Gain This gain can, in some circumstances, reduce speed response overshoot at the expense of smoothness of operation. Excessively high values result in over-damping and sluggish response.



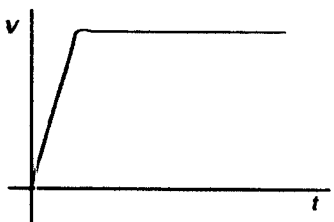
Derivative gain high.

In general, the higher the *inertia* of the system (motor and load combined), the greater are the levels of proportional and integral gain required. The default values assigned to these parameters (**Pr13** = 3, **Pr14** = 2) relate to an unloaded motor. Doubling the inertia of the system would require the values of the P and I parameters to be doubled.

Stability A system is inherently more stable with lower values of integral gain.

With systems of low inertia, too high an integral gain will result in high-frequency instability. This can be corrected by reducing the I-term.

With high-inertia systems, a high integral gain can result in low-frequency high-amplitude oscillation, which can only be corrected by reducing the I-term or increasing the P-term.



Ideal response.

The response of the drive to step changes can be monitored via the speed output on analog output Channel 1, terminal B11. This facilitates the adjustment of the PID parameters to achieve the ideal response, with minimum overshoot and quickness of response together with stability.

The benefits of the PID gains cannot be fully realised if the mechanical installation of the motor and its load allows any free movement between the two. It is important that couplings should not be slack, and than any provisions for preventing relative motion, such as tensioners, should be properly adjusted and maintained.

6.4 Protection

The *VECTOR* drive software incorporates protection logic to inhibit output in the event of —

- Motor and cable short circuit or earth fault
- Motor over-temperature
- IGBT stack or heatsink over-temperature
- DC bus over-voltage
- Supply under-voltage
- Loss of one phase of the supply

Any fault that causes the drive to trip produces a signal to indicate the cause. Refer to the information under Diagnostics.

Automatic protection requires two parameters to be set by the user — **Pr41** and **Pr55**.

Pr41 Motor full load current (FLC). Enter the appropriate value from the motor rating plate. The software logic limits the drive output current to 150% of FLC.

Pr55 Peak current time limit. This provides an overload trip integrating overload with time. The value is adjustable between zero and 60 seconds. What value is chosen will depend mainly on the application and the type of load being driven. The choice may also be affected by the characteristics of the motor.

Over-temperature protection of the motor requires a hard-wired input from a motor thermistor to terminal B13. Also, parameter **b16** must be set to 1. The voltage of the thermistor output is read by parameter **Pr88**. If the voltage exceeds 2.0V, the drive trip operates.

6.5 Diagnostics — Fault Finding

SAFETY FIRST
Electric Shock Risk
Work on the drive and associated equipment and wiring should be undertaken only by suitably-qualified competent personnel. If the protective cover of the drive is to be removed, or if any external terminals are to be worked on, it is essential to WAIT TWO MINUTES after the drive has been disconnected at the main supply switchgear, to allow internal devices to discharge.

FAULT CHARACTERISTIC — *ACTION*

Display does not illuminate and drive does not run.

Check that Control Pod is connected.

Check mains supply, fuses, circuit breaker.

NOTE — If blown fuses blow again, or breaker trips again, contact the supplier of the drive.

Check control fuses.

Display shows* rdY*, motor does not start.

Drive is not enabled. Check **b02** , **b15** , and terminal B1.

Display shows* 0*, motor does not start.

Incorrect encoder or motor phase connections.
Check wiring of speed reference.
Check that **b02** = 0
Check the control wiring.

continued...

FAULT CHARACTERISTIC — *ACTION*

Display shows Trip Code.

Refer to Trip Codes for cause.

NOTES —

- Thermal trip devices should never be continually tripped and reset.
- **OC** trip can be caused by cable or motor insulation faults.
- **OU** trips may be caused by decelerating too rapidly. Increase the value of the decelerating parameters **Pr11** or **Pr12** as appropriate or decrease the value of **Pr07**.
- If **Err...** trip is displayed, try disconnecting the drive from the supply, wait 2 minutes, reconnect and run the drive. If the fault persists, consult the supplier of the drive.

Drive does not respond to serial communications.

Check —

Serial link parity enable **b18**
Serial link BCC enable **b19**
Serial link address **Pr22**
Baud rate **Pr23**

Check the wiring and terminations of the serial link cabling.

If after performing any of the above actions the drive still malfunctions, consult the supplier of the drive for assistance.

GENERAL NOTES

- Any trip, internal or external, immediately inhibits the drive power output bridge. The motor coasts to rest.
- Internal protection trips are always active and cannot be disabled.

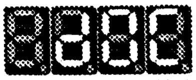
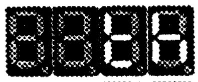
6.6 Healthy Indications

Motor stopped, drive energised, ready to run on command.

Numerical value on display —
Motor running speed, in rpm.

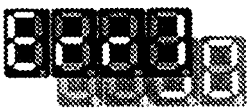
6.7 Trip Codes

- *Any trip, internal or external, immediately inhibits the drive power output bridge. The motor coasts to rest.*
- *Internal protection trips are always active and cannot be disabled (except* **th trip,** *by* **b16***).*
- *An external trip* **Et** *can be applied at terminal* CON2-10.

	**dOC**	**b81**	DC overcurrent trip caused by excess current flowing in the inverter bridge.
	**Et**	**b87**	External trip has been applied at terminal B2 or by **b10**.
	*Unused decimals flashing*		Ixt alarm, time-dependent overload. Drive has entered the Ixt region, leading to a trip if the load is not reduced.
	**It**	**b86**	Integrating overload (Ixt) trip. The output current as defined by **Pr41** and **Pr55** has reached the allowable limit.
	**OC**	**b80**	Instantaneous overcurrent trip. Excess current flowing in the IGBT inverter bridge, caused by short-circuit or low-impedance earth fault.
	**Oh**	**b85**	Heat sink over-temperature. The heat sink has reached its upper safe working limit due to loss of ambient air or ambient air too hot.
	**OU**	**b82**	DC bus over-voltage. Caused by mains supply overvoltage (even if momentary), or high-impedance earth fault, or excessive regeneration due to a high rate of deceleration, or insufficient braking resistance.
	**St**	**b88**	Software trip.
	**th**	**b84**	Motor thermistor (if fitted and connected) impedance high due to sensing excess temperature.
	**UU**	**b83**	Under-voltage caused by loss of mains supply or low mains supply voltage (even if momentary).

6.8 Error Codes

NOTE! Err... *trips may require expert attention. Please consult the supplier of the drive.*



Err... Alternating with error code number (**b90**)

b90 **Err** codes indicate a hardware fault within the drive. Occurs only at power-up. Is a lockout condition — refer to Note 4 below.

Error Codes

Err	**1**	RAM check failure at power-on
Err	**2**	NVRAM data parity failure at power-on
Err	**3**	NVRAM data save timeout error
Err	**4**	MD21 DPRAM check failure at power-on
Err	**5**	Reference encoder input frequency overflow
Err	**6**	CPU to drive EPROM software mismatch
Err	**7**	4-20mA mode set-up failure
Err	**8**	Overspeed trip

NOTES

1 **In the event of an Err 2 or Err 3 trip, the Drive parameters** (Motor Map, page 23) **should be checked and re-stored before running.**

2 **Err** 5 trip will occur if reference encoder input frequency >100kHz.

3 **Err 8** is caused by motor shaft speed overshoot, in excess of the value of **Pr35** above the limits set by **Pr03** and **Pr04**. Systems experiencing this fault should either remove the cause of the excess overshoot or increase the value of **Pr03** and/or **Pr04**, or more than 10 rpm in the opposite direction if both **Pr03** and **Pr04** are in the same direction.

4 **Err** codes are normally reset by disconnecting and reconnecting the power supply. If this is not successful, disconnect the supply, depress simultaneously the UP and DOWN keys at the keypad, and reconnect whilst holding the UP and DOWN keys.

7
Parameters

7.1 Parameters, Values and Functions

In the *VECTOR* digital drive, **parameters** take the place of the adjustable potentiometers and the movable links of an analog drive. Parameters are of two basic classes; some are adjustable over a range of **real** numerical values and correspond to a potentiometer. These are distinguished by the initial letters **Pr** before the parameter number, eg **Pr12**. The other class is the **bit** parameter, corresponding to adjustable links. Bit parameters are distinguished by the initial letter **b** before the number, eg **b21**.

Real parameter values range from -9999 to +9999 with a floating decimal point, eg 1.25, 12.5, 125 or 1250. The decimal is dependent on parameter resolution.

Bit Values

Bit values are 0 or 1. Bit parameters represent status variables, which adopt one of two possible states — for example, enabled or disabled, on or off, forward or reverse, etc.

Both classes of parameter also belong in one of two other sub-classes—

Read-Only (R-O)
These are the parameters which are set by the drive logic. The operator can monitor R-O parameters by means of the keypad and display or the serial communications link to verify status, but cannot make any adjustment to them.

Read-Write (R/W)
Read-write parameters are those which the operator can set by by keypad entry or through the serial link; they can also be set by background programme execution — by a process controller for example. Their purpose is to optimise the *VECTOR* drive performance for a given application. Like R-O parameters, R/W parameters can be monitored by means of the keypad and display or through the serial link to verify performance, but unlike R-O parameters they can be adjusted.

Default Values of Parameters
Most R/W parameters have 'default' values, set during manufacture. New R/W parameter values selected during operation are stored in the non-volatile memory. Whatever values are last assigned to them remain after power-down, but the values assigned during manufacture can be recalled by parameter **b10**. Exceptionally, the four parameters of the Motor Map have no default value. Values assigned to the Motor Map parameters remain unless changed by the operator.

Access and Security

Parameters and their values are accessible through the keypad. The software is equipped with a Security Code (for the user to write as required) which, unless entered first, prevents access to parameters for the purpose of writing. All parameters can be read without use of the Security Code. The procedure for assigning and changing the Security Code are on page 21.

Additionally, parameters can be accessed, read, and changed by signals through a serial communications link from a host computer, a terminal, a process controller, or other communicating device.

7.2 Numerical Parameters — R/W

- When the MODE key is pressed, the display will show the number of the parameter last read or changed.
- Parameters are listed in the sequence in which they appear in the Keypad Display when the UP key is operated.
- The symbol » beside a parameter number, eg **Pr05»** indicates that the drive must be reset by setting **b26** = 0 to make a change of value effective. All other R/W parameter values become effective as soon as they are changed.

Pr00 Null Parameter

Used as a destination for programmable analog inputs. Always reads 00.

Pr01 Speed Reference 1

Digital speed reference 1, forward or reverse. Functional when drive is enabled. Motor speed may be limited by Minimum and Maximum Speed Limits **Pr03** and **Pr04**.

Type R/W, real values
Units Revolutions per minute (rpm)
Range +6000rpm to -6000rpm
Default +100rpm

Related parameters
Pr02 Pr03 Pr04 b06

Pr02 Speed Reference 2

Digital speed reference 2, forward or reverse. Functional when drive is enabled. Motor speed may be limited by Minimum and Maximum Speed Limits **Pr03** and **Pr04.**

Type R/W, real values
Units Revolutions per minute (rpm)
Range +6000rpm to -6000rpm
Default +100rpm

Related parameters
Pr01 Pr03 Pr04 b06

Pr03 Minimum Speed Limit

Sets the lower limit of speed. If **Pr03** is given a positive value, the drive will operate the motor at speeds between **Pr03** and **Pr04** in the forward direction only. If **Pr03** is given a negative value, the value becomes the maximum speed in reverse. Also sets a lower base level for the overspeed trip, **Pr35.**
Limitation: **Pr03** < **Pr04.**

Type R/W, real values
Units Revolutions per minute (rpm)
Range +6000rpm to -6000rpm
Default -1500 rpm

Related parameters
Pr01 Pr04

Pr04 Maximum Speed Limit

Sets a maximum above which the speed references are not effective. Also sets a higher base level for the overspeed trip, **Pr35.**
Limitation: **Pr04** > **Pr03**

Type R/W, real values
Units Revolutions per minute (rpm)
Range -6000rpm to +6000rpm
Default +1500 rpm

Related parameters
Pr00 Pr01 Pr03

Pr05» Analog Speed Reference Filter — Determines the response time of the analog input.

Type R/W, real values
Units Milliseconds (ms)
Range

Select one of 6 values*	(ms)	2	4	8	16	32	64	128
Programming code number		0	1	2	3	4	5	6

Default 8ms
Resolution 2.44mV

* Values as utilised at the keypad.

When selecting a value of **Pr05** through the Serial Link, send 0, 1, 2, 3, 4, or 5, where 0 = 2ms, 1 = 4ms ... 5 = 128ms.

When reading parameters through the Serial Link, values are shown in ms.

Pr06 Torque Limit: Motoring — Determines maximum available torque when the drive is operating in the motoring mode.

Type R/W, real values
Units % of full load torque (FLT)
Range 1% to 150%FLT
Default 150%FLT
Resolution 0.5% steps

Pr07 Torque Limit: Regenerating — Determines maximum available torque when the drive is operating in the generating mode.

Type R/W, real values
Units % of full load torque (FLT)
Range 1% to 150%FLT
Default 150%FLT
Resolution 0.5% steps

Pr08 Internal Torque Reference — Sets a digital value for torque reference, or torque feed forward.

Type R/W, real values
Units % of full load torque (FLT)
Range +150% to -150%FLT
Default Zero

Related parameters
b04 b05 Pr06 Pr07

Pr09 Forward Acceleration Rate — Sets the rate at which the drive accelerates the motor in a forward direction, and is in effect an acceleration ramp.

Type R/W, real values
Units milliseconds per revolution per minute
Range +0.01 to +99.99ms $(rpm)^{-1}$
Default 1.0ms rpm^{-1}

Related parameters
Pr10 Pr11 Pr12

Pr10 Reverse Acceleration Rate — Sets the rate at which the drive accelerates the motor in the reverse direction, and is in effect an acceleration ramp.

Type R/W, real values
Units milliseconds per revolution per minute
Range +0.01 to +99.99ms $(rpm)^{-1}$
Default 1.0ms rpm^{-1}

Related parameters
Pr09 Pr11 Pr12

Pr11 Forward Deceleration Rate — Sets the rate at which the drive decelerates the motor in a forward direction, and is in effect a deceleration ramp.

Type R/W, real values
Units milliseconds per revolution per minute
Range +0.01 to +99.99ms $(rpm)^{-1}$
Default 1.0ms rpm^{-1}

Related parameters
Pr09 Pr10 Pr12

Pr12 Reverse Deceleration Rate

Sets the rate at which the drive decelerates the motor in the reverse direction, and is in effect a deceleration ramp.

Type R/W, real values
Units milliseconds per revolution per minute
Range +0.01 to +99.99ms $(rpm)^{-1}$
Default 1.0ms rpm^{-1}

Related parameters
Pr09 Pr10 Pr11

Pr13 Speed Loop Proportional Gain

Sets the value of the proportional gain compensation. The greater the proportional term, the smaller will be the instantaneous speed error in response to a step change of load. If set too high, **Pr13** will cause the speed to overshoot and oscillate.

Type R/W, real values
Units per unit (pu)
Range 0.1 to 8.0pu
Default 3pu

Related parameters
Pr14 Pr15

Pr14 Speed Loop Integral Gain

Sets the value of the integral gain compensation. The greater the integral term, the quicker the speed recovers from a step-change of load. **Pr14** provides 'stiffness' in the system. If set too high, **Pr14** will cause instability in the speed response.

Type R/W, real values
Units per unit (pu)
Range 0.0 to 8.0pu
Default 2pu

Related parameters
Pr13 Pr15

Pr15 Speed Loop Derivative Gain

Sets the value of the derivative (differential) gain compensation. The derivative term can reduce the speed-response overshoot in some circumstances. If set too high, **Pr14** will cause instability in the speed response.

Type R/W, real values
Units per unit (pu)
Range 0.0 to 8.0pu
Default zero

Related parameters
Pr13 Pr14

Pr16 Hard Speed Reference

A digital speed reference added to the the post-ramp speed reference before subtraction of the speed (encoder) feedback. Disabled when the drive receives a 'Stop' command.

NOTE! **Pr16** is applied after the speed limits (**Pr03**, **Pr04**) and after the ramps (**Pr09** — **Pr12**) and should be used with care.

Type R/W, real values
Units revolutions per minute (rpm)
Range -250.00rpm to +250.00 rpm
Default zero
Resolution 0.25 rpm (actual; displays 0.1 rpm)

Related parameter
b11 (Bypasses **Pr16**)

Pr17 Scaling of Analog Speed Input

Type R/W, real values
Units revolutions per volt (rpm V^{-1})
Range -600.0 to +600.0 rpm V^{-1}
Default +150.0

Related parameters
Pr18 Pr72 Pr84

Pr18 Speed Reference Offset

Reference offset added to the scaled analog speed input **Pr17**.

NOTE A 2-volt offset applied to a full 10-volt input reference may cause **Err5** overflow tripping.

Type R/W, real values
Units Volts
Range -10.0 to +10.0V
Default zero

Related parameters
Pr17 Pr72 Pr84

Pr19 Scaling of Analog Input Channel 3, Terminal B14

Type R/W, real values
Range -999.9 to +999.9
Default 0

Related parameters
Pr20 Pr21 Pr74 Pr86

Pr20 Offset of Analog Input Channel 3, Terminal B14

Type R/W, real values
Units unitary
Range -10.0 to +10.0V
Default 0

Related parameters
Pr19 Pr21 Pr74 Pr86

Pr21» Destination of Analog Input Channel 3

Selects which parameter is controlled by Channel 3 input at Terminal B14.

Type R/W, real values
Range All parameters from **Pr00** through to **Pr69**
Default **Pr00**

Pr22 Serial Link — Address

Defines the unique address of the drive.

Type R/W, real values
Range 00 to 32
Default 01

Pr23» Serial Link — Baud Rate

Permits the drive Baud rate to be set to correspond with that of the communicating device.

When READING, the actual value of the Baud rate is displayed.

When WRITING, integers 0 to 6 represent Baud rates as below —

Type R/W, real values
Range

Select one of 7 values (Baud)	300	600	1200	2400	4800	9600	19.2k
Programming code number	0	1	2	3	4	5	6

Default 9600Baud

Pr24 Factory-set Security Key

For factory test use only

Pr25 Security Code

When a Security Code has been applied (refer to page 21) to a drive, R/W parameters cannot be changed unless the correct code is entered, but all parameters can be read without hindrance. Drives can be given unique codes.

Type R/W, integer values
Range 100 to 9999
Default zero

Related parameters
b21

Pr26» Destination of Logic Input Channel 0 — Selects which bit parameter is controlled by logic input Channel 0, Terminal B4.

Type R/W, real values
Range All parameters from **b00** through to **b63**
Default **b05**

Pr27» Destination of Logic Input Channel 1 — Selects which bit parameter is controlled by logic input Channel 1, Terminal B3.

Type R/W, real values
Range All parameters from **b00** through to **b63**
Default **b00**

Pr28» Programmable Output F2 Source — Selects which bit parameter controls the state of logic output Channel 0, Terminal B7.

Type R/W, real values
Range 00 to 99
Default **b72** (at zero speed)

Pr29» Programmable Output F1 Source — Selects which bit parameter controls the state of logic output Channel 1, Terminal B6.

Type R/W, real values
Range 00 to 99
Default **b73** (at speed)

Pr30 Offset of Analog Input Channel 2 — Reference offset added to the scaled analog input Channel 2, Terminal B16.

Type R/W, real values
Range -10.0V to +10.0V
Default 0.0V

Related parameters
Pr31 Pr32 Pr87 Pr90

Pr31 Scaling of Analog Input Channel 2 (Terminal B16)

Type R/W, real values
Range -999.9 to +999.9
Default 0.0

Related parameters
Pr30 Pr32 Pr87 Pr90

Pr32» Destination of Analog Input Channel 2 — Selects which parameter is controlled by analog input Channel 2, Terminal B16.

Type R/W, real values
Range All parameters from **Pr00** to **Pr63**
Default **Pr00**

Related parameters
Pr30 Pr31 Pr87 Pr90

Pr33» Programmable Output F2 Source — Selects which bit parameter controls the state of logic output Channel 2, Terminal B5.

Type R/W, real values
Range 00 to 99
Default **b64** (drive healthy)

Pr34 Torque Output Scaling (Terminal B10) — Provides a means to attain a full-scale (10V) output at Terminal 10 to agree with a required value of Active Current (**Pr75**).

Type R/W, real values
Range 0 to 600
Default 150

Related parameter
Pr75

Pr35 Overspeed Trip Threshold

Sets the threshold of the Overspeed Trip (**Err8**). Expressed in rpm above speed limits **Pr03** and **Pr04**.

NOTE! If **Pr03** and **Pr04** are set in the *same direction*, the threshold is 10 rpmin the opposite direction. Refer also to **Pr03** page 32, and Note 3 page 30.

Type R/W, real values
Range 0 to 600
Default 150

Pr36» Programmable Logic Input F2. Destination

Defines the parameter to which the F2 logic input is destined.

NOTE! As standard, logic input F2 default to **Et**. To enable F2 to be directed to a parameter, and to disable the default **Et**, links LK27 and LK28 must be moved to the right, *ie* towards the terminal block.

Type R/W, real values
Range 0 to 63
Default 0 (default action is **Et** trip)

Pr37 through to **Pr39** *Reserved for* MD21 *Applications*

Pr40 Drive Model *Adjusted during manufacture, and not adjustable thereafter.*

Type Preset

Pr41» Motor Full Load Current (FLC)

Rated FLC of the driven motor must be entered before the drive is operated. The available range of values is dependent on the drive model.

Type R/W, real values
Units Amps
Range

VB75	1.5A to 2.1A	VB400	3.8A to 9.5A
VB110	1.5A to 2.8A	VB550	5.6A to 12A
VB150	2.1A to 3.8A	VB750	9.5A to 16A
VB220	2.8A to 5.6A	VB1100S	12A to 22A

Default Parameter **b10** 'Reset to Default' DOES NOT AFFECT **Pr41**

Pr42» Motor Magnetising Current

The value should preferably be obtained from the manufacturer of the motor. Alternatively, it can be measured by operating the motor without load and at rated frequency and voltage.

Type R/W, real values
Units Amps
Range 25% to 85% of Full Load Current setting
Default Parameter **b10** 'Reset to Default' DOES NOT AFFECT **Pr42**

Pr43» Motor Base Frequency

Motor base frequency is the output frequency at which the drive delivers the (motor) rated operating voltage.

Type R/W, real values
Units Hz
Default Parameter **b10** 'Reset to Default' DOES NOT AFFECT **Pr43**

Pr44» Motor Full Load Slip

The value should preferably be obtained from the manufacturer of the motor. Alternatively, it can be measured by operating the motor at rated frequency, voltage and load.

Pr44 = $0.0525p(n_o - n_f)$
where — p = number of poles
n_o = no-load speed, and
n_f = full-load speed

Type R/W, real values
Units radian per second
Range 3.5 to 31.99 rad s^{-1}
Default Parameter **b10** 'Reset to Default' DOES NOT AFFECT **Pr44**

Pr45» Motor Poles

Sets the drive to correspond with the number of poles of the motor.

Type R/W, real values
Range 2, 4, 6 or 8
Default Parameter **b10** 'Reset to Default' DOES NOT AFFECT **Pr45**

Pr46» Inverter Switching Frequency

Sets the frequency at which the inverter generates the PWM output waveform. Higher values produce less acoustic noise but increase the inverter heat losses.

NOTE! Drive modules VB1100S requires derating at 9kHz and 12kHz. Please refer to Section 2.3 page 7.

Type R/W, real values
Units kHz
Range

Select value in kHz	3kHz	6kHz	9kHz	12kHz
Programming code number	0	1	2	3

Default 3kHz

Pr47 Torque Demand Slew Rate

Limits the rate-of-rise of torque, thus limiting the mechanical impulse fed into the system. Too high a value can cause oscillation

Type R/W, real values
Units ms. $\%^{-1}$
Range 0 to 5.0
Default 0

Pr48 *RESERVED*

Pr49 Keypad Display Mode Selector

Programming code number	*Display mode...*
0	Display the full menu of parameters
1	Display all except **b80** to **b91**
2	Display a mini-menu — **b00** to **b17**, **Pr00** to **Pr20**, **Pr49** to **Pr52**, and **Pr70** to **Pr89**.

Default 2

Pr50 Scaling of Programmable Analog Output Channel 1, Terminal B11

Type R/W, real values
Range -999.9 to +999.9
Default 150.0

Related parameters
Pr51

Pr51» Source of Analog Output Channel 1

Selects which real parameter controls the output of analog output Channel 1, Terminal B11.

Type R/W, real values
Range All parameters from **Pr00** through to **Pr99**
Default **Pr70**

Related parameters
Pr50

Pr52 Speed Reference Percentage Trim

Adds a trim to the final speed reference. For example, if the selected speed reference is **Pr01**, the trim applied is —

$$Pr01 \times \left(1 + \frac{Pr52}{100}\right)$$

Type R/W, real values
Range - 50.0 to + 50.0 per cent
Default zero

Pr53 Ix t Threshold Current — Sets the value of current above which the I x t protection will begin to integrate.

Type R/W, real values
Units Amps
Range as **Pr41**
Default as **Pr41**

Pr54 Zero Speed Window — Defines the limits between which the 'zero speed' relay operates.

NOTE! If **Pr54** = 0, the relay may oscillate.

Type R/W, real values
Units rpm
Range zero to 50rpm
Default 6rpm

Pr55 Current x Time Limit (I x t) — Defines the time for which the peak current is permitted, and thus sets the I x t overload trip.

Type R/W, real values
Units seconds
Range 0.5 to 30s in steps of 0.5s
Default 30

Related parameters
Pr53

Pr56 At-Speed Window — Defines limits between which the 'at speed' relay operates.

Type R/W, real values
Units rpm
Range zero to 50rpm
Default 6rpm

NOTE — If **Pr56** = 0, *the relay may oscillate.*

Pr57 Last Trip — Holds the Trip Code of the last malfunction causing a trip. This data is stored in non-volatile memory and is not destroyed by loss of supply power.

Type R-O, real values

Related parameters
b80 b81 b82 b83 b84 b85 b86 b87 b88 b89

Pr58 *RESERVED*

Pr59 *RESERVED*

Pr60 to **Pr69** *Reserved for* MD21 *applications.*

7.3 Numerical Parameters — R-O

Pr70 Motor Speed — Monitors motor actual speed in rpm. This is the value normally displayed at the keypad when the drive is running.

Type R-O, integer values
Units rpm
Range +6000 to -6000

Pr71 Motor Frequency — Monitors actual frequency delivered to the motor.

Type R-O, integer values
Units Hz
Range 0 to 400Hz

Pr72 Analog Speed Reference — Monitors analog speed reference.

Type R-O, integer values
Units rpm
Range +6000 to -6000

Pr73 Shaft Revolutions Counter — Monitors shaft revolutions after each power-up. Each complete forward revolution is recorded as one positive integer. If the maximum is reached, the counter continues from zero.

Type R-O, integer values
Units One unit per complete revolution
Range +8191 to -8192

Pr74 Analog Input Channel 3 Monitor — Monitors the Channel 3 (terminal B14) input after scaling.

Type R-O, real values
Units Volts
Range ±10 V

Pr75 Active Current — Monitors the active current supplied to the motor as a proportion of full load active current, and is therefore a measure of the ratio of torque applied to maximum torque.

Type R-O, integer values
Units per cent
Range - 150% to +150%

Pr76 Speed Reference — pre-Ramp — Value of the speed reference before the ramp generator.

Pr77 Speed Reference — post-Ramp — Value of the speed reference after the ramp generator. Ramp can be bypassed by **b14**.

Pr78 DC Bus Voltage — Monitors the actual voltage of the DC bus link, within the operating range.

Type R-O, real values
Units Volts
Range 400V to 800V

Pr79 *RESERVED*

Pr80 I x t Accumulator — Monitors the percentage of I x t accumulated when the drive is above the overload threshold, indicating how close to trip. Trip at 100%. Time to trip (t_{trip} in seconds) is calculated from —

$$t_{trip} = \frac{1.04 \times \mathbf{Pr53}^2}{\mathbf{Pr82}^2 - (\mathbf{Pr53} + 10\%)^2} \times \mathbf{Pr55}$$

Type R-O, integer values
Units per cent
Range 0 to 100%

Pr81 Speed Error

Monitors the speed error, ie the difference between the set speed (reference) and actual motor shaft speed.

Type R-O, real values
Units rpm
Range ± 930 rpm

Pr82 Motor Line Current

Monitors the total current delivered to the motor.

Type R-O, integer values
Units amps
Range 0 to 150% FLC of motor

Pr83 Relative Shaft Position

Monitors the angular displacement of the motor shaft relative to the position it held on each occasion when the drive is powered-up, or relative to the encoder marker pulse if used.

Type R-O, integer values
Units Degrees of rotation
Range 0 to 360° Resolution 0.1°

Pr84 Analog Input Channel 1 Conversion Value

Units Volts, -10,00 to +10.00
Resolution 0.01 V
Accuracy 10-bit

Pr85 Analog Input Channel 2 Conversion Value

Units Volts, -10,00 to +10.00
Resolution 0.01 V
Accuracy 10-bit

Pr86 Analog Input Channel 3 Conversion Value

Units Volts, -10,00 to +10.00
Resolution 0.01 V
Accuracy 10-bit

Pr87 Monitor Analog Input Channel 2 after Offset and before Scaling

Units Volts, -10,00 to +10.00
Resolution 0.01 V
Accuracy 10-bit

Pr88 Analog Input Channel 4 Conversion Value

Units Volts, 0 to +10.00

Pr89 Value Presented to Analog Output Channel 1, Terminal B11

Units Volts, -10.00 to +10.00
Resolution 0.01 V
Accuracy 12-bit

Pr90 Monitor — Analog Input Channel 2

Type R-O, integer values
Units Volts
Range -10.0V to +10.0V
Default 0.0V

Related parameters
Pr30 Pr31 Pr32 Pr87

Pr91 Speed Loop Output

Monitors the value of compensated speed loop demand. Normally, this parameter is configured as a torque demand for the torque loop.

Range -150 to +150 per cent

Pr94 to **Pr98** *Reserved for* MD21 *applications*

Pr99 Software Version Number

7.4 Bit Parameters — R/W

b00 Null Parameter

Used as a destination for programmable digital outputs. Always reads A0.

b01 Software Trip

The function of this parameter is to perform a trip only. It does not have the effect of a 'Power-off Reset', for which function **b26** must be used.

Type R/W, digital
Function **b01** = 0 Trip the drive

b02 Drive Enable

Enables or disables the drive after power-up. Normally, when the drive is powered-down, **b02** remains as set. To enable the drive, **b02** must be set to 0 and a (negative logic) signal is also required at terminal B1. (If **b15** = 0 , **b02** resets to default on power-off — refer to **b15**.)

Type R/W, digital
Default 1
Function **b02** = 0 Enable
b02 = 1 Disable

Related parameters
b15 b67 b68
Refer also to Control Terminal B1

b03 Drive Reset

Resets the drive to operational status after a trip, provided that the cause of the trip has been corrected or removed.

Type R/W, digital
Default 1
Function **b03** = 0 Reset
b03 = 1 Normal status

Related parameters
b64 b80 b81 b82 b83 b84 b85
b86 b89 b90

b04 Control Mode — torque demand

Selects control by speed error with torque demand or by speed error only. Effectively bypasses the internal torque reference **Pr08**.

Type R/W, digital
Default 1
Function **b04** = 0 Torque control
b04 = 1 Speed control

Related parameters
b05 Pr08

b05 Zero Torque Reference

Applies a zero torque demand.

Type R/W, digital
Default 1
Function **b05** = 0 Zero torque demand
b05 = 1 Speed reference

Related parameters
b06 Pr02 Pr05 Pr08 Pr17

NOTE! — Default is controlled by logic input F0.

b06 Speed Reference Selector

Provides the choice of external digital speed references.

Type R/W, digital
Default 1
Function **b06** = 0 Speed reference 2
b06 = 1 Speed reference 1

Related parameters **Pr01 Pr02**

b07 A/D Speed Reference Selector Selects either analog or digital internal speed reference input.

Type R/W, digital
Default 1
Function **b07** = 0 Analog speed reference
b07 = 1 Digital speed reference

Related parameters
Pr01 Pr02 Pr16 Pr72

b08 Stop Sets a zero speed reference either pre- or post-ramp, dependent on the setting of **b20**.

When **b08** = 0, the drive is DISABLED when motor speed reaches zero. If the motor speed does not reach zero, due to there being a value in **Pr16** or due to an over-running load, the drive does not disable.

Type R/W, digital
Default 1
Function **b08** = 0 Decelerate to zero speed
b08 = 1 Normal status

b09 Speed Reference Invert Permits digital or analog externals speed reference signal to be inverted.

Type R/W, digital
Default 1
Function **b09** = 0 Invert speed reference
b09 = 1 Normal status

b10» Reset Parameters to Default Enables all parameters to be returned to their default setting simultaneously.

NOTES —
1 No effect on **Pr41, Pr42, Pr43, Pr44,** and **Pr45.**
2 After reset, a 'store' must be performed — refer to **b26**. Default values are assumed on next power-up.

Type R/W, digital
Default 1
Function **b10** = 0 Reset to default values
b10 = 1 Normal status

b11 Bypass for Hard Speed Reference

Type R/W, digital
Default 0
Function **b11** = 0 Normal
b11 = 1 Bypass active

b12 Shaft Encoder Revolutions Counter Reset

Type R/W, digital
Default 1
Function **b12** = 0 Continuously reset
b12 = 1 No action

Related parameters
Pr73

b13 Power-up in Last Trip state Enables the drive, after being powered-down in a tripped state, to be returned to that same state after the next power-up. The drive is then unhealthy, requiring the correction or removal of the cause of the trip, if it still remains, before applying the reset, **b03**.

NOTE! — does not apply in the case of under-voltage trip **UU**.

Type R/W, digital
Default 1
Function **b13** = 0 Power-up in Last Trip State
b13 = 1 Normal status

b14 Ramp Bypass

Enables the acceleration and deceleration ramps to be bypassed and thereby disabled as a group.

Type R/W, digital
Default 1
Function **b14** = 0 Ramps bypassed
b14 = 1 Normal status

b15 Auto or Manual Start Mode

By setting parameter **b15** = 0, **b02** is forced to default on power-down so that, on power-up, the drive is disabled, requiring **b02** to be set to 0 to enable. (An enable signal must also be applied at terminal B1.) After the first power-up, **b02** must be set to zero to run the drive. The drive will subsequently start automatically unless **b15** is set to 0.

Type R/W, digital
Default 1
Function **b15** = 0 Causes **b02** = 1 (Disable) on power-up
b15 = 1 Normal status of **b02**

Related parameters
b02 b67 b68
Refer also to Control Terminal B1

b16 Motor Thermistor enable

Enables the motor thermistor sensing circuitry.

Type R/W, digital
Default 1
Function **b16** = 0 Sensing circuit disabled
b16 = 1 Normal status

b17 *RESERVED*

b18 Serial Link Parity enable

Selects whether or not a parity bit is included in Serial Link transmissions.

Type R/W, digital
Default 1
Function **b18** = 0 No parity bit
b18 = 1 Include parity bit

b19 Serial Link, Block Checksum Enable

Selects whether or not a block checksum (BCC) error check is included in a Serial Link communication.

NOTE! After a Serial Comms message, a rogue character must be included. If **b19** = 0 the rogue character is ignored.

Type R/W, digital
Default 1
Function **b19** = 0 No BCC
b19 = 1 BCC

b20 Ramp to Stop or Hard Stop

Selects a zero speed reference *before* or *after* the Ramp function. Hard stop provides full-torque deceleration, which may not be desirable in some applications.

Type R/W, digital
Default 1
Function **b20** = 0 Hard stop
b20 = 1 Ramp to stop

b21 Security Code Key Enable

Locks the Security Code **Pr25** against accidental or unauthorised alteration of the code. The current code must be entered to enable **b21** to be changed. (This is not required until a code is assigned.)

Type R/W, digital
Default 1
Function **b21** = 0 **Pr25** can be changed
b21 = 1 **Pr25** cannot be changed

b22 Open-Loop Mode

Selects open or closed loop operation. Provides a crude open-loop control mode to turn and **unloaded** motor. May be convenient to use during commissioning, but **must not** be used continuously, ie in normal operation.

Type R/W, digital
Default 1
Function **b22** = 0 Open loop (no encoder)
b22 = 1 Closed loop (encoder feedback normal

b23 *RESERVED*

b24 Logic Outputs Inversion

If **b24** = 0, the logic of all three logic outputs, F0 to F2, is inverted. Outputs will be *activated* (+24V) for a logic 0.

Type R/W, digital
Default 1
Function **b24** = 0 Logic inverted
b24 = 1 Not inverted

b25 Logic Inputs Inversion

If **b25** = 0, the logic of all three logic inputs, F0 to F2, is inverted. Zero volts will equal logic 1.

Type R/W, digital
Default 1
Function **b25** = 0 Logic inverted
b25 = 1 Not inverted

b26 Hard Reset

Provides an effective 'Power-off Reset'. It is necessary to use this function in order to *save* certain parameters, eg the Motor Map parameters **Pr41** to **Pr45**.

Type R/W, digital
Default 1
Function **b26** = 0 Hard reset performed
b26 = 1 Normal status

b27 Common Torque Limit

The two available torque limits, **Pr06** and **Pr07**, can be separately active, or the **Pr06** value can be applied to both.

Type R/W, digital
Default 1
Function **b27** = 0 **Pr07** will be set to the value of **Pr06**
b27 = 1 **Pr06** and **Pr07** torque limits are separate

b28 Ramp Hold

Stops the advance of the ramp when activated. When de-activated, allows the ramp to advance.

Type R/W, digital
Default 1
Function **b28** = 0 Ramp value hold
b28 = 1 Normal ramp

b29 *RESERVED*

b30 Torque Mode Selection

Controls the manner in which torque is applied in relation to direction (sense) of speed demand; speed override control depends on torque mode.

Type R/W, digital
Default 1
Function **b30** = 0 Torque applied in either direction dependent on the sign (+ or -) of the torque reference parameter **Pr08.** Speed override limited only by speed clamps **Pr03** and **Pr04**.
b30 = 1 Torque applied if the sense of the speed and torque demands are the same. Speed override set by speed reference.

b31 to **b61** *Reserved for* MD21 *applications*

7.5 Bit Parameters — R-O

b64 Drive Healthy — Indicates that the drive is in a healthy state, ie it is powered-up and no faults are detected.

Type R-O, digital
Function **b64** = 0 Drive not healthy
b64 = 1 Drive healthy

b65 Logic Function F0 Status — Indicates the status of input terminal B4.

Type R-O, digital
Function **b65** = 0 Logic level 'low'
b65 = 1 Logic level 'high'

b66 Logic Function F1 Status — Indicates the status of input terminal B3.

Type R-O, digital
Function **b66** = 0 Logic level 'low'
b66 = 1 Logic level 'high'

b67 Drive Enable Input Status — Indicates the status of input terminal B1, drive enable signal.

Type R-O, digital
Function **b67** = 0 Logic level 'low'
b67 = 1 Logic level 'high'

Related parameters
b02 b08 b15 b68

b68 Drive Enabled Status — Indicates the condition of the drive, whether enabled or disabled.

Type R-O, digital
Function **b68** = 0 Drive disabled
b68 = 1 Drive enabled

Related parameters
b02 b08 b15 b67

b69 Forward or Reverse Rotation — Indicates the condition of the motor — whether rotating forward or reverse.

Type R-O, digital
Function **b69** = 0 Motor running in reverse
b69 = 1 Motor running forward

b70 Logic Function F2 Status — Indicates the status of input terminal B10.

Type R-O, digital
Function **b70** = 0 Logic level 'low'
b70 = 1 Logic level 'high'

Related parameter
Pr36

b71 *RESERVED*

b72 Drive at Zero Speed — Indicates a condition of the drive — whether speed <**Pr54**.

Type R-O, digital
Function **b72** = 0 Drive running
b72 = 1 Drive at zero speed

b73 Drive at Speed — Indicates a condition of the drive — whether speed < Set Speed ±**Pr56**.

Type R-O, digital
Function **b73** = 0 Drive not at set speed
b73 = 1 Drive at set speed

b74 Torque Limit Indicator — Indicates that the torque limit has been reached. Also indicated at the Control Pod display (decimal points flashing).

Type R-O, digital
Function **b74** = 0 Drive within torque limit
b74 = 1 Drive at torque limit

b75 Motor Thermistor Alarm — Indicates that the motor thermistor has operated due to high temperature. Does NOT trip the drive. (Only when **b16** = 1, circuit enabled.)

Type R-O, digital
Function **b74** = 0 Motor overtemperature
b74 = 1 Motor temperature within limit

b80 Over-current Trip (OC) — Indicates that an over-current trip condition exists — output current has exceeded upper limit programmed for the motor. May indicate a motor earth fault or short circuit, but the cause may be incorrect setting of the Motor Map parameters **Pr41 to Pr45** inclusive.

Type R-O, digital
Function **b80** = 0 Trip inactive
b80 = 1 Trip active

b81 DC Link Current Trip (dOC) — Indicates that the drive has tripped because the DC link current has exceeded the permitted maximum. May indicate a motor earth fault, short circuit or power semiconductor device failure.

Type R-O, digital
Function **b81** = 0 Trip inactive
b81 = 1 Trip active

b82 Over-voltage Trip (OU) — Indicates that the drive has tripped because the DC link voltage has exceeded the permitted maximum.

Type R-O, digital
Function **b82** = 0 Trip inactive
b82 = 1 Trip active

b83 Under-voltage Trip (UU) — Indicates that the drive has tripped because the DC link voltage has fallen below the permitted minimum. The cause may be a disturbance in the power supply to the drive.

Type R-O, digital
Function **b83** = 0 Trip inactive
b83 = 1 Trip active

b84 Motor Over-temperature Trip (th) — Indicates that the drive has tripped because the motor temperature sensor has operated (terminal B13).

Type R-O digital
Function **b84** = 0 Trip inactive
b84 = 1 Trip active

b85 Drive IGBT Stack Over-temperature Trip (Oh) — Indicates that the drive has tripped because the inverter stack has exceeded the maximum permitted operating temperature.

Type R-O digital
Function **b85** = 0 Trip inactive
b85 = 1 Trip active

b86 I x t Trip (It) — Indicates that the drive has exceeded the maximum permitted time on overload.

Type R-O digital
Function **b86** = 0 Trip inactive
b86 = 1 Trip active

b87 External Trip (**Et**)

Indicates that the drive has received a trip signal from an external source at terminal B2.

NOTE!' If links LK27 and LK28 are in the position to the LEFT, an **Et** trip will occur.

Type R-O digital
Function **b87** = 0 Trip inactive
b87 = 1 Trip active

b88 Software Trip status (**St**)

Indicates that the Miscellaneous Trip bit parameter **b01** has been set to trip.

Type R-O digital
Function **b88** = 0 Trip inactive
b88 = 1 Trip active

b89 Ix t Alarm (flashing decimals)

Indicates that the drive is in an overload condition and that a trip will follow if the condition persists.

Type R-O digital
Function **b89** = 0 Alarm inactive
b89 = 1 Alarm active

b90 Hardware Fault (**Err...**)

Indicates that the self-diagnostic system has detected an internal fault. The supplier of the drive should be asked to assist.

Type R-O digital
Function **b90** = 0 Trip inactive
b90 = 1 Trip active

b91 to **b99** *Reserved for* MD21 *applications*

7.6 Parameters Index

Numerical Parameters

READ-WRITE (R/W)

Pr00	Null parameter
Pr01	Speed reference 1
Pr02	Speed reference 2
Pr03	Minimum speed limit
Pr04	Maximum speed limit
Pr05»	Analog Speed Reference filter
Pr06	Torque limit — motoring
Pr07	Torque limit — regenerating
Pr08	Internal Torque Reference
Pr09	Forward acceleration rate
Pr10	Reverse acceleration rate
Pr11	Forward deceleration rate
Pr12	Reverse deceleration rate
Pr13	Proportional gain
Pr14	Integral gain
Pr15	Derivative gain
Pr16	Hard speed reference
Pr17	Analog speed input scaling
Pr18	Speed reference offset
Pr19	Channel 3 input scaling
Pr20	Channel 3 offset
Pr21»	Destination of Channel 3
Pr22	Serial link address
Pr23»	Serial link Baud rate
Pr24	Factory set security key
Pr25	Security code
Pr26»	Destination, programmable input F0
Pr27»	Destination, programmable input F1
Pr28»	Source, programmable output F2
Pr29»	Source, programmable output F1
Pr30	Analog input channel 2 offset
Pr31	Analog input channel 2 scaling
Pr32»	Analog input channel 2 destination
Pr33»	Source, programmable output F0
Pr34	Torque output scaling (Terminal B10)
Pr35	Overspeed trip threshold
Pr36»	Destination, programmable input F2
Pr37 to **Pr39**	*Reserved for* MD21
Pr40	Drive model
Pr41»	Full load current
Pr42»	Magnetising current
Pr43»	Base frequency
Pr44»	Full load slip
Pr45»	Motor pole count
Pr46»	Inverter switching frequency
Pr47	Torque demand slew rate
Pr48	*Reserved*
Pr49	Keypad display mode selector
Pr50	Scaling anal. output 1
Pr51»	Source analog output 1
Pr52	Speed reference trim
Pr53	I x t threshold current
Pr54	Zero speed window
Pr55	I x t time limit
Pr56	At-speed window
Pr57	Last trip
Pr58, **Pr59**	*Reserved*
Pr60 to **Pr69**	*Reserved for* MD21

READ ONLY (RO)

Pr70	Motor speed
Pr71	Motor frequency
Pr72	Analog speed reference
Pr73	Shaft revolutions counter
Pr74	Analog input channel 3 monitor
Pr75	Active current
Pr76	Speed reference — pre-ramp
Pr77	Speed reference — post-ramp
Pr78	DC bus voltage
Pr79	*Reserved*
Pr80	I x t accumulator
Pr81	Speed error
Pr82	Motor line current
Pr83	Relative shaft position
Pr84	Analog input channel 1 conversion
Pr85	Analog input channel 2 conversion
Pr86	Analog input channel 3 conversion
Pr87	Analog input channel 2 post-offset
Pr88	Analog input channel 4 conversion
Pr89	Analog output channel 1 value
Pr90	Analog input channel 2 monitor
Pr91	Speed loop output
Pr94 to **Pr98**	*Reserved for* MD21
Pr99	Software version number

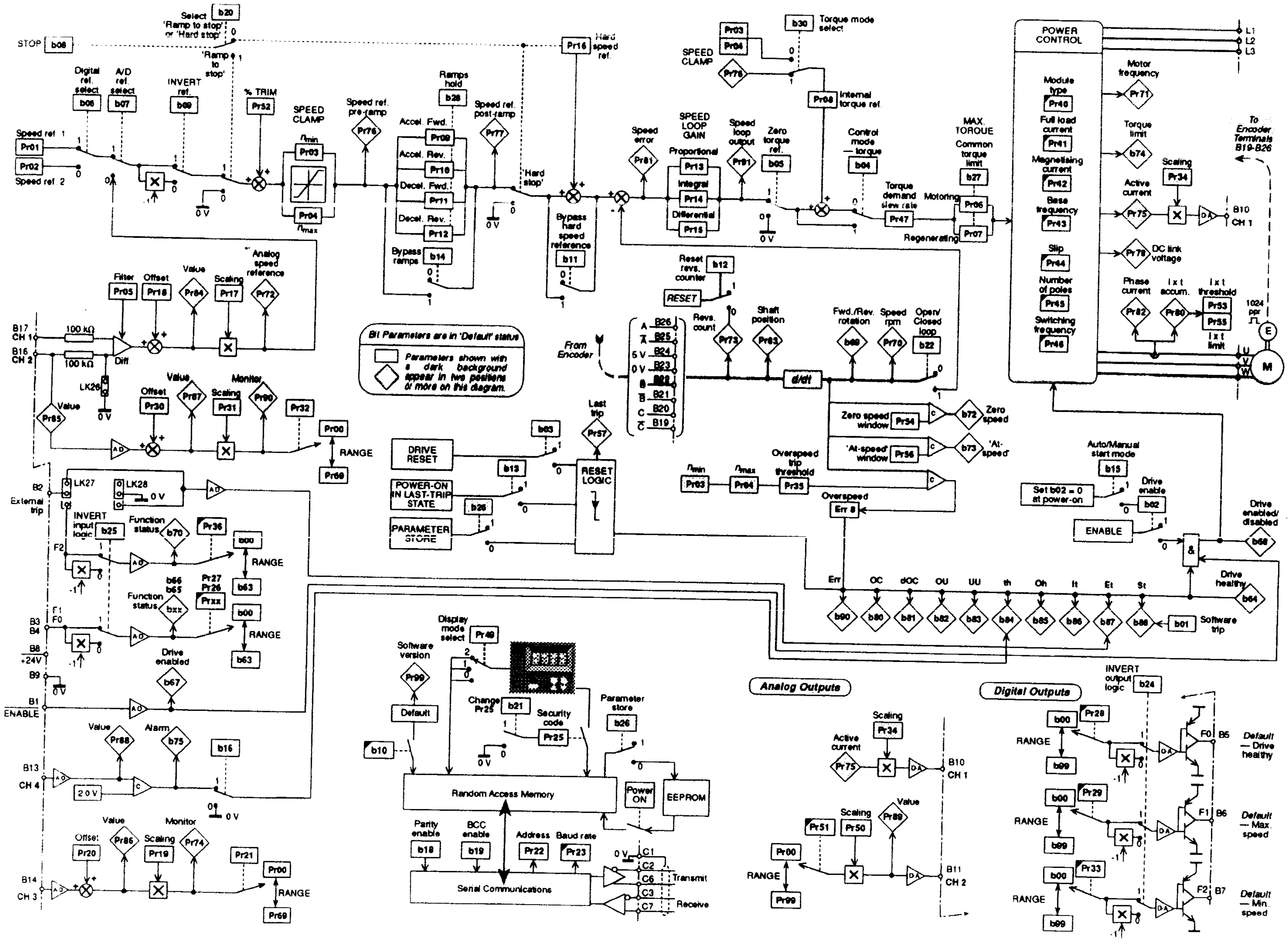
Bit Parameters

READ-WRITE (R/W)

b00	Null parameter
b01	Software trip
b02	Drive enable
b03	Drive reset
b04	Control mode — torque
b05	Zero torque reference
b06	Speed reference selector
b07	A/D Speed reference selector
b08	Stop
b09	Speed reference invert
b10»	Reset parameters to default
b11	Hard speed reference bypass
b12	Shaft encoder revs counter reset
b13	Power-up in Last Trip state
b14	Ramp bypass
b15	Auto or Manual Start mode
b16	Motor thermistor enable
b17	*Reserved*
b18	Serial Link parity enable
b19	Serial Link BCC enable
b20	Ramp to stop or 'Hard stop'
b21	Security code key enable
b22	Open-loop mode
b23	*Reserved*
b24	Inversion, logic outputs
b25	Inversion, logic inputs
b26	Hard Reset
b27	Common torque limit
b28	Ramp hold
b29	*Reserved*
b30	Torque mode selector
b31 to **b61**	*Reserved for* MD21

READ ONLY (RO)

b64	Drive healthy
b65	Function status F0
b66	Function status F1
b67	'Drive enable' Input status
b68	Drive enabled/disabled status
b69	Forward or reverse rotation
b70	Function status F2
b71	*Reserved*
b72	Drive at zero speed
b73	Drive at speed
b74	Torque limit indicator
b75	Motor thermistor alarm
b80	Trip (**OC**)
b81	Trip (**dOC**)
b82	Trip (**OU**)
b83	Trip (**UU**)
b84	Trip (motor) (**th**)
b85	Trip(inverter) (**Oh**)
b86	Trip (**It**)
b87	External trip (**Et**)
b88	Software trip (**St**)
b89	I x t alarm (...)
b90	Hardware fault (**Err...**)
b91 to **b99**	*Reserved for* MD21


POWER CONTROL
Module type
Full load current
Magnetising current
Base frequency
Slip
Number of poles
Switching frequency
Motor frequency
Torque limit
Active current
DC link voltage
Phase current
I x t accum.
I x t threshold
I x t limit
1024 ppr
To Encoder Terminals B19-B26
SPEED CLAMP
% TRIM
Speed ref. pre-ramp
Speed ref. post-ramp
Ramps hold
Accel. Fwd.
Accel. Rev.
Decel. Fwd.
Decel. Rev.
Bypass ramps
Hard speed ref.
Bypass hard speed reference
'Hard stop'
Select 'Ramp to stop' or 'Hard stop'
'Ramp to stop'
STOP
Digital ref. select
A/D ref. select
INVERT ref.
Speed ref. 1
Speed ref. 2
Speed error
SPEED LOOP GAIN
Proportional
Integral
Differential
Speed loop output
Zero torque ref.
Control mode — torque
Torque mode select
Internal torque ref.
Torque demand slew rate
Motoring
Regenerating
MAX. TORQUE
Common torque limit
Analog speed reference
Filter
Offset
Value
Scaling
Monitor
Diff
RANGE
Bit Parameters are in 'Default' status
Parameters shown with a dark background appear in two positions or more on this diagram.
Reset revs. counter
RESET
Revs. count
Shaft position
Fwd./Rev. rotation
Speed rpm
Open/Closed loop
From Encoder
d/dt
Zero speed window
Zero speed
'At-speed' window
'At-speed'
Overspeed trip threshold
Overspeed
Last trip
RESET LOGIC
DRIVE RESET
POWER-ON IN LAST-TRIP STATE
PARAMETER STORE
Auto/Manual start mode
Set b02 = 0 at power-on
Drive enable
ENABLE
Drive enabled/disabled
Drive healthy
Software trip
Err OC dOC OU UU th Oh It Et St
External trip
INVERT input logic
Function status
Drive enabled
ENABLE
Alarm
Software version
Default
Display mode select
Change Pr25
Security code
Parameter store
Random Access Memory
Power ON
EEPROM
Parity enable
BCC enable
Address
Baud rate
Serial Communications
Transmit
Receive
Analog Outputs
Active current
Digital Outputs
INVERT output logic
Default — Drive healthy
Default — Max. speed
Default — Min. speed

8
Serial Communications

A communications link is standard in all *VECTOR* 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. *VECTOR* 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 *VECTOR* drives, Fig. 13, and up to 99 if line buffers are used.

The communication port of the drive module is the terminal block 'C', Fig. 8. The standard connection is the RS485, Fig. 14, or RS422 4-wire link; 3-wire RS232 can be connected also, Fig. 15. Protocol is ANSI x 3.28 - 2.5 - A4, as standard for industrial interfaces.

8.1 Fundamentals

Logic processors, such as computers, PLCs, and the communications system of *VECTOR* 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 *VECTOR* drives, the on-state is represented by a positive voltage, and the off-state by zero volts. The two 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'.

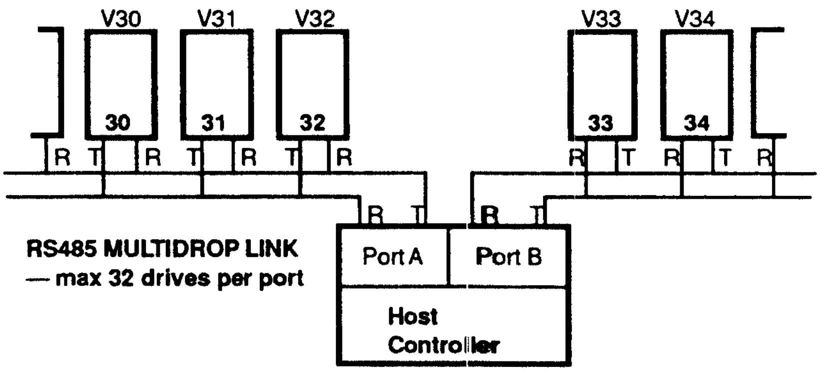
Early in the development of computer technology it was recognised that a long stream of bits without, so to speak, any punctuation marks would be unmanageable and at risk of transmission errors passing unrecognised. The byte was adopted as a standard unit. To ensure that each byte is distinct, a start 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 structure — the 'framing' or 'character format' — of the byte is significant. There is more than one convention for 'framing' the character. The format in *VECTOR* drives is ten bits as shown diagrammatically on the following page.

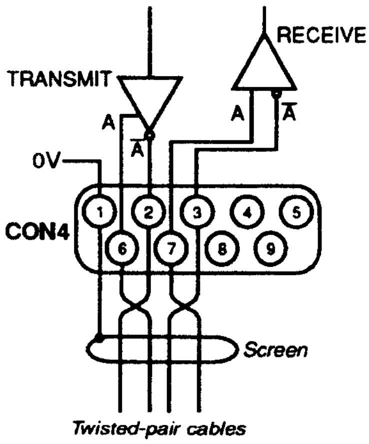
<table>
<tr><td></td><td colspan="7">'Low' ASCII character byte</td><td></td><td></td></tr>
<tr><td colspan="4">1st hex character</td><td colspan="4">2nd hex character</td><td></td><td></td></tr>
<tr><td>Start bit</td><td colspan="7">Seven data bits, variable</td><td>Parity bit</td><td>Stop bit</td></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.

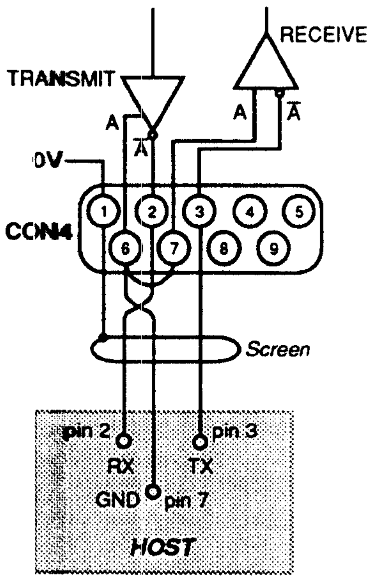
The character set used in *VECTOR* drives is the 'low' American Standard Code for Information Interchange (ASCII), comprising 128 characters, decimally numbered 0 to 127. In the low ASCII set, the first hex character extends only from decimal 0 to 7, binary 0000, 0001 etc to 0111. This being so, the



13 Serial address Pr22. Unique identity code for up to 32 drives per communications port at the host.



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



15 Connections for RS232 link.

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, hex 20, 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 *VECTOR* drive are formed of ASCII 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, below.

Preliminary Adjustment of the Drive

Each drive requires a unique identity number, or serial address, set by parameter **Pr22**. The baud rate, **Pr23**, and the parity enable bit, **b18**, require to be set to match the host. Data, drive status and the parameter set-up can be read from the drive in any mode, provided only that the drive is energised, and that the serial address, Baud rate and parity bit parameters are correctly set.

8.2 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 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, the six in the following table are used in *VECTOR* serial communications.

CONTROL CHARACTERS in *VECTOR* VB75-1100 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
BS	Backspace (go to previous parameter)	08	H
NAK	Negative acknowledge (message not understood)	15	U

Serial Address

Each drive is given an identity or address (**Pr22**, Fig.13) 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.

Parameter Identification

For transmission by serial link, parameters are identified by a number. The serial identities of parameters **Pr00** through to **Pr99** are 0 to 99. For example the identity for **Pr 23** is 23.

The serial identities of bit parameters **b00** through to **b99** are 100 to 199. Thus, the identity for parameter **b23** is 123

Each numerical parameter writes and reads a variable numerical value within its range, whatever the value happens to be at the time, with three exceptions — **Pr05, Pr23,** and **Pr49**. Each of these can hold one of a group of fixed values. Their programming code numbers and the values corresponding to them are —

Pr05		Pr23		Pr49	
WRITE	READ (ms)	WRITE	READ (Baud)	WRITE	READ
0	2	0	300	0	*Preselection*
1	4	1	600	1	*of menu*
2	8	2	1200	2	*display*
3	16	3	2400		
4	32	4	9600		
5	128	5	19.2		

Data

Data to be sent or requested occupies the next six characters after the parameter number. Data is handled as a floating point signed decimal number. All of the operating parameters of the drive are **numerical** values, such as frequency, load, current, etc. For example, speed is given by the range +6000 to -6000, the value being in rpm. The value '95rpm in a reverse direction' may be sent as —

-	0	9	5	.	0

— but different formats are valid so long as there are up to six characters preceded by a space or by a sign, + or -. A single space is treated as a '+' sign. For example, for the value of 60, all of the following are valid —

+	6	0	.	0	0	=	60
	6	0				=	60
-	6	0	.	0		=	-60
-	0	0	6	0	.	=	-60

The state of **bit-parameters** is transmitted and received as real-value data, of value 0 or 1. Again, the format is flexible so long as no more than 5 characters are comprised, and not more than one space-character is used, for example —

	1			
+	0	0	0	1

— and so on.

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 may be terminated by a block checksum character (BCC, page 57) if selected. BCC is selected by **b19** = 1. If not selected (**b19** = 0), BCC is ignored on reception, but a random character must be attached at the end of the string. A Carriage Return (ODH = Control-M) is sent on transmit.

8.3 Structure of Messages

Host to Drive

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

a request for information, or —
a command

Both kinds must start with the control character EOT (Control-D) to indicate that a message is 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**, sending the parameter number instructs the particular drive addressed to supply data relating to that parameter. A data request message is terminated by the control character ENQ to indicate that the host is ready to receive 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 57).

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 parameter number 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.

Multiple Drives

A message can be sent to two or more more addresses simultaneously. If several drives are always to respond to the same request or instruction, all must be given the address 0 (zero).

8.4 Sending Data

Host command —

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

For example, the message to the drive —

"change set speed of drive number 14 to 476rpm in reverse"

would be sent as —

CONTROL	ADDRESS				CONTROL	PARAM			DATA						CONTROL	
EOT Control-D	1	1	4	4	STX Control-B	0	0	1	-	4	7	6	.	0	ETX Control-C	# BCC

Send again, with different parameter and/or data

The drive will respond with an acknowledgement, either —

ACK if the message is understood *and* implemented, 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 respond with NAK.

8.5 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 - parameter - end

For example, to find the speed set point **Pr01** of drive number 12, send —

CONTROL	ADDRESS				PARAM			CONTROL
EOT Control-D	1	1	2	2	0	0	1	ENQ Control-E

The drive replies in the following form —

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

For example —

CONTROL	PARAM			DATA						CONTROL	
STX Control-B	0	0	1	+	4	7	6	.	0	ETX Control-C	, BCC

The reply first confirms that the data sent is the speed set point, **Pr01**; the six characters immediately following give the present setting in rpm. The first character is either + or -, to indicate direction of rotation; the remainder is the numerical value —

"forward at 476rpm" 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 parameter. 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 parameter in numerical order, send the positive acknowledgement ACK (Control-F). The drive will respond by transmitting the data relating to the next parameter in sequence.

Previous Parameter

To obtain data from the same drive for the previous parameter in numerical order, send backspace BS (Control-H).

Invalid Parameter Number

If the host sends a parameter number which the drive does not recognise, eg 223, the drive will respond with NAK.

8.6 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 (XOR) is performed on all nine characters of the message after the start-of-text command.

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

"set speed to 476rpm in reverse"

it is sent as --

Reset	EOT (Control-D)
Serial address	1 1 4 4
Start of text	STX (Control-B)
Not included in BCC calculation	
	BCC calculation starts here
Parameter	Parameter number
Reverse	- (a minus sign)
476	476
End of message	ETX (Control-C)
finally,	BCC, calculated as shown

Each of the separate digits,

, - 4 7 6 and Control-C

is represented by a hexadecimal character and calculated in binary as shown in the table on the following page. The XOR is the final summation.

Character	*Binary Code*	
(**Pr01**) 1	0011	0001
- (minus)	0010	1101
4	0011	0100
7	0011	0111
6	0011	0110
ETX (Control-C)	0000	0011
XOR	0010	1010

The final XOR is 00101010 = 2A (hex) = 42 (decimal) — which is represented by the character *.

Thus the complete message to set the speed of drive number 14, say, to 476rpm in reverse is —

CONTROL	ADDRESS				CONTROL	PARAM			DATA						CONTROL	
EOT Control-D	1	1	4	4	STX Control-B	0	0	1	-	4	7	6	.	0	ETX Control-C	* BCC

NOTE — The ASCII characters from 00 to 1F (hex), plus 'space', are used only for control codes. The transmitted BCC must therefore exceed the value of 32 (decimal). Whenever the XOR produces a (decimal) number not greater than 32, it is necessary to add 32 to it to avoid confusion with the control characters.

9
Braking

8.1 Introduction

When an AC motor is mechanically driven, it operates as a generator provided that a voltage is applied at its terminals. When torque is provided by the inertia of the driven load rather than by the electrical power supply, the motor delivers power.

During deceleration of an AC motor and its load, a proportion of the stored kinetic energy can be converted by the motor into electrical energy and returned to the inverter. When a high-inertia load is decelerated in a short time the energy delivered can be too great for the DC link capacitance to absorb alone. The effect is to increase the voltage of the DC link and a DC overvoltage trip may occur as a result.

As industrial inverter drives are able to absorb in the DC link capacitor only a small proportion of the energy stored in the driven load when it is at full speed, greater dynamic braking torque can be applied to a motor only if an electrical load, ie a resistor, can be switched into the DC link to absorb stored energy. Excess voltage in the DC link is prevented by the switching of the braking unit under the control of a dedicated braking control circuit. The duty of the braking control unit during regeneration is to prevent the DC voltage rising above maximum and to prevent overcharging of the DC bus capacitor.

Inherent in the characteristic of this type of inverter drive is the constant V/f ratio of the output (constant torque) below base frequency, and constant voltage (constant power) above base frequency.

Because of the constant-V/f characteristic, regenerated power declines towards zero speed. When coasting to a stop, the drive system is ordinarily brought finally to rest by its fixed losses which are mostly friction.

As regenerated power is maximum and constant at any speed above base frequency, this is where the braking resistor does most of its work. The maximum braking torque is a function of the regenerated current, which is inversely proportional to resistor value at constant voltage. Choice of resistor value determines the braking torque.

The power rating of the resistor, on the other hand, depends upon the braking duty cycle — the braking time and the repetition time — and on the cooling available for the resistor. Data for the calculation of resistor values and ratings are given below, with an example.

Separately, the resistor must be protected against continuous overload by a thermal trip relay, as shown in Fig. 16.

8.2 Braking Resistors

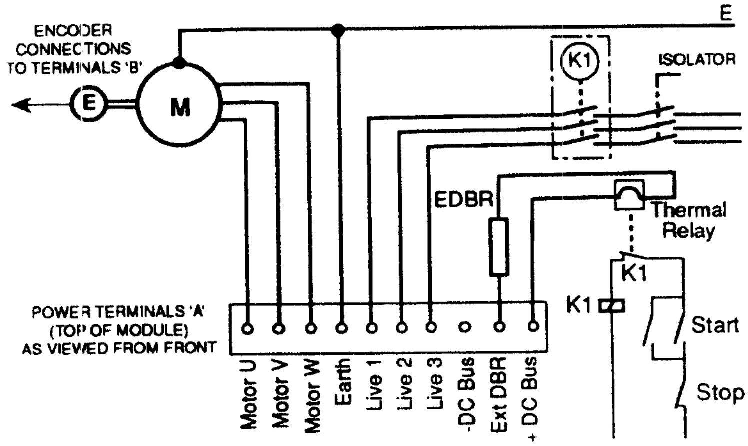
Module type	*Resistor size*	*Maximum regenerative power*
VB75 VB110 VB150	80Ω, 150W	1.5kW for 10s, continuous rating, with a minimum cooling time of 90s.
VB220 VB400 VB550 VB750 VB1100S	40Ω, 300W	3.0kW for 10s, continuous rating, with a minimum cooling time of 90s.

External Braking Resistor Connections

Refer to Fig. 16.

ON the larger *VECTOR* drives, (VB400, VB550, VB750 and VB1100S), provision is made to fit an external resistor of higher rating that the standard on-board resistor for increased dynamic braking performance. To protect the installation from the risk of damage it is essential that —

- The internal resistor is disconnected. For this it is essential to consult the supplier of the drive.
- The external resistor is fitted with a thermal protection relay, wired to trip the supply contactor.



16 A thermal trip relay wired to trip the drive supply circuit automatically is essential protection for an External Dynamic Braking Resistor (EDBR).

APPLICATION of the BRAKING RESISTOR

IMPORTANT NOTE

The application of an external braking resistor absolutely requires that the internal resistors are first disconnected.

Maximum DC link voltage is 70V above normal DC bus voltage, **Pr78**. The resistor, cabling and insulation must be suitable for this operating voltage.

Install the braking resistor in accordance with instructions provided by its supplier or manufacturer. The braking resistor MUST incorporate a thermal trip device, which MUST be connected to a trip release mechanism on the supply-side contactor or circuit breaker, Fig. 16.

The following notes are for guidance in the selection of resistors. In case of uncertainty, the supplier of the drive should be asked for advice. In any case, when ordering resistors, complete data about the installation and the application should be made available to the resistor supplier, who should be asked to provide appropriate overload-factor and cooling curves.

The size and rating of the resistor are calculated with respect to the power to be absorbed, the rate at which power will be delivered, and the time-lapse between successive decelerations.

Kinetic energy of the motor and load = $0.5\ J\ \omega^2$

where J = total moment of inertia (kg m^2) of the motor and driven machine.

NOTE If there is gearing between the motor and the driven machine, J is the value reflected at the motor shaft.

ω = angular velocity (radians s^{-1}), or, alternatively, use $\frac{2\pi \times n}{60}$

As the energy is proportional to the square of the angular velocity, most of the energy in the system is concentrated at the higher operating speeds, and is initially delivered to the resistor at the start of the deceleration. If the motor is operated at speeds above base frequency, the energy delivered to the resistor is constant until the speed falls below base frequency.

Resistors intended for braking duty should be capable of tolerating thermal shock. 'Pulse rated' resistors are recommended.

Terms

The *value* of a resistor is its resistance in ohms. Note that a resistor of *low* value will draw a *high* current.

The *rating* of a resistor is the measure of the power (kW) that it is designed to absorb continuously.

Recommended values —

Module type	*Resistance value* Ω	*Rating* W	*Short-time rating* 10s	*Cooling time* s
VB75 to VB220	80	150	1.5kW	90
VB400 to VB1100S	40	300	3.0kW	90

If an external braking resistor is used, the maximum braking currents are —

Module type	*Max braking current* A rms
VB75 to VB220	2
VB400 to VB1100S	20

EXAMPLE

A load inertia of 0.5kg m^2 is to be decelerated from 1500rpm to rest. Calculate the braking resistor value (Ω) *and power rating* (kW).

DATA

Drive type VB750	7.5kW
Motor	7.5kW
Motor nominal torque rating	47Nm
Decelerating time	*to be determined*
Repeat cycle time	30 seconds
Load inertia (J)	0.5kg m^2
Resistor value (R)	*to be calculated*
Resistor rating (P_r)	*to be calculated*
Resistor operating voltage (V)	660V (**Pr78** + 70V)

The first essential step is to determine the *minimum decelerating time*, t_b.

$$t_b = \frac{2\pi \times J \times n}{60 \times M_{b\,max}}$$

Maximum deceleration occurs at 150% of motor nominal torque. The value to apply for $M_{b\ max}$ is therefore 1.5 x 47 = 70.5, and the *decelerating time* is —

$$t_b = \frac{2\pi \times 0.5 \times 1500}{60 \times 70.5}$$

$$= 1.11 \text{ seconds}$$

A *practical* deceleration time t_d can now be decided. For this example, let t_d = 2s.

Calculate the *actual braking torque* M_b required to decelerate the load in 2s —

$$M_b = \frac{2\pi \times J \times n}{60 \times t_d}$$

$$= \frac{2\pi \times 0.5 \times 1500}{60 \times 2}$$

$$= 39 \text{ Nm}$$

Braking *power* is —

$$P_b = \frac{2\pi \times M_b \times 1500}{60 \times 10^3} \quad \text{in kW}$$

$$P_b = \frac{2\pi \times 39 \times 1500}{60 \times 10^3}$$

$$= 6\text{kW}$$

Resistor value R

The VB750 drive is capable of regenerating up to 150% of rated current (11.25kW) for up to 30 seconds maximum. This is in excess of the 6kW required for this application.

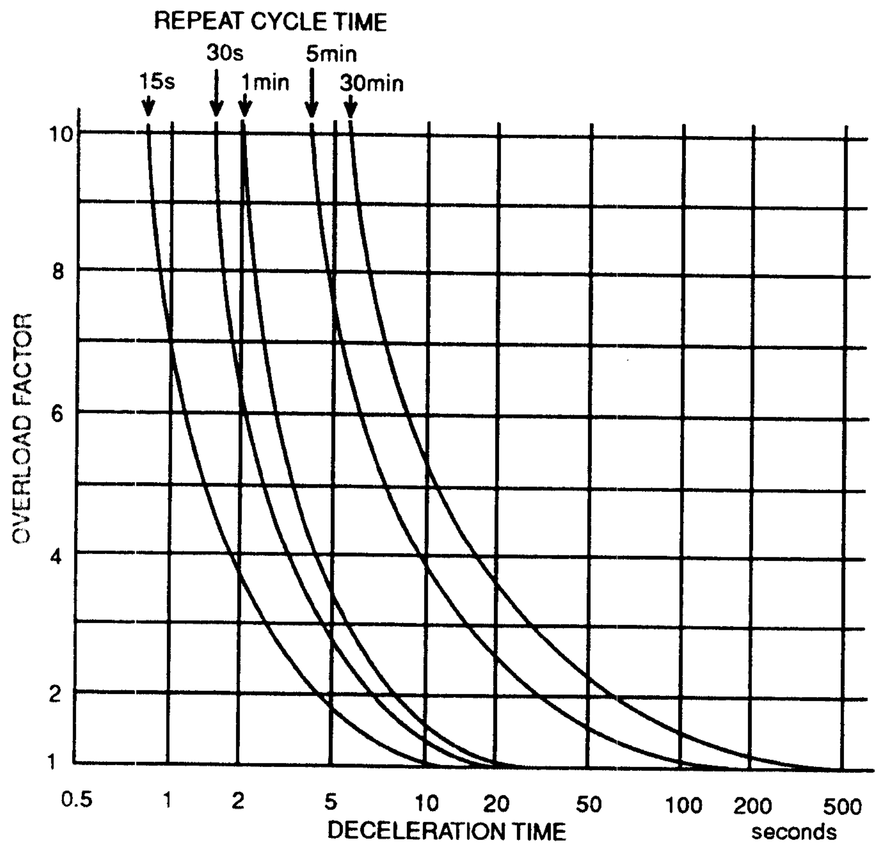
The *value* of the resistor is —

$$R = \frac{V^2}{P_b} = \frac{660^2}{6 \times 10^3}$$

$$= 72.6\Omega$$

Resistor power rating P_r

As the braking resistor operates intermittently, its power rating is 'intermittent' rather than 'continuous'. Advantage can be taken of the overload rating of the resistor by applying an overload factor, which will be derived from a set of cooling curves which can be obtained from the manufacturer or supplier of the resistor.



17 Typical cooling curves for power resistor overload factors. These curves are typical examples only. *For practical application use curves supplied by the resistor manufacturer.*

In this example, deceleration time is taken as 7s, repeat cycle time 30 seconds. From Fig.17, reading from 7s on the horizontal axis and vertically to the 30-second curve, the overload factor is 2.

The power *rating* of the chosen resistor is —

$$P_r = \frac{P_b}{\text{O/L factor}}$$

$$= \frac{6\text{kW}}{2}$$

$$= 3\text{kW}$$

For practical purposes, it can be assumed that 15% to 20% of energy dissipated during regenerative braking are due to electrical losses in the motor and drive, and mechanical losses in the motor and load, all of which which would assist braking.

In practice, using the recommended resistor value will result in extra braking torque being available. However, the rate of energy feedback from the load inertia is determined by the rate of deceleration.

If the rate of deceleration is unchanged, the *VECTOR* drive will compensate the duty cycle of the braking transistor so that the average power-absorption remains constant.

CAUTIONARY NOTES

The installation MUST be equipped with a thermal protection relay operating a trip release on the supply switchgear (Fig. 16).

The resistors fitted internal to the drive MUST be disconnected.

10
Electromagnetic Compatibility

IMMUNITY

If the instructions in this guide are observed, *VECTOR* 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.

Additionally, the *VECTOR* drive has been subjected to noise-level tests in accordance with IEC 801 pt. 4, without adverse result.

EMISSIONS

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

Emission can be minimised by using the lowest switching frequency selectable for the drive.

Motor Chokes

Motor chokes can be of service if long cable runs — in excess of 200m — are necessary. The chokes will also assist in the reduction of radiated radio-frequency interference (RFI) from the cables between the drive and the motor, by limiting the rate-of-rise of voltage in the cables.

Using inductors of increased size can also assist in the reduction of motor noise, but this will be at the expense of high-speed torque.

In either case, the supplier of the drive should be asked for advice.

Motor Cable

The motor cable carries the highest radio-frequency voltage and current. The electric and magnetic fields associated with the cable diminish rapidly with increasing distance, and sufficient attenuation can usually be achieved by ensuring the segregation of signal cables to a separation distance of at least 0.3m from the motor cable. Parallel runs exceeding about 10m should be avoided if possible.

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

Supply Cable

If emission into the supply causes trouble, a suitable filter must be installed. The supplier of the drive should be asked to advise.

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